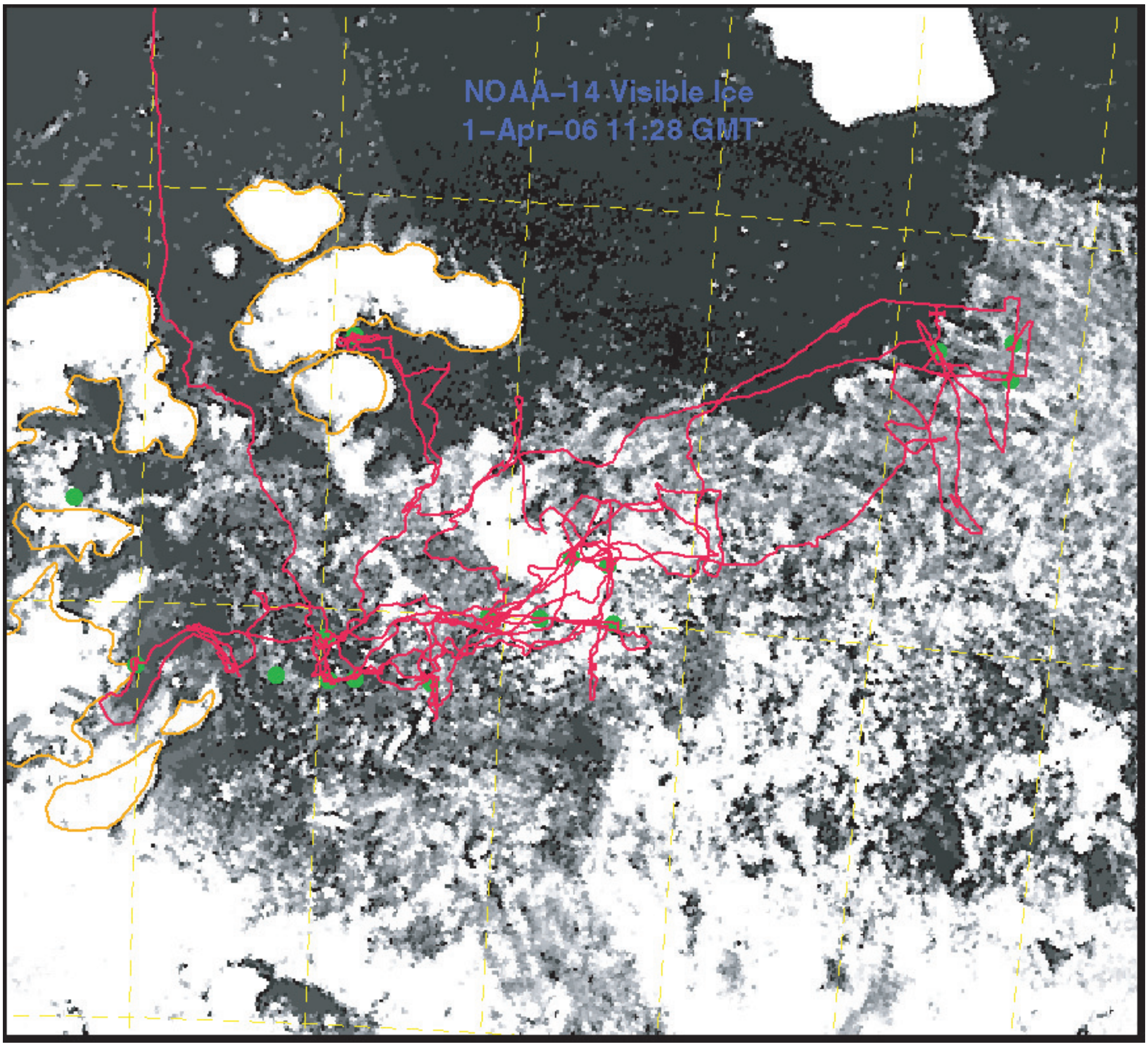
SHALDRIL II 2006
NBP0602A
Cruise Report



Shallow Drilling On The
SHALDRIL
Antarctic Continental Margin

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

There are many, many people that have worked together to make SHALDRIL happen. We would especially like to thank Jay Ardai, Jesse Doren, Jim Holik, Leon Holloway, and Ashley Lowe for their dedication to the project over the many years we have all been working on this. Captain Mike Watson's command of the *Nathaniel B. Palmer* made it possible to work in conditions that were formidable at best and ensured we had our chance. It was a pleasure to sail with Andy Frazer and everybody from Seacore and we are so pleased they have been part of our project. Lastly, we appreciate the support that Scott Borg and Tom Wagner from the NSF Office of Polar Programs have given us over the years—not only financial, but also the time and patience to get this done.

Sincerely,
The NBP0602A Science Party

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CHAPTER 1: CRUISE SUMMARY

Table of Contents

CRUISE SUMMARY

All around the Antarctic continent seaward dipping strata have been deeply eroded by ice shelves as they advanced onto the continental shelf. Older strata occur just beneath the seafloor, but are typically buried beneath a few meters to a few tens of meters of glacial sediment. With some exceptions, the stiff glacial overburden has prevented sampling older strata using conventional piston coring. The concept behind SHALDRIL is to drill through the glacial section and sample older deposits. The success of this method is dependent upon having a mobile drilling platform capable of operating in ice-covered waters, and a drilling system that can retrieve core in a matter of hours. This approach is also dependent upon having a solid seismic stratigraphic framework for a given study area. This enables selection of numerous sites, which increases the odds of being able to sample the desired stratigraphic targets where ice conditions allow. In this manner, a stratigraphic section can be pieced together using a grid of seismic data. Another important aspect is SHALDRIL targets condensed sections because they have the greatest likelihood of yielding suitable fossil material for dating the sediments. When it comes to working in adverse ice conditions, SHALDRIL II was a good test of this strategy because severe ice conditions prevented us from drilling any of our primary sites. Yet, each of the stratigraphic targets was sampled.

The 36-day SHALDRIL II cruise to the northwestern Weddell Sea (Fig. 1-1) began in Punta Arenas, Chile on 1 March and ended on 5 April 2006 (Fig. 1-2). The primary drilling targets were in the northern portion of the James Ross Basin, which is known to contain one of the thickest, most complete Neogene successions anywhere on Antarctica and its adjacent margins (Anderson, 1999) (Fig. 1-3). Previous seismic investigations have revealed a virtually continuous succession of seaward-dipping strata on the continental shelf (Fig. 1-3). The succession spans the late Eocene through Pleistocene, based on correlations to outcropping strata on Seymour Island and results from SHALDRIL II (Fig. 1-4). Older (Eocene through Oligocene), steeply dipping strata onlap basement rocks and form a virtually continuous belt around the basin margin. Where older strata onlap basement they are locally situated within meters of the seafloor, thus providing suitable drilling targets (Fig. 1-5). The Joinville Plateau bounds the basin on its northeast side (Fig. 1-3). Another thick succession of sedimentary strata composes a southward dipping ramp along the southern part of the plateau (Fig. 1-6).

During the 2005 cruise (SHALDRIL I) we often faced ice that reached nearly $^{10}/_{10}$ coverage; however, this ice was typically thin first-year sea ice that did not affect our ability to hold station. During SHALDRIL II we found ourselves facing a new obstacle in the form of large floes of very thick, multiyear sea ice. This ice, which had apparently moved into the area from the southern Weddell Sea, had to be treated with the respect due an iceberg, as the ship could not hold station once these floes were upon us. The concentration of these floes was so great that they virtually prevented nighttime operation because it was impossible to distinguish between icebergs and multiyear sea ice using radar.

Further complicating the situation was the fact that the drift of the ice was fast (up to 0.8 kn) and unpredictable, frequently changing course as the pipe was lowered through the water column. To have any chance of completing a hole in these conditions required finding open areas and maneuvering the ship while on station to within the allowable limits.

We learned early in the cruise that it would be impossible to remain on station for the length of time necessary to drill through thick glacial overburden and sample older strata. The first two sites occupied during SHALDRIL II (NBP0602A-1 and -2), located near Proposed Sites JRB6 and JRB4 on the continental shelf, were both terminated due to ice before reaching the stratigraphic target. Our longest time on station in this area was 30 hours (Hole NBP0602A-1C), while the maximum sub-bottom depth reached was 52.2 meters below the seafloor (mbsf) in Hole NBP0602A-2B. This meant that our primary proposed sites could not be drilled without a break in sea-ice conditions. We therefore focused on backup sites where the targeted sections were closer to the seafloor.

Our backup sites were all located in the very northern part of the James Ross Basin where Eocene and younger strata onlap acoustic basement (Fig. 1-5). Our seismic coverage in this area is good enough for us to correlate to our proposed sites further south where a stratigraphic framework for the basin exists (Anderson et al., 1991; Sloan et al., 1995). Unfortunately, sea-ice conditions were not much better at the alternate site locations; however, we did occupy two sites in this area (NBP0602A-3 and -4), with the former reaching the targeted upper Eocene/lower Oligocene strata before being abandoned due to drifting sea ice.

After terminating Site NBP0602A-4 prior to reaching the target interval again due to drifting ice, we began a seismic survey to search for additional sites to the northeast, where we expected open waters based on the sea-ice imagery we had acquired. We discovered that the southern margin of the Joinville Island Plateau contains a thick wedge of strata, and older strata from deep in the wedge crop out along the flanks of the plateau. The first site in this area (NBP0602A-5) sampled middle Miocene muddy sands, which occupy the middle part of the stratigraphic wedge. The second site (NBP0602A-6) was drilled at a location higher in the section and sampled 20 m of Pliocene sand. During our attempt to sample the older part of the section (Site NBP0602A-7), the drill string broke without obvious cause. We tried again, but this time the BHA section of the pipe broke. These failures were tentatively attributed to strong currents and/or a surface gravel lag that tended to collapse into the hole. Thus, we decided to reassess ice conditions at our other locations.

After a day of unsuccessfully searching for ice-free sites we decided to drill our Holocene site in the Firth of Tay (Site NBP0602A-8). This decision was prompted by an advancing low-pressure system, which we hoped would disperse sea ice in the James Ross Basin area. As it turned out, this was a good decision because the wind blew consistently in the 20- to 40-kn range for about 24 hours. Despite strong winds, the ship held station and the site was drilled to a sub-bottom depth of 79 m, where stiff glacial till was encountered.

Core recovery was good (~85%), except in the upper 20 m of the section where soft, water-saturated sediments were encountered. Dr. Eugene Domack offered to acquire a jumbo piston core through the upper 20 m of the section during the next Palmer cruise (NBP0603). If they are unable to reach the site, we will revisit it during our planned 2007 cruise.

After departing the Firth of Tay we were met with very strong winds and were forced to wait out a storm. The next day we revisited our original proposed sites where we found open water behind a large iceberg. The drill string was lowered (Site NBP0602A-9), but just as it reached mudline, the iceberg began to drift away at nearly 1 kn. Within minutes sea ice moved into the area and we were forced to shift to a new location, where we were able to drill only to 10 mbsf before ice forced us to abandon the site. We maneuvered around the large iceberg to drill a new site (NBP0602A-10), but once again drifting sea ice prevented us from continuing the site. At this point there was another low-pressure system moving our way so we decided to occupy a site behind Seymour Island in Admiralty Sound.

Our objectives at this site (NBP0602A-11) were of a technical nature, intended to address several questions about drilling and sampling sedimentary rock while stabilizing the ship in fast ice. We were unable to locate a suitable site in fast ice so opted for an area of open water in the northern part of the sound. The ship was able to hold station well in winds up to 45 kn, and we were able to recover sedimentary rock for a long enough period to measure the penetration rate (~1 m per hour) and core recovery (~50%).

We departed Admiralty Sound on the afternoon of 30 March and steamed east to discover that our sites along the northern edge of the basin were still covered by sea ice. We thus continued north and east toward Joinville Island where we believed Oligocene and early Miocene strata are situated near the seafloor. We made our way to our preferred site early in the evening of 31 March and began lowering pipe. At this stage we had less that 12 hours of drilling time left in our quest to sample the elusive Oligocene section before we would have to head north.

Everyone on board was totally committed to drilling this last site, despite having had drilling problems in this area previously. Our first core sampled lithified muddy sand that proved to be Oligocene in age. We were able to retrieve about 4 m of core before drifting sea ice forced us to abandon the site, just minutes before our agreed departure time. And thus the scientific portion of SHALDRIL II ended.

Sea-ice conditions encountered during SHALDRIL II were the worst-case scenario: thick multiyear ice drifting at rates that were totally unpredicted from our knowledge of currents in the area. As a result, we did not drill at any of our proposed sites. Yet, we sampled every one of our stratigraphic targets. The mobility of SHALDRIL enabled us to improvise to overcome bad weather and severe sea-ice conditions by exploiting alternate sites. The deepest penetration in areas affected by sea ice was to 50 mbsf, but we were able to move onto location and acquire several meters of core in the most adverse conditions.

Our drill and run strategy certainly proved viable. It is probably safe to say that none of the core retrieved during SHALDRIL II could have been acquired by standard piston coring.

The SHALDRIL cores will undoubtedly reveal much about the climate history and glacial evolution of the Antarctic Peninsula. The older time intervals we have sampled (late Eocene-earliest Oligocene, late Oligocene, middle Miocene, and early Pliocene) are all poorly represented in the outcrop record of the region, and the recovered material is well suited for paleoclimatic studies (Fig. 1-4). The sediments have never been deeply buried, and a rich variety of opaline, calcareous, and organic-walled microfossils has been observed in preliminary shipboard analysis of the samples. Additionally, we have collected two excellent, expanded Holocene records (Maxwell Bay during SHALDRIL I, and the Firth of Tay during this cruise) that will provide regional coverage needed to better understand Holocene climate evolution. We were unable to continuously core a grounding zone wedge (Proposed Site JRB5). This simply was not possible given the limited time we had on any given station.

In addition to the scientific accomplishments, we have tested the ship and the drilling and coring systems under the most adverse, conditions and have gathered considerable data for planning future SHALDRIL cruises. The ship is capable of holding station in winds up to 45 kn; our hope was to be able to maintain station in 30-kn winds. The drilling rig is capable of penetrating up to 20 m of glacial overburden and sampling older strata within 24 hours. Core recovery in partially lithified sedimentary material is quite good (greater than 80%). Drilling in sedimentary rock is a bit slower than we had hoped, but the information we have gathered will enable us to make realistic estimates for future SHALDRIL projects.

The ultimate assessment of SHALDRIL II will come after the science is done. We believe it has been a success, but we cannot help but wonder just what we would have accomplished had we had a good ice year.

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Sloan, B.J., Lawver, L.A., and Anderson, J.B., 1995. Seismic stratigraphy of the Palmer Basin. *In* Cooper, A.K., Barker, P.F., and Brancolini, G. (Eds.), *Geology and Seismic Stratigraphy of the Antarctic Margin*. American Geophysical Union, Antarctic Research Series, v. 68, p. 235-260.

Figure 1-1. Map of Antarctica showing the NBP0602A SHALDRIL II study area.

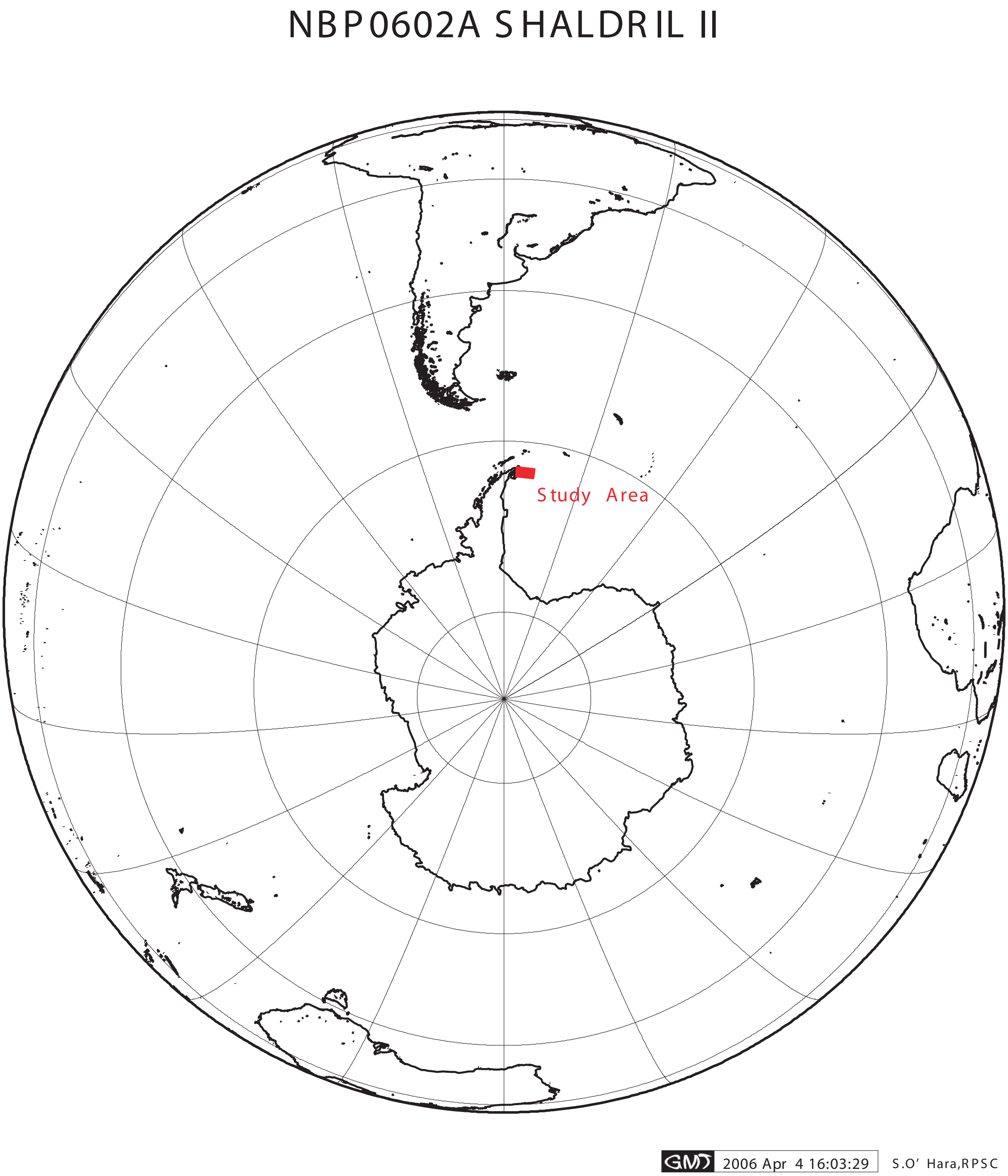


Figure 1-2. Areal map showing the NBP0602A cruise track, proposed drill sites, and final drill sites.

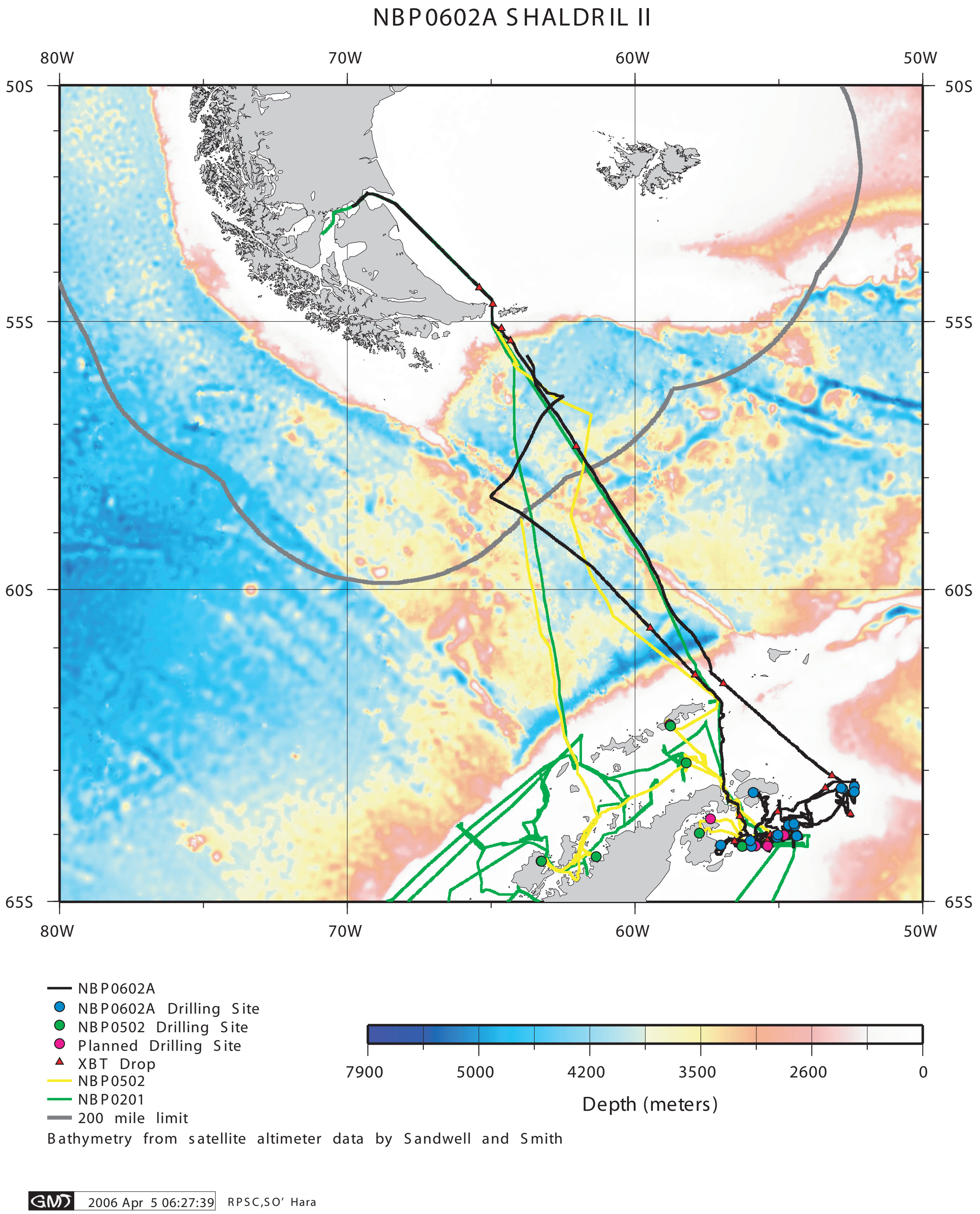


Figure 1-3. NBP0602A study area showing age of outcropping sediments and seismic stratigraphy of the area.

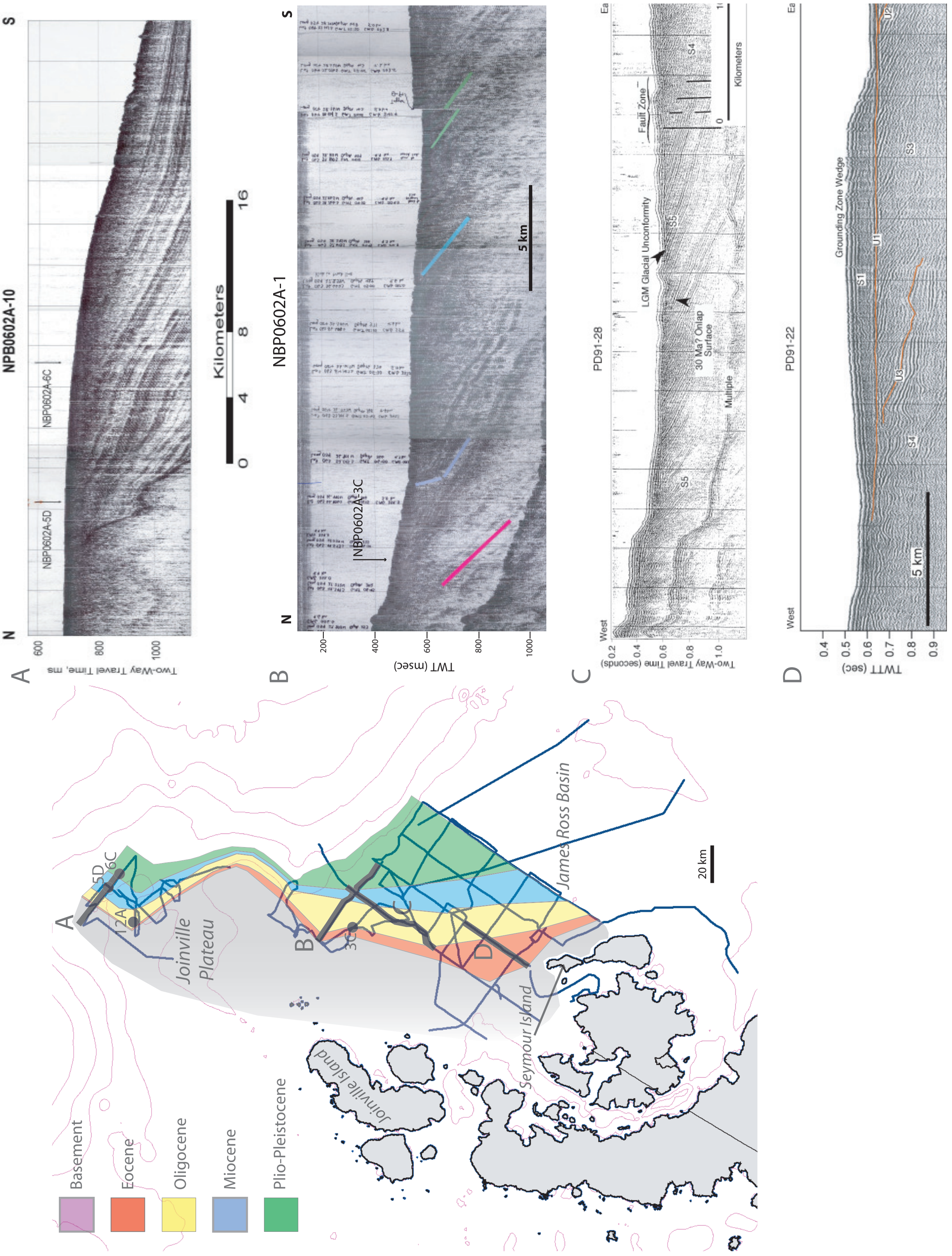


Figure 1-4. Ages of sediments recovered during NBP0602A, correlated to the James Ross/ Seymour Island stratigraphy and timing of major climatic events in the region. See Anderson (1999) for complete references.

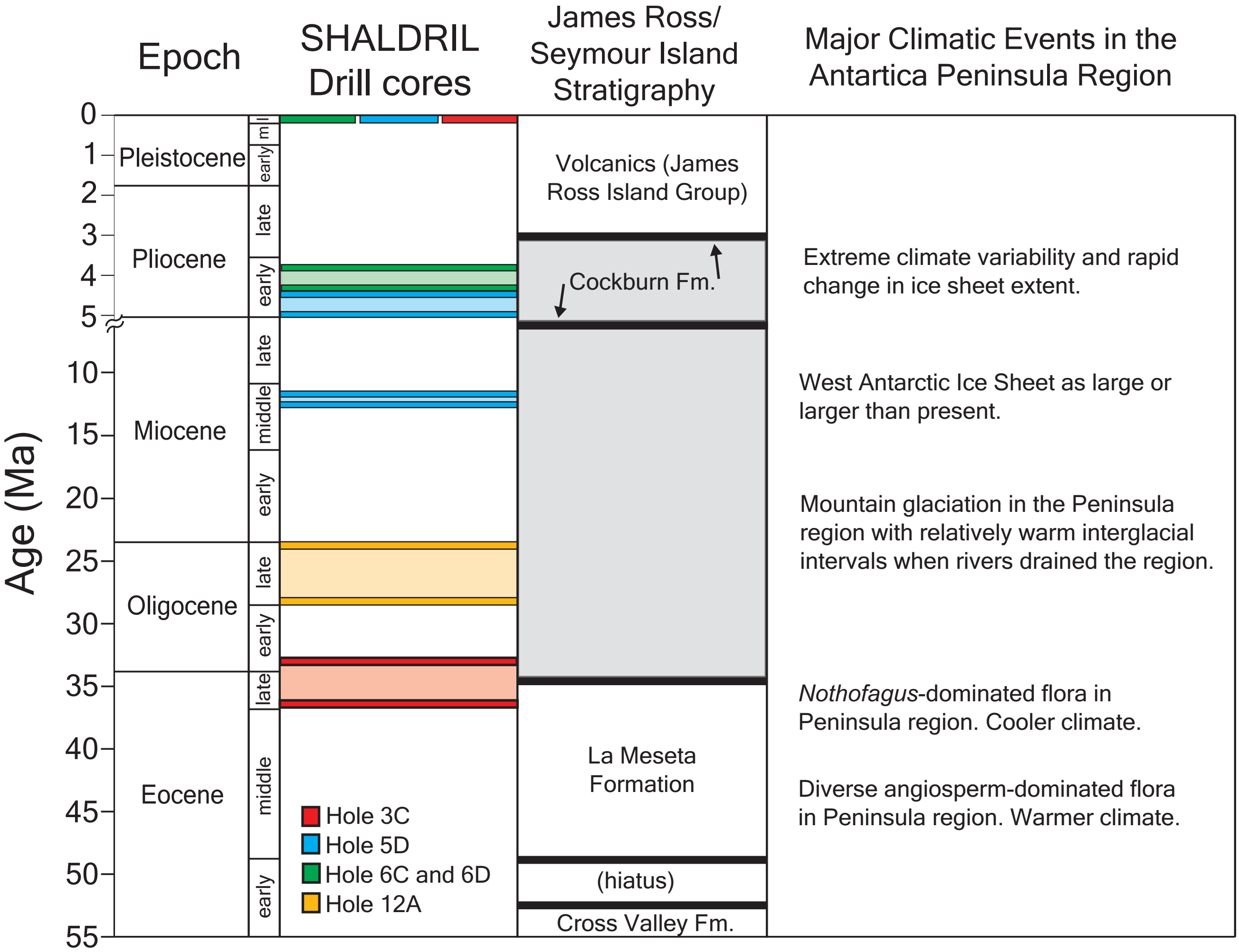


Figure 1-5. Seismic Line NBP0602A-02 showing older strata onlapping basement.

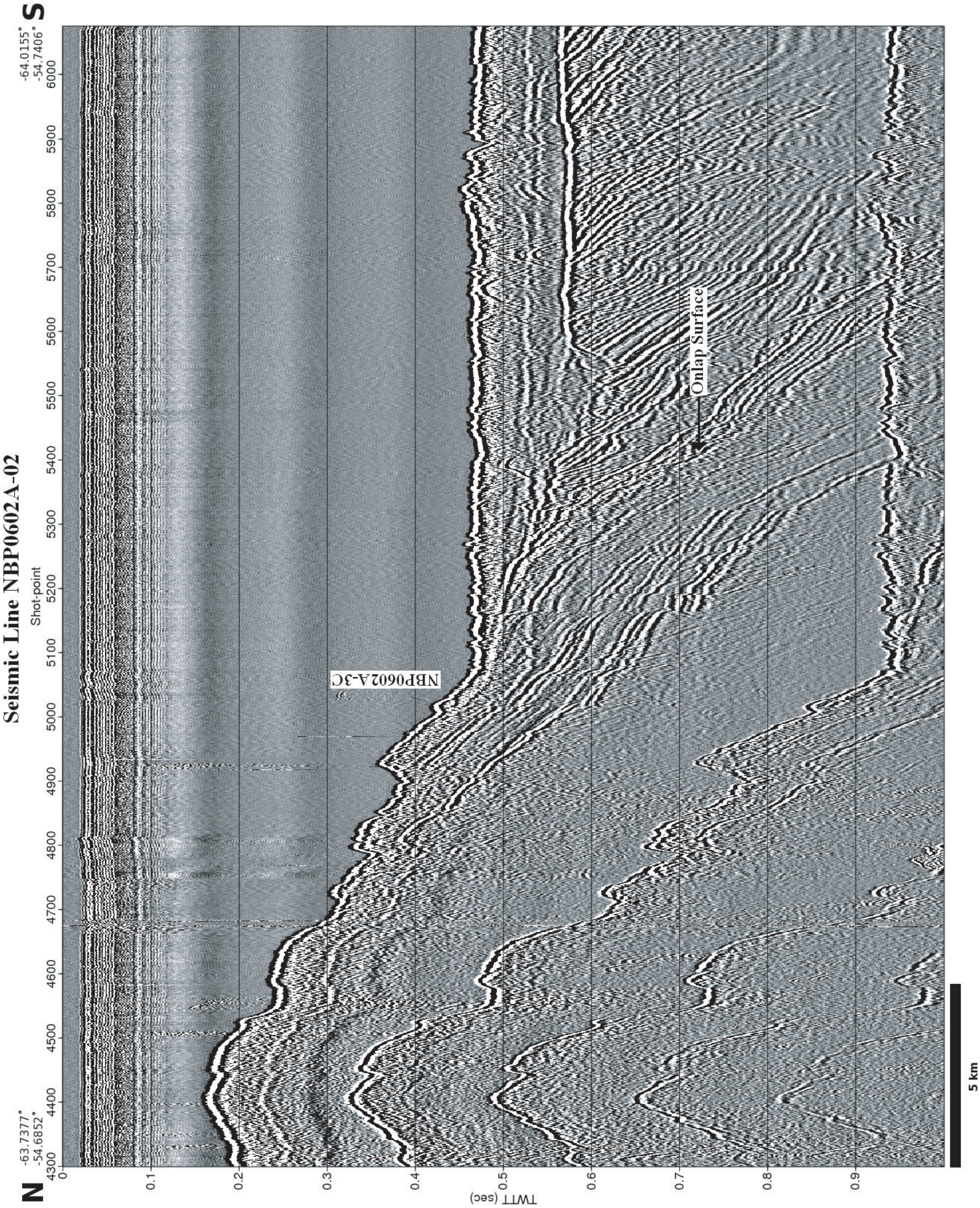
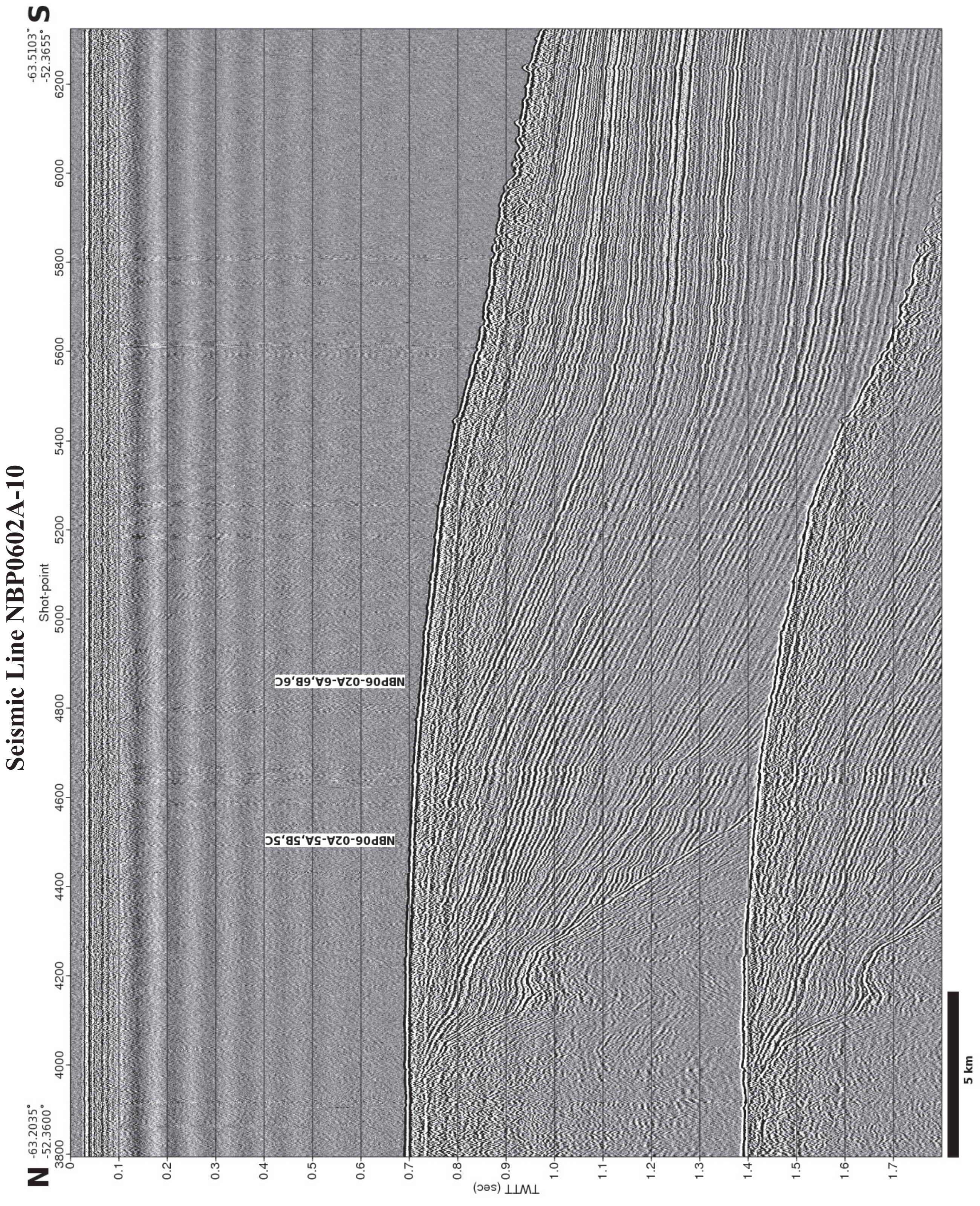


Figure 1-6. Seismic Line NBP0602A-10 showing thick succession of southward dipping strata along the southern part of the Joinville Plateau.



CHAPTER 2: EXPLANATORY NOTES
Table of Contents

EXPLANATORY NOTES

INTRODUCTION

In this chapter, we describe the shipboard procedures and observations that led to our preliminary conclusions. These data are also useful for selecting samples for shore-based research. This information concerns only shipboard operations and analyses described in the site reports in this cruise report volume.

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E. **Physical Properties:** Caroline Childs, Anne Christopher, Joel Cubley, Matthew Curren, Patricia Manley, Katharine North, Fred Weaver
F. **Site Summary**: John Anderson plus Patricia Manley, Julia Smith Wellner, or Woody Wise, as appropriate
Appendix: Shipboard Scientific Party

In addition to each site chapter, summary core descriptions ("barrel sheets" and images of each core) are presented as appendices to each site report (see **"Core Description Procedures"**).

HANDLING OF DRILL CORES DURING SHALDRIL OPERATIONS

The following guidelines are intended to standardize the processing and archiving of core material, especially drill core, collected during SHALDRIL operations on the RV/IB *Nathaniel B. Palmer*. The different activities involved in the processing and archiving of the material are divided among several groups, including Raytheon Polar Services Company (RPSC) personnel, Antarctic Marine Geology Research Facility (AMGRF) personnel, the Shipboard Science Party, and Seacore personnel. Seacore personnel are responsible for retrieving the core. Once the core leaves the rig floor a combination of RPSC, AMGRF, and Science Party personnel complete the tasks outlined below. Upon completion of these tasks, RPSC manages the refrigerated shipment of cores to the AMGRF at Florida State University.

Core Nomenclature

Numbering of Sites, Holes, Cores

SHALDRIL sites are numbered consecutively and refer to one or more holes drilled while the ship is positioned at one GPS location. Multiple holes may be drilled at a single site by pulling the drill pipe above the seafloor (out of the hole), moving the ship some distance from the previous hole, and then drilling another hole.

For all SHALDRIL drill sites, a letter suffix distinguishes each hole drilled at the same locality. The first hole drilled is assigned the site number modified by the suffix "A"; the second hole takes the site number modified by the suffix "B"; and so forth. It is important to distinguish among holes drilled at a site because stratigraphically equivalent sediments or rocks from different holes may not have the same sub-bottom depths. Conventional Kasten or piston cores taken at the site will follow this same nomenclature.

The cored interval is measured in meters below seafloor (mbsf). The depth interval assigned to an individual core begins with the depth below the seafloor at which the particular coring run begins and extends to the depth that the coring run ends (Fig. 2-1). Each cored interval is generally the length of a core barrel. It may be less, however, particularly for push cores taken with the extended core barrel. Coring intervals may be shorter and may not necessarily be consecutive if they are separated by drilled (i.e., non-cored) intervals.

Cores taken from a hole are numbered serially from the top of the hole downward. Core numbers and their associated cored intervals in mbsf ideally are unique in a given hole. The top mbsf of a core is calculated by adding the depth of the intervals of all the cored (or drilled) intervals above that core. When the recovered core is shorter than the cored interval, the top of the recovered core is equated with the top of the cored interval for curation purposes (e.g., Cores 1 and 5 in Fig. 2-1).

A core-type designator will follow core numbers for all drill cores and will be "R" for standard rotary cores, "R_a" for rotary cores utilizing the alien bit, "E" for extended core barrels or push samplers, "E_s" for spring-loaded, non-rotating extended nose core barrels, "H" for hammer cores, and "PB" for piggyback diamond rotary cores. A "w" can be added to the core-type designator to indicate a washed core (e.g., "$R_{a\text{-}w}$"). "R_n" will be used in notes for the non-coring center bit, but there will never be a core labeled with this designation. These various types of cores come in different lengths, i.e., up to 5 m for standard rotary cores, 1-3 m for extended core barrels that are pushed rather than drilled into the sediment (including "push" and "Shelby" cores), 3 m for diamond rotary cores, and a variable amount of rubble for hammer cores.

When full recovery is obtained, the core is subdivided into sections 1.5 m in length (Fig. 2-2). The lowermost section will generally be shorter than 1.5 m. In some cases, all sections may be cut into intervals less than 1.5 m to preserve features of interest. Sections less than 1.5 m in length also may be cut when the core liner is severely damaged.

By convention, material recovered from the core catcher (CC) is placed immediately below the last section and is labeled “CC” (Fig. 2-2). The core catcher is assigned the depth of the top of the cored interval in cases when material is recovered only in the core catcher (even though information from the driller or other sources may indicate the depth from which it was actually recovered).

Labeling of Cores and Sections

All core sections are labeled with a waterproof permanent marker (or electric scribe). Each core liner section is labeled twice, once on each side, 180° apart. The following information is included on each core section:

- Ship name and year
- Cruise number
- Site number
- Hole (A, B, C, etc.)
- Core number
- Core type
- Section number

For example, Core 2 from the second hole drilled with the extended core barrel at Site 1 during the 2006 SHALDRIL cruise on the *NB Palmer* would be labeled: NBP0602A-1B-2E.

Individual sections of a core are labeled numerically from the top to the base. The uppermost section is designated 1, the next as 2, and so on. (*Note: this protocol is the opposite of standard piston coring nomenclature.*) Section numbers appear on the core liner after the core number. Thus, NBP0602A-1B-2E-1 would designate the first (uppermost) section of Core 2. The next section of Core 2 would be NBP0602A-1B-2E-2. Figure 2-2 graphically depicts the core-labeling scheme for a variety of core recovery scenarios.

The orientation of the core is also marked on each core section. An arrow pointing in the up direction is drawn directly on the core liner in two places, 180° apart. If a foam insert is placed in a whole core to fill a sediment gap prior to splitting, a note is made on the core liner marking its location.

Other Types of Cores Obtained during Drilling Cruises

Kasten cores were collected during the inaugural SHALDRIL cruise, and there is a chance that in the future piston cores could be collected during other drilling cruises.

These cores will be labeled according to standard convention modified to match the terminology described above. For example, a Kasten core is labeled by the cruise name (e.g., NBP0602A represents the second half of the second cruise of 2006), the site number (01 for the first site of the cruise), the hole letter (A for the first hole at the site), and KC to indicate a Kasten core (thus NBP0602A-1A-KC). If another Kasten core is taken at the first site, it will be NBP0602A-1B-KC. Drill core obtained from that site after Kasten coring twice will be labeled NBP0602A-1C. Sites that are occupied for Kasten coring without drilling will still be numbered sequentially with the drill core sites. Thus, the second site to be drilled might have core labeled NBP0602A-4B if two sites were Kasten cored without drill coring and a Kasten core was taken at the fourth site before drilling commenced. Other core types include piston cores (labeled “P”) and grab samples (labeled “GS”).

Drill-Core Processing

In this section the individual steps for processing core, from the time the core leaves the rig floor to its final storage location in the refrigerated container, are specified in detail. The steps are shown graphically in Figures 2-3 and 2-4.

CORE SECTIONING (STATION 1):

Core liner from each run is carried from the rig floor into the Helo hanger room and laid out horizontally on the core sectioning rack (Fig. 2-4). End caps are placed on the core liner and sealed using either tape, acetone sealant, or a combination of both. End caps are black for the top and red for the base for ODP-style core liners, whereas the end caps for the smaller core liners are yellow and hand labeled top and bottom

The liner is marked off in 1.5-m intervals starting at the top of the recovered material in the core. If recovered sediment is more than 2 m but less than 3 m, then the core is sectioned in two equal parts. Electrical tape and acetone are used to affix the section end caps. End caps for each section are also color coded, black for the top and red for the base of each section. Each section is then labeled with the cruise, site, hole, core, and core-type designators.

FAST-TRACK SAMPLING (STATION 1):

Fast-track sampling for biostratigraphic analysis initially comes from the core catcher samples when present (otherwise the base of the core), and if needed from the base of each section. No sections will be cut from any of the liners for fast-track analysis.

EQUILIBRATE CORES (STATION 2):

Once cores are labeled, sectioned, and sampled for fast-track analyses, they are taken into the main core lab (i.e., Aft Dry Lab) (Fig. 2-3) to equilibrate to room temperature before being analyzed on the multisensor core logger (MSCL). This process usually takes 4-5 hours.

CORE RECOVERY LOG (STATION 2):

Throughout the cruise a spreadsheet is compiled that includes a list of all the cores brought on deck. Once cores are sectioned, labeled, and brought into the main core lab (= Aft Dry Lab) for equilibration, pertinent core data (ID, length, sub-bottom depth, etc.) is entered into the Core Recovery Log spreadsheet (Fig. 2-5).

MULTISENSOR CORE LOGGING (STATION 3):

Once the cores have equilibrated to room temperature, they are run on the MSCL for gamma density, *p*-wave velocity, electrical resistivity (ER), and magnetic susceptibility (MS) (Fig. 2-3). Density is determined by measuring the attenuation of gamma rays through the cores; *p*-wave velocity is measured using Acoustic Rolling Contact transducers; ER is measured using a non-contact coil array; and MS is measured using a loop or point sensor. The core is usually logged at 1- or 2-cm intervals. After all the sections of a core have been run, the data are processed, and then downloaded to the local server.

CORE SPLITTING, CLEANING, AND DEPTH LABELING (STATION 4):

After each section is run on the MSCL, it is carried into the Baltic Room for splitting (Fig. 2-3). Soft sediment cores are split using the soft-sediment carriage on the core splitter. This carriage cuts each side of the liner (but not the sediment) along the whole length of the section. Once the liner is cut, the sediment is split by pulling a wire along the length of the section. Indurated cores are cut using the “super-saw” carriage on the core splitter. In this mode, a water-cooled saw is pulled along the length of the core, cutting both the liner and sediment in half.

Once the core is cut in half, each section is cleaned by scraping the surface with a 4” stainless-steel spatula in a motion perpendicular to the long axis of the core. Depth markers are then placed at appropriate intervals along the length of the core. Each section of core is labeled on both the sample and archive sides with the appropriate Core/Section designation (see “**Labeling of Cores and Sections**” for core-labeling protocols). In case the sediment is not equally distributed within the liner, the half with the most sediment is designated the sample half.

CORE PHOTOGRAPHY (STATION 3):

The best-preserved core half of each section is then taken back to the MSCL and run through a color line scan digital imaging system. Continuous digital photos are acquired down each section. Image resolution depends on core width but typically is about 300 dpi for a 75-mm diameter core. The digital photographs are then downloaded, renamed with the proper core/section designation, and placed on the local server.

CORE DESCRIPTION (STATION 5):

The archive section of the core is placed on the core description table after the section is photographed (Fig. 2-3). The core is logged for color (using Munsel charts), structure, grain size, and basic lithologic variation. See Figure 2-6 for an example of a

Graphic Core Description Log for the barrel sheets and Figure 2-7 for lithologic symbols for the barrel sheets. Smear slides are taken to verify lithologic components.

ELECTRICAL RESISTIVITY (STATION 6):

The sample half of the core is placed on the core-sampling table (Fig. 2-3). Resistivity measurements are taken every 5 cm using the ER probe. This is a non-invasive probe and does not disturb the core.

*PHYSICAL PROPERTY SAMPLING** (STATION 6):*

Five cc of sediment is taken with a syringe every 5-10 cm or at an interval deemed appropriate for the sediment type for discrete physical property measurements. The samples are placed in weighed vials, sealed with electric tape, and placed in travel containers in the cool room for storage until shipment. Discrete samples will be processed onshore for water content, saturated bulk density, porosity, and void ratio. Final physical property measurements for SHALDRIL NBP0602A will be performed at Middlebury College.

*ADDITIONAL SHIPBOARD SAMPLING** (STATION 6):*

Any additional sampling required for basic core characterization or ephemeral properties (such as bulk density) is conducted at this station. Samples taken are placed in bags and hand labeled, and the sample data entered into a spreadsheet. Standard sampling supplies (bags, bag sealer, foam plugs, sampling tubes, etc.) are stored at this station. All sampling data (e.g., Core ID, interval, description of sample) is given to the curators for inclusion in the AMGRF Sample Database.

*****SAMPLING WILL ONLY BE CONDUCTED AS DEEMED APPROPRIATE BY THE PIs FOR NECESSARY SCIENCE AND ONLY TO THE EXTENT THAT CORE PRESERVATION IS NOT COMPROMISED.***

CORE WRAPPING (STATION 7):

After the core is described and sampled, the sample and archive halves are wrapped in plastic wrap (Reynolds 900 film) (Fig. 2-3) and then placed into standard ODP-style D-tubes, which are labeled with each core's information.

MAIN LAB CORE STORAGE (STATION 8):

A movable core rack with space for 50 sections is utilized to temporarily store core in the Aft Dry Lab (Fig. 2-3). This storage rack will allow 75 m of core to be held in the lab at any one time.

BOX CORES FOR REFRIGERATED STORAGE (STATION 7):

In preparation for refrigerated storage and shipment of cores, 10 individual D-tubes are packed into a shipping box. Each box is then labeled (with cruise, hole, and core designations), stapled shut, and wrapped with strapping tape.

TRANSPORT OF CORES TO REFRIGERATED STORAGE (STATION 9):

The boxes containing the cores are carried to the deck area just aft of the Baltic Room. Boxes are stacked five to a pallet and securely strapped into place. The pallet is then lifted by electric wench and placed on the Helo deck near the refrigerated storage container (Fig. 2-4).

CORE STORAGE ON HELO DECK (STATION 10):

The boxes can be stacked in the refrigerated van (Fig. 2-8). There is a stacking limitation of 8 boxes high, which is primarily a weight limitation to avoid crushing the core.

Kasten-Core Processing

After coming on deck, Kasten cores are carried to the sampling table where ER measurements will be made at a 2-cm interval. Discrete samples are also taken at this interval. After sampling, the Kasten cores are archived by means of half-liner sampling. The archive core is then affixed with depth labels and sent to the MSCL station and analyzed in a similar fashion to other sediment cores. Final steps are the same as above for Stations 5 and 7.

Shipping

Material headed to the AMGRF should be shipped to:

Antarctic Marine Geology Research Facility
108 Carraway Building
Florida State University
Tallahassee, FL 32306-4100
ATTN: Fred M. Weaver &/or Matthew Curren
Telephone: 850-644-2407
FAX: 850-644-4442

via:

NSF Contractor Representative
U.S. Naval Construction Battalion Center
Building 471, North End
Port Hueneme, CA 93043
ATTN: Jackie Samuel

SITE GEOPHYSICS

Core sites for the NBP0602A SHALDRIL cruise were selected based on several previous cruises. The seven sites planned for the northwestern Weddell Sea are based on a seismic survey completed during R/V *Polar Duke* Cruise PD91 (Anderson et al., 1992, 1994). The selected sites were further surveyed during RV/IB *Nathaniel B. Palmer*

Cruise NBP0201 in preparation for SHALDRIL (Wellner and Anderson, 2004). Seismic data was collected during NBP0602A to further constrain alternate sites as needed due to weather and ice conditions. The data were collected using two 50 in^3 airguns and a single channel ITI streamer.

LITHOSTRATIGRAPHY

Core Description Procedures

General Description Procedures

Procedures used for describing the cores in this volume are similar to those used in previous studies published by the AMGRF (e.g., Kaharoeddin et al., 1988; Bryan, 1992a, b). These procedures are presented below.

The description of each core consists of four types of information included in the lithologic logs (barrel sheets):

1. The primary information (latitude, longitude, water depth, core length);
2. The lithologic description (using megascopic and smear-slide observations);
3. Information concerning core conditions that are not inherent to the lithologic character of the sediments (disturbance, missing section, etc.);
4. Whole core MS, ER, and density data collected onboard the RV/IB *Nathaniel B. Palmer*. The data are corrected for end-of-core effects and plotted next to the graphic lithology.

Most of the primary information is obtained from the deck log or from other information provided by the chief scientist(s) of the cruise. Core conditions not inherent to the lithologic character of the sediments are recorded from the deck log and from initial observations after cutting the core liner.

A graphic log illustrating the main lithologic boundaries, inclusions, sedimentary structures, and disturbances of the sedimentary units accompanies each core description. The positions of the core section breaks are indicated on the log in order to inform the investigator as to where samples should not be taken, since cutting of cores into sections may result in sediment disturbance. Not all information appearing in the written portion of the lithologic description is illustrated in the graphic log.

Megascopic Examination and Description

The description elements of each unit are presented below:

1. The upper and lower boundaries of the unit. Lithologic units are recognized on the basis of compositional, textural, and other sedimentological characteristics.

2. Lithologic name and Munsell color code of the sediment. Gradual changes in texture or color of the unit are described accordingly. The term “graded” can be applied to the name of a unit (see “**Sediment Classification**”). Interlayering with other types of sediment is also noted.
3. Observable distribution of volcanic ash, manganese nodules, and staining.
4. Internal structures within the unit: zone, layer, lamina, lens, stringer.
5. Inclusions: sedimentary clasts, pebbles, lapilli, manganese nodules.
6. Bioturbation.
7. Disturbances due to the coring operation and/or transportation.
8. Nature of the bottom contact of the unit: sharp, gradational, unconformable, etc.

Sediment classification is based both on smear-slide observations and megascopic core descriptions. Sediments larger than fine sand (>250 µm) are usually excluded during smear-slide preparation. In the case of sediments with mixed sizes (both greater and less than 250 µm), classification of the sediment based on smear slides is included in addition to the megascopic description. Time constraints for shipboard processing precluded the ability to estimate coarse vs. fine fraction based on sieving procedures.

Glaciomarine sediments generally consist of mixed size classes (such as pebbles in mud). However, no attempt is generally made to utilize a separate classification for these sediments. Instead, the matrix is classified according to the guidelines outlined herein for fine-grained sediments, and clasts are described separately as inclusions within the lithology. Where a separate classification is used, see “**Detrital Sediments**”.

The size class and sorting of a sand or pebble unit are usually indicated in the description. Size classes of sand-size fractions are determined by use of the AMSTRAT (American/Canadian Stratigraphic) size-class comparison card. On this card, each of the five size classes (very coarse, coarse, medium, fine, very fine) of sand-size particles has been divided into two subclasses (very coarse upper, very coarse lower; coarse upper, coarse lower; etc.). The ten subclasses (separated by 0.5 phi intervals) are graphically depicted on the card for comparison with the sediment. Determination of the mean grain size of sand is a matter of matching the size of the most abundant grains to one of the five size classes exhibited on the card.

A unit may exhibit several colors, and color changes within a unit are described as being gradational or sharp (abrupt). Mottling refers to irregular spots of differing color within the sediment, and the color of mottling may be included in the description. The color of the sediment is determined by visual comparison of fresh sediment with the Munsell color chart. If the color of a sediment cannot be matched exactly with the color chart, the closest color is used.

Any variation in the abundance of a major component in a unit, observable either megascopically or through smear-slide analyses, is given in the description. Minor constituents that are scattered within a unit (micromanganese nodules, lapilli, ash, etc.)

may also be identified on smear slides. Their abundance is determined after a thorough examination of the core and described as scattered, common, or abundant. Manganese and ferrous oxides that occur as staining materials can be either in the form of small patches or spread uniformly within an interval. These stainings are described as slightly, moderately, or highly stained.

In describing the internal structures within a sedimentary unit, the stratigraphic position of each structure is noted, and, when applicable, the composition and color are described. Each structure is defined as follows:

1. *Zones* are defined as small intervals (less than 20 cm) in which a notable change in the abundance of some components or inclusions in the unit can be detected, either through megascopic examination or smear-slide analysis.
2. *Layers* have a thickness of 1-10 cm and are separated from the main unit by a discrete change in lithology and distinct planes of contact. Layers less than 5 cm are usually not included on the graphic lithology column of the core description form, but are denoted by a symbol in the structure column.
3. *Laminae* are similar to layers, but have a thickness of less than 1 cm.
4. *Stringers* are laminae that are discontinuous and often irregular in form.

In the description of a unit, the following sequence is used: zone, layer, lamina, stringer.

Inclusions within a unit are described in the following manner:

1. *Sedimentary clasts* are described in detail, including size, composition, color, and position in the core. (Example: “Sedimentary clasts up to 12 mm composed of calcareous, ash-bearing mud, diatomaceous mud, and muddy diatomaceous ooze, all olive gray (5Y 4/1), common throughout.”)
2. *Manganese nodules* are described as to their size and position in the core.
3. *Volcaniclastics* are described as to their textural class and position in the core. Sometimes the rock type (pumice, scoria) is also mentioned.
4. *Pebbles* are described as to their size, roundness, and position in the core. (Example: “Subangular to subrounded, very fine to fine pebbles common throughout.”) Occasionally their rock type is also given. Coatings, encrustations, and cementation by manganese or ferrous oxides are common on clastics and volcaniclastics; they are mentioned when present.

Bioturbated sediments are described in terms of slightly, moderately, or highly bioturbated. The qualifiers can be approximated as follows:

1. Slightly: less than 5% bioturbation.
2. Moderately: between 5% to 30% bioturbation.
3. Highly: 30% or more bioturbation.

Operational disturbances may occur during coring, transportation, and occasionally during splitting of the core. They may result in partial or total loss of the primary sedimentary structures and the stratigraphic integrity of the sediment. The degree of operational disturbance is described in terms of slightly, moderately, or highly disturbed, and can be approximated as follows:

1. *Slightly disturbed* sediments still retain most of their primary sedimentary structures, particularly along the central axis of the core.
2. *Moderately disturbed* sediments have lost almost half of their original structures and must be sampled carefully if they are to be stratigraphically meaningful.
3. *Highly disturbed* sediments have lost most or all of their primary structures; it is not recommended that they be sampled for stratigraphic study because of mixing of sediment components.

Highly mixed sediment that has randomly entered the core by suction during the coring operation is described as *flow-in* and is usually characterized by vertical striations that can be traced from the base of the core.

Water trapped in the liner can wash sediment along the side of the liner during transport. Sediments disturbed in this manner are described as *slightly or moderately washed along the side*, and can still be sampled carefully for stratigraphic work. The term "highly washed along the side" is not used because such sediment is almost always highly disturbed. An uncommon disturbance occurs when the overlying sediment is dragged along the side of the liner. Cores described in this manner can be sampled (carefully) for stratigraphic work.

Smear-Slide Analysis

Smear slides are routinely made from each macroscopically visible lithologic unit in the core (as recognized by compositional, textural, and color changes). If the core is homogeneous in composition (e.g., a diatomaceous ooze), typically three slides (top, middle, base) may be made for the entire core.

Smear slides are made as follows: using a toothpick, a small amount of sediment is obtained from the core. This sample is mixed with a drop of distilled water on a standard glass coverslip until the sediment and water are smeared into a very thin film. The coverslip is then dried on a hot plate using low temperature. When the slurry is dry, the coverslip is affixed to a standard 1” x 3” glass slide using several drops of Norland Optical Adhesive #61. The slide is then placed under an ultraviolet lamp for 5-10 minutes to cure the adhesive. After curing, the slide is ready for viewing under a petrographic microscope. Using transmitted light and phase contrast, biogenic sediment components and heavy minerals are readily visible. Polarized light is used to view most clastic components.

For each smear slide, the percent abundance of the following constituents is estimated using the percentage composition chart of Shvetsov (Terry and Chilingar, 1955) and reported in a smear-slide analysis spreadsheet:

1. Minerals: quartz, feldspar, mica, heavy minerals, calcite, volcanic glass, glauconite, pyrite, and micromanganese nodules.
2. Biogenic constituents: foraminifers, calcareous nannofossils, unspecified carbonate, diatoms, radiolarians, sponge spicules, silicoflagellates, ebridians, and ostracodes.
3. Sand/silt/clay ratios of the terrigenous fraction.

Sediment Classification

The system of sediment classification used in this volume is modified from Kaharoeddin et al. (1988). This classification is based on abundance estimates of constituent particles (from smear-slide observations) and megascopic examination.

The three major groups of sediment are (Fig. 2-9):

1. *Pelagic sediments* consisting of pelagic clay, siliceous ooze, calcareous ooze, or mixtures of siliceous and calcareous ooze.
2. *Transitional sediments* consisting of mixtures of biogenic and clastic sediments.
3. *Terrigenous and volcanic detrital sediments*, which include glacial and glaciomarine sediments.

Pelagic Sediments

A. Pelagic Clay

This type of sediment accumulates at a very slow rate and generally has a brown hue. Authigenic components are common (5% or more in estimated abundance); however, they may be present only in small quantities and distributed in such a manner that they are not found on the smear slide. Usually a careful examination of the core, aided by smear-slide analysis, is necessary to determine whether or not a sediment is pelagic clay. The primary components of pelagic clay are clay minerals and silt-size quartz particles, and the clay may contain less than 30% biogenic components. A qualifier cannot be added to pelagic clay; hence, pelagic clay containing 25% diatoms is not called diatomaceous pelagic clay.

B. Pelagic Biogenic Sediments

Included in this group are sediments containing at least 30% biogenic skeletons, but containing less than 30% silt and clay. They are named according to their principal fossil types: diatomaceous ooze, radiolarian ooze, siliceous ooze, foraminiferal ooze, nannofossil ooze, or calcareous ooze. A second (lesser) biogenic component may be used as a qualifier if it comprises more than 15% of the sediment. The following rules apply for naming pelagic biogenic sediments:

1. If both the principal and lesser fossil types are similar in their chemical composition (i.e., calcareous or siliceous), the sediment may be called a siliceous ooze or calcareous ooze, depending on its chemical composition.
2. Calcareous sediment that contains unspecified carbonate as more than one-third of the total carbonate is called calcareous ooze.
3. If the principal and lesser fossil types differ in chemical composition, then both components are used in the sediment name, joined by a hyphen (e.g., diatomaceous-foraminiferal ooze).

C. Transitional Biogenic Sediments

Included in this group are sediments containing at least 30% silt and clay. Two subdivisions are recognized: transitional siliceous sediments having at least 15% diatoms but less than 30% calcareous skeletons, and transitional calcareous sediments having at least 30% calcareous skeletons. The following rules apply for naming transitional biogenic sediments:

1. Transitional siliceous sediment is called muddy diatomaceous ooze if diatoms are more abundant than silt and clay; otherwise, it is called diatomaceous mud.
2. Transitional calcareous sediments are named according to their principal fossil types: marly foraminiferal ooze or marly nannofossil ooze. If the lesser biogenic component exceeds 15%, the sediment is called marly calcareous ooze.

Detrital Sediments

A. Terrigenous Detrital Sediments

Sediments in this group are classified according to their texture as defined by the standard size classes of sediment according to Friedman and Sanders (1978; Figs. 2-10 and 2-11). Sand/silt/clay ratios of the terrigenous fraction, based upon optical examination of smear slides, are presented on the core description logs. These ratios are used to assist in classification of terrigenous sediments. The following rules apply for sediments that are primarily composed of mixtures of sand, silt, and clay:

1. The sediments are named after their major clastic component (end-member) if that component is greater than or equal to 70% (i.e., sand, silt, clay).
2. Sediments containing a mixture of silt and clay greater than or equal to 70% are called mud.
3. Sediments containing between 30% and 50% sand and between 50% and 70% mud, silt, or clay are called sandy mud.
4. Sediments containing between 50% and 70% sand and between 30% and 50% mud are called muddy sand.

5. Sediments containing a minor component between 15% and 30% (e.g., diatoms or pebbles) should have a qualifier (e.g., diatomaceous muddy sand).

Pebbles are seldom encountered as a distinct sedimentary unit in marine sediments except in glaciomarine sediments. The following rules apply for the naming of sediments that consist primarily of pebbles:

1. Sediments containing 70% or more pebbles are called pebbles.
2. Sediments containing between 50% and 70% pebbles and between 30% and 50% either mud or sand are called muddy pebbles or sandy pebbles, respectively.

Pebble units often contain finer matrix sediment, some or nearly all of which may be washed away during core retrieval or transportation. Removal of matrix sediment by washing is usually easily identified during core description. If the matrix sediment constitutes more than 10% of a pebble unit, the composition of the matrix is mentioned.

In graded sequences in which the size of the particles ranges from one textural class to another (e.g., silt to sand), the term *graded clastics* is used as the name of the unit. If the size of the particles ranges within one textural class, the unit is named according to its textural class (e.g., “sand, yellow gray (5Y 7/2), graded”).

B. Glacial and Glaciomarine Sediments

Since SHALDRIL involves sampling glacial and glaciomarine deposits, a significant portion of the cored intervals will likely contain these poorly sorted sediments. The non-genetic classification used to classify glacial and glaciomarine deposits is as follows:

1. *Diamicton*: an unsorted mixture of gravel, sand, and mud in more or less equal quantities; stratification and fossils are rare. Pebbles tend to be angular with striations.
2. *Pebbly mud*: mud containing dispersed pebbles in concentrations exceeding 30% by volume.
3. *Gravel*: sediments consisting of greater than 70% pebbles.

C. Volcaniclastics

This sediment group is classified according to the classification proposed by Fisher (1961, 1966). The nomenclature and the size limits are as follows:

1. *Fine ash*: less than 63 µm.
2. *Coarse ash*: 63 µm to 2 mm.
3. *Lapilli*: 2 to 64 mm.

As suggested by Fisher (1966), the term “volcanic” is not used as an adjective of ash or lapilli. The term “volcaniclastic” is used only for graded sequences where the particle size grades from ash to lapilli; thus, the name of the unit is *graded volcaniclastics*. In the case of graded sequences where the sizes of the particles fall within one textural class, the unit is named according to its textural class (e.g., “coarse ash, brownish black (5YR 2/1), graded, well sorted”).

Volcaniclastics containing biogenic or terrigenous components in excess of 15% will have a qualifier with the term "bearing" added (e.g., “diatom-bearing coarse ash”). The same term is also added to the qualifier of other groups of sediment if the unit contains more than 15% volcaniclastics (e.g., “ash-bearing diatomaceous ooze”).

BIOSTRATIGRAPHY

Introduction

Shipboard biostratigraphic investigation of SHALDRIL cores includes primarily two microfossil groups, diatoms and calcareous nannofossils, supplemented by radiolarians, silicoflagellates, and foraminifers.

Ages for all datum events are calibrated to the geomagnetic polarity timescale (GPTS) of Cande and Kent (1992, 1995) and the Cenozoic global chronostratigraphic compilation of Berggren et al. (1995). Gradstein et al. (2004) recently proposed a new timescale for the Neogene. The reversal ages of the GPTS, however, have not yet been revised to this new timescale, which prevents revision of the age calibrations for Southern Ocean biostratigraphic datum events. Future revision of SHALDRIL core age interpretations will likely include biostratigraphic age calibrations revised to the Gradstein et al. (2004) timescale.

Preliminary ages for SHALDRIL cores are assigned primarily based upon core-catcher samples. Samples from within the cores are examined when a refined age determination is necessary and time permits. Correlations to standard chronostratigraphic frameworks will likely be further enhanced by shore-based studies of other microfossil groups (e.g., foraminifers and dinoflagellates), magnetostratigraphic data, and strontium isotope stratigraphy.

Diatoms

Zonal Schemes

The goal of initial diatom work on SHALDRIL cores is to identify important biostratigraphic datums and delineate zonal boundaries. Several extensive diatom biostratigraphic studies have been carried out for Cenozoic cores recovered in the Southern Ocean region (e.g., Schrader, 1976; Gersonde and Burckle, 1990; Baldauf and Barron, 1991; Harwood and Maruyama, 1992; Gersonde and Bárcena, 1998; Zielinski and Gersonde, 2002; Censarek and Gersonde, 2002). These studies resulted in several proposed zonal schemes and numerous revisions. Currently, detailed and well-calibrated Southern Ocean zonal schemes only exist for the Oligocene to Pleistocene. The schemes utilized during the SHALDRIL cruise are drawn primarily from three sources: Zielinski and Gersonde (2002), Censarek and Gersonde (2002), and Harwood and Maruyama (1992). Figures 2-12 through 2-14 illustrate these zonal schemes, marker species datums, and age calibrations.

The Plio-Pleistocene diatom zonal scheme applied to SHALDRIL cores is that proposed by Zielinski and Gersonde (2002) for the southern regions of the Southern Ocean (Fig. 2-12). This zonal scheme relies primarily upon biostratigraphic data collected from cores in the Atlantic sector of the Southern Ocean during Ocean Drilling Program (ODP) Leg 177 (Zielinski and Gersonde, 2002), although the datums used in this scheme are well established from biostratigraphic studies at many sites around the Southern Ocean.

One new feature of this revised scheme is the addition of the last occurrence (LO) datums of *Rouxia constricta* and *Rouxia leventerae* in the middle and late Pleistocene. These datums were recently recognized as biostratigraphically useful and used to refine the Pleistocene diatom zonation (Zielinski and Gersonde, 2002; Zielinski et al., 2002). The age calibrations for most diatom events in the Plio-Pleistocene interval are tied to magnetostratigraphic records and have relatively precise age calibrations. One zonal datum of uncertain age is the first occurrence (FO) of *Fragilariopsis barroni* (4.2-4.6 Ma). A hiatus is present in many Southern Ocean sections in the 4.5-4.0 Ma interval, and this datum may also be diachronous across different latitudes/regions. In addition to the primary zonal datums, several other diatom datums are biostratigraphically useful in the Plio-Pleistocene interval (Table 2-1). These events are utilized where possible for age assessment of SHALDRIL cores.

The middle to upper Miocene diatom zonal scheme applied to SHALDRIL cores is a modified version of that proposed by Censarek and Gersonde (2002) for the southern regions of the Southern Ocean (Fig. 2-13). This zonal scheme relies upon biostratigraphic data collected from cores in the Atlantic sector of the Southern Ocean during ODP Legs 113 and 177 (Censarek and Gersonde, 2002). Minor modifications to this zonation include: utilization of the first common occurrence (FcO) of *Actinocyclus ingens* (16.1 Ma) for the base of the *A. ingens-Denticulopsis maccollumii* Zone; the addition of the FO of *Thalassiosira torokina* (9.0 Ma) and the FO of *Actinocyclus ingens* var. *ovalis* (8.6-8.7 Ma) as subzonal markers in the *Asteromphalus kennettii-Fragilariopsis praecurta* Zone; and the addition of the LO of *Nitzschia miocenica* (6.0-6.2 Ma) as a subzonal marker in the *Hemidiscus triangularus-Fragilariopsis aurica* Zone (Fig. 2-13). In addition to the primary zonal datums, several other diatom datums are biostratigraphically useful in the middle to upper Miocene interval (Table 2-2).

The names of several Southern Ocean diatom zones in the Miocene to Pleistocene interval have been changed to reflect recent taxonomic revisions. The former Plio-

Pleistocene *Nitzschia* spp. zones have been changed to *Fragilariopsis* spp., following the taxonomic revisions of Gersonde and Bárcena (1998), Zielinski and Gersonde (2002), and Censarek and Gersonde (2002). The names of the former *Nitzschia hustedtii-Nitzschia grossepunctata* and *N. hustedtii* Zones in the Miocene have also been changed to the *Denticulopsis simonsenii* and *D. simonsenii-N. grossepunctata* Zones, respectively, in order to reflect taxonomic clarifications in the *Denticulopsis* group by Yanagisawa and Akiba (1990).

The lower Oligocene to lower Miocene diatom zonal scheme applied to SHALDRIL cores is a modified version of that proposed by Harwood and Maruyama (1992) (Fig. 2-14). This zonal scheme relies primarily upon biostratigraphic data collected from cores in the Indian sector of the Southern Ocean during ODP Leg 120 (Harwood and Maruyama, 1992). Roberts et al. (2003) recently revised age calibrations for several of the zonal datums utilized in this scheme through detailed correlation to magnetostratigraphic records. Modifications made to the zonation originally proposed by Harwood and Maruyama (1992) include: the use of the FO of *Rhizosolenia antarctica* (33.2 Ma) as the only subzonal datum in the *Rhizosolenia oligocaenica* Zone; the use of the last common occurrence (LcO) of *Rocella vigilans* var. A (~29.0 Ma) as a subzonal marker in the *R. vigilans* Zone; and the use of the FcO of *Thalassiosira praefraga* (20.5 Ma) as the base of the *T. praefraga* Zone. In addition to the primary zonal datums, several other datums are biostratigraphically useful in the lower Oligocene to lower Miocene interval (Tables 2-2 and 2-3). These events are utilized to refine and corroborate the age information indicated by the zonal datums.

A well-established Southern Ocean diatom zonal scheme for the middle to upper Eocene does not currently exist. Diverse diatom assemblages existed through this interval in both shelf areas and in open-ocean regions (e.g., Hajós, 1976; Gombos, 1983; Gombos and Ciesielski, 1983; Harwood and Bohaty, 2000), but very few datum events have been identified and chronostratigraphically calibrated. Several diatom, ebridian, and silicoflagellate datums that are presently identified as biostratigraphically useful for the middle to upper Eocene are listed in Table 2-3. This list will be further developed and zonal schemes will be constructed as more diatom work is completed for this time interval, which will allow further age refinement of SHALDRIL cores. In particular, cores from ODP Leg 189 on the Tasman Rise will allow for development of a middle to upper Eocene diatom zonal scheme for the Southern Ocean region.

The application of the standard Southern Ocean diatom zonal schemes to Antarctic shelf sections is problematic. Antarctic-shelf diatom assemblages are typically very different than open-ocean assemblages, and many of the marker taxa that are biostratigraphically useful at deep-sea locations are either not present or are present in low abundance in coastal/neritic shelf assemblages. Consequently, refined zonal schemes for application in shelf areas are currently in development. To date, informal Antarctic shelf zonal schemes have been proposed for the Oligocene to lower Miocene (Harwood et al., 1998; Scherer et al., 2001; Harwood and Bohaty, 2001) and for the upper Miocene to upper Pliocene (Winter and Harwood, 1997).

Although drilling has been limited in shelf areas, several sections provide reference data for shelf diatom assemblages. Shelf sites located in the Ross Sea/McMurdo Sound area include: Deep Sea Drilling Project (DSDP) Leg 28 cores (McCollum, 1975; Steinhauff et al., 1987), the MSSTS-1 drill core (Harwood, 1986), the CIROS-1 and CIROS-2 drill cores (Harwood, 1989; Winter and Harwood, 1997); the Ross Ice Shelf Project (RISP) cores (Harwood et al., 1989), the Dry Valley Drilling Project (DVDP) drill cores 10 and 11 (Brady, 1979, 1981; Winter and Harwood, 1997), the Cape Roberts Project (CRP) drill cores CRP-1, CRP-2/2A, and CRP-3 (Harwood et al., 1998; Scherer et al., 2001; Harwood and Bohaty, 2001); and Eocene erratics collected from southern McMurdo Sound (Harwood and Bohaty, 2000). Reference material for the Prydz Bay region includes ODP Leg 119 cores (Baldauf and Barron, 1991; Barron and Mahood, 1993; Mahood et al., 1993), Leg 188 cores (Mahood and Barron, 1996; Whitehead and Bohaty, 2003), and outcrops from the region containing diatomaceous sediments (e.g., Pickard et al., 1988; Harwood et al., 2000; Whitehead et al., 2001). Shelf sections around the Antarctic Peninsula are of particular relevance for SHALDRIL cores. Previous drilling of pre-Quaternary sections in this region, however, is limited to cores recovered during ODP Leg 178 (Winter and Iwai, 2002; Iwai and Winter, 2002).

Reworking is one potential problem in the biostratigraphic study of glacially-influenced sediments. The degree of diatom reworking can be qualitatively assessed from abundance, preservation, and/or the presence of obviously older or allochthonous taxa within a younger assemblage. Some taxa typically reworked in Southern Ocean sediments include: *A. ingens*, *Denticulopsis dimorpha* var. *areolata,* and *D. simonsenii*; these taxa are both heavily silicified and very abundant in certain intervals, thus easily reworked and incorporated into younger sediments. In sections where reworking is suspected, we preferentially rely upon FO or FcO datums for biostratigraphic age constraint.

Diatom Preparation

Samples from SHALDRIL cores are prepared for diatom analysis using standard procedures. A smear or strewn slide is initially prepared for all samples and examined under the microscope. If necessary, the samples are further prepared using chemical treatment and/or sieving. The chemically treated samples are reacted in small beakers with 10% HCl in order to remove the carbonate component, followed by 10% H_2O_2 to remove labile organic material. The samples are not heated during chemical treatment. Selected samples are also sieved at 10 µm using nylon screens. All samples are prepared using 20x40 mm coverslips and mounted using Norland Optical Adhesive #61 (refractive index = 1.56). The slides are examined on a Nikon Eclipse E800 microscope at 400x, 600x, and 1000x.

Relative diatom abundance is determined from smear or strewn slides made from the unsieved preparations. The total relative abundance of diatoms (as a group) is determined at 400x magnification and is based on the average number of specimens observed per field of view (FOV). Several traverses are made across the coverslip, and abundance estimates are recorded as follows:

A (Abundant) = >10 valves per FOV
C (Common) = 3-9 valves per FOV
F (Few) = 1 to 2 valve(s) per FOV
R (Rare) = 1 valve in 2-30 FOVs
T (Trace) = Very rare fragments present
B (Barren) = No diatom valves or fragments present

The qualitative abundance of individual diatom taxa is based on the number of specimens observed per FOV at 1000x (oil objective). Individual species abundance categories are listed below. Generally, ¼ to ½ of the 20x40 mm coverslip is examined (40 mm = ~200 FOV). After initial abundance determinations are made at 1000x, the slides are routinely scanned at 400x to identify rare taxa.

A (Abundant) = ≥ 2 valves per FOV
C (Common) = 1 to 5 valve(s) in 5 FOVs
F (Few) = ~1 to 3 valve(s) in 20 FOVs
R (Rare) = ~1 to 2 valve(s) in 60 FOVs
X (Present) = ≤ 1 valve or identifiable fragment per traverse of coverslip
r = Rare occurrences of a taxon interpreted as reworked specimens
d = Rare occurrences of a taxon interpreted as downcore contamination
fr = Specimens occurring only as fragments

The degree of siliceous microfossil fragmentation often mirrors dissolution, but the two factors are not necessarily dependent (i.e., well-preserved samples can be highly fragmented). Preservation of diatoms, therefore, is qualitatively based on the degree of dissolution and is rated as follows:

G (Good) = Slight to no dissolution
M (Moderate) = Moderate dissolution
P (Poor) = Severe effects of dissolution

In addition, the degree of fragmentation is also noted:

L (Low) = Minimal fragmentation
M (Moderate) = Frustules moderately fragmented
H (High) = Frustules highly fragmented; very few complete valves present

Taxonomy

The diatom taxonomic concepts followed here are based primarily on descriptions and illustrations of taxa from Eocene to Recent sections in Antarctic and Subantarctic waters. Most biostratigraphic and taxonomic work in the Southern Ocean has been derived from deep-sea sections. The following papers are the primary references in this pool of literature: Abbott (1974), McCollum (1975), Gombos (1977), Schrader (1976), Fenner et al. (1976), Akiba (1982), Ciesielski (1983), Gombos (1983), Gombos and Ciesielski (1983), Ciesielski (1986), Gersonde and Burckle (1990), Gersonde (1990, 1991), Fenner (1991), Baldauf and Barron (1991), Harwood and Maruyama (1992), Mahood and Barron (1996), Gersonde and Bárcena (1998), Zielinski and Gersonde (2002), Censarek and Gersonde (2002), Iwai and Winter (2002), Winter and Iwai (2002), and Bohaty et al. (2003).

In addition, an important supplement to the papers above are reports containing taxonomic descriptions and illustrations of coastal and neritic taxa, including Harwood (1986, 1989), Bohaty et al. (1998), Harwood et al. (1998), Scherer et al. (2001), and Harwood and Bohaty (2000, 2001). Several reports from North Pacific cores and outcrops also provide taxonomic guidelines for Oligocene and Miocene diatom taxa, including: Schrader and Fenner (1976), Barron (1985a, b), Akiba (1986), Akiba and Yanagisawa (1986), Yanagisawa and Akiba (1990), Akiba et al. (1993), Yanagisawa (1995), Gladenkov and Barron (1995), Scherer and Koç (1996), Gladenkov (1998), Komura (1998), and Barron et al. (2004).

A number of Neogene diatom taxa from the Southern Ocean have recently been transferred from the genus *Nitzschia* to *Fragilariopsis* (Gersonde and Bárcena, 1998; Zielinski and Gersonde, 2002; Censarek and Gersonde, 2002). We follow these revisions with a few exceptions. Several Miocene and Pliocene taxa, including *Nitzschia miocenica* and *Nitzschia reinholdii,* are left assigned to *Nitzschia* pending further SEM investigation of these taxa and establishment of morphological ties to *Fragilariopsis.*

For many Southern Ocean diatom taxa, intermediate or transitional forms often precede the FO or follow the LO of the “sensu stricto” forms. The precise placement of datum levels is therefore difficult in intervals where these evolutionary transitions occur. For example, transitional or intermediate forms have been documented between *Thalassiosira jacksonii* and *T. inura*, *F. aurica* and *F. barronii*, *Fragilariopsis praeinterfrigidaria* and *F. interfrigidaria*, *F. interfrigidaria* and *F. weaveri*, and *F. barronii* and *F. kerguelensis*, all of which involve zonal marker taxa. In some cases, such as the *F. aurica*-*F. barronii* lineage, the transition take places over a short time (narrow stratigraphic) interval and the problem is seen only in expanded sections sampled at high resolution.

Stricter taxonomic divisions than currently defined for the above taxa are needed to further refine the Southern Ocean zonal scheme. Where possible, the zonal datum levels are identified by the first or last common appearance of "sensu stricto" forms in the biostratigraphic assessment of SHALDRIL cores.

Calcareous Nannofossils

Biostratigraphy

For Cenozoic sediments of the Antarctic Peninsula region, the cosmopolitan nannofossil biostratigraphic schemes of Martini (1971) and Okada and Bukry (1980) are employed with major modifications. The absence of low- to mid-latitude marker species in the Southern Ocean necessitates the combination of many of the zones, particularly in the Neogene (Pospichal et al., 1992) (Fig. 2-15). Wei and Wise (1992) calibrated several useful Neogene high-latitude nannofossil datums to the timescale of Berggren et al., 1985 (subsequently recalibrated with Berggren et al., 1995). About five useful zones are used for the austral high-latitude Neogene.

Higher resolution is possible for the Oligocene to mid-middle Eocene (Wise, 1983; Wei and Wise, 1990; Wei and Thierstein, 1991) (Fig. 2-15). Wei (1992) calibrated ages for key datums in the region of the Kerguelen Plateau against the magnetostratigraphy; these are indicated in bold type on Figure 2-15, where they are shown against the Berggren et al. (1995) timescale.

As noted by Wei (1992), biomagnetostratigraphic correlations at several Southern Ocean sites may show considerably different ages relative to those compiled from the middle latitudes by Berggren et al. (1985, 1995). Where such differences exist, we have chosen to use (in most instances) ages derived from the high-latitude calibrations against the magnetostratigraphy. As noted above, where such ages differ from those in the lower latitudes Figure 2-15 shows the high-latitude ages in bold type following the corresponding datum level (similarly, high-latitude biostratigraphic datums are also indicated in bold type). For major differences in age assignment, arrows on the chart indicate where a datum has been repositioned for purposes of this cruise.

Methods

Smear slides are prepared for calcareous nannofossil study using standard techniques. Slides are examined using the light microscope under cross-polarized, plain-transmitted, and phase-contrast light at 1000-1200x magnification. Species preservation and abundance vary significantly due to etching, dissolution, or calcite overgrowth. Preservation and abundance are indicated as follows:

G (Good)	= Little or no evidence of dissolution and/or overgrowth; primary morphological characteristics only slightly altered; specimens are identifiable to the species level
M (Moderate)	= Specimens exhibit some etching and/or overgrowth; primary morphological characteristics sometimes altered; however, most specimens are identifiable to the species level
P (Poor)	= Specimens are severely etched or exhibit overgrowth; primary morphological characteristics

largely destroyed; fragmentation has occurred; specimens cannot be identified at the species and/or generic level

Six calcareous nannofossil abundance levels are indicated as follows:

V (Very abundant) = 10-100 specimens per FOV
A (Abundant) = 1-10 specimens per FOV
C (Common) = 1 specimen per 2-10 FOVs
F (Few) = 1 specimen per 11-100 FOVs
R (Rare) = 1 specimen per 101-1000 FOVs
B (Barren) = No nannofossils found in the sample

Silicoflagellates

Silicoflagellates are most commonly preserved in diatomites underlying modern or ancient ocean upwelling areas or in diatomites preserved by nearby volcanism. During the SHALDRIL cruise, silicoflagellates are observed generally as a secondary fossil group in diatom or calcareous nannofossil preparations.

To determine the abundance of silicoflagellates, all specimens that consist of more than ½ of a complete skeleton are counted. The silicoflagellate zonation followed is that utilized by McCartney and Wise (1990) and McCartney and Harwood (1992). The compilation by Perch-Nielsen (1985) is also helpful.

PHYSICAL PROPERTIES

Introduction and General Objectives

Shipboard physical properties determinations provide a first look at variations in core material characteristics and may be correlated with core lithology and regional seismic data. The principal objectives of the physical properties measurement program are closely connected to the main scientific and operational goals. They can be grouped together as follows:

1. Providing comprehensive physical properties datasets, including those from ER probes, the MS meter, gamma-ray attenuation porosity evaluator (GRAPE), and *p*-wave logger (PWL).
2. Measuring MS on whole round sections along the length of the recovered core.

All instruments/apparatuses used in the shipboard laboratory and principles of methods are described in Blum (1997). Measurements are made on whole and half liner sections of cores using the MSCL.

Sampling Strategy

Whole core sections are scanned with the MSCL before being split. We then select physical properties samples from the split cores. Where recovery permits, we sample every 5 to 10 cm depending on the sediment type. Final physical property measurements of the discrete samples are done onshore after the cruise. Water content, porosity, saturated bulk density, and void ratios will be determined using wet and dry weight volumes.

Core Measurements

Multisensor Core Logger

The MSCL includes four physical properties sensors that analyze MS, gamma density, *p*-wave velocity, and ER. Individual, unsplit core sections are placed on the MSCL, which automatically moves the section through the sensors on a fiberglass track. MSCL data are sampled at discrete intervals, with the sampling rate chosen to optimize data resolution within the time limitations of running each core section through the device. All sensor data are logged at an interval of 2 cm and acquisition times of 1 s. Core sections are run through the MSCL after they had warmed to 21°C. Gamma data are most reliable in undisturbed cores. Where cores do not fill the liners, are disturbed, or fractured, we expect the gamma density to have a generally lower value.

P-wave velocity acquisition operates simultaneously with the gamma density and transmits a 500-kHz *p*-wave pulse (2-µs wave period; 120 V) through the core. A pair of displacement transducers monitors the separation between the *p*-wave transducers. Data are collected at 2-cm intervals. The quality of the data is assessed by examining the arrival time and amplitude of the received pulse. Data with anomalously large travel times or low amplitudes are discarded. Magnetic susceptibility is determined on all sections at 2-cm intervals using the 1.0 (1 s integration time) range on the Bartington meter (model MS2C), which has a 63- to 88-mm coil diameter, depending on the core diameter. Magnetic susceptibility helps detect variations in magnetic properties caused by lithologic changes or alteration. Electrical resistivity is measured using a non-contact inductive coil array enabling resistivity to be measured through plastic liners. A downcore resolution of approximately 2-4 cm can be achieved with an accuracy that depends on core size and quality. Combined with gamma density, these data enable grain size to be derived.

Electrical Resistivity

The Middlebury ER probes consist of four (two current, two potential) collinear and equally spaced (5 mm) electrodes in the Wenner configuration. This basic configuration was modified by aligning the probes in a horizontal plane. The ER probe is calibrated using saline solutions of known resistivity values. The probe is placed on the surface of the split core at 2- to 5-cm intervals with the probes aligned parallel to bedding. The voltage potential is measured and averaged for 1000 samples within a 5 second window. The voltage is then converted to resistance, and, using the calibration constants, then to resistivity. The core resistivity values are then obtained for the entire length of the core.

UNDERWAY GEOPHYSICS

Underway geophysical data are collected during all transits. Data collection is organized and monitored by the shipboard scientific party. Data editing and processing is completed by the science party and by RPSC support staff.

Navigation

Navigation data is obtained from two independent GPS units, which combined offer complete redundancy for navigational data. Two Seatex Seapath 200 heading, attitude, and position systems operate as the primary navigational data and as the primary input into the dynamic positioning system (DP). These systems receive DGPS corrections from a Fugro SeaSTAR receiver. All GPS systems output a data string every 0.5 s while on DP. This output has to be reduced to a 1 Hz data string for the collection of Chirp data.

Chirp Sub-Bottom Profiler

High-resolution seismic data are acquired with a Bathy 2000 hull-mounted chirp sonar system (echo sounder or precision depth recorder). This chirp system emits a high-frequency, swept-frequency signal with a predominant frequency of 3.5 kHz. The data are recorded digitally and require minimal processing. Chirp profiles typically image the upper tens of meters of sediment beneath the seafloor with a vertical resolution of 2 m.

Multibeam Swath Bathymetry

Prior to drilling, multibeam swath bathymetry surveys are conducted around each drill site. These data are used to avoid areas where iceberg plowing and sediment gravity flows had disturbed the seafloor. Multibeam bathymetric data is collected with a hull-mounted Simrad EM120 swath profiler. This system operates at 12 kHz using 191 beams. For this work we have operated in equal distance mode, rather than equal angle. Ping editing is conducted manually aboard the ship to remove anomalous spikes. A corrective sound velocity is calculated after obtaining a temperature profile for each area using an expendable bathythermograph and a surface salinity measurement.

Seismic Data

In order to image the deeper subsurface and select drill sites, intermediate-resolution seismic surveys are conducted with one or two 210 in^3 generator injector airguns. Some surveys are collected with the airguns configured down to 50 in^3 for higher frequency data. Solid array streamer data are recorded digitally on an Elics digital acquisition system. The data have an average stratigraphic resolution of ~10 m. Tuning problems result in a bubble pulse in the upper 10 to 20 milliseconds of some of the data. Chirp data are used to fill these gap.

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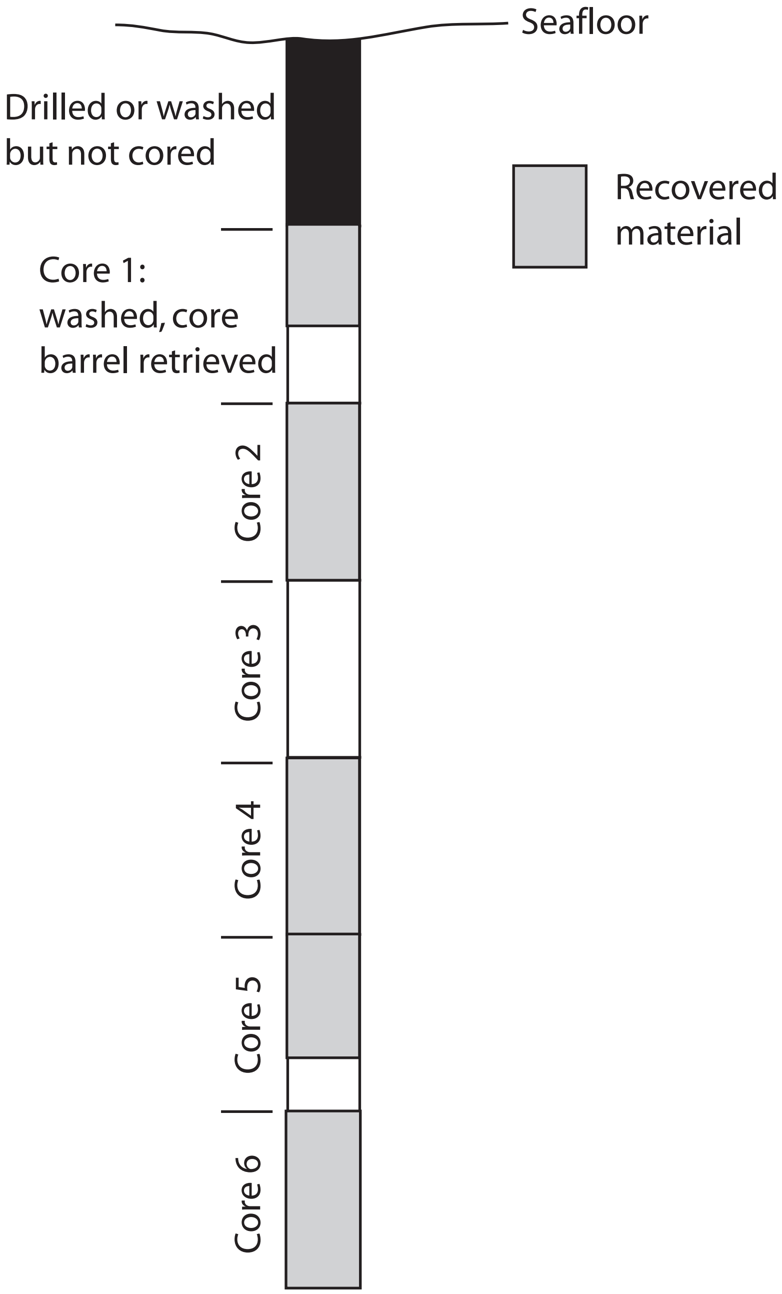
Figure 2-1. An example of numbered cores[1].



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[1] An error in labeling at Site NBP0602A-2 resulted in drilled (i.e., non-cored) intervals to be given core numbers erroneously. At all other sites, non-cored intervals are not given a core number.

Figure 2-2. An example of numbered core sections.

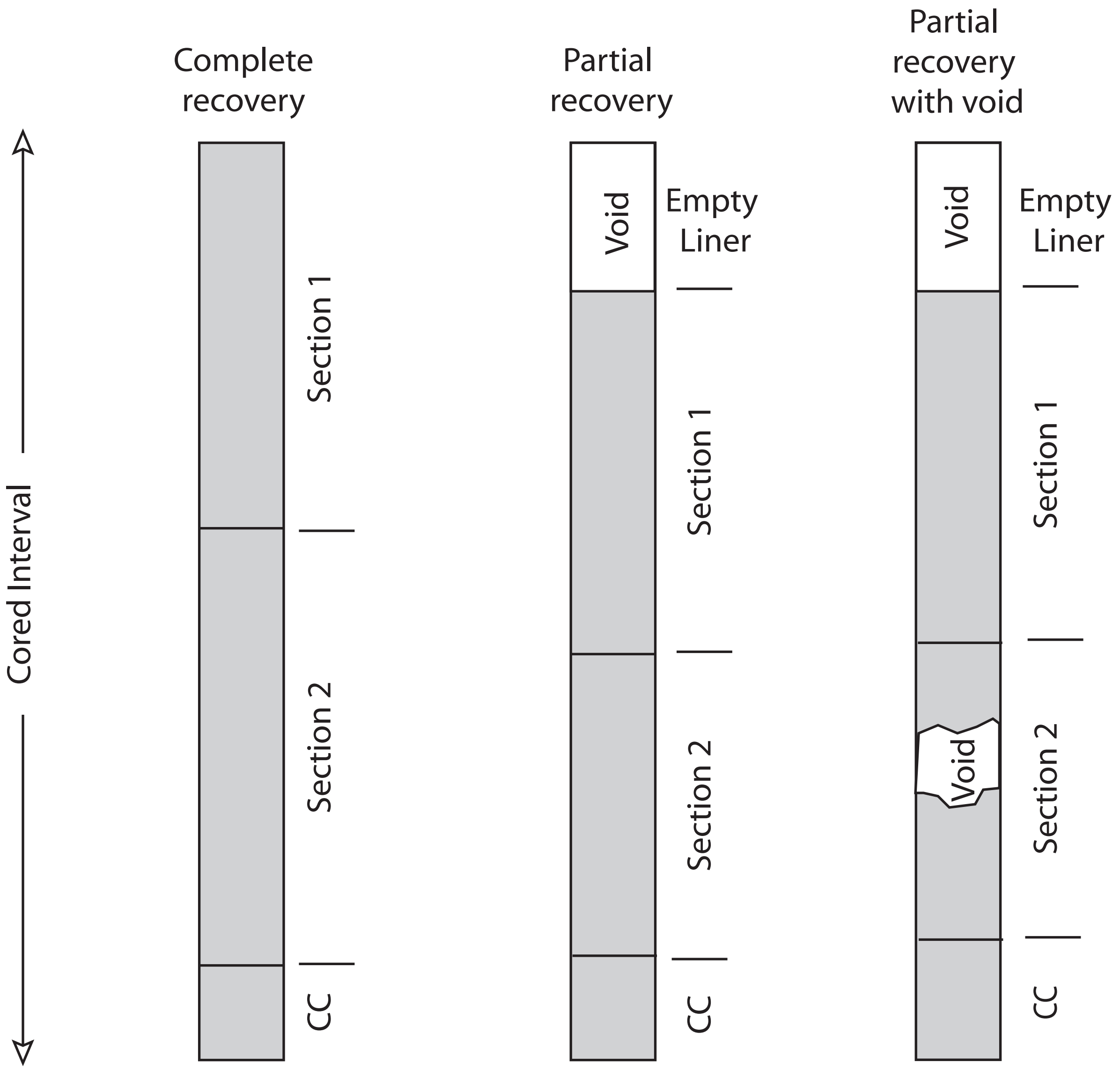


Figure 2-3. Deck layout and drill-core processing steps.

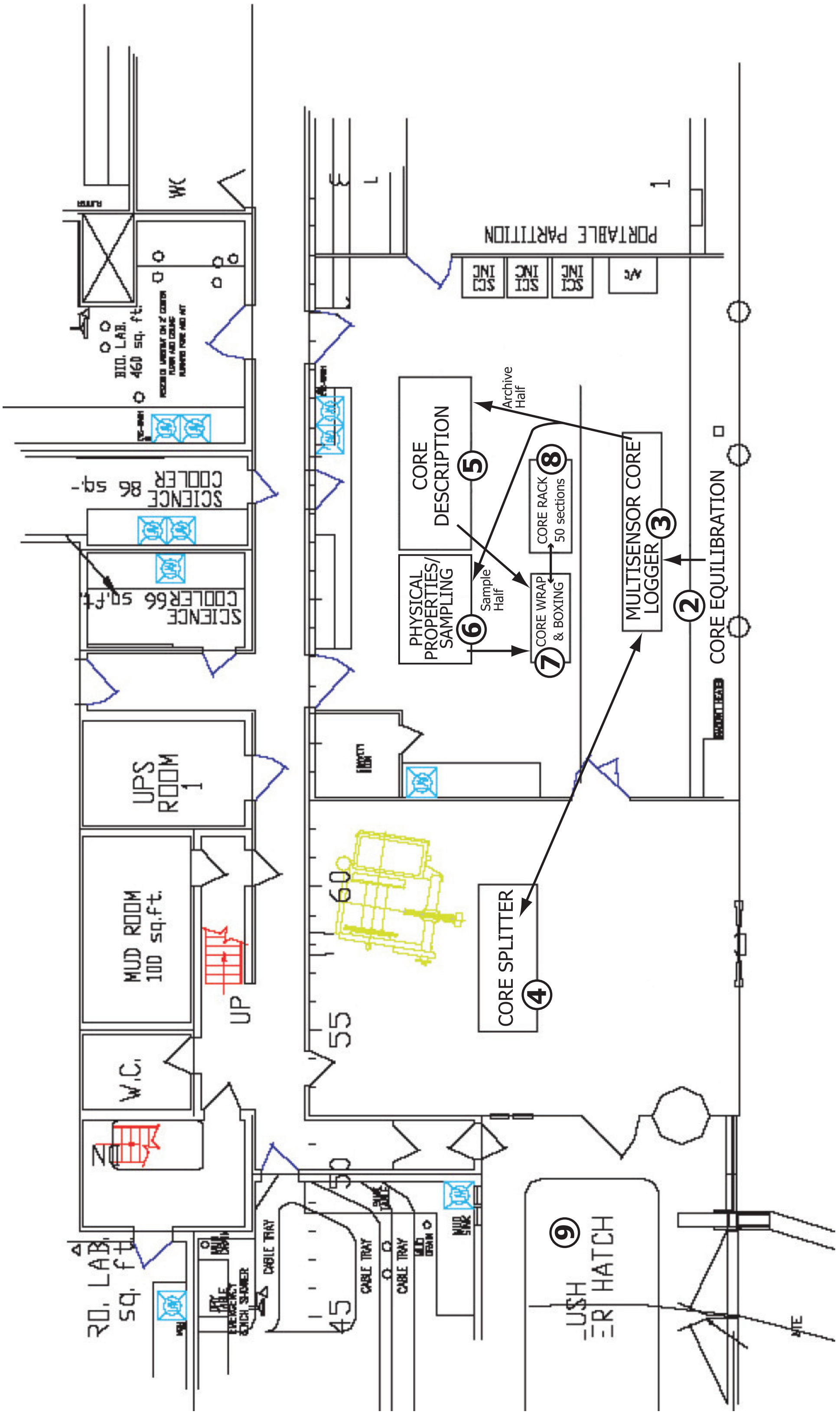


Figure 2-4. Deck layout and drill-core processing steps (continued).

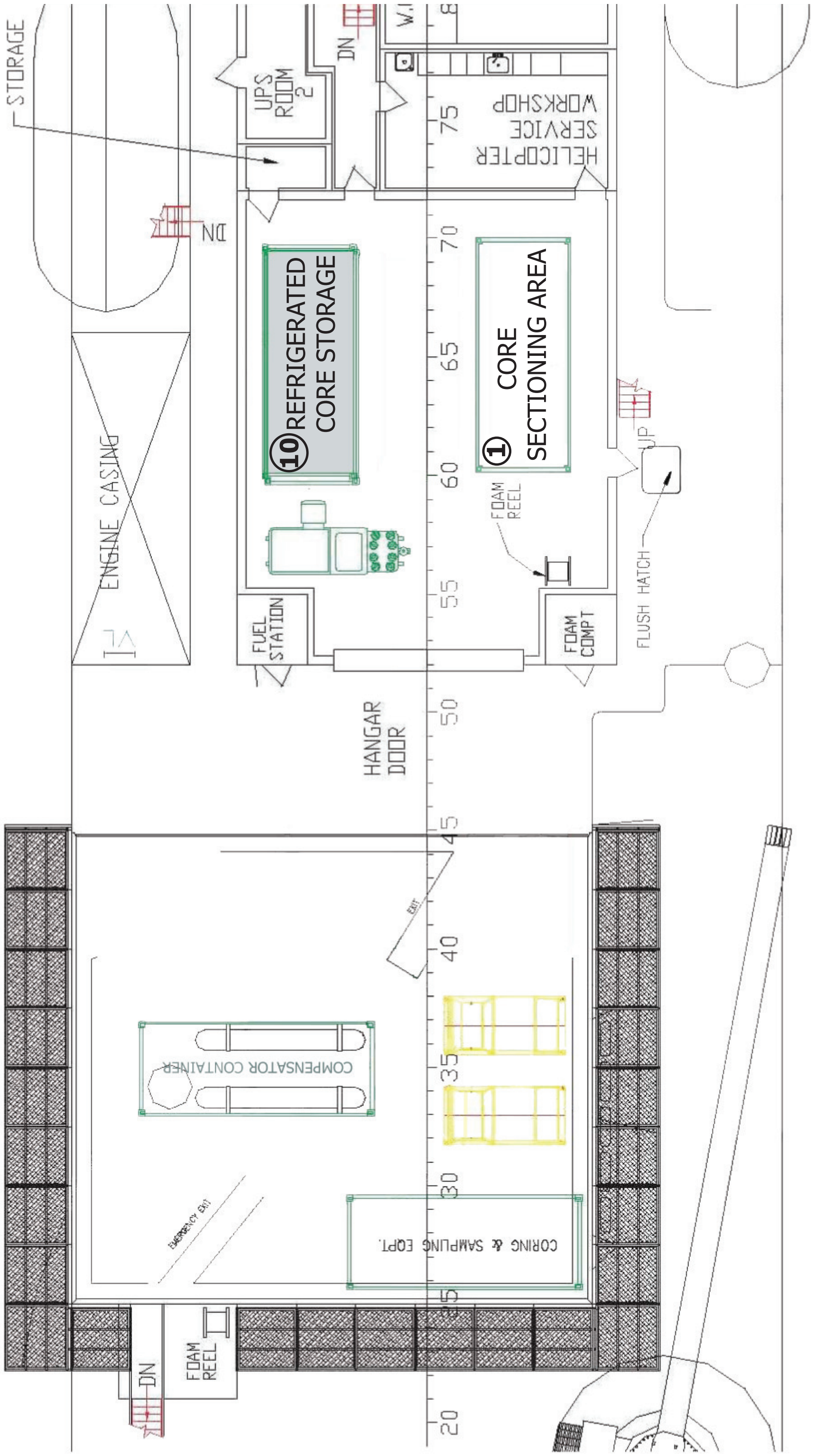


Figure 2-5. Example of a core recovery log.

NBP0602A SHALDRIL II Site 2 (Proposed Site JRB4)

Multibeam Water Depth: 384 m @ A; 341 m @ B; 385 m @ C

Station Number/Hole	Core Number	Core Type	Top (mbsf)	Bottom (mbsf)	Interval Cored (m)	"Push Distance" (m)	Recovery: total (m)	Recovery: competent (m)	Recovery: disturbed (m)	Gaps (m)	Recovery Corrected (m)	Total Recovery (%)	Recovery Corrected (%)	Section Number	Section Lengths (cm)	Date (JD)	Time on Deck (GMT)	Initials	Comments
2A	1	Ra-w	0	5.7	n/a	0	0	0	0	0	0	0.0%	0.0%	n/a	n/a	67	1349	JSW	No recovery
2A	2	Ra	5.7	9.24	6.5-9.24	2.74	3.33	3.33	0	0	3.33	121.5%	121.5%	1 2 3	0-150 150-242 242-333	67	1515	JSW	5.7-6.5 still very soft; drilling began at 6.5 m; site ended due to ice
2B	1	Rn	0	22.66	n/a	0	0	0	0	0	0	0.0%	0.0%	n/a	n/a	67	2130	JSW	Soft sediment, relatively little resistance
2B	2	Ra	22.66	25.66	25.66-22.66	3	0.51	0.51	0	0	0.51	17.0%	17.0%	1	0-57.5	67	2431	CLD	Bottom section of core tube full of water
2B	3	Ra	25.66	29.0	29-25.66	3.3	0.86	0.86	0	0	0.86	25.7%	25.7%	1	0-91.5	68	0030	CLD	Bottom section of core tube full of water
2B	4	Ra-w	29.0	48.0	washed	19.0	1.3	0	1.3	0	0	6.8%	0.0%	1	0-130 [0-135.5]*	68	0340	JFC	Wash core; top of section has a gap
2B	5	Ra	48.0	51.3	51.3-48	3.3	0.92	0.92	0	0	0.92	27.9%	27.9%	1	0-92* [0-94]*	68	0433	JFC	Top of core has a gap
2B	6	Ra	51.3	52.2	52.2-51.3	0.9	0	0	0	0	0	0.0%	0.0%	n/a	baggie	68	0615	JSW	Bagged core catcher
2C	1	Rn	0	10.5	n/a	0	0	0	0	0	0	0.0%	0.0%	n/a	n/a	68	1515	JSW	No recovery
2C	2	Ra	10.5	11.2	11.2-10.5	0.7	0	0	0	0	0	0.0%	0.0%	n/a	baggie	68	1615	JSW	

* Liner measurement from helo hanger may contain gap at top or botoom. Core and foam should equal original measurement. As long as this extra is from top or bottom of core (not middle) do not count in total core length.

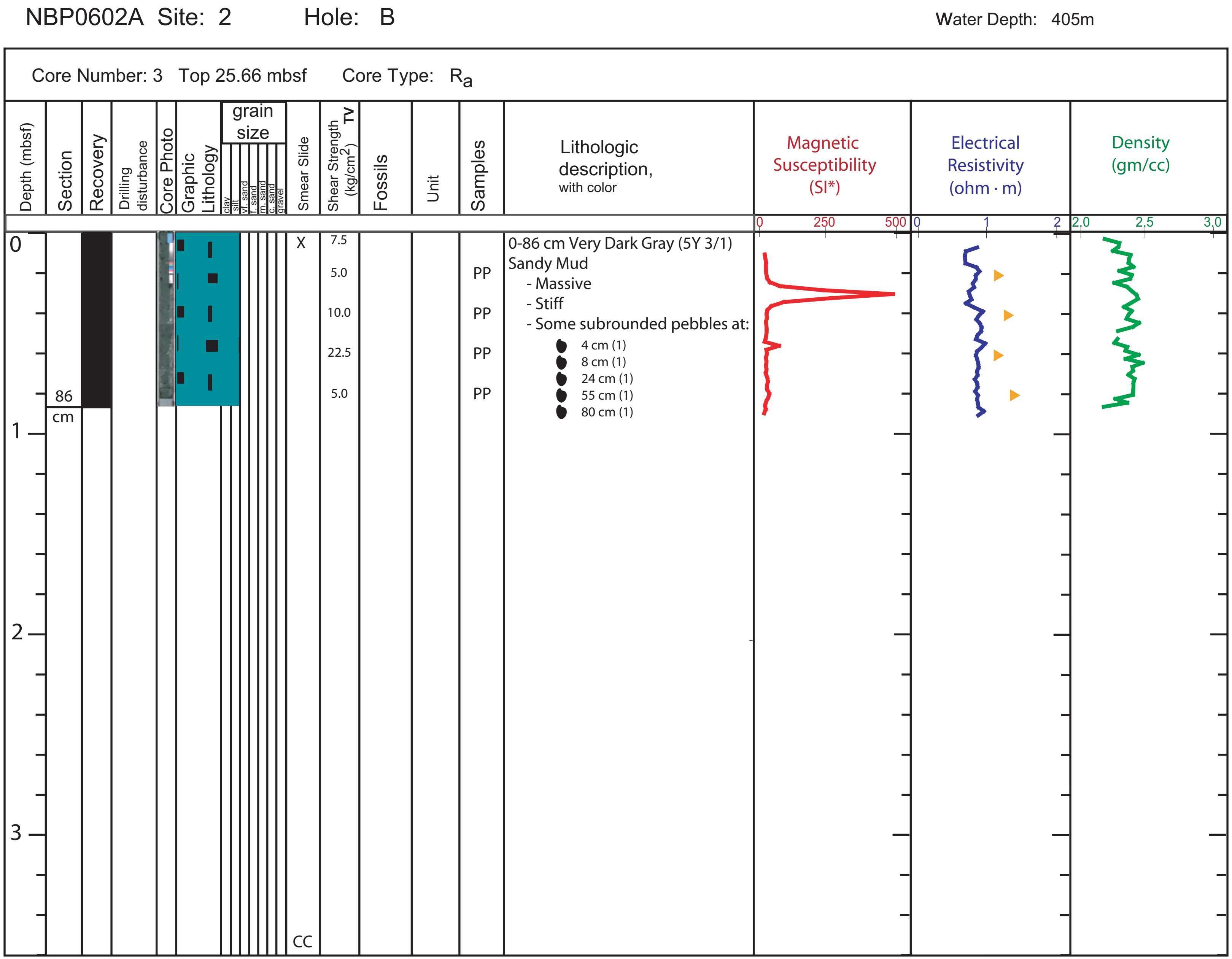


Figure 2-6. Example of a Core Description Log (barrel sheet).

Figure 2-7. Key to symbols used to represent lithology, contacts, accessories, fossils, samples taken, core recovery, and drilling disturbance in the barrel sheets.

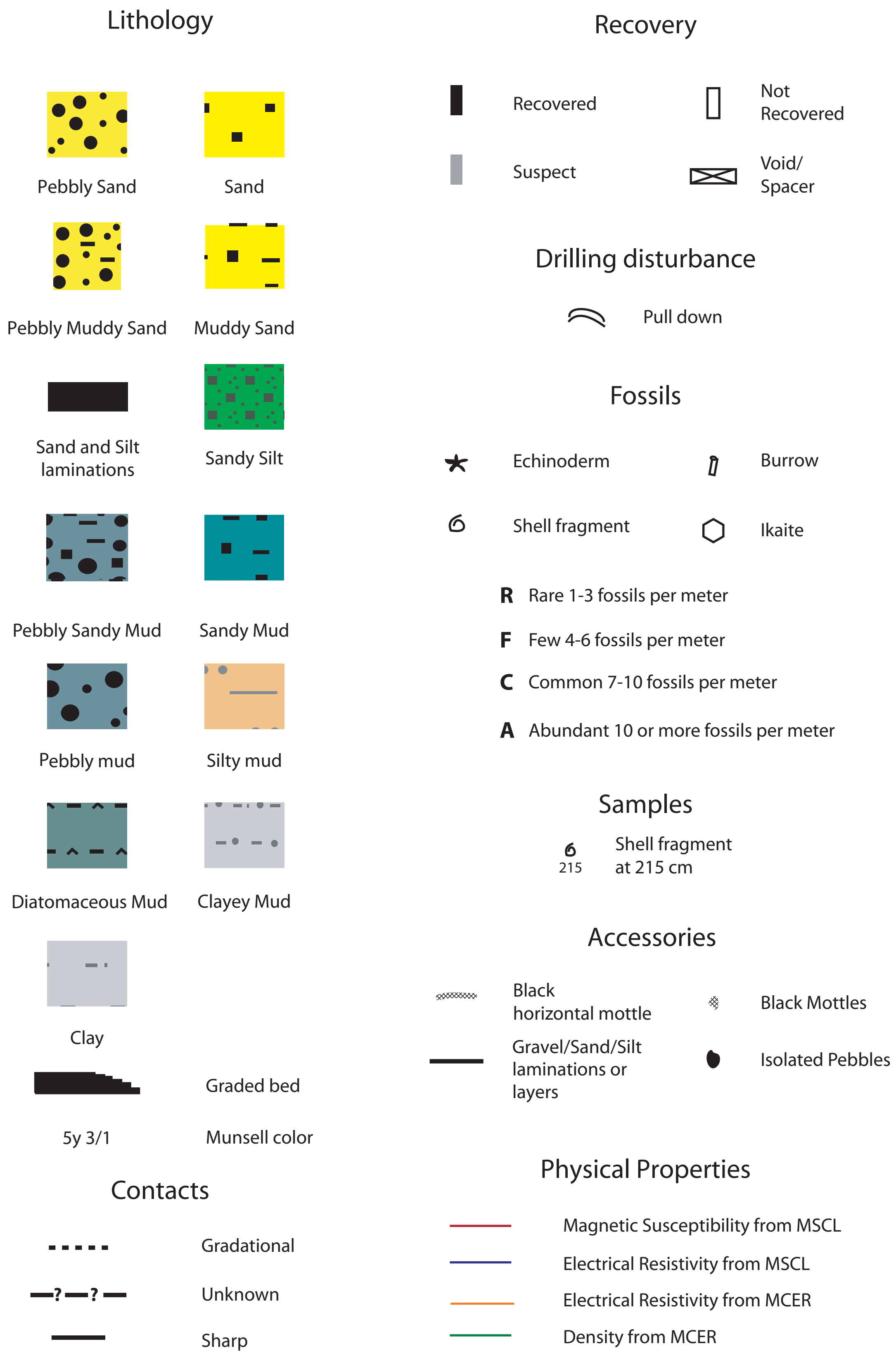


Figure 2-8. Arrangement of core boxes in the refrigerated van.

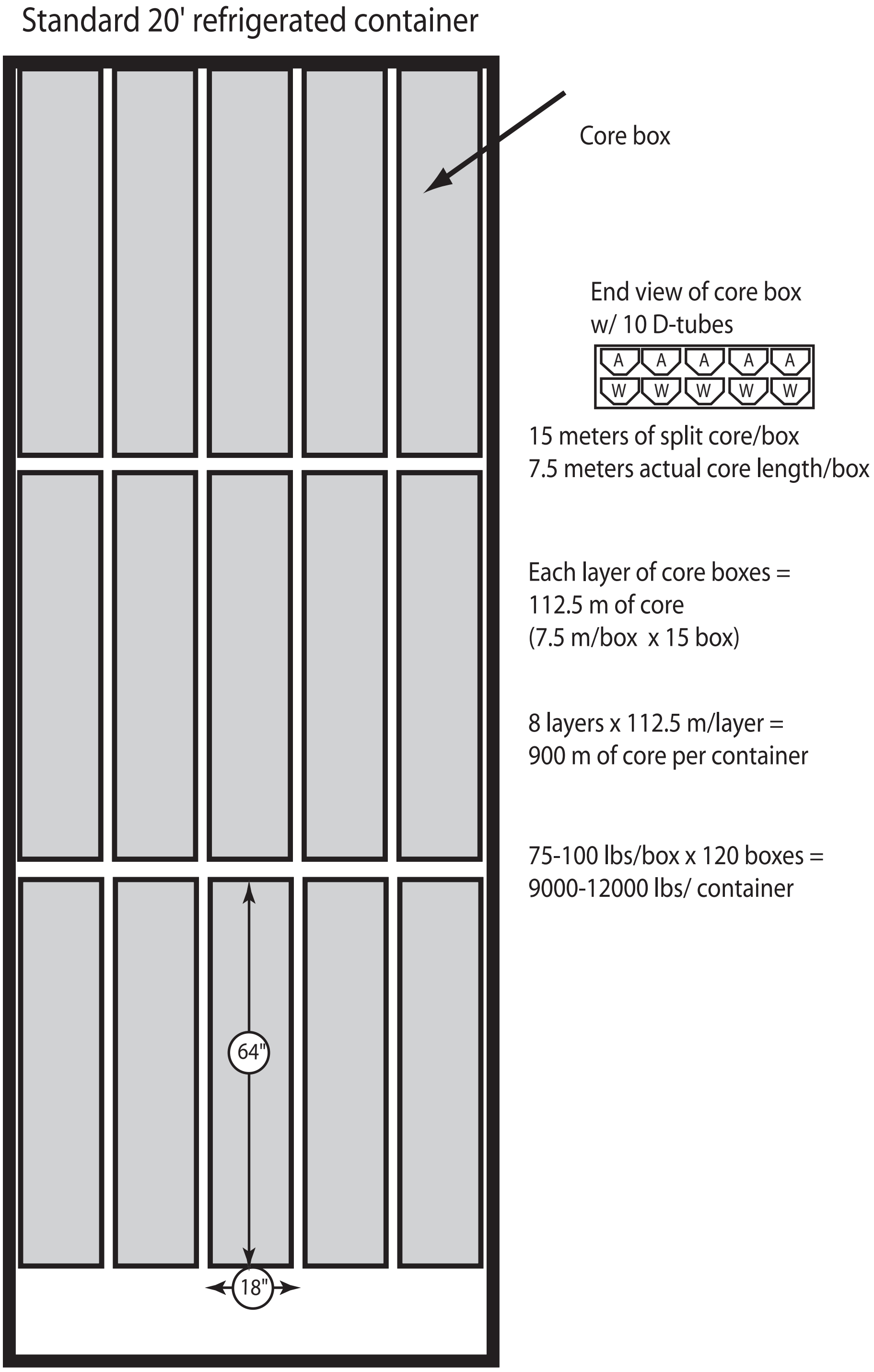


Figure 2-9. Classification scheme used for marine sediments (after Kaharoeddin et al., 1988).

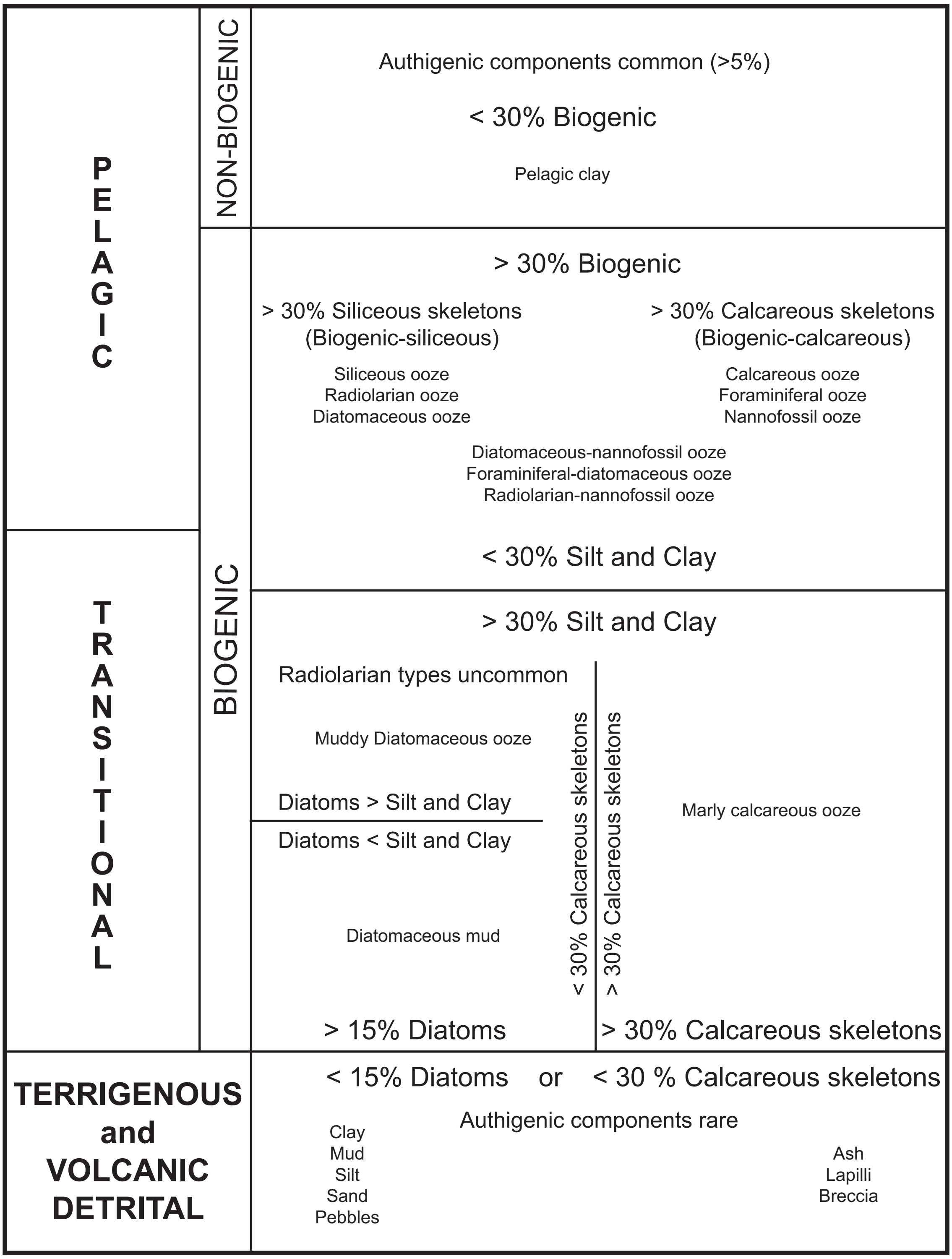


Figure 2-10. Ternary diagram showing classification of siliciclastic sediment components based on grain size (after Friedman and Sanders, 1978).

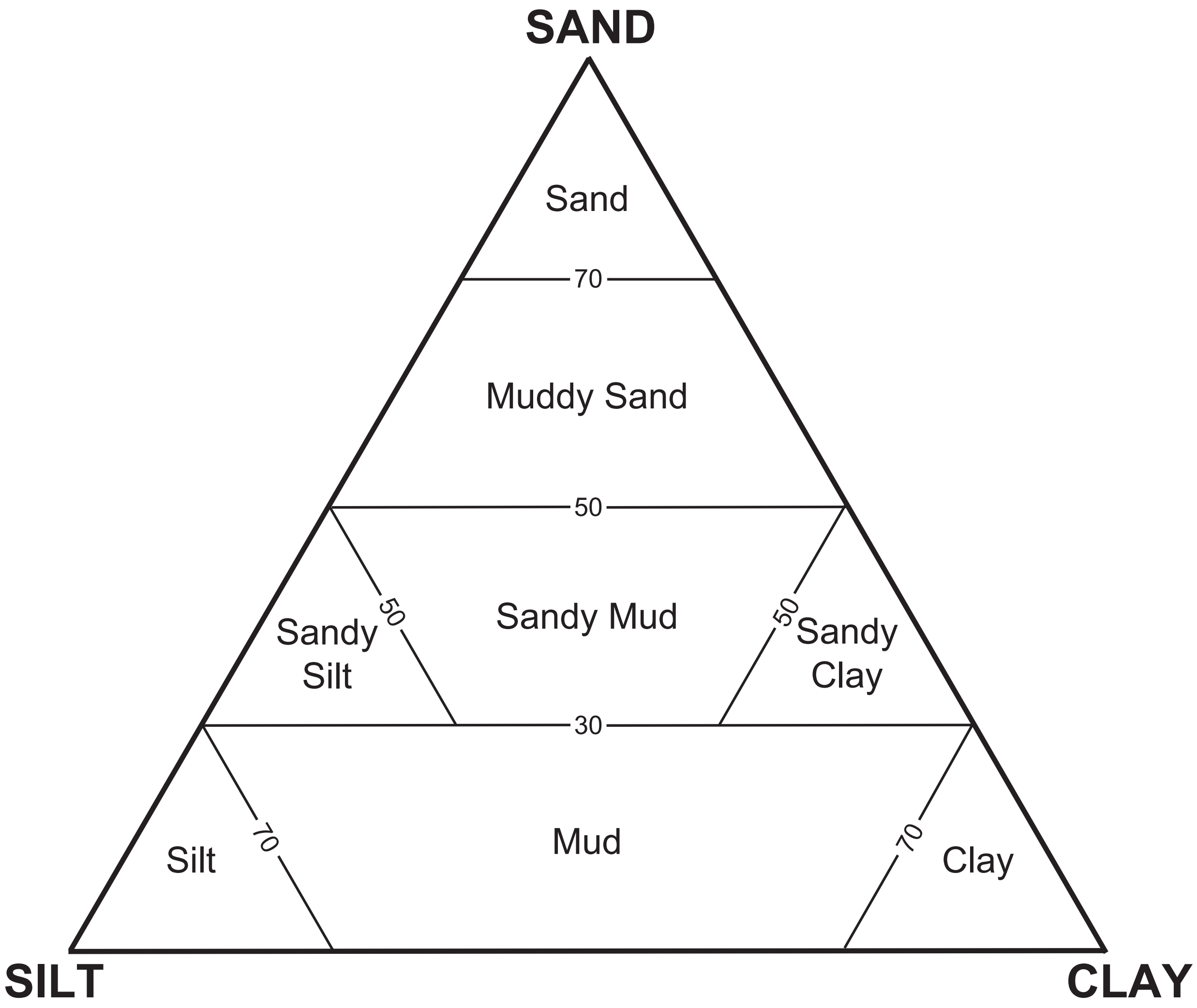
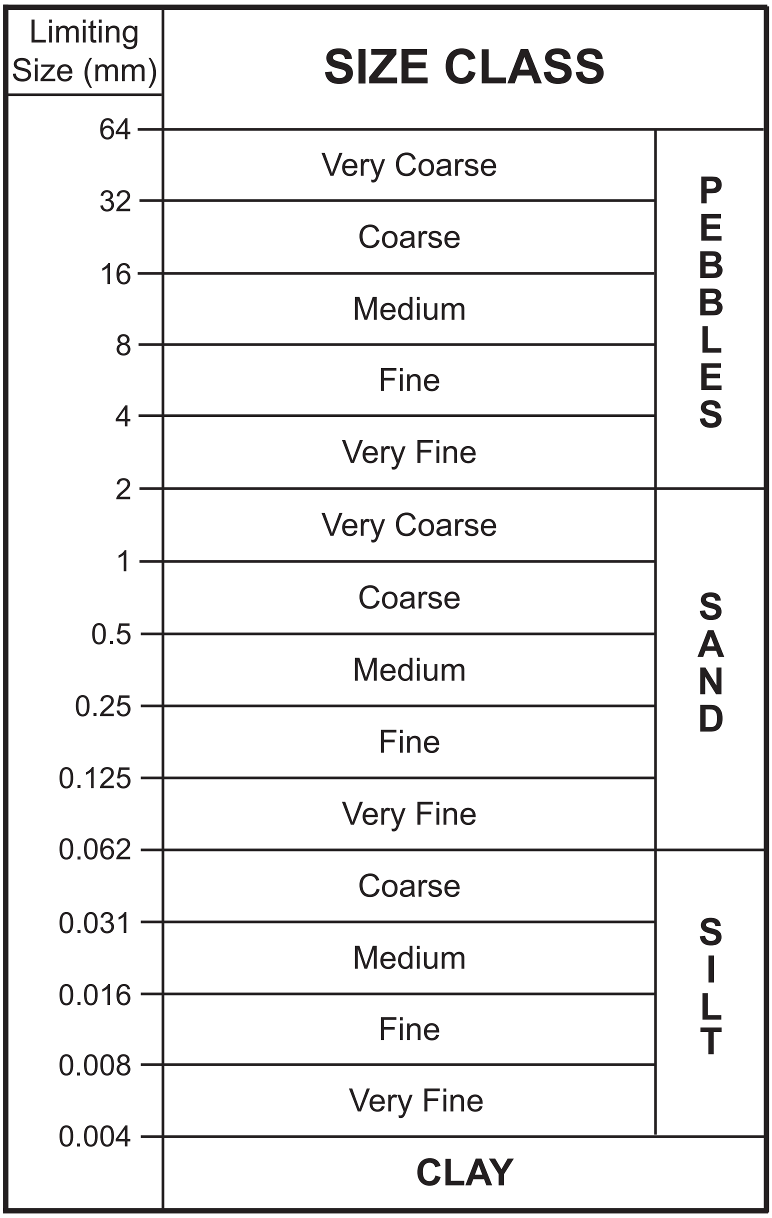


Figure 2-11. Standard size classes of sediment (after Friedman and Sanders, 1978).



Limiting Size (mm)	SIZE CLASS	
64		
	Very Coarse	PEBBLES
32		
	Coarse	
16		
	Medium	
8		
	Fine	
4		
	Very Fine	
2		
	Very Coarse	SAND
1		
	Coarse	
0.5		
	Medium	
0.25		
	Fine	
0.125		
	Very Fine	
0.062		
	Coarse	SILT
0.031		
	Medium	
0.016		
	Fine	
0.008		
	Very Fine	
0.004		
	CLAY	

Figure 2-12. Plio-Pleistocene diatom zonal scheme applied to the sections recovered during SHALDRIL. This scheme was proposed by Zielinksi and Gersonde (2002) and utilizes datums that are typically identified in southern areas of the Antarctic region. All ages are calibrated to the GPTS of Berggren et al. (1995). Brackets represent FO or LO datums and filled triangles represent FcO or LcO datums.

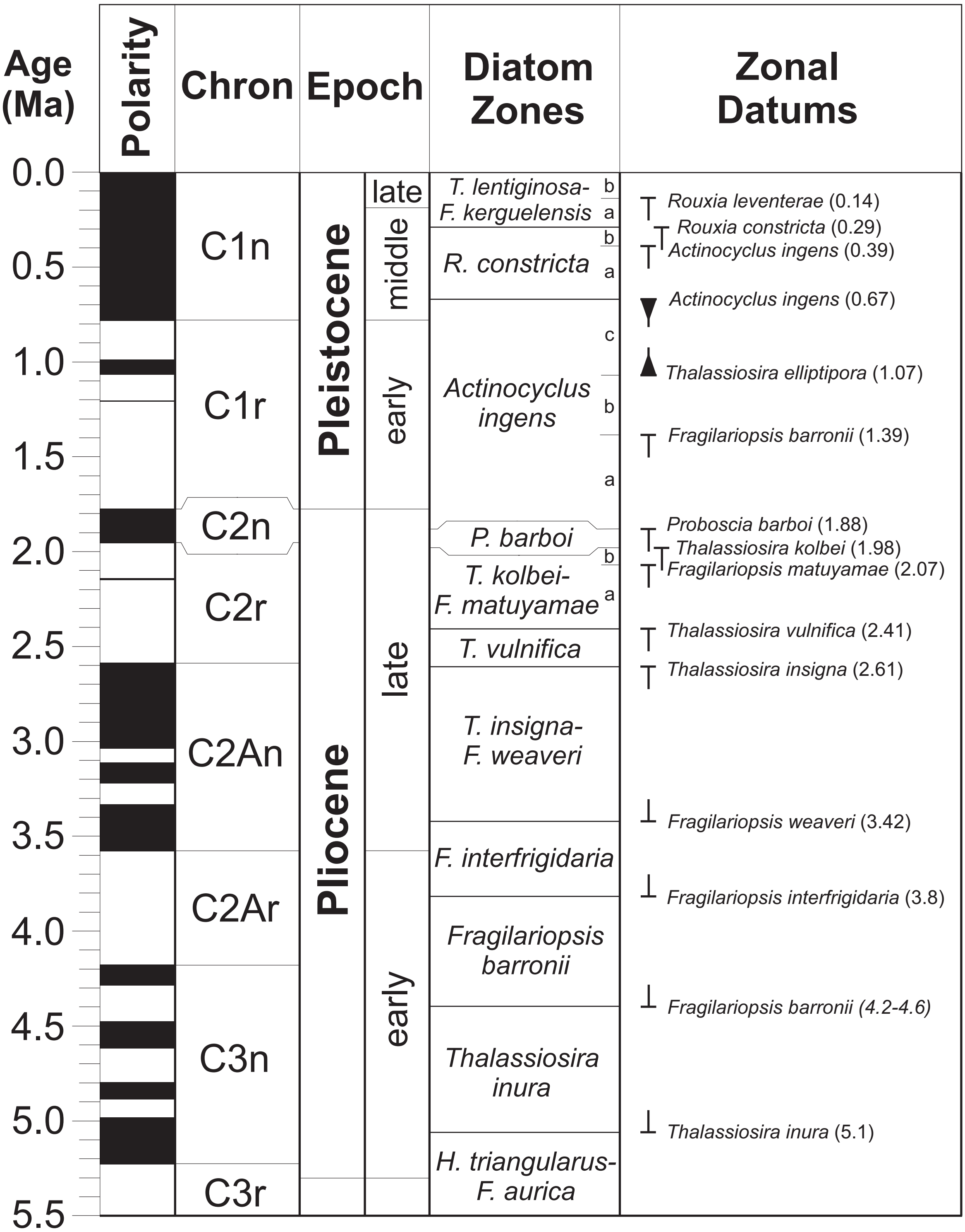


Figure 2-13. Middle to late Miocene diatom zonal scheme applied to sections recovered during SHALDRIL. This zonal scheme was proposed by Censarek and Gersonde (2002) and utilizes datums that are typically identified in southern areas of the Antarctic region. All ages are calibrated to the GPTS of Berggren et al. (1995). Brackets represent FO or LO datums and filled triangles represent FcO or LcO datums.

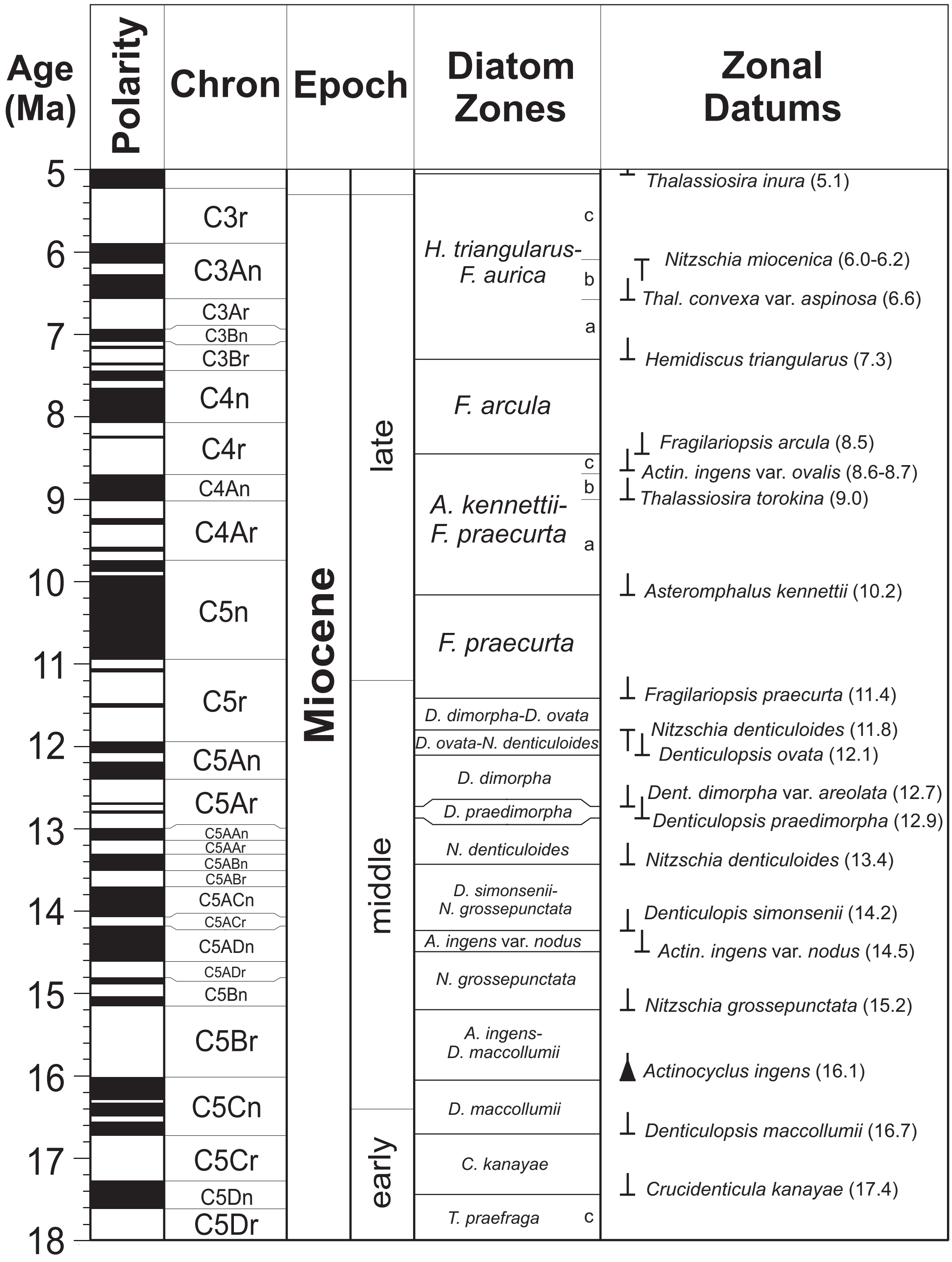


Figure 2-14. Oligocene to early Miocene diatom zonal scheme for the Southern Ocean. This zonal scheme represents a modified version of that proposed by Harwood and Maruyama (1992). All ages are calibrated to the GPTS of Berggren et al. (1995). Brackets represent FO or LO datums and filled triangles represent FcO or LcO datums.

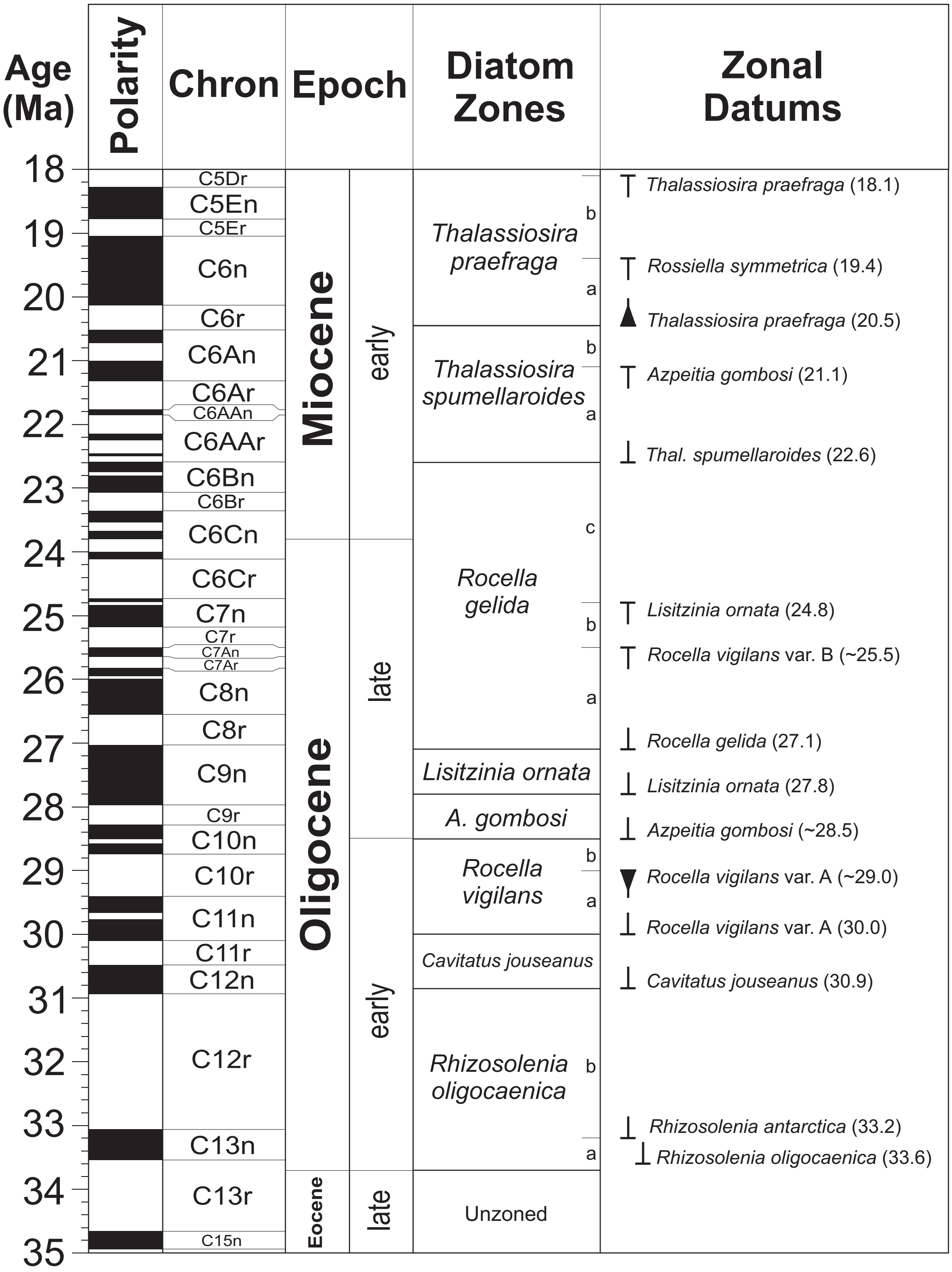


Figure 2-15. Holocene through middle Eocene timescale and calcareous nannofossil biostratigraphic datums applied to sections recovered during SHALDRIL NBP0602A against those for planktonic foraminifers (modified from Berggren et al., 1995; Gradstein et al., 1994; and Erba et al., 1995). High-latitude zonations used for SHALDRIL vs. low-latitude zonations are indicated under "SHALDRIL" and "Low Latitude" respectively. High-latitude biostratigraphic datum and age correlations are indicated in bold type under "Biostratigraphic Datums"; foraminiferal datums are underlined. Planktonic foraminifer zonations adopted from Berggren (1992a; Neogene Kerguelen); Stott and Kennett (1990; Antarctic Paleogene; modified by Huber, 1991 and Berggren, 1992b). Nannofossil zonations from Wise (1983; Antarctic Oligocene to mid-middle Eocene; modified by Wei and Wise, 1990 and Wei and Thierstein, 1991, and calibrated against magnetostratigraphy by Wei, 1992). (Figure shown on next two pages.)

Figure 2-15. (Caption on previous page.)

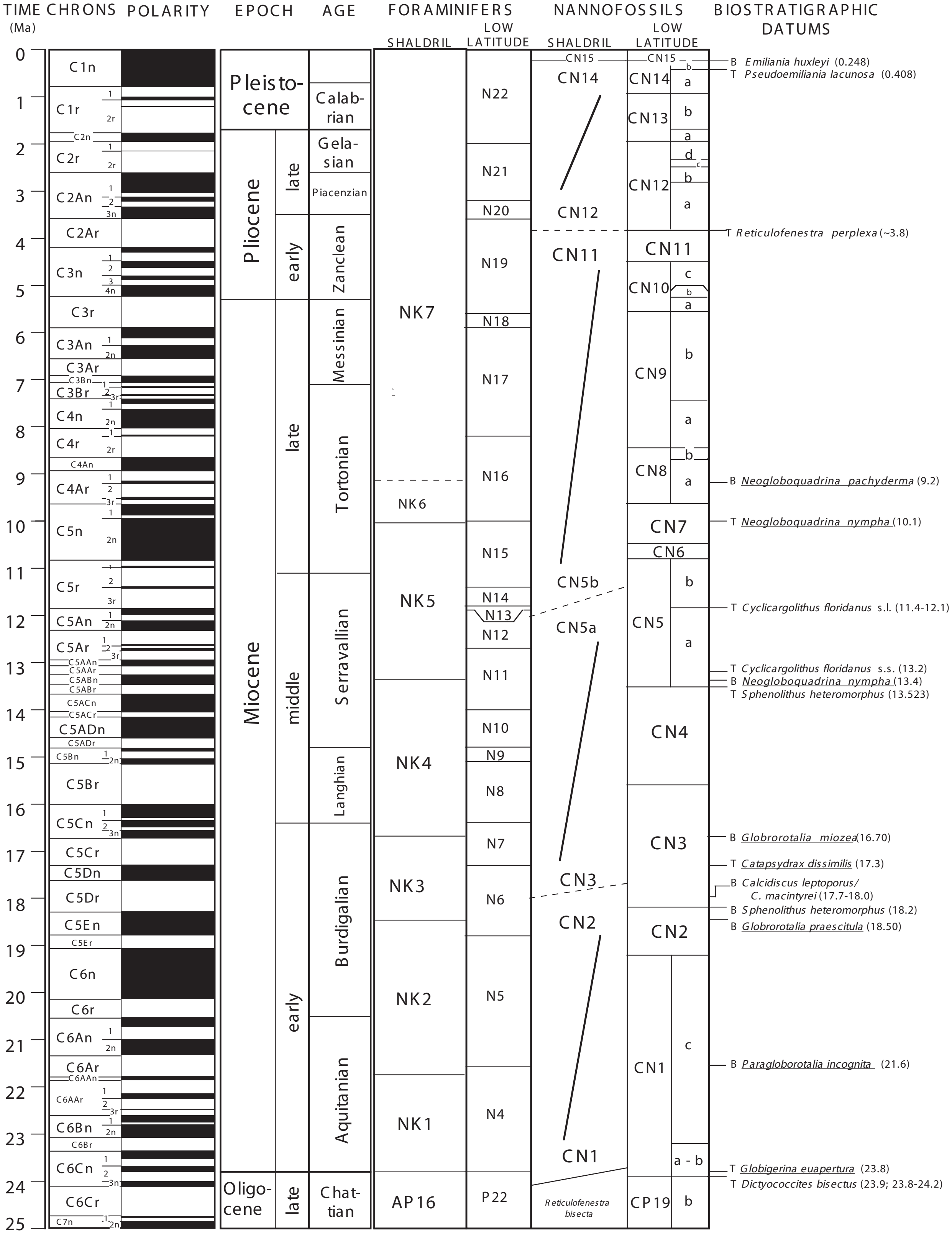


Figure 2-15 (continued).

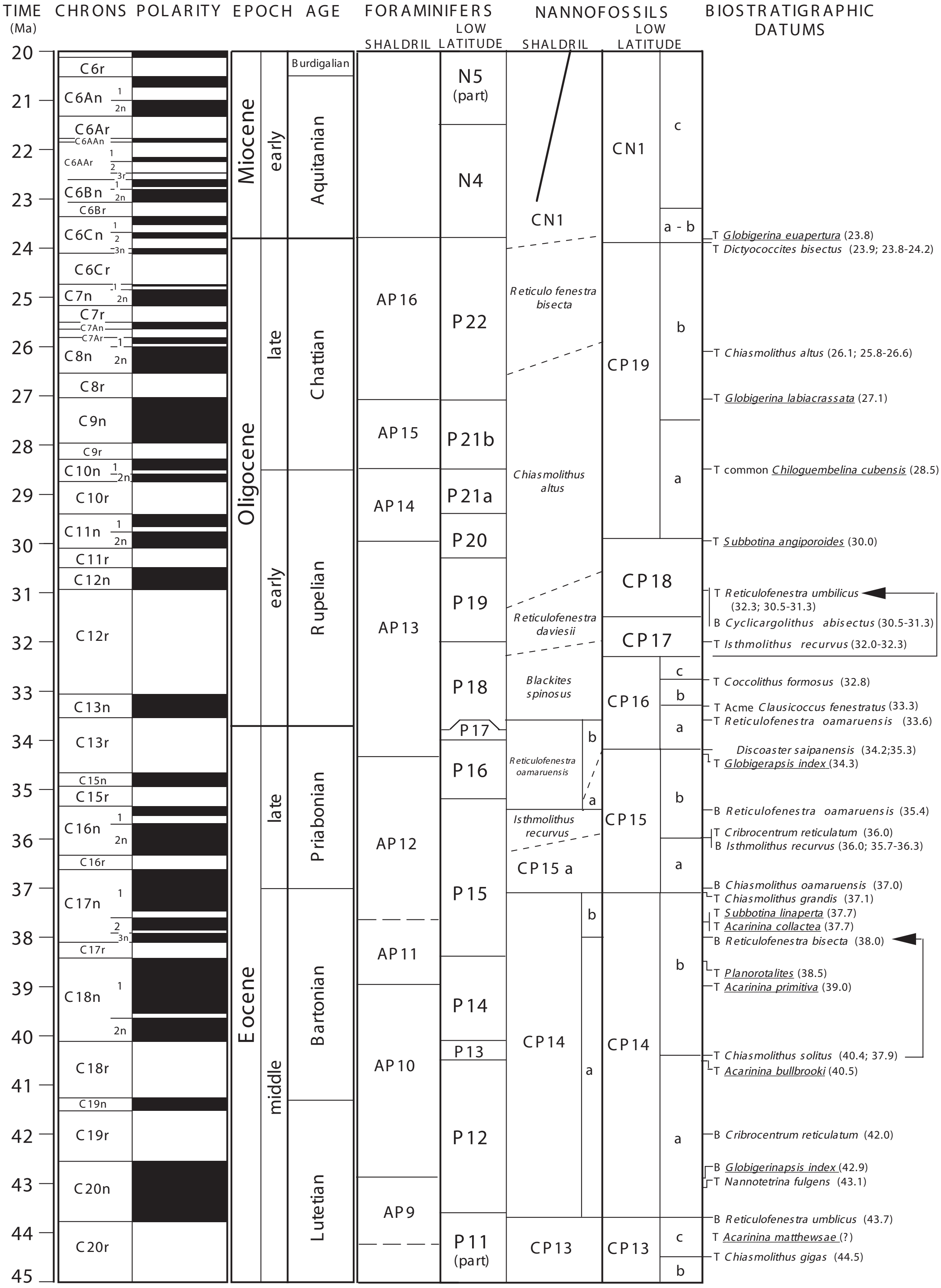


Table 2-1. Plio-Pleistocene diatom events and calibrations for the Southern Ocean. All ages are calibrated to the Berggren et al. (1995) timescale, and zonal datums are labeled in bold type.

		"Southern" Calibration				"Northern" Calibration				Other Calibrations	
Event	**Taxon**	**Upper Age (Ma)**	**Lower Age (Ma)**	**Average Age (Ma)**	**Source**	**Upper Age (Ma)**	**Lower Age (Ma)**	**Average Age (Ma)**	**Source**	**Age (Ma)**	**Source(s)**
LO	***Rouxia leventerae***	0.13	0.14	0.14	ZG, Zet	-	-	-	-	-	-
LO	*Hemidiscus karstenii*	0.18	0.19	0.19	ZG	0.18	0.19	0.19	ZG	0.19	Bu
LO	***Rouxia constricta***	0.28	0.30	0.29	Zet	0.28	0.30	0.29	Zet	-	-
LO	***Actinocyclus ingens***	0.36	0.42	0.39	ZG	0.45	0.51	0.48	ZG	0.55	S1
FcO	*Hemidiscus karstenii*	-	-	-	-	0.41	0.43	0.42	ZG	0.42	Bu, GB
LcO	***Actinocyclus ingens***	0.64	0.70	0.67	ZG	0.56	0.64	0.60	ZG	0.66	C1, HM, GB
LO	*Nitzschia reinholdii*	2.72	2.72	2.72	ZG	0.60	0.77	0.69	ZG	0.65 / 3.4	BB / HM
LO	*Fragilariopsis fossilis*	-	-	-	-	0.70	0.99	0.85	ZG	0.9	Bu
LO	*Thalassiosira elliptipora*	0.61	0.85	0.73	ZG	0.77	0.82	0.80	ZG	0.65-0.69	C1, HM
LO	*Thalassiosira fasciculata*	0.81	0.87	0.84	ZG	0.76	0.87	0.82	ZG	0.75	GB
FcO	***Thalassiosira elliptipora***	1.01	1.13	1.07	ZG	1.00	1.07	1.04	ZG	1.04-1.13	F, GB
LO	*Actinocyclus* sp. F of ZG	1.20	1.42	1.31	ZG	1.20	1.42	1.31	ZG	-	-
LO	***Fragilariopsis barronii***	1.36	1.41	1.39	ZG	1.26	1.48	1.37	ZG	1.30-1.35	HM, WH, GB
LO	*Rouxia antarctica*	1.35	1.56	1.46	ZG	1.35	1.56	1.46	ZG	-	-
LO	*T. tetraoestrupii* var. *reimerii*	1.32	1.60	1.46	ZG	1.35	1.48	1.42	ZG	1.6	MB
LO	***Proboscia barboi***	1.82	1.94	1.88	ZG	1.82	1.94	1.88	ZG	1.7-1.8	F, C1, BB, GB
FO	*Fragilariopsis kerguelensis*	2.04	2.34	2.19	ZG	1.93	1.93	1.93	ZG	3.2	HM
LO	***Thalassiosira kolbei***	1.98	1.98	1.98	ZG	1.98	2.08	2.03	ZG	1.9	HM, WH, GB
LO	***Fragilariopsis matuyamae***	2.07	2.07	2.07	ZG	2.07	2.12	2.10	ZG	2.1	GB
FO	*T. tetraoestrupii* var. *reimerii*	2.43	2.66	2.55	ZG	2.43	2.66	2.55	ZG	2.4	MB
FO	*Fragilariopsis matuyamae*	2.36	2.40	2.38	ZG	2.50	2.66	2.58	ZG	2.6	GB
FO	*Actinocyclus* sp. F of ZG	-	-	-	-	1.84	2.34	2.09	ZG	-	-
FO	*Rouxia constricta*	1.60	1.60	1.60	ZG	0.91	0.91	0.91	ZG	-	-
LO	*Actinocyclus maccollumi*	2.31	2.76	2.54	ZG	2.31	2.76	2.54	ZG	1.7-2.8	HM
LO	*Actinocyclus karstenii*	2.24	2.34	2.29	ZG	2.24	2.34	2.29	ZG	1.7-2.8	HM
LO	***Thalassiosira vulnifica***	2.38	2.43	2.41	ZG	2.38	2.55	2.47	ZG	2.3-2.5	C1, BB, GB, WI
LO	*Thalassiosira inura*	2.37	2.37	2.37	ZG	2.55	2.65	2.60	ZG	1.9	HM, WH
FO	*Actinocyclus maccollumi*	2.50	3.30	2.90	ZG	2.50	3.30	2.90	ZG	2.80-3.10	HM
LO	*Thalassiosira lentiginosa* var. *ovalis*	-	-	-	-	-	-	-	-	2.5	C1, HM
LO	*Fragilariopsis praeinterfrigidaria*	2.55	3.30	2.93	ZG	2.55	3.30	2.93	ZG	3.7	HM
LO	***Thalassiosira insigna***	2.55	2.66	2.61	ZG	2.55	2.66	2.61	ZG	2.5-2.7	C1, GB, WI
LO	*Fragilariopsis weaveri*	2.54	2.66	2.60	ZG	2.54	2.66	2.60	ZG	2.8	C1
LO	*Thalassiosira convexa*	2.56	2.64	2.60	ZG	2.56	2.64	2.60	ZG	-	-
LO	*Thalassiosira striata*	1.80	3.50	2.65	ZG	1.80	3.50	2.65	ZG	2.4-3.2	HM, WH
LO	*Fragilariopsis interfrigidaria*	2.58	2.96	2.77	ZG	2.58	2.96	2.77	ZG	2.7	HM
LO	*Thalassiosira complicata*	2.92	3.31	3.12	ZG	2.92	3.31	3.12	ZG	3.2-3.5	HM
FO	*Thalassiosira vulnifica*	3.20	3.21	3.21	WB	-	-	-	-	2.7-3.2	BB, HM, WI
LO	*Fragilariopsis aurica*	-	-	-	-	3.37	3.37	3.37	ZG	3.7-4.2	HM
FO	*Thalassiosira lentiginosa* var. *ovalis*	-	-	-	-	-	-	-	-	3.4	HM
FO	***Fragilariopsis weaveri***	3.42	3.42	3.42	ZG	3.42	3.42	3.42	ZG	3.2-3.4	BB, HM, WB
FO	*Thalassiosira insigna*	3.42	3.42	3.42	ZG	3.42	3.42	3.42	ZG	3.20-3.40	HM, WB
FO	***Fragilariopsis interfrigidaria***	3.75	3.88	3.82	WB	3.80	3.80	3.80	ZG	3.7-3.8	BB, HM, WI
LO	*Fragilariopsis arcula*	-	-	-	-	4.08	4.08	4.08	ZG	3.9-4.6	HM
FO	***Fragilariopsis barronii***	4.15	4.16	4.16	WB	-	-	-	-	4.2-4.6	C1, BB, WI
FO	*Thalassiosira striata*	-	-	-	-	-	-	-	-	4.5	HM
FO	*Thalassiosira complicata*	-	-	-	-	-	-	-	-	4.5-4.7	HM
FO	***Thalassiosira inura***	5.03	5.09	5.06	WB	-	-	-	-	4.8-5.0	BB, CG
FO	*Fragilariopsis praeinterfrigidaria*	5.09	5.09	5.09	CG	-	-	-	-	-	-

Notes: Source references are as follows: Bu = Burckle et al. (1978), Cl = Ciesielski (1983), F = Fenner (1991), BB = Baldauf and Barron (1991), HM = Harwood and Maruyama (1992), WH = Winter and Harwood (1997), MB = Mahood and Barron (1995), GB = Gersonde and Bárcena (1998), WI = Winter and Iwai (2002), ZG = Zielinski and Gersonde (2002), CG = Censarek and Gersonde (2002), Zet = Zielinski et al. (2002), WB = Whitehead and Bohaty (2003), and Sl = Stickley et al. (2004a).

Table 2-2. Miocene diatom events and age calibrations for the Southern Ocean. All ages are calibrated to the Berggren et al. (1995) timescale, and zonal datums are labeled in bold type.

		"Southern" Calibration				"Northern" Calibration				Other Calibrations	
Event	**Taxon**	**Upper Age (Ma)**	**Lower Age (Ma)**	**Average Age (Ma)**	**Source**	**Upper Age (Ma)**	**Lower Age (Ma)**	**Average Age (Ma)**	**Source**	**Age (Ma)**	**Source(s)**
LO	*Hemidiscus triangularus*	5.13	5.13	5.13	CG	6.43	6.43	6.43	CG	5.8	HM
FO	*Thalassiosira tetraoestrupii* group	-	-	-	-	-	-	-	-	5.6-5.8	BB, HM
LO	*Fragilariopsis donahuensis*	-	-	-	-	-	-	-	-	5.8	HM
LO	*Nitzschia miocenica*	-	-	-	-	-	-	-	-	6.0-6.2	BB, BI
FO	***Thalassiosira convexa* var. *aspinosa***	6.58	6.58	6.58	CG	6.54	6.54	6.54	CG	6.7	B
FO	***Hemidiscus triangularus***	7.30	7.30	7.30	CG	7.30	7.30	7.30	CG	6.2	HM
LO	*Denticulopsis crassa*	7.39	7.76	7.58	CG	7.51	7.51	7.51	CG	8.7	WI
FO	*Fragilariopsis reinholdii*	-	-	-	-	7.96	8.23	8.10	CG	8.1 / 6.4	B / HM
FO	***Fragilariopsis arcula***	8.41	8.49	8.45	CG	7.40	7.40	7.40	CG	-	-
FO	*Actinocyclus ingens* var. *ovalis*	8.49	8.49	8.49	CG	8.70	8.70	8.70	CG	8.7	HM
FO	*Thalassiosira torokina*	-	-	-	-	-	-	-	-	9.0	HM
FO	***Asteromphalus kennettii***	10.12	10.21	10.17	CG	10.30	10.31	10.31	CG	10.3	BB
LO	*Denticulopsis dimorpha* var. *areolata*	-	-	-	-	-	-	-	-	9.9-10.9	S1
LcO	*Denticulopsis dimorpha* var. *areolata*	-	-	-	-	-	-	-	-	10.7	HM
LO	*Denticulopsis ovata*	4.93	4.93	4.93	CG	10.50	10.60	10.55	CG	-	-
FO	*Fragilariopsis aurica*	9.50	10.30	9.90	CG	6.94	6.94	6.94	CG	-	-
FO	*Denticulopsis crassa*	9.70	10.12	9.91	CG	10.95	10.95	10.95	CG	-	-
FO	***Fragilariopsis praecurta***	11.40	11.43	11.42	CG	10.95	10.95	10.95	CG	-	-
LO	***Nitzschia denticuloides***	11.78	11.82	11.80	CG	11.86	11.86	11.86	CG	11.5-11.8	HM, Bo
FO	***Denticulopsis ovata***	12.11	12.11	12.11	CG	11.10	11.10	11.10	CG	-	-
FO	***Denticulopsis dimorpha* var. *areolata***	12.73	12.74	12.74	CG	12.12	12.12	12.12	CG	12.2	BB
LO	*Crucidenticula nicobarica*	-	-	-	-	-	-	-	-	12.3	BB, HM
LO	*Denticulopsis praedimorpha*	-	-	-	-	12.25	12.25	12.25	CG	-	-
LO	*Actinocyclus ingens* var. *nodus*	-	-	-	-	-	-	-	-	12.5	HM
FO	***Denticulopsis praedimorpha***	12.81	12.92	12.87	CG	-	-	-	-	12.84	BB
FO	***Nitzschia denticuloides***	13.48	13.38	13.43	CG	-	-	-	-	-	-
FO	***Denticulopsis simonsenii***	14.18	14.30	14.24	CG	14.22	14.22	14.22	CG	14.2	BB, HM
FO	***Actinocyclus ingens* var. *nodus***	14.18	14.80	14.49	CG	14.35	14.35	14.35	CG	14.4-14.5	HM, PM
FO	***Nitzschia grossepunctata***	15.20	15.20	15.20	CG	-	-	-	-	-	-
FcO	***Actinocyclus ingens***	14.80	17.30	16.05	GG	16.20	16.20	16.20	CG	16.2-16.3	BB, HM
FO	***Denticulopsis maccollumii***	16.70	16.70	16.70	CG	-	-	-	-	16.6-16.7	HM
FO	***Crucidenticula kanayae***	17.27	17.61	17.44	CG	-	-	-	-	17.7	BB
LO	***Thalassiosira praefraga***	-	-	-	-	-	-	-	-	17.8-18.4	YA, HM
LO	*Asteromphalus symmetricus*	-	-	-	-	-	-	-	-	18.5	HM
LO	***Rossiella symmetrica***	-	-	-	-	-	-	-	-	19.4	HM
FcO	***Thalassiosira praefraga***	-	-	-	-	-	-	-	-	20.3-20.8	HM, YA
LO	***Azpeitia gombosi***	-	-	-	-	-	-	-	-	21.1	HM
LO	*Rocella gelida*	-	-	-	-	-	-	-	-	22.3 / 24.3	BB, HM / Bet
FO	***Thalassiosira spumellaroides***	-	-	-	-	-	-	-	-	22.6	HM
FO	*Thalassiosira praefraga*	-	-	-	-	-	-	-	-	22.67-22.94	Bet

Notes: Source references are as follows: BB = Baldauf and Barron (1991), B = Barron (1992), HM = Harwood and Maruyama (1992), BI = Baldauf and Iwai (1995), YA = Yanagisawa and Akiba (1998), WI = Winter and Iwai (2002), CG = Censarek and Gersonde (2002), Bo = Bohaty et al. (2003), PM = Pfuhl and McCave (2003), Sl = Stickley et al. (2004a), and Bet = Barron et al. (2004).

Table 2-3. Eocene-Oligocene diatom events and age calibrations for the Southern Ocean. All ages are calibrated to the Berggren et al. (1995) timescale, and zonal datums are labeled in bold type.

Event	Datum	Age (Ma)	Chron	Source(s)	Site(s)	Notes
LO	***Lisitzinia ornata***	~24.8	C7n(?)	R	744	
LO	***Rocella vigilans* var. B**	24.8-26.3	C7n to C8n	R	744, 748	
FO	***Rocella gelida***	27.1	C9n/C8r boundary	R	744	
FO	***Lisitzinia ornata***	27.8	C9n	R	744, 748	
FO	*Rocella vigilans* var. B	27.6-27.8	C9n	R	744, 748	
FO	***Azpeitia gombosi***	~28.5	C10n	HM, R	748	
FO	*Cavitatus rectus*	28.51-28.65	C10n.1r to C10n.2n	Bet	1220 (eq. Pacific)	
LcO	***Rocella vigilans* var. A**	~29.0	C10r	R, S1, S2	748, 1172	
FO	***Rocella vigilans* var. A**	30.0	C11n.2n	R, S1, S2	748, 1172	
FO	***Cavitatus jouseanus***	30.8-30.9	C12n	R	744, 748	
FO	***Rhizosolenia antarctica***	33.2	C13n	R	748	
LO	*Hemiaulus caracteristicus*	33.2-33.4	C13n	BB, S1, S2, u	744, 748, 1172	
LO	*A. ammodochium* (double, loricate)	~33.3	C13n	BH	748	Ebridian
LO	*Distephanosira architecturalis*	~33.5	base C13n	S1, S2, u	738, 744, 748, 1172	
LO	*Micromarsupium anceps*	~33.5	base C13n	BH	748	Ebridian
FO	***Rhizosolenia oligocaenica***	33.6-33.8	C13r	R	744, 748	
LcO	*Naviculopsis constricta*	~34.7	C13r/C15n boundary	C2	703	Silicoflagellate
FO	*Craniopsis octo*	~40	C18n to C18r	BH	748	Ebridian
LO	*T. inconspicuum* var. *trilobata*	~40.5	C18r	HM, Sp	748, 1172	
LcO	*T. inconspicuum* var. *trilobata*	~45	C20r	Sp	1172	

Notes: Source references are as follows: C2 = Ciesielski (1991), BB = Baldauf and Barron (1991), BH = Bohaty and Harwood (2000), R = Roberts et al. (2003), Sp = C. Stickley (personal communication, 2003), Sl = Stickley et al. (2004a), S2 = Stickley et al. (2004b), Bet = Barron et al. (2004), u = Bohaty unpublished data from Sites 738, 744, and 748.

APPENDIX 2-1

TECHNICAL IMPROVEMENTS SHALDRIL 2006

Following the inaugural 2005 SHALDRIL cruise, a debriefing meeting was held at Rice University in early June. At that meeting technical problems from the 2005 cruise were highlighted and an action plan formulated for the SHALDRIL 2006 cruise.

Although the rig had generally performed well with few mechanical problems during the inaugural cruise, a list of recommended improvements was compiled at the end of the 2005 cruise. This list was discussed at Seacore's in-house debriefing, and it was decided Seacore would address all items prior to the 2006 SHALDRIL cruise.

The inhole tools were of greatest concern. Good penetration rates and core recovery were achieved in the softer clays of Maxwell Bay; however, subsequent boreholes in tills and harder sediments had met with little success. While weather conditions limited available site selection, it was agreed that the set of tools used had not met expectations and that an improved set of tools should be sourced for SHALDRIL 2006.

Modifications made for the 2006 SHALDRIL cruise are outlined below.

Rig Improvements

The most significant modification made to the rig was the installation of a new gimbal frame for the power swivel. One of the challenges of installing a drilling system on the *Nathaniel B. Palmer* was the limited deck space and the critical angle required to run drill pipe between the deck crane and the aft control cabin. This challenge was met by building an angled gimbal frame that directed the drill pipe into the narrow gap available. Just prior to the 2005 mobilization a discrepancy between the plans and the resulting structure was discovered. This resulted in a hasty last-minute modification that corrected the angle, but resulted in a forward and aft error. The error had minimal effect while running wireline tools into the API string, but it may have contributed to the subsequent piggyback string failures.

A complete new gimbal frame was fabricated in the UK and installed during the 2006 mobilization. In addition to correcting the errors in the original frame, the new frame was also slightly shortened, effectively giving more height in the derrick. During the 2006 cruise this new gimbal frame has proven to be precise, and the larger diameter SHALDRIL wireline tools were run with no interference problems.

During the 2005 cruise the Nylatron-type material used to manufacture the rooster box wheels delaminated under extreme cold temperature. For the 2006 cruise a complete set of new wheels made of steel with rubber tires were fitted. Unfortunately, these wheels also failed and were replaced with the original wheels (kept as spares) after being machined concentric by the ship engineers. By changing wheels during rig moves minimal drilling time was lost, and the large stock of spares meant there was no risk of complete failure. This is an area of concern that will be addressed by Seacore's design department when the rig returns to the UK.

Other modifications to the rig were mostly associated with instrumentation and control, relating to the drill shack. There were also some safety features added to address possible hazards identified during the 2005 cruise, including a “dead” man cut out of the rig controls when the driller left the drill shack, better access to the derrick from the helo deck, and guarding of winches and wires.

Inhole Tool and Bit Development

All of the available options for inhole tooling that would be suitable for SHALDRIL 2006 were researched and assessed during summer 2005. The conclusions, recommendations, and budget were presented to the SHALDRIL committee at a meeting in Houston in August 2005. There were seven separate options outlined, but the preferred option was to work with Marshall Pardey and modify an existing set of DOSECC tools to suit SHALDRIL's requirements. It was decided at the meeting that while the modified system custom built for SHALDRIL was the way forward, there were some budget constraints that had to be addressed before a final decision could be made. Meanwhile, Seacore continued to work with Marshall Pardey on the final tool designs, and with American Diamond Tools for the bit designs. At the end of September Seacore placed an order for the production of one complete system for projects offshore New Zealand. The SHALDRIL committee was offered (and took) the opportunity to take advantage of discounted production costs associated with producing two systems at once, with Seacore buying the tools and leasing them to SHALDRIL for the 2006 cruise. Production was immediately started and the tools were fit-tested and inspected by the SHALDRIL committee in Salt Lake City in mid-December. (See Appendix 2-2 for a report on the inspection visit and description of the tools.)

Prior to the SHALDRIL 2006 cruise, Seacore completed two projects using the new inhole equipment. The inhole tools performed well, with recovery improving with increasing experience, but the initial production run of bits contained major flaws resulting in total failure. American Diamond Tools worked hard to rectify this fault, and subsequent bits have turned in high meterage. SHALDRIL II benefited greatly from this field-testing and experience. In addition to the initial order of two systems, Seacore has invested in a third complete set of tools with ongoing development of geotechnical tools to be run with the same bottom hole assembly.

Recognition should go to Marshall Pardey for the final design of the tools, to Bob Vredenburg, whose company built the tools, and to American Diamond Tools for the production of the diamond bits. The staffs of these companies showed great commitment, enthusiasm, and genuine interest for this project.

APPENDIX 2-2

SHALDRIL II CORING/SAMPLING PROGRAM

Introduction

SHALDRIL had several new sampling concepts and tools available to pursue coring operations during the 2006 cruise. It was felt that at least two different concepts with varying degrees of sampling/coring options would need to be available in order to have sufficient capabilities on hand to overcome potential obstacles that might occur in these remote locations. The soft sediment sampling during the shake down cruise in 2005 was very successful; however, there were issues penetrating the stiff tills that overlie much of the continental shelf in the region. This was primarily due to the sampling equipment available at the time, as well as weather conditions.

Five of the six proposed drill sites for the 2006 season were expected to have stiff diamicton overlying the lithified Tertiary section that was of interest to the cruise. The sixth target was a 100 m thick section of very pebbly, over-compacted diamicton.

Background

In general, two deployment methods were devised to allow coring tools to be operated for this cruise. These included:

1. Coring tools through advancement with a newly designed common Bottom Hole Assembly (BHA) (SHALDRIL tools) including Piggyback Diamond Coring (PBCH*) with an HQ mining string, if required; and

2. Piggyback Diamond Coring (PBCH) utilizing an HQ mining string both with and without a seafloor template option using hardware developed at the Ocean Drilling Program (ODP), which was designed as a drill-in BHA system (i.e., more robust BHA with roller cone primary and center bit)

*PBCH utilizes a small mining-style diamond core rig position in the rooster box above the top drive of the main rig. Once the main drill string can be held in tension to allow the passive heave compensator to work, the PBCH rods can be deployed through the main BHA and allowed to advance without heave compensation being required for the smaller rig. This type of coring has recovery typically greater than 90%.

The specific coring/sampling tools which all take a 3 m core included:

1. **Spring-loaded, non-rotating Extended Nose Core Barrel,** which uses an Integrated Ocean Drilling Program (IODP) liner,
2. **Alien-type Corer** (diamond system that is advanced in tandem with the primary bit utilizing a non-rotating inner barrel, which uses an IODP liner)

3. HQ3 Diamond Core Barrel (HQ3 liner)
4. HQ3 Push Sampler (HQ3 liner)
5. **Non-coring center bit**

(Items highlighted are those produced in Salt lake City, Utah, and were modified designs of the original SHALDRIL suite of tools.)

Two other push samplers were also available. These included:

1. 1 ½ m HQ3 push sampler (HQ3 liner)
2. 1 m Shelby tube sampler (3" outer diameter (OD))

Details of the deployment methods and specifics of the coring tools are discussed in the followings paragraphs. Listed below are the general overall dimensions of the specific tools that were available for SHALDRIL II.

Tool Description	**Bit OD/ID, (in./mm)**	**Liner Size, (in./mm)**	**Length, (ft/m)**	**Liner Type**
Extended Corer	3.80 x 3.18 (96.5 x 80.8)	2.44 (62)	10(3)	IODP
Alien Corer	3.80 x 2.40 (96.5 x 60.96)	2.44 (62)	10(3)	IODP
Non-Coring Assembly	3.80(96.5)	n/a	n/a	n/a
HQ3 PBCH	3.782 x 2.406 (96.06 x 61.1)	2.406(61.1)	10(3)	HQ3
HQ3 Push Sampler	Used in combination w/ non coring assy	2.406(61.1)	5/10(1 ½ , 3)	HQ3
3" Shelby Tube	Used in combination w/ non coring assy	2.83(71.9)	3(1)	n/a

Modified Bottom Hole Assembly

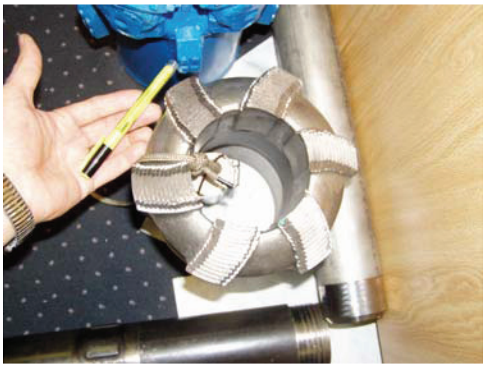
The first option surrounds the new suite of SHALDRIL/Seacore tools that were designed to work within a common BHA. The original SHALDRIL suite of tools were designed to operate with a drill bit with an internal diameter (ID) of 3.345". This is the same size core diameter that is used for a conventional PQ diamond coring string. For SHALDRIL, the bit throat was modified to accommodate a larger 3.85" ID, thus eliminating the PQ coring option for this specific bit since borehole re-entry is not planned with the outer coring string. This larger throat allows a conventional HQ coring string (PBCH) to be deployed through the common BHA bit if material is encountered deeper in the borehole where high-speed diamond coring is required.

If the bit throat had not been made larger, then an HQ core bit would have to be sacrificed to core through the PQ bit throat prior to having a hole large enough for the HQ coring string to pass. This operation would have required the HQ string to be removed and redeployed with a fresh bit prior to initiating actual coring operations. Since onsite time was limited for SHALDRIL II and there was potential for drifting ice, it was felt important to modify the original SHALDRIL suite of tools to be compatible w/ the Seacore PBCH, as well as to have multiple tools fitting the same BHA in order to reduce tripping times to change BHAs.

Another feature of the SHALDRIL/Seacore system is that it uses a latch sub at the top of the BHA both to hold in a seal sleeve, as well as having two internal tangs for driving the non-coring assembly. The sealing sleeve is sealed externally with O-rings at both the top and bottom of the sleeve. All the latches have a series of stacked seals that force all the flow through the latch and out the small bit attached to the specific coring assembly being used. The concept involves keeping the small bit from plugging and staying fully lubricated during the coring operation. Since the inner bit is essentially within an inch or two of the outer bit, it is assumed that there will be sufficient flow across the face of the outer fixed cutter bit to keep it clean and free of debris buildup. Presently, there is no mechanism to split or divert the flow between the outer and inner bits.

Outer BHA Bits

Two types of outer bits were designed that use an impregnated matrix, but cast similar to a large bladed-type drag bit. This design basically allows the bit to remove soft sediments but has a harder cutting structure should limited rock be encountered. The other style of bit is identical but with added Thermally Stable Diamonds (TSD) on the leading edge to enhance the cutting capability of the bit. Both bits have identical dimensions of 7.75” x 3.85”. Larger diameter bits of the same two types were also manufactured, which provide more annulus in case clays encountered might be susceptible to swelling, resulting in bit balling and reducing the progress of the borehole. The dimensions of these bits are 8.5” x 3.85”. The outer core barrel is 7” x 4 1/8”and the drill collars provided by Seacore are 7” x 4” with the conventional ODP drill pipe making up the rest of the string. Schematically illustrated drawings of the bits are shown in Figure 1.



Inner/Coring Bits

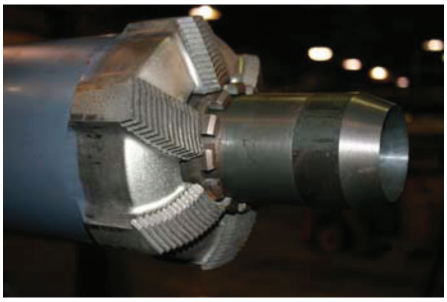
Three other bits were provided for the new coring tools. These included:

1. Alien impregnated diamond bit 3.80” x 2.4”
2. Alien polycrystalline diamond compact (PDC) bit 3.8” x 2.4”
3. Extended core bit using an impregnated 3.80” x 3.18” diamond bit
4. PDC non-coring center bit

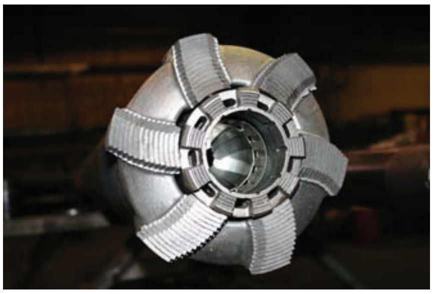
Cores for the bits listed under items 1 through 3 all use the same size IODP liner. The original extended corer developed for the original SHALDRIL suite of tools did not use a secondary bit as noted above, but was necessary in this case to reduce the gap between the bits when going to the larger throated concept.

Coring Tools

Prior to switching over to PBCH for either option, two coring assemblies as mentioned above were available to be operated in this modified BHA. These included an extended-nose, spring-loaded corer and what is referred to as the alien corer. The extended-nose corer is typically used for sediments after push and/or piston sampling is exhausted; however, the design of this sampler is much more versatile than IODP’s extended core barrel (XCB) and can be used for sampling much of what is traditionally sampled with a piston corer. All flow through either coring assembly is directed through the inner bit before passing over the face of the larger outer bit. This helps to ensure that the inner bits will not plug and thus prevents them from being damaged from being starved of flow. A 3 m hydraulic piston corer (HPC) was also available and compatible for this system but was not purchased due to budget constraints and since the objective of the cruise was directed toward harder material. Push samplers in a variety of sizes were available in case soft material was indeed encountered. These push samplers are operated off the non-coring assembly hardware by removing the bit and replacing it with a sample head. An illustration of the different coring assemblies is shown in Figure 2.



Extended-Nose Corer - As noted above the extended-nose corer is similar to IODP’s XCB-type coring system. The non-rotating spring-loaded barrel is in advance of the primary outer bit. These include a 2” or 4” nose section. The thin kerf secondary extended-nose bit is positioned in the throat of the larger outer bit. Several options of basket catchers were available with up to five different spring thicknesses available. These included thickness of 0.005”, 0.008”, 0.010”, 0.012”, and 0.015”.



Alien Corer - The alien corer is similar to the extended-nose corer but is designed to core harder, more consolidated material. Because SHALDRIL opted to increase the throat size through the outer bit, the same liner size was employed. The conventional alien barrel requires a smaller HQ3 core size to be cut. The inner barrel for this system is similar to a conventional triple tube coring system in that it resides up and inside the outer coring tube. Core catchers for the alien sampler are conventional core lifter type (collet) and were also available in tandem with a basket catcher. Varying spring material was also used in combination with the core lifter. Another nice feature incorporated into the latch assembly and common to both these tools is a pump out port. This port can be accessed to allow the core to be pumped out without full removal to the latch and inner tube. This feature assisted in turning the barrel around once on deck with the added benefit of not having to completely remove the latch each time a liner is removed/replaced.

Non-Coring Option - Another option existed where a full face bit can be deployed to drill through sections where core is not required, or to re-drill down to a specific level in case the previous borehole was abandoned due to weather or approaching ice. The bit is set with 15 small PDC cutters and measures 3.80” in diameter. No other cutting structure versions were manufactured for SHALDRIL II.

Operating Sequence - The operating sequence adopted for SHALDRIL used the extended-nose sampler to start, then switched over to the alien corer when harder material was encountered, and if possible complete the borehole to 100 m with this system; however, holes were typically initiated with the alien corer as harder material occurred very near the seafloor at most sites. If the formation became too hard below a certain depth where the PBCH could be deployed, then the alien barrel was tripped out and the PBCH rods tripped in and HQ coring initiated.

Hardware Purchased

The amount of hardware purchased for SHALDRIL II along with spares was felt to be more than adequate for the amount of work planned during the cruise. The main assemblies consisted of the following:

1. 4 - CHD latches
2. 2 - Non-coring assemblies
3. 3 - Alien coring assemblies
4. 3 - Extended-nose coring assemblies
5. 3 - BHAs
6. 3 - 7 ¾ x 3.85 impregnated bits
7. 3 - 7 ¾ x 3.85 impregnated bits w/ TSD
8. 1 - 8 ½ x 3.85 impregnated bits
9. 1 - 8 ½ x 3.85 impregnated bits w/ TSD
10. 10 - Impregnated extended-nose bits
11. 10 - Impregnated alien bits
12. 2 - PDC alien bits
13. 4 - Overshot/jar assemblies

While this slightly larger core size was indeed different from the original SHALDRIL suite of tools, very little changed with the components other than increasing the diameter of some of the tubing and adjusting the bit sizes. The latches were identical to the original Longyear CHD 134 latch with the exception of the different threads cut to accommodate the varying sizes of tubes used in this system.

Very good recovery has been reported with the original SHALDRIL suite of tools, and Seacore's experience proved similar with work completed offshore New Zealand in December 2005. The bits developed all proved to work efficiently in the materials they were designed for. With the additions of the different kinds of bits added to the inventory for SHALDRIL, there was sufficient coverage for the range of materials expected.

Tool Operations

Each of the three coring tools is deployed on different sized tubes, thread types, and are of different overall length, which makes keeping track of which barrel and bit combination rather tedious. While some combinations of the tubes are box to box and others are box to pin, it would appear easier to have different bands cut into the tubes themselves so that the system is foolproof. It might also make more sense, if possible with this larger assembly, to have all the tubes the same type and length and have the differences for core type adjusted in the specific latch accompanying the specific corer.

The present CHD latch is quite heavy and may require two persons to hold and rotate it while making it up, as well as another person backing up the tube itself. Due to the weight of the latch and the safety issues surrounding its handling (it can easily be dropped while attempting to make up the inner barrel, and without proper handling cross threading could be another issue), care will need to be exercised when re-dressing all of these barrels, especially the extended-nose and alien barrels.

Another issue that may need to be addressed in the future is switching over to a bayonet-type connection between the inner tube barrels and CHD latch. Therefore, one may want to investigate whether this type of connection between the inner tube barrels and CHD latch might be feasible and whether it could be accomplished by adding another short sub to the assembly to accommodate the additional space required.

One very nice feature provided is that wraparound wrenches are supplied for all the different tube sizes. These wrenches used the standard Longyear handle but the jaws were all custom built to fit the specific tube. In addition, American Diamond Tools laser-applied TC bands on the gripping surface to increase the holding power of these wrenches.

Drill-in Bottom Hole Assembly

As noted above, the first option allows up to three coring/drilling systems, as well as push samplers, to be deployed through the same string. Should rock be encounter at a very shallow depth where the common BHA bit cannot be advanced easily with the present bit design then an altogether different approach can be deployed. The hardware adopted for this concept revolves around the use of a drill-in BHA (DI-BHA) that was developed by the ODP in the early 1990s when a Diamond Coring System (DCS) was under development at Texas A&M University (TAMU). This hardware basically uses a robust roller-cone bit and a one- or two-cone center bit latched into its throat. The latch used to hold the center bit in place employs a similar XCB-type latch as used by IODP, but modified with one-way dogs. This requires the latch to be loaded into the throat of the outer bit prior to tripping pipe. The center bit is removable via wireline once the BHA has been drilled to depth to allow a clear passage for the PBCH to be initiated. The same pulling neck used on the coring tools described above has been adapted to this latch. Illustrations of the two bits are presented on Figures 3 and 4.

For SHALDRIL II, only one center bit and one outer bit were manufactured. These were new roller cones manufactured by Bits Ulterra, formally known as Gearhart/Rock Bit International. Without spacers added to the latch, the center bit resides in the throat of the outer bit at the same level as the other five outer cones. Existing DI-BHA hardware was provided by IODP. These components included bit subs on the order of 3- and 5-m lengths and 3-m lengths of drill collars. The weight of all the DI-BHA hardware is ~132 lb/ft.

The outer bit was originally designed with a 4.05” throat and used a 4” center bit. Even though Seacore is using ODP drill pipe and all the DI-BHA hardware have a 4 1/8” ID, the drill collars used by Seacore were all 4” ID. Therefore so as to not have to bore out the drill collars, the bits were modified so they would pass the restriction.

Optional Spudding Alternatives

There are two options for this hardware to be deployed. The choice is dependent upon the thickness of the overburden sediment. If it is shallow, then a seafloor clump weight must be deployed with the DI-BHA. The clump weight is installed in the top of the moonpool in port and then lowered and suspended on cables once onsite when not used. If required for this operation, it is raised so that a short (and variable) section of the DI-BHA pipe can be positioned beneath the clump weight. The length is in fixed intervals dependent upon lengths of Seacore’s drill collars. The collars are fitted with a small recess that allows them to be bolted to the clump weight via a split flange. The clump weight is then lowered on the drill string and the BHA slowly rotated through the upper sediment until buried. This would position the clump on the seafloor and serves as the reaction necessary to tension back and activate the passive heave compensator. The center bit would then be removed prior to the PBCH rods being tripped in to initiate coring from beneath the short section of DI-BHA and the clump weight.

If the material in question is located deeper and at a sufficient depth where the weight of drill collars within the BHA can be used as reaction, then the clump weight can be eliminated in lieu of the DI-BHA being drilled to depth. The DI-BHA is a short 3- or 5-m length of 8 ½” x 4 1/8” collar material that has a special cavity placed in the throat of the bore. The DI-BHA is crossed back over to Seacore’s 7” drill collars with a crossover sub. Typically, a minimum of 20 m may need to be drilled into the seafloor before there is sufficient weight below the neutral axis of the drill string to tension back against. This non-clump weight option is a much simpler operation in that the BHA would be allowed to pass through the clump weight which is hung-off within the vessel’s moonpool as described above. Once the depth in question is reached, the center bit is removed and the heave compensator is activated. The PBCH is then deployed through the drill string and coring is initiated from the depth the DI-BHA is advanced to the termination depth of the borehole.

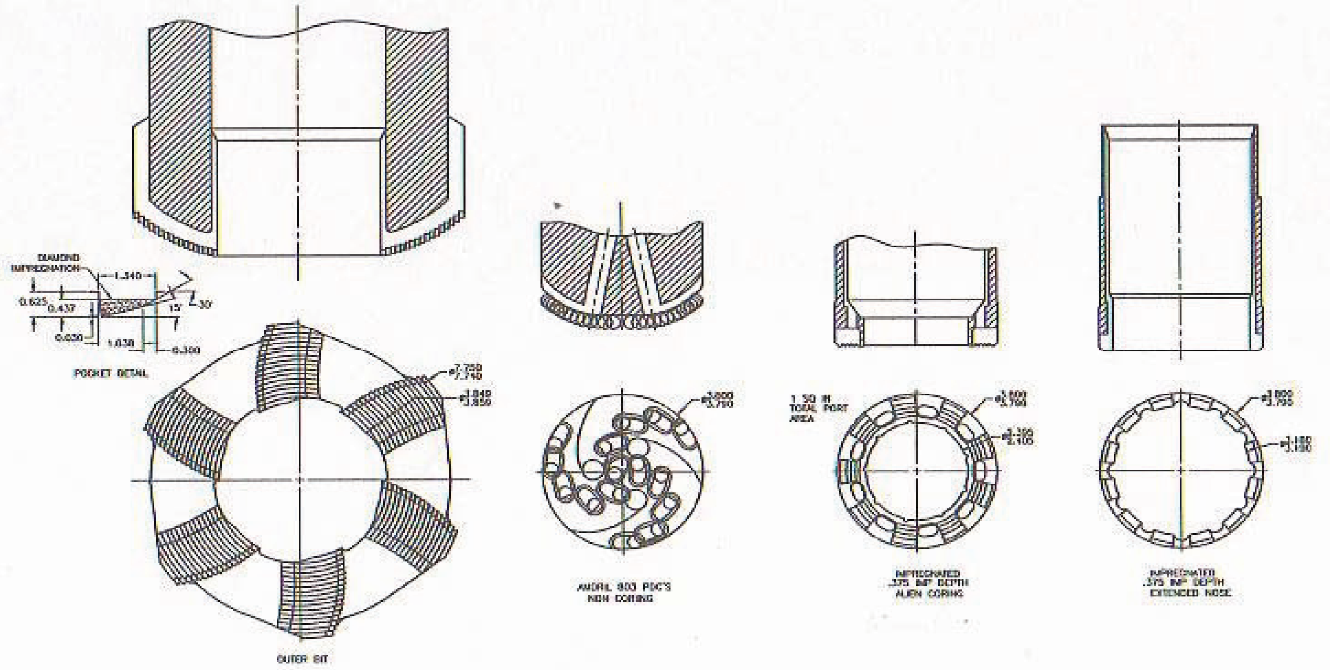

DIAMOND IMPREGNATION
1.340
0.625
0.437
0.030
1.038
0.300
15°
30°
POCKET DETAIL
ø7.750
7.740
ø3.840
3.850
OUTER BIT
ø3.800
3.790
AMDRIL 803 PDC'S
NON CORING
1.50 IN
TOTAL PORT
AREA
ø3.800
3.790
ø2.100
2.105
IMPREGNATED
.375 IMP DEPTH
ALIEN CORING
ø3.800
3.790
ø1.180
1.190
IMPREGNATED
.375 IMP DEPTH
EXTENDED NOSE

Figure 1

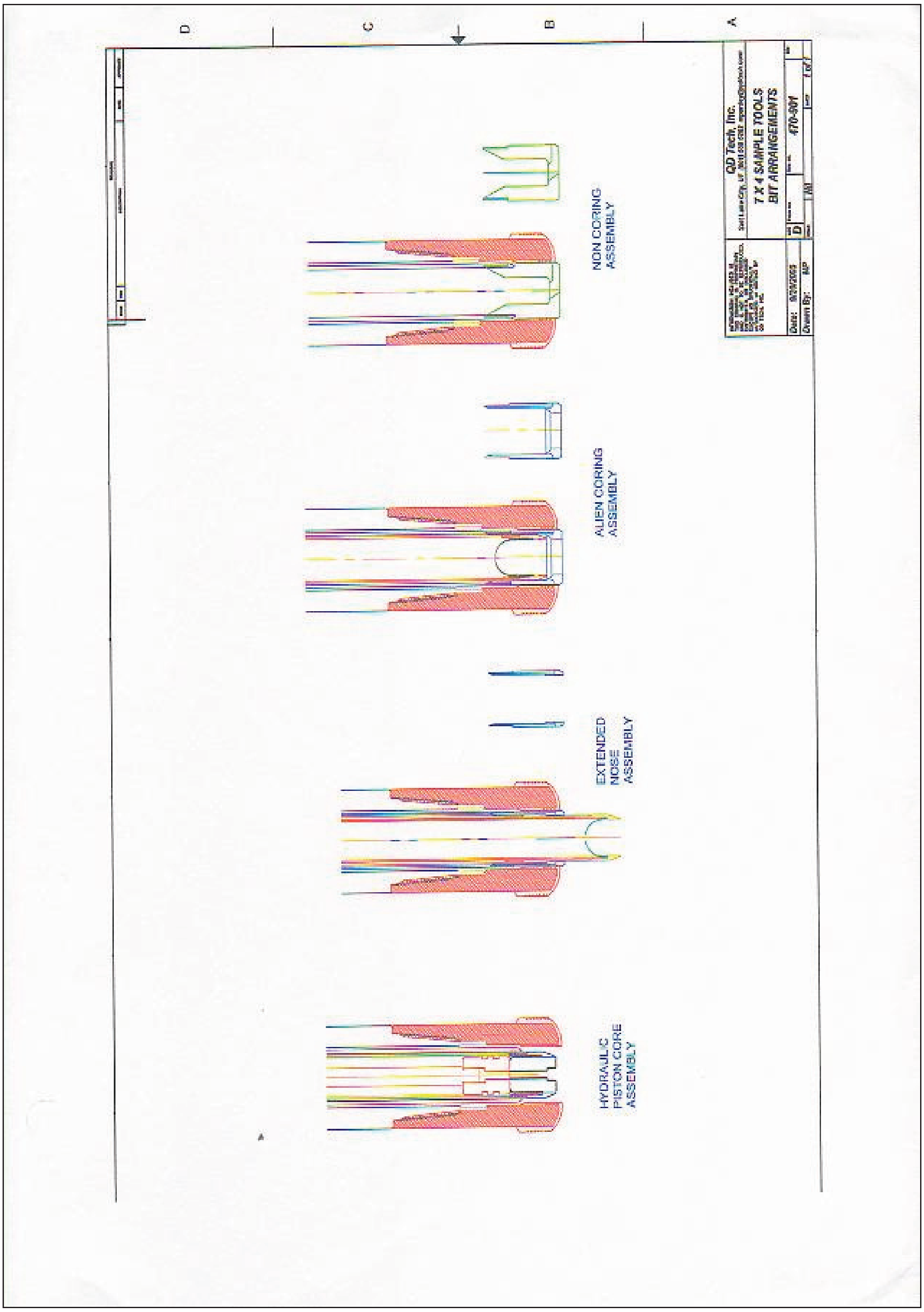

D
C
B
A
NON CORING ASSEMBLY
ALIEN CORING ASSEMBLY
EXTENDED NOSE ASSEMBLY
HYDRAULIC PISTON CORE ASSEMBLY
QD Tech, Inc.
7 X 4 SAMPLE TOOLS BIT ARRANGEMENTS
470-801
D
Date:
Drawn By: MP

Figure 2

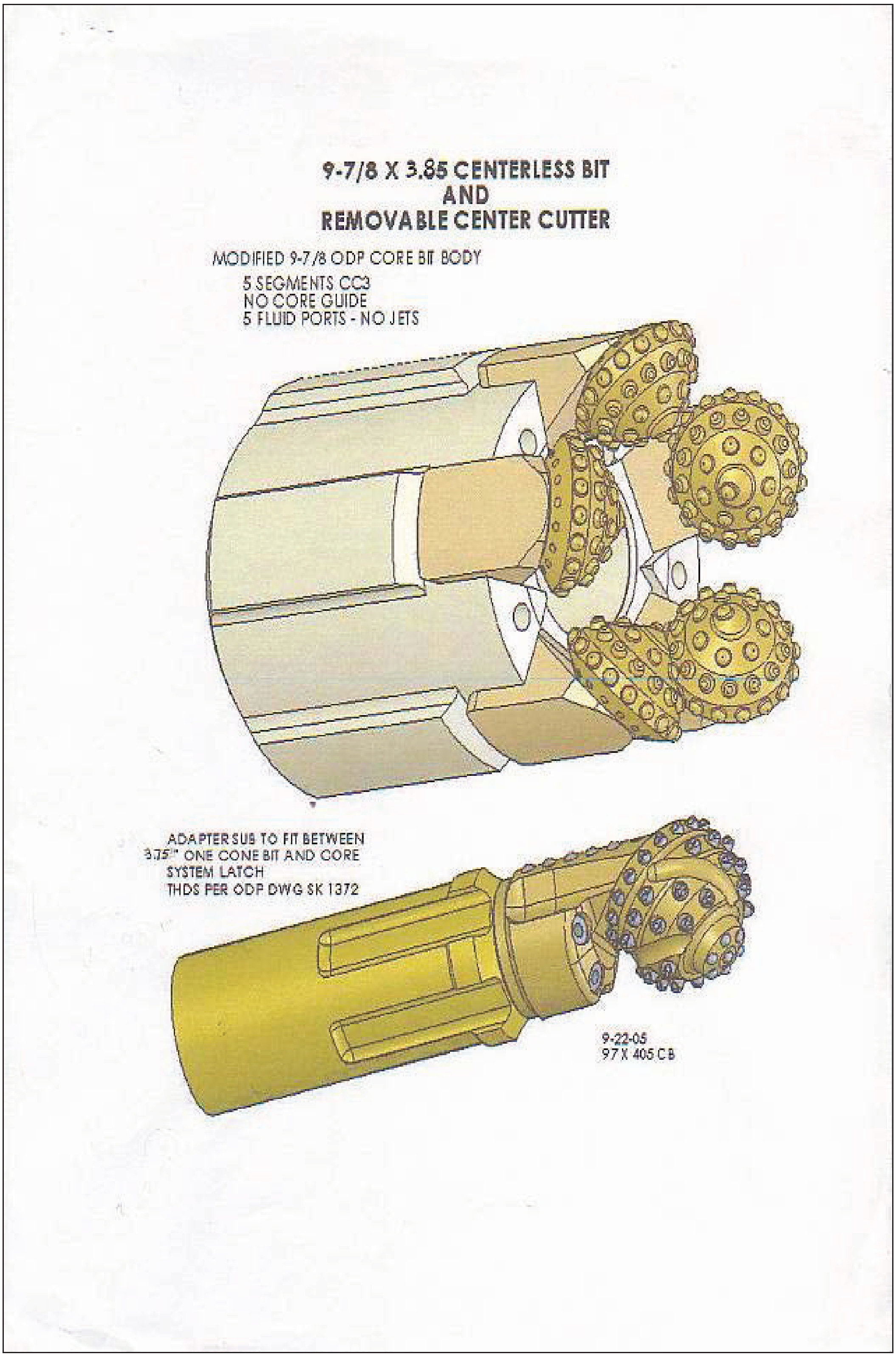

9-7/8 X 3.85 CENTERLESS BIT
AND
REMOVABLE CENTER CUTTER
MODIFIED 9-7/8 ODP CORE BIT BODY
5 SEGMENTS CC3
NO CORE GUIDE
5 FLUID PORTS - NO JETS
ADAPTER SUB TO FIT BETWEEN
3.75" ONE CONE BIT AND CORE
SYSTEM LATCH
THDS PER ODP DWG SK 1372
9-22-05
97 X 405 C B

Figure 3

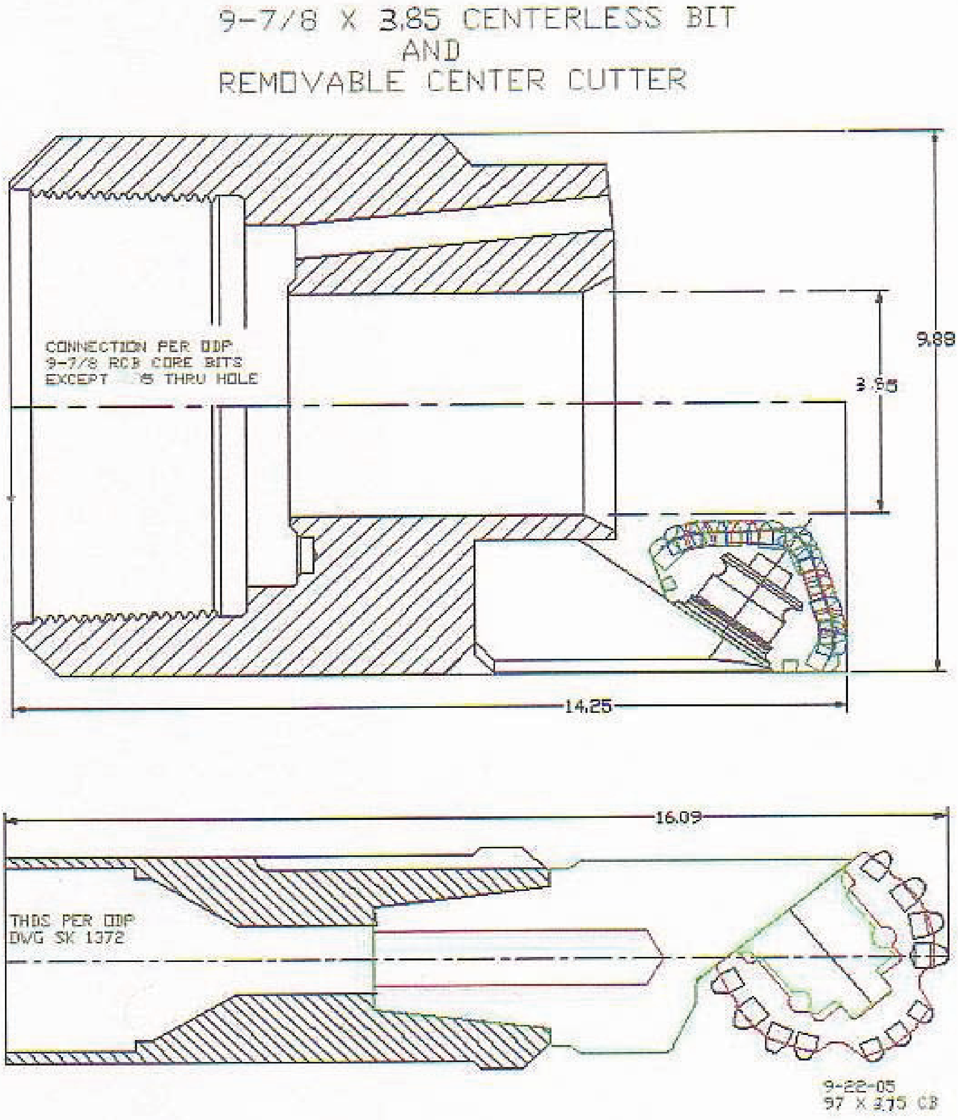

9-7/8 X 3.85 CENTERLESS BIT
AND
REMOVABLE CENTER CUTTER
CONNECTION PER ODP
9-7/8 RCB CORE BITS
EXCEPT .5 THRU HOLE
9.88
3.95
14.25
16.09
THDS PER ODP
DWG SK 1372
9-22-05
97 X 3.75 CB

Figure 4

APPENDIX 2-3

ACRONYMS AND ABBREVIATIONS

General Acronyms

ADCP - acoustic Doppler current profiler
AMGRF - Antarctic Marine Geology Research Facility
AMSTRAT - American/Canadian Stratigraphic
API - American Petroleum Institute
BHA - bottom hole assembly
CC - core catcher
CHD - coring heavy duty
CRP - Cape Roberts Project
CTD - conductivity, temperature, and depth
DCS - diamond coring system
DI-BHA - drill-in bottom hole assembly
DIC - differential interference contrast
DP - dynamic positioning
DSDP - Deep Sea Drilling Project
DVDP - Dry Valley Drilling Project
ER - electrical resistivity
FcO - first common occurrence
FO - first occurrence
FOV - field of view
GI - general injector
GPS - global positioning system
GPTS - geomagnetic polarity timescale
GRAPE - gamma-ray attenuation porosity evaluator
HPC - hydraulic piston corer
ID - internal diameter
IODP - Integrated Ocean Drilling Program
JRB - James Ross Basin
LcO - last common occurrence
LO - last occurrence
MCER - Middlebury College electrical resistivity probe
MS - magnetic susceptibility
MSCL - multisensor core logger
NBP - *Nathaniel B. Palmer*
OD - outer diameter
ODP - Ocean Drilling Program
PBCH - piggyback diamond coring
PDC - polycrystalline diamond compact
PH - phase contrast
POL - polarizing light

PWL - *p*-wave logger
RISP - Ross Ice Shelf Project
RPSC - Raytheon Polar Services Company
R/V - research vessel
RV/IB - research vessel/icebreaker
TAMU - Texas A&M University
TSD - thermally stable diamonds
UK - United Kingdom
XCB - extended core barrel

Core/Drilling Designators

E - extended core barrel or push sampler
E_s - spring-loaded, non-rotating, extended-nose core barrel
GS - grab sample
H - hammer core
KC - Kasten core
P - piston core
PB - piggyback diamond rotary core
R - standard rotary core
R_a - rotary core utilizing the alien bit
R_n - non-coring center bit.
w - washed core (e.g., $R_{a\text{-}w}$)

Units of Measure

µm - microns
µs - microsecond
C - Celsius
cal. yr. BP - calendar years before present
cc - cubic centimeter
cm - centimeter
dpi - dots per inch (image resolution)
ft - foot
g - gram
GMT - Greenwich Mean Time
hr - hour
Hz - hertz
in^3 - cubic inch
ka - absolute age in thousands of years
kHz - kilohertz
km - kilometer
kn - knot
m - meter
Ma - absolute age in millions of years

mbsf - meters below seafloor
mbsl - meters below sea level
min - minute
mm - millimeter
m.y. - million years
s - second
UTC - Coordinated Universal Time
V - volt
yr - year

Chemical Formulas

H_2O_2 - hydrogen peroxide
HCl - hydrochloric acid

CHAPTER 3: SITES 1 and 2
Table of Contents

HOLES NBP0602A-1A-KC, -1B-KC, -1C

Date/time occupied (date; Julian Day; GMT): 6 March 2006; 065; 2115

Date/time departed: 8 March 2006; 067; 0315

Time on station: 30 hr

Geographic area: Northern James Ross Basin

Ice coverage during station: $^3/_{10}$ to $^9/_{10}$

Kasten Cores: 63° 59.986' S, 54° 22.563' W; 398 mbsl

NBP0602A-1A-KC: no recovery
NBP0602A-1B-KC: bag sample; muddy pebbly fine sand

Drill Hole 1C: 64° 00.990' S, 54° 22.262' W

Water depth (multibeam, m): 406

Water depth (drill-pipe measurement from sea level, m): 408

Total penetration (m): 7

Number of drill runs: 1

Total length of cored section (m): 7 (washed)

Total drill core recovered (m): 0.05

Drill-core recovery (%): N/A

Oldest sediment drilled:
Depth sub-bottom (m): 0 to 7
Nature: Pebbly mud
Age: Quaternary

Principal Results: After an uneventful crossing of Drake Passage, we attempted to reach Proposed Site JRB2 off Seymour Island for the first SHALDRIL II site. This attempt had to be temporarily abandoned when we encountered heavy, multiyear pack ice ($^9/_{10}$ coverage). As a result, we sought somewhat more open waters in the vicinity of Proposed Site JRB6 toward the outer shelf, where the objective was to sample the younger glacial section represented by uppermost seismic Unit S1, the age of which is predicted to be Plio-Pleistocene based on aggradational stratal geometry. Below a thin uppermost glacial diamicton, dipping sedimentary units presumably record multiple Pleistocene glacial-interglacial cycles.

The second Kasten core attempted at Site NBP0602A-1 returned a varied benthic invertebrate surface assemblage of agglutinated foraminifers and bryozoans, some of which encrusted large pebbles, along with very dark greenish gray Quaternary diatomaceous mud dominated by *Chaetoceros* resting spores and a flora of sea-ice proximal diatoms. The first drill core penetrated to 7 mbsf, although sediment was only recovered from the core catcher. This sediment, a dark greenish gray pebbly mud, contains an assortment of modern and reworked extinct diatom species. Before subsequent cores could breach the surface sedimentary veneer, a floe of multiyear sea ice larger than the ship forced the vessel off station and the site had to be abandoned. By that point the aerial coverage of the relatively fast-moving sea ice had increased from $^{3}/_{10}$ to $^{9}/_{10}$ within the hour.

HOLE NBP0602A-2A

Date/time occupied (date; Julian Day; GMT): 8 March 2006; 067; 0815

Date/time departed: 9 March 2006; 068; 1615

Time on station: 8 hr

Geographic area: Northern James Ross Basin

Ice coverage during station: $^{2}/_{10}$ to $^{4}/_{10}$

Position: 64° 01.404' S, 55° 01.363' W

Water depth (multibeam, m): 384

Water depth (drill-pipe measurement from sea level, m): 386.5

Total penetration (m): 9.24

Number of drill runs: 1

Total length of cored section (m): 2.74

Total drill core recovered (m): 3.33

Drill-core recovery (%): 122

Oldest sediment drilled:

Depth sub-bottom (m): 9.24
Nature: Pebbly sandy silt
Age: Quaternary

HOLE NBP0602A-2B

Date/time occupied (date; Julian Day; GMT): 9 March 2006; 068; 1615

Date/time departed: 10 March 2006; 069; 0800

Time on station: 15 hr, 15 min

Geographic area: Northern James Ross Basin

Ice coverage during station: $^{1}/_{10}$ to $^{4}/_{10}$

Position: 64° 02.220' S, 55° 03.680' W

Water depth (multibeam, m): 341

Water depth (drill-pipe measurement from sea level, m): 341

Total penetration (m): 52.2

Number of drill runs: 6

Total length of cored section (m): 10.5

Total drill core recovered (m): 2.29

Drill-core recovery (%): 22

Oldest sediment drilled:
Depth sub-bottom (m): 52.2
Nature: Pebbly sandy silt
Age: Quaternary

HOLE NBP0602A-2C

Date/time occupied (date; Julian Day; GMT): 9 March 2006; 068; 0815

Date/time departed: 9 March 2006; 068; 1930

Time on station: 11 hr, 15 min

Geographic area: Northern James Ross Basin

Ice coverage during station: $^2/_{10}$ to $^5/_{10}$

Position: 63° 59.862' S, 55° 01.386' W

Water depth (multibeam, m): 385

Water depth (drill-pipe measurement from sea level, m): 386

Total penetration (m): 11.2

Number of drill cores: 1

Total length of cored section (m): 0.5

Total drill core recovered (m): 0.2

Drill-core recovery (%): 40

Oldest sediment drilled:
Depth sub-bottom (m): 11.2
Nature: Mud
Age: Quaternary

Principal Results: Three holes were drilled near Proposed Site JRB4 to ascertain the age of the seismic U3 unconformity, which is believed to have been eroded by the first advance of the West Antarctic Ice Sheet onto the continental shelf in this region during the Miocene. Ever-shifting sea ice, covering $^1/_{10}$ to $^5/_{10}$ of the area around the sites, permitted only short windows of opportunity to penetrate the glacial sediments overlying the older strata of interest. Due to the ice, attempts were made to speed up the coring process, i.e., all cores were initially washed down as far as possible before fixed-interval coring was begun, and Hole NBP0602A-2B was spot cored successfully to a depth of 52.2 mbsf. Nevertheless, all three holes appear to have terminated in Quaternary sediments by the time sea ice forced abandonment of each, although the near or complete absence of diatom fragments in the lower section of Hole 2B (~48 to 52 mbsf) leaves open the question of whether Miocene strata were actually reached.

The sediments in Hole NBP0602A-2B consist of very dark gray, poorly sorted, stiff, sandy silts from 22 to 29 mbsf and very dark greenish silts of a similar nature below that. Mostly isolated medium to coarse pebbles occur throughout. Rare, poorly preserved diatoms in Hole NBP0602A-2A and in the upper portion of NBP0602A-2C represent modern forms mixed with reworked middle to upper Miocene and occasionally Eocene-Oligocene taxa.

SEISMIC STRATIGRAPHY

Anderson et al. (1992) and Sloan et al. (1995) used intermediate-resolution seismic data to conduct a seismic stratigraphic analysis of the continental shelf in the northern part of the James Ross Basin. These authors divided the stratigraphic succession into five seismic units and mapped these units around the northwestern margin of the basin (Fig. 3-1). Anderson (1999) renamed these units in order to better correlate with the names of the units on the other side of the Antarctic Peninsula. This report uses the terminology of Anderson (1999).

The age model used to infer the age of stratigraphic units is based on similarities in stratigraphic architecture between the James Ross Basin and the continental margin north of the Antarctic Peninsula (Bart and Anderson, 1995) (Fig. 3-2). Ocean Drilling Program (ODP) Leg 178 provides the few chronostratigraphic constraints of the age of Miocene and younger strata in the region (Fig. 3-2). In addition, a single seismic line acquired to the north of Seymour Island allows along-strike correlation of the Eocene strata on the island to the lower part of the section imaged in the seismic records.

The oldest unit, Unit S5, is inferred to be of late Eocene age based on along-strike correlation to onshore strata (Anderson, 1999). A prominent onlap surface separates Unit S5 from S4 (Fig. 3-1), and is tentatively correlated to the 30 Ma lowstand surface of Haq et al. (1987). A shelf-wide unconformity (U3) and change in seismic facies marks the stratigraphic boundary between Units S4 and S3. Unit S4 is characterized by continuous reflectors that indicate progradation toward the southeast. Unit S3 is characterized by kilometer-scale crosscutting surfaces with width to depth ratios indicative of paleo-troughs. The units directly above these surfaces exhibit chaotic reflection patterns. These combined features indicate erosion and deposition by a grounded ice sheet with large ice streams (see Anderson, 1999).

Units S5 and S4 follow the curvature of the basin, whereas the younger units (S3 through S1) dip toward the east. Unit S3 is tentatively assigned a middle to late Miocene age, based on the assumption that initial glaciation of the shelf corresponded with glaciation of the shelf on the northern side of the Antarctic Peninsula. One important objective of SHALDRIL is to attempt to better constrain the timing of initial ice sheet expansion onto the continental shelf.

A change from progradational to aggradational stratal architecture marks the boundary between Units S2 and S1 (Fig. 3-1). Based on correlations to similar stratal stacking patterns around West Antarctica, Unit S1 is assigned a Plio-Pleistocene age.

Figure 3-1. A, B. Dip lines from Cruise PD-91 showing the primary surfaces and seismic facies. **C.** Strike line from Cruise NBP0201 illustrating the shelf-wide unconformity interpreted as the glacial onset. See Figure 1-3 for line locations.

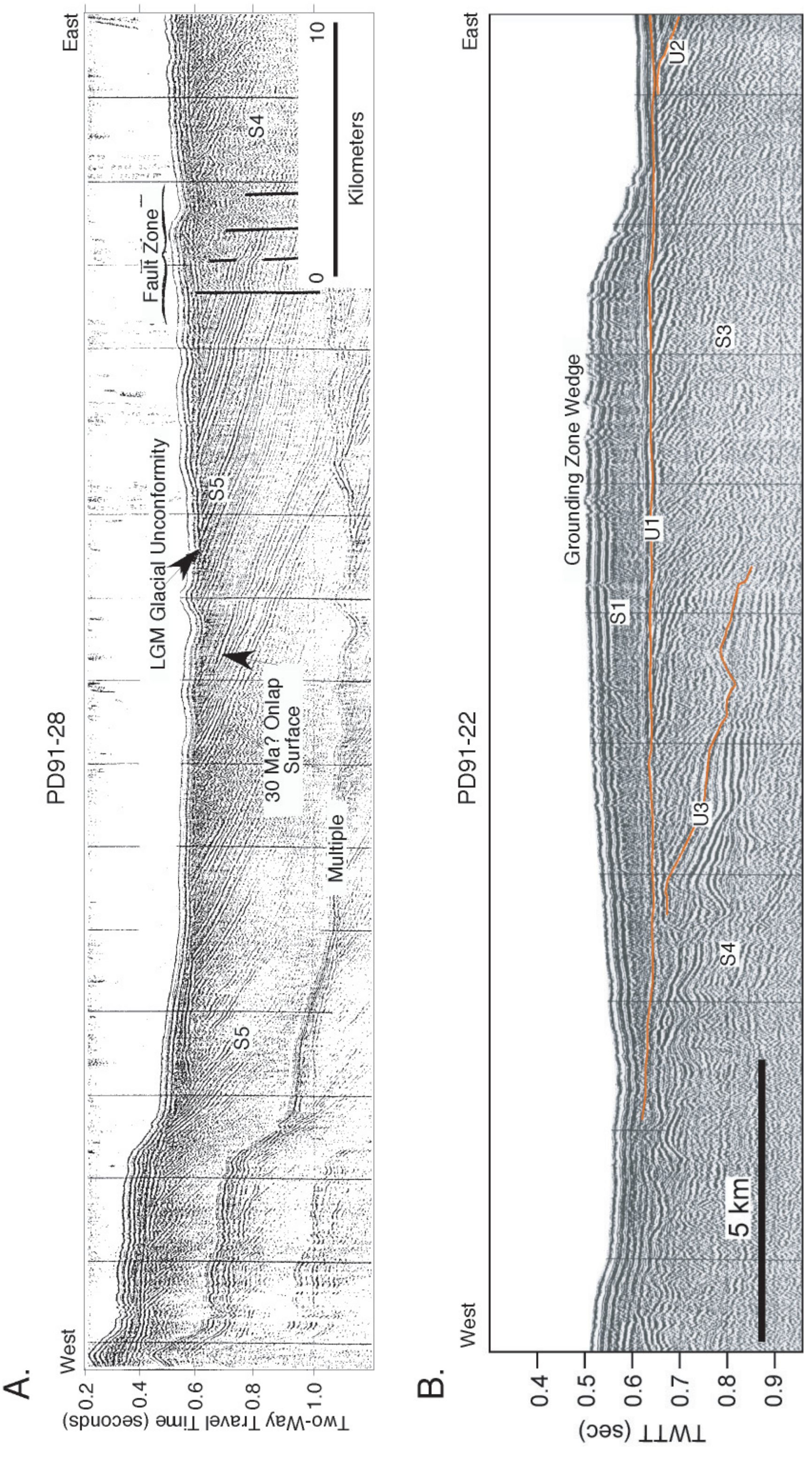


Figure 3-1 (continued).

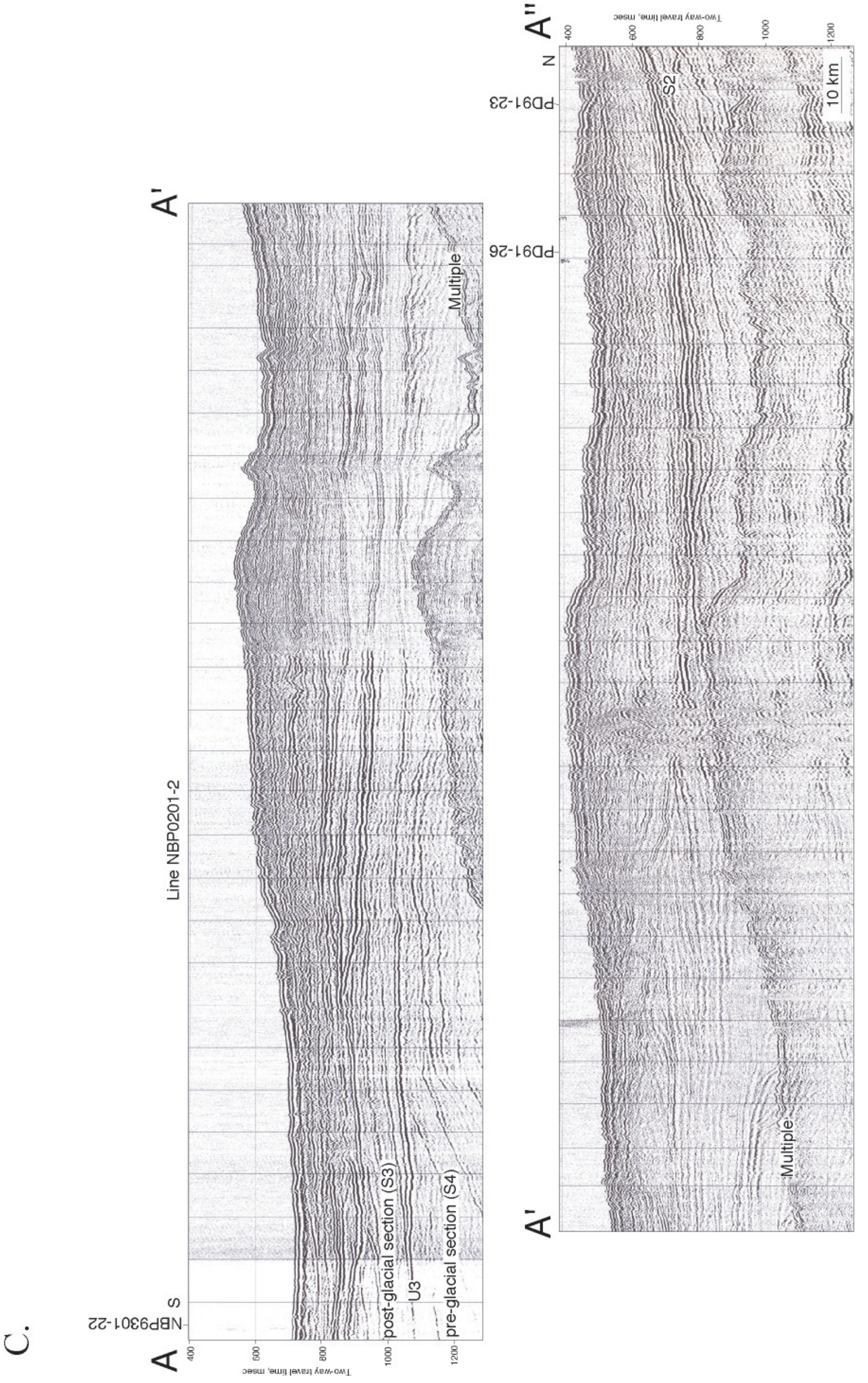
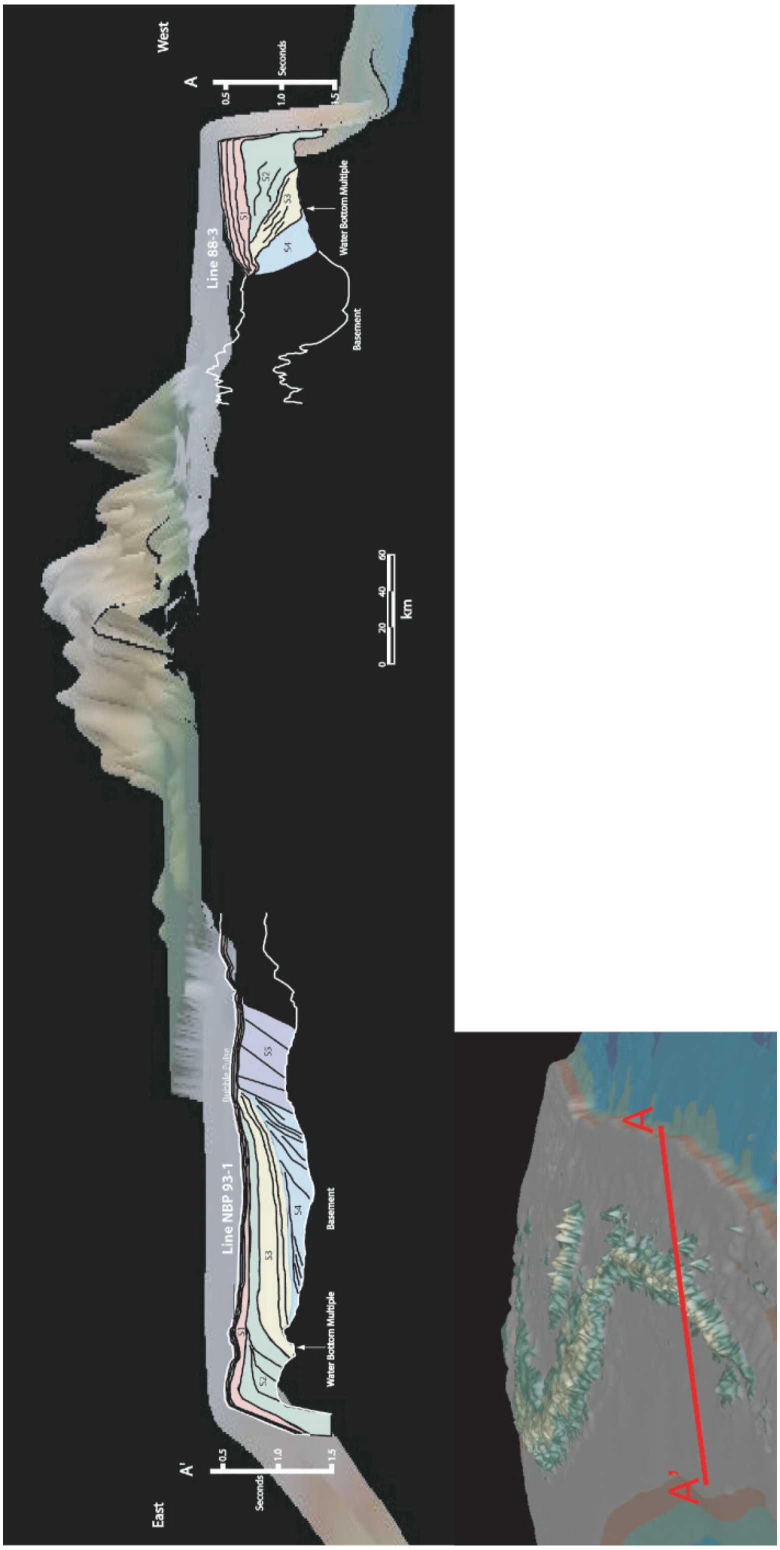


Figure 3-2. Topographic and bathymetric data across the Antarctic Peninsula with a comparison of stratigraphic units on either side of the peninsula. Seismic Line NBP93-1 is just south of the proposed SHALDRIL II sites.



SITE 1

A. OBJECTIVES

Site NBP0602A-1 was an alternate site for Proposed Site JRB6 on the outer shelf (Fig. 3-3). The objective at this site was to sample Unit S1, the youngest stratigraphic unit in the stratigraphic classification of Anderson (1999). Unit S1 has an aggradational stratal geometry similar to younger strata on the Pacific Antarctic Peninsula margin, which have been assigned a Plio-Pleistocene age (Shipboard Scientific Party, 1999). The main objective of this site was to test this correlation and to sample the younger glacial section. The site was abandoned before the target depth was reached.

B. OPERATIONS

Site NBP0602A-1 is located near Proposed Site JRB6. The location was reached at 2100 on 6 March. When the station was first occupied the winds were under 20 kn; by the time the station was completed winds were nearly 30 kn, although no station-keeping problems occurred due to the wind. Rather, drifting multiyear ice floes, many of which were larger than the ship, made station keeping difficult.

Since this was the first drill site of the cruise, extra preparation time was needed before drilling commenced: the clump weight had to be lowered into the moonpool, the collars had to be put in order, and the drill pipe had to be measured as it was run in the hole. While this activity was underway, two Kasten cores were taken at 63° 59.986' S, 54° 22.563' W in 398 m of water. NBP0602A-1A-KC had no recovery (Table 3-1). During the second coring attempt (NBP0602A-1B-KC), about 30 m of extra wire was released without the winch operator knowing if the bottom had been penetrated. Upon retrieval the core barrel was empty; however, sediment was stuck in the weights, indicating the barrel fell over onto the seafloor. A small bag of sediment was obtained from the weights (Table 3-1).

Stringing of drill pipe began at 0910 on 7 March. The site position was shifted a few times to avoid heavy ice closing in on the ship. This was done with the pipe in the water by maneuvering the ship at a maximum speed of 1 kn. The final location of Hole NBP0602A-1C was 64° 00.990' S, 54° 22.262' W in 406 m of water. Although the plan was to use the non-coring rotary bit to start the hole, approaching ice limited available drilling time, so the hole was begun with the alien bit. This allowed coring to start at the beginning of the hole and gave better odds that something would be recovered before the hole had to be abandoned. The pipe met little resistance upon reaching the mudline at 1629, and penetrated to a final depth of 7 mbsf with just a couple of hesitations. At that time, an ice floe of over 100 m in diameter began pushing against the ship and the site had to be abandoned at 1648. A small amount of sediment from the core catcher was bagged.

Despite leaving Site NBP0602A-1 without any core, the time spent on station was not wasted. All of the drilling preparations were completed and everyone onboard gained the practice needed to hit the next site at full speed.

C. LITHOSTRATIGRAPHY

Site NBP0602A-1 consists of three holes, including two Kasten cores and one drill hole. No core was recovered from any of the holes, although some sediment was bagged from the second Kasten core and core catcher of the drill hole (Table 3-1).

The second Kasten core, NBP0602A-1B-KC, only sampled the surface (Fig. 3-4). Surface sediment from this site consists of very dark greenish gray (GLEY 1 10Y 3/1), poorly sorted, soft, pebbly, sandy diatomaceous mud. One very coarse pebble (4 cm) was found, while the rest of the pebbles are medium size (<1.6 cm). Bryozoans and agglutinated foraminifers are also present in the sediment. Smear-slide analysis of the <250 µm fraction (Table 3-2) indicates the sediment consists of almost equal amounts of clay (42%) and quartz + feldspar (40%), with quartz more abundant than feldspar. The sediment also contains a small amount of heavy minerals (3%), plus trace amounts of mica, glauconite, hornblende, and volcanic glass. Biogenic analysis indicates diatoms comprise 15% of the fine fraction. In addition to diatoms, other siliceous microfossils occur in trace numbers, including radiolarians, sponge spicules, and silicoflagellates. The sediment also contains hematite-stained quartz grains, which tend to be more rounded than the surrounding sediment. Fecal pellets and chloritic mica occur, as do trace amounts of microcline.

Hole NBP0602A-1C penetrated from 0 to 7 mbsf, although sediment was only recovered from the core catcher. The sediment consists of very dark greenish gray (GLEY 1 10Y 3/1) pebbly mud, with clay more abundant than silt. Two coarse pebbles (2 cm and 3 cm) were found, as were numerous medium-size pebbles. Smear-slide analysis of the <250 µm fraction (Table 3-2) indicates the sediment consists primarily of clay (58%) and quartz + feldspar (35%), with less but equal amounts of mica and heavy minerals (2% each). Glauconite and hornblende occur in trace amounts. Diatoms compose a small percentage of the sediment (3%). Additionally, sponge spicules and radiolarians occur in trace amounts. Hematite-stained quartz grains tend to be more rounded than the surrounding sediment. Fecal pellets and chloritic mica also occur.

D. BIOSTRATIGRAPHY

Initial shipboard paleontological work focused on the characterization of diatom assemblages in smear slides. No sediment was recovered in the initial Kasten core attempt at this site (Kasten Core NBP0602A-1A-KC). The second Kasten core (NBP0602A-1B-KC) recovered a small, bagged sample of sandy diatomaceous mud. Diatoms are few in abundance and poorly preserved in this sample. All diatom taxa observed are modern (extant) species. The assemblage is dominated by *Chaetoceros* resting spores, *Thalassiosira antarctica* group, *Actinocyclus actinochilus,* and *Fragilariopsis curta* (Table 3-3). All identified taxa are characteristic of the modern sea-ice zone around the Antarctic margin (Armand et al., 2005).

In Hole NBP0602A-1C, a sample was retrieved from the core catcher of the only core run. Diatoms are rare and poorly preserved in this sample. The assemblage consists of a mixed assortment of modern (extant) and extinct species (Table 3-3). Extinct taxa, such as *Actinocyclus ingens, Denticulopsis simonsenii,* and *D. vulgaris,* are interpreted as reworked into Pleistocene-Holocene sediment recovered in this hole. The *Denticulopsis* taxa, specifically, indicate a middle to late Miocene age of the reworked material.

F. SITE SUMMARY

Site NBP0602A-1 occupied a location near Proposed Site JRB6 toward the outer shelf in the northern James Ross Basin. It targeted Seismic Unit S1, which is predicted to be Plio-Pleistocene. Two Kasten cores were attempted at the site, and the second Kasten core returned a varied benthic invertebrate surface assemblage of agglutinated foraminifers and bryozoans, usually encrusting large pebbles, along with a very dark greenish gray Quaternary diatomaceous mud dominated by *Chaetoceros* resting spores and a flora of sea-ice proximal diatoms. The drilled hole penetrated to 7 mbsf, although sediment was only recovered from the core catcher. This sediment, a dark greenish gray pebbly mud, contains an assortment of modern and reworked diatom species. Before subsequent cores could breach the surface sedimentary veneer, the site had to be abandoned due to ice.

Figure 3-3. Multibeam images of Site NBP0602A-1.

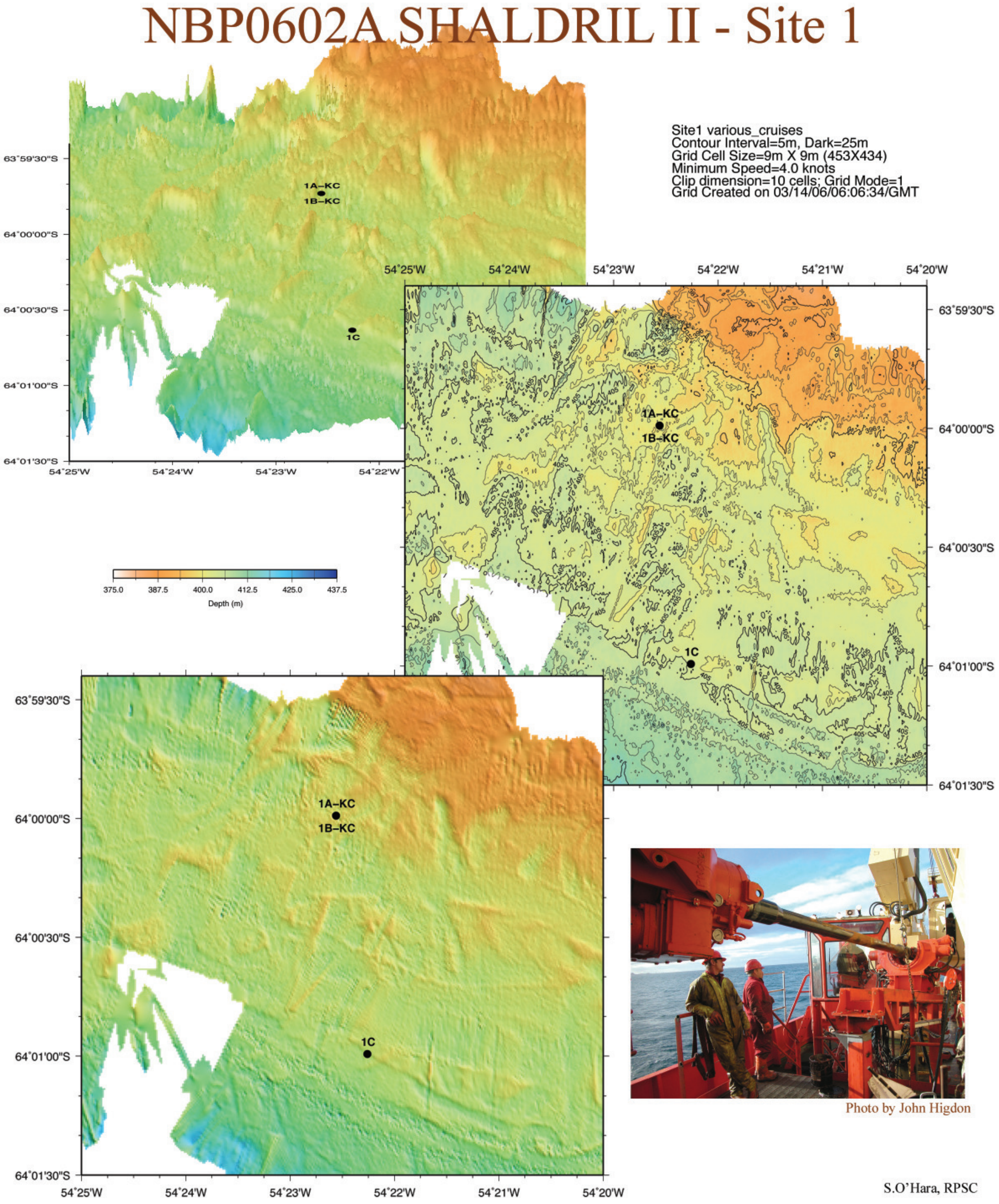


Figure 3-4. 3.5 kHz data of Hole NBP0602A-1C.

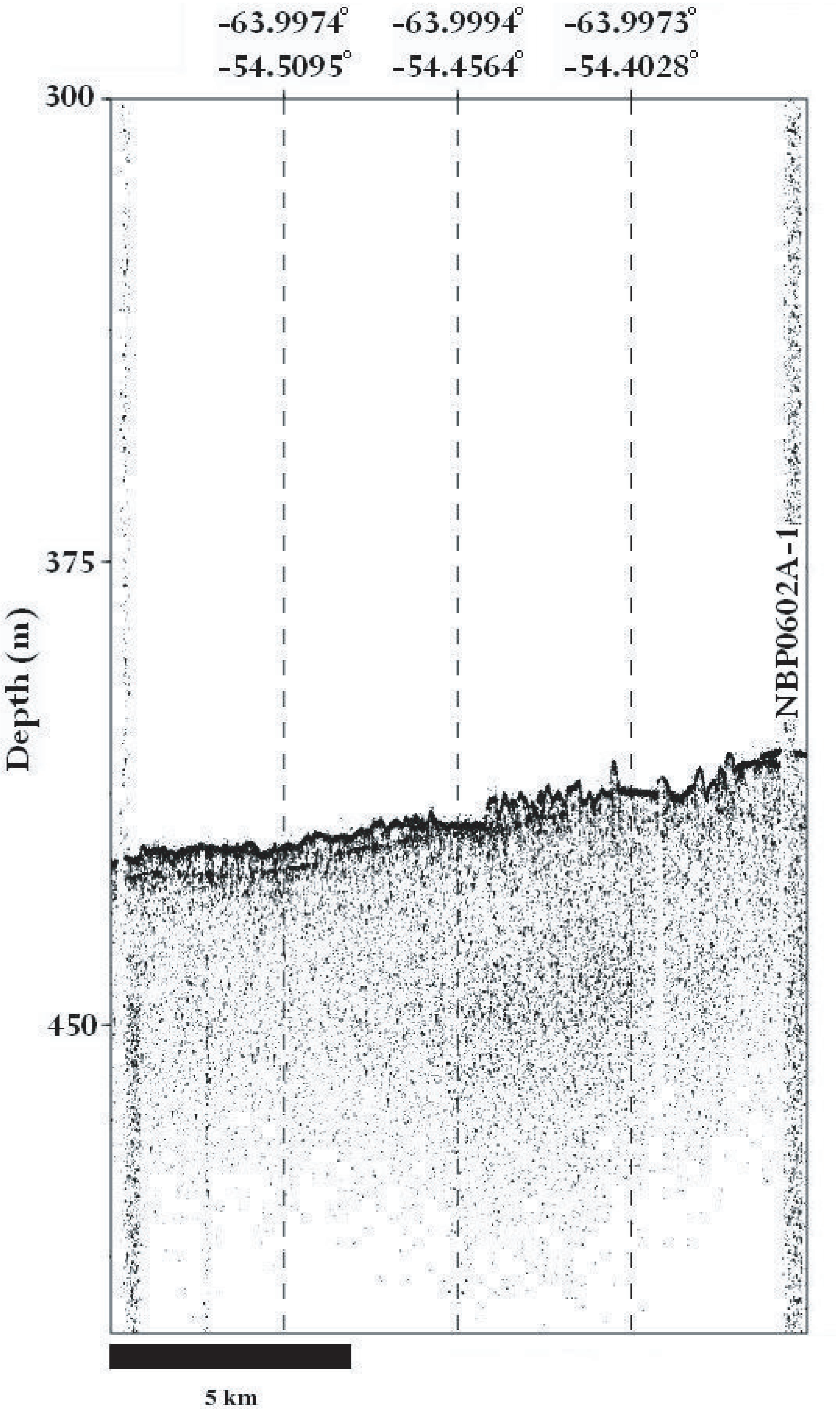


Table 3-1. Drilling and coring recovery log for Holes NBP0602A-1A-KC, -1B-KC, and -1C.

NBP0602A SHALDRIL II Site 1 (proposed Site JRB6)
Multibeam Water Depth: 398 m @ A, B; 406 m @ C

Station Number/Hole	Core Number	Core Type	Top (mbsf)	Bottom (mbsf)	Interval Cored ("push distance") (m)	Recovery: total (m)	Recovery: competent (m)	Recovery: disturbed (m)	Gaps (m)	Recovery Corrected (m)	Total Recovery (%)	Recovery Corrected (%)	Section Number	Section Lengths (cm)	Date (JD)	Time on Deck (GMT)	Initials	Comments
1A	1	KC	0	0	0	0	0	0	0	0	0	0	n/a	n/a	65	2250	JSW	no recovery
1B	1	KC	0	surface	surface	CC	0	0	0	0	0	0	n/a	n/a	65	2335	JSW	1 bag of sample
1C	1	Ra	0	7	7	CC	0	0	0	0	0	0	n/a	n/a	66	1700	JSW	1 bag of sample

Table 3-2. Smear-slide data for Holes NBP0602A-1B-KC and -1C.

Sample	Depth (mbsf)	Components													Grain Size			Sorting	Roundness	Lithology	Comments
		Minerals									Biogenic										
		Clay	Feldspar	Glauconite	Heavy Minerals	Hornblende	Mica	Microcline	Quartz	Volcanic Glass	Diatoms	Radiolarians	Silicoflagellates	Sponge Spicules	Sand	Silt	Clay				
Hole 1B-KC																					
NBP0602A-1B-KC-CC	surface	42	10	tr	3	tr	tr	tr	30	tr	15	tr	tr	tr	10	40	50	P	a-sr	Sandy diatomaceous mud	Chloritic mica; hematite-stained quartz grains (more rounded); fecal pellets
Hole 1C																					
NBP0602A-1C-1R_a-CC	7.0	58	7	tr	2	tr	2		28		3	tr		tr	5	30	65	P	a-sr	Mud	Cloritic mica; hematite-stained quartz grains (more rounded); fecal pellets

Notes: Sample: R_a = cored using alien coring bit; Components: Numbers represent percentages, tr = trace; Sorting: P = poor; Roundness: a = angular, sr = subrounded.

Table 3-3. Stratigraphic occurrence and relative abundance of diatom taxa in Holes NBP0602A-1B-KC, -1C, -2A, -2B, and -2C.

						Planktonic, Extant Diatoms																			**Benthic/Sea-Ice Benthic, Extant Diatoms**			**Extinct Diatoms**					
Cruise/Hole/Core/Interval	**Depth (mbsf)**	**Slide Preparation**	**Diatom Abundance**	**Preservation**	**Fragmentation**	*Actinocyclus actinochilus*	*Chaetoceros* spp. (small veg. cells & resting spores)	*Coscinodiscus* spp.	*Eucampia antarctica* var. *recta*	*Fragilariopsis curta*	*Fragilariopsis cylindrus*	*Fragilariopsis kerguelensis*	*Fragilariopsis separanda*	*Isthmia* spp.	*Odontella weissflogii*	*Paralia* spp.	*Proboscia* spp.	*Rhizosolenia* spp.	*Stellarima microtrias*	*Synedropsis* spp.	*Thalassionema nitzschioides*	*Thalassiosira antarctica* var. *antarctica*	*Thal. gracilis* var. *gracilis / expecta*	*Thalassiothrix/Trichotoxon* spp.	*Amphora* spp.	*Cocconeis* spp. (several taxa)	*Navicula directa*	*Actinocyclus ingens*	*Denticulopsis simonsenii / vulgaris*	*Hemiaulus* spp.	*Pyxilla* spp.	*Stephanopyxis* spp. (large, heavily silicified)	*Trinacria excavata* group
Hole 1B-KC																																	
NBP0602A-1B-KC-CC	0.00	smear	F	P	H	R	F		X	R	X	X	X		X				X	X		R		fr(X)		fr(X)	X						
Hole 1C																																	
NBP0602A-1C-1R$_a$-CC	7.00	smear	R	P	H		X	fr(X)		X				X		X	X	R	X		X	X		fr(X)		X		R	X				
Hole 2A																																	
NBP0602A-2A-2R$_a$, 150cm	8.00	smear	R	P	H	X	R	fr(X)	R	X		X				R		X			fr(X)	X	X			R		X	X	X		X	fr(X)
NBP0602A-2A-2R$_a$-CC	9.24	smear	R	P	H	fr(X)	R	fr(R)	R							X			fr(X)		fr(X)		X	fr(X)	X	fr(X)		X	X			X	
Hole 2B																																	
NBP0602A-2B-2R$_a$, 0cm	22.66	smear	X	P	H	fr(?)		fr(R)				fr(X)				fr(X)			X		fr(X)							X	R			X	fr(X)
NBP0602A-2B-2R$_a$-CC	23.17	smear	X	P	H	fr(?)	X	fr(X)								X		fr(X)			fr(X)							R	X		fr(X)		
NBP0602A-2B-3R$_a$, 0cm	25.66	smear	X	P	H			fr(R)	X										fr(X)							fr(X)		X	fr(X)			fr(X)	fr(X)
NBP0602A-2B-3R$_a$-CC	26.52	smear	X	P	H		X	fr(X)								fr(X)			fr(X)		fr(X)					fr(X)		fr(X)	X			X	fr(X)
NBP0602A-2B-4R$_a$, 0cm	29.00	smear	X	P	H	X	X	fr(X)	fr(X)									X	X							fr(X)						X	
NBP0602A-2B-4R$_a$, 150cm	30.30	smear	B	-	-																												
NBP0602A-2B-5R$_a$, 0cm	48.00	smear	X	P	H			fr(X)								X																	
NBP0602A-2B-5R$_a$, 20cm	48.20	smear	B	-	-																												
NBP0602A-2B-5R$_a$, 45cm	48.45	smear	B	-	-																												
NBP0602A-2B-5R$_a$, 57cm	48.57	smear	B	-	-																												
NBP0602A-2B-5R$_a$, 80cm	48.80	smear	B	-	-																												
NBP0602A-2B-5R$_a$, 92cm	48.92	smear	B	-	-																												
NBP0602A-2B-6R$_a$-CC	51.30	smear	B	-	-																												
Hole 2C																																	
NBP0602A-2C-2R$_a$-CC	10.50	smear	B	-	-																												

Notes: Abundance: F = few, R = rare, X = present, B = barren, fr = fragments; Preservation: P = poor; Fragmentation: H = high.

SITE 2

A. OBJECTIVES

Site NBP0602A-2 occupied a location near Proposed Site JRB4 (Fig. 3-5). The objective for this site was to sample the U3 unconformity (Fig. 3-6) of Anderson (1999), which is interpreted to mark the initial advance of the ice sheet onto the continental shelf. Ice cover forced us to move the site off the seismic line, and it was later determined that the new site was situated over a thick wedge of glacial sediments. Thus, the stratigraphic target was not reached because ice forced abandonment of the site just before reaching the older section.

B. OPERATIONS

Site NBP0602A-2 occupied a location near Proposed Site JRB4. No Kasten cores were taken since piston cores were collected near the site during Cruise NBP0201. Due to drifting ice floes in the region, the *NB Palmer* could not stay on station for more than a few hours, up to a maximum of 12 hours at Hole NBP0602A-2B. Three holes were drilled at different locations based on where ice conditions best-allowed position to be held. Transit between holes was done with most of the drill pipe in the water. Maximum speed permitted during such movement was 2 kn through the water using the acoustic Doppler current profiler (ADCP) speed. This practice did not lead to any difficulties with any of the equipment and allowed new holes to be started quickly as ice conditions allowed.

Hole NBP0602A-2A was drilled at 64° 01.404' S, 55° 01.363' W in 384 m of water. The hole was begun with the alien bit but intentionally washed to 6.5 mbsf. One core run, to a depth of 9.24 mbsf (Table 3-4), was achieved before ice forced the hole to be abandoned. The recorded core length of 3.33 m represents 122% recovery for the core run. This excess is attributed to expansion of the sedimentary material.

Hole NBP0602A-2B was drilled at 64° 02.220' S, 55° 03.680' W in 341 m of water. The non-coring bit was used to start the hole and drilled to a depth of 22.66 mbsf. After that, five core runs were completed to a total depth of 52.2 mbsf using the alien bit (Table 3-4). The deepest of those runs had no recovery. The four core runs that covered the depths from 22.66 to 51.3 mbsf recovered a total of 3.59 m of core. It should be noted that the goal throughout drilling this hole was to achieve depth, and thus the older sediment, as quickly as possible; core recovery was not emphasized because of the need to reach depth in the limited time allowed by the ice. The hole was terminated at 52.2 mbsf depth when ice forced abandonment of the site.

Hole NBP0602A-2C was drilled at 63° 59.862' S, 55° 01.386' W in 385 m of water. As with Hole NBP0602A-2B, it was begun with the non-coring bit (Table 3-4).

The first cored interval was from 10.5 to 11.2 mbsf using the alien bit. No core was retrieved and the site had to be abandoned due to ice.

Amongst these three holes, a total of 38.8 m of overburden was penetrated before coring began and an additional 19 m were washed. This 57.8 m of penetration was achieved in less than four hours. The fact that glaciomarine sedimentary overburden could be penetrated so quickly made it possible to achieve the depths reached in the extremely short time frame allowed by ice conditions.

C. LITHOSTRATIGRAPHY

Site NBP0602A-2 consists of three drill cores. Hole NBP0602A-2A penetrated from 0 to 9.24 mbsf, although recovery started at 6.5 m after intentionally washing to that depth (Fig. 3-7). Sediment obtained from this hole consists of very dark gray (5Y 3/1), poorly sorted, sandy silt with coarse, subangular pebbles. Within Core NBP0602A-2A-$2R_a$, the upper 150 cm is soft; the next segment, from 150-243 cm, is firm; and the last segment, from 243-333 cm, is stiff. Sand comprises 10-20% of the core and 1-2 pebbles occur every 10-20 cm. Shell fragments are also present. Smear-slide analysis of the <250 µm fraction (Table 3-5) indicates the sediment consists primarily of clay (50-60%) and quartz + feldspar (35-40%), as well as lesser amounts of heavy minerals and mica. In addition, trace amounts of glauconite, hornblende, and volcanic glass are present. Up to 1% of the sediment consists of diatoms, with trace amounts of sponge spicules. Sediments from this hole also contain hematite-stained quartz grains that tend to be more rounded than the surrounding sediment.

Hole NBP0602A-2B began coring at 22.66 mbsf and reached 52.2 mbsf, although a large gap exists where the hole was washed from 29.0-48.0 mbsf (Fig. 3-8; Appendix 3-1); however, all sediment recovered is interpreted to be part of the same unit. The sediment in the upper part (22.66 to 29.0 mbsf) consists of very dark gray (5Y 3/1), poorly sorted, stiff, sandy silt, and sediment in the lower part (29.0 to 52.2 mbsf) consists of very dark greenish gray (GLEY 1 2.5/ 10Y), poorly sorted, stiff, sandy silt. The sand is angular to subrounded and comprises 10-20% of the hole. Subangular to subrounded, medium to coarse pebbles occur throughout the hole, usually isolated, although occasionally occurring in groups of up to four. The distribution of pebbles is random, but typically spaced 5 to 20 cm apart. Two small, thin, vertical sand packets, no more than 0.5 cm wide and 2 cm long, occur toward the base of the hole. No visible shell material is evident. Smear-slide analysis of the <250 µm fraction (Table 3-5) indicates the sediment consists primarily of clay (50-60%) with lesser amounts of quartz + feldspar (30-45%). Heavy minerals comprise 5% or less, while mica comprises 1% or less, with trace amounts of hornblende, volcanic glass, glauconite, and microcline. Diatoms are present in low abundance and sponge spicules in trace amounts. Sediments from the second hole also contain hematite-stained quartz grains that tend to be more rounded than the surrounding sediment.

Hole NBP0602A-2C attempted to sample from 0 to 11.2 mbsf; however, this hole had no recovery except for sediment found in the core catcher at the bottom of the 10.5-11.2 mbsf cored interval. Analysis of this sediment indicates it consists of poorly sorted mud with subangular to angular sand grains and some pebbles. Smear-slide analysis of the <250 μm fraction (Table 3-5) indicates the sediment contains primarily clay (50%), with lesser amounts of quartz + feldspar (40%). This sediment has a higher percentage of heavy minerals (up to 10%) than the previous holes. Mica, hornblende, and glauconite are found in trace amounts. No biogenics are present.

D. BIOSTRATIGRAPHY

Site NBP0602A-2 was chosen with the goal of penetrating a thin uppermost unit of glacial diamicton that overlies dipping sedimentary units of presumed Miocene age. Initial shipboard paleontological work included smear-slide examination of diatom assemblages.

Two samples from Hole NBP0602A-2A were examined (at 8.0 and 9.24 mbsf). These samples contain rare, poorly preserved diatoms, although a number of taxa could be identified (Table 3-3). Both samples contain a mixed assemblage of modern (extant) taxa and extinct taxa interpreted as reworked. The sediments are most likely latest Pleistocene or Holocene in age, although given the low abundance and poor preservation of the diatoms, diatom biostratigraphy only constrains the age to less than ~3.0 Ma based on the presence of *Actinocyclus actinochilus.* The occurrence of *Denticulopsis simonsenii* and *D. vulgaris* indicates that middle to late Miocene age sediment is at least one component of the reworked material.

Samples from the upper section of Hole NBP0602A-2B (Cores NBP0602A-2B-$2R_a$ through -$4R_a$; ~22 to 29 mbsf) contain rare, poorly preserved diatoms. As with the samples from Hole NBP0602A-2A, the diatom assemblages appear to represent mixed ages with a definite component of reworked specimens. The "modern" component is poorly represented, but rare specimens of *A. actinochilus* and *Fragilariopsis kerguelensis* provide a maximum age of ~3.0 Ma for the upper part of the Hole 2B section. In the "extinct" component of the diatom assemblage, the presence of *Denticulopsis* taxa indicates a middle to late Miocene age of reworked sediment, and the presence of *Pyxilla* spp. in Sample NBP0602A-2B-$2R_a$-CC indicates an additional component of Eocene-Oligocene age reworked material.

The samples from the lower section of Hole NBP0602A-2B (Cores NBP0602A-2B-$5R_a$ and -$6R_a$; ~48 to 52 mbsf) contain extremely rare diatom fragments or are completely barren of diatoms. Diatom biostratigraphy therefore does not provide any age constraint for basal sediment reached in the hole, leaving open the question of whether the target horizon was penetrated.

One sample from Hole NBP0602A-2C was examined for diatoms (Sample NBP0602A-2C-2R_a-CC; 10.50 mbsf). No diatoms were observed in this sample.

E. PHYSICAL PROPERTIES

The objective of the physical properties program at Site NBP0602A-2 was to aid in the interpretation of stratigraphic and geophysical data from the targeted Neogene seaward dipping stratigraphic section.

Physical property measurements were made by three methods: 1) The multisensor core logger (MSCL) that sampled every 2 cm and recorded magnetic susceptibility (MS), electrical resistivity (ER), *p*-wave velocities, and gamma-ray attenuation porosity evaluator (GRAPE) data on whole core sections; 2) The Middlebury College electrical resistivity probe (MCER) measurements on the split core sections; and 3) discrete samples taken.

Both Holes NBP0602A-2A and -2B had MCER-ER measurements made at ~20-cm intervals and discrete samples taken at the same interval. Discrete samples (2-10 cc, but normally 5 cc, using a syringe sampling system) were not processed onboard. These samples were stored in weighed vials and kept in the cooler for transport back to Middlebury College.

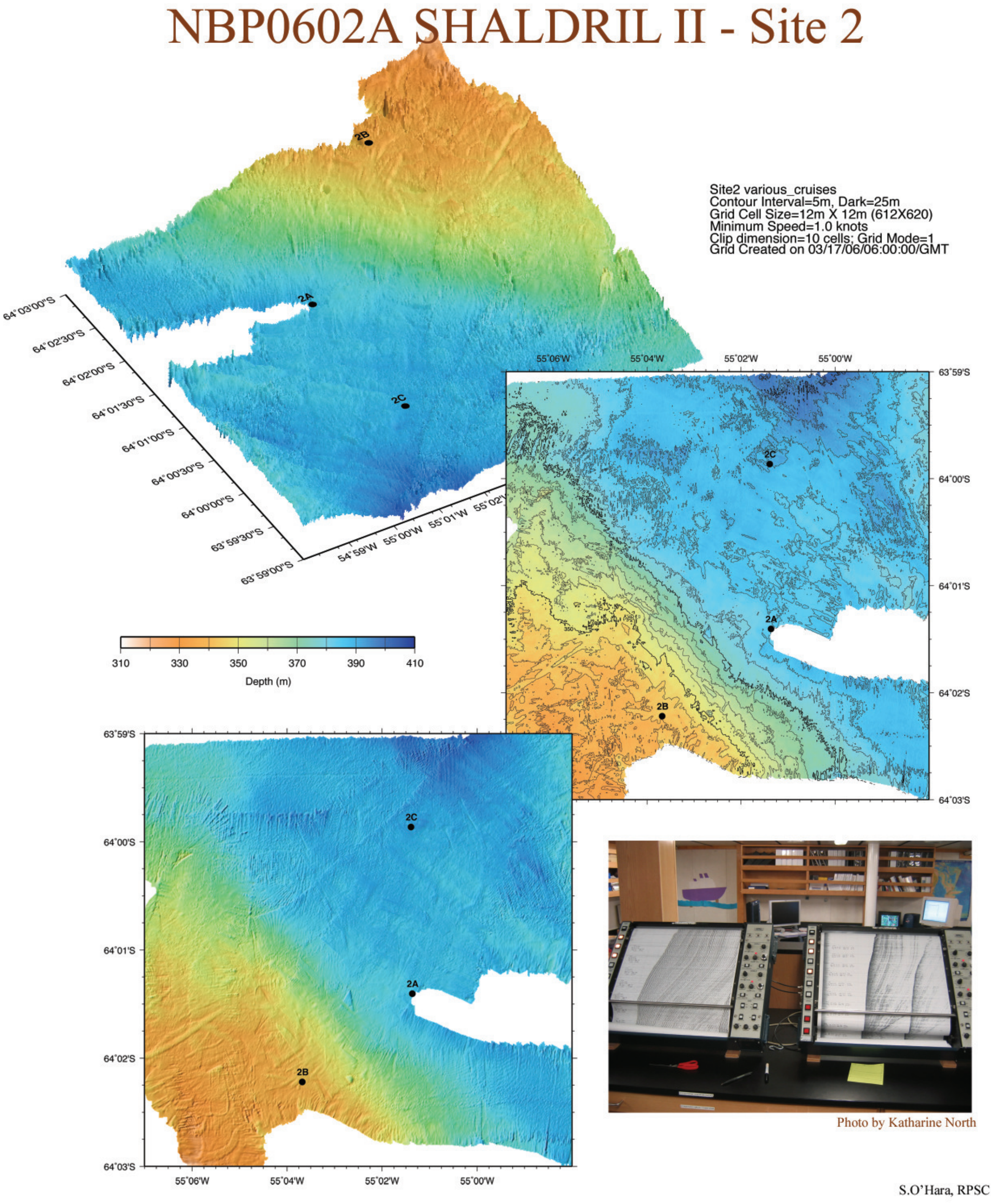
For both Holes NBP0602A-2A and -2B, downhole variations in ER vary slightly, ranging from 0.9 to 2 ohm-m, and show a downhole increase. Density measurements range from 1 to 2.7 g/cc and also show a downhole increase. Magnetic susceptibility is relatively low throughout both holes. Spikes in MS appear correlated to large pebbles within the core.

Core disturbances (gaps) are readily observed in the ER and MS data and have been removed, as have measurements near the core ends (edge effect). Comparing the MSCL with the MCER data shows that the inductive ER method (MSCL) is slightly lower and smoothed in comparison to the galvanic ER method (MCER), with the exception of Core NBP0602A-2B-5R_a. Electrical resistivity measurements vary with porosity; thus, the relatively high ER measurements correspond with the lower density measurements (lower porosity). An example of this is in Core 5R_a at 30 cm. Here a low-density reading corresponds to a large increase in ER. Using Boyce's (1968) equation, which relates ER to porosity, these sediments have porosities that vary between 30 and 40%. Due to limited recovery, minimal interpretation can be made at this time.

F. SITE SUMMARY

Three holes were drilled at Site NBP0602A-2, near Proposed Site JRB4, targeting the U3 seismic unconformity, which is interpreted to represent the onset of glaciation in the region. Drifting ice permitted only short windows of opportunity to penetrate the glacial sediments overlying the older dipping strata. All three holes appear to have terminated in Quaternary sediments by the time sea ice forced the holes to be terminated. The sediments in Hole NBP0602A-2B, which reached 52.2 mbsf, consist of very dark gray, poorly sorted, stiff, sandy silts from 22-29 mbsf, and very dark greenish gray silts of a similar nature below that. Mostly isolated medium to coarse pebbles occur throughout. Rare, poorly preserved diatoms in Hole NBP0602A-2A and in the upper portion of NBP0602A-2B represent modern (extant) forms mixed with reworked middle to upper Miocene and few Eocene-Oligocene taxa. The lowermost sediments of Hole 2B contain very rare fragments or are barren of diatoms, making it impossible to determine the age of those sediments.

Figure 3-5. Multibeam images of Site NBP0602A-2.

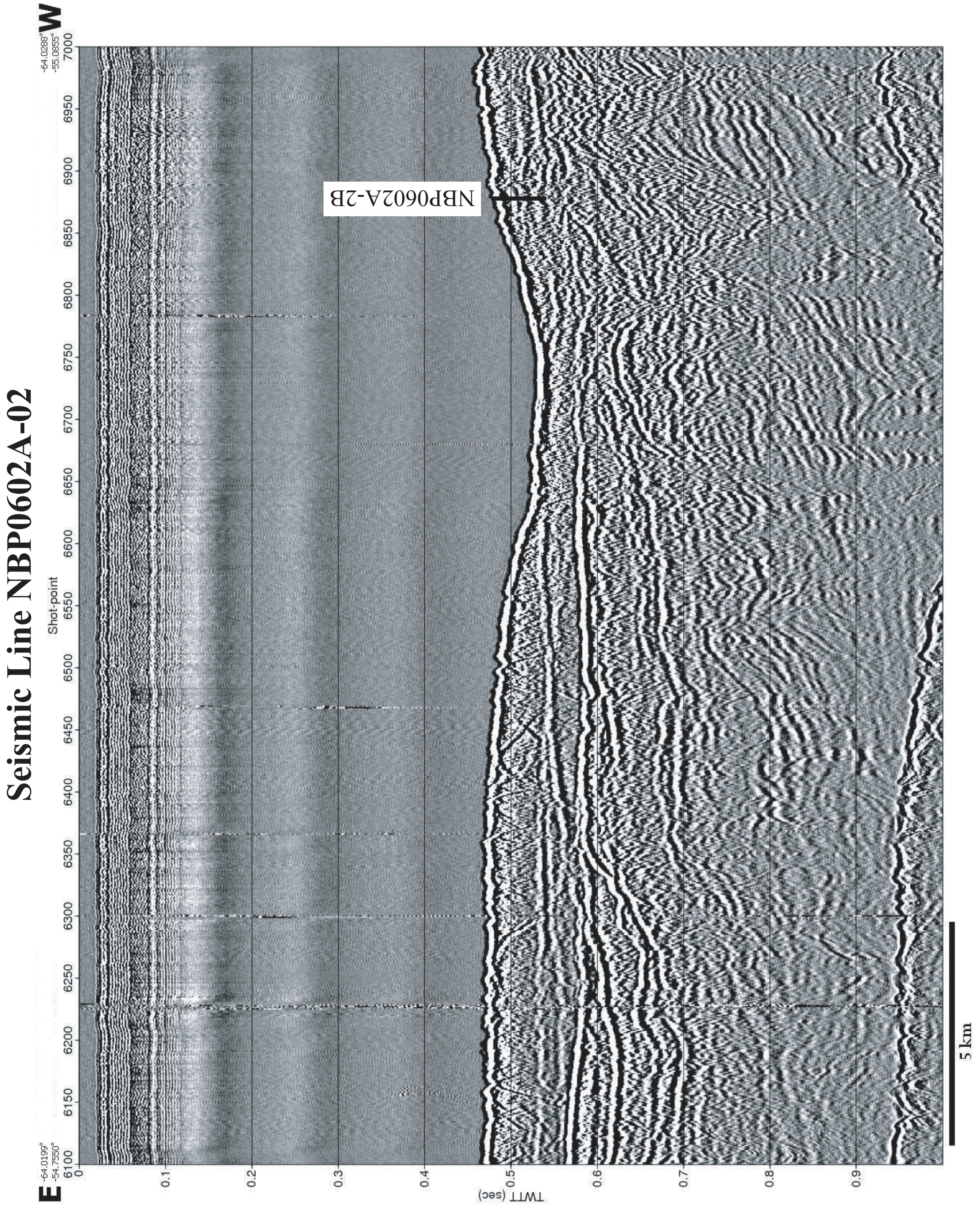


Site2 various_cruises
Contour Interval=5m, Dark=25m
Grid Cell Size=12m X 12m (612X620)
Minimum Speed=1.0 knots
Clip dimension=10 cells; Grid Mode=1
Grid Created on 03/17/06/06:00:00/GMT

Photo by Katharine North

S.O'Hara, RPSC

Figure 3-6. Location of Hole NBP0602A-2B on Seismic Line NBP0602A-02.



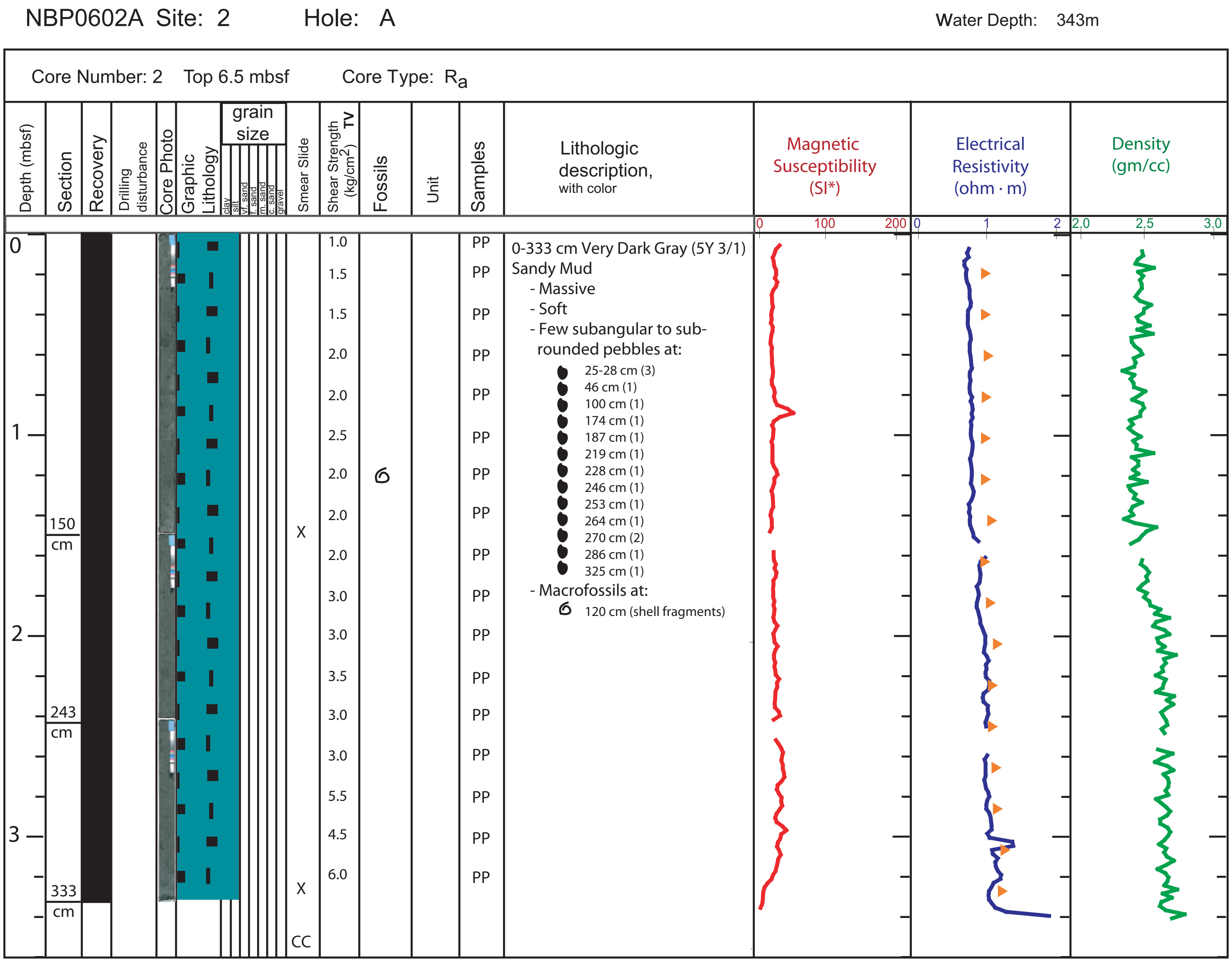
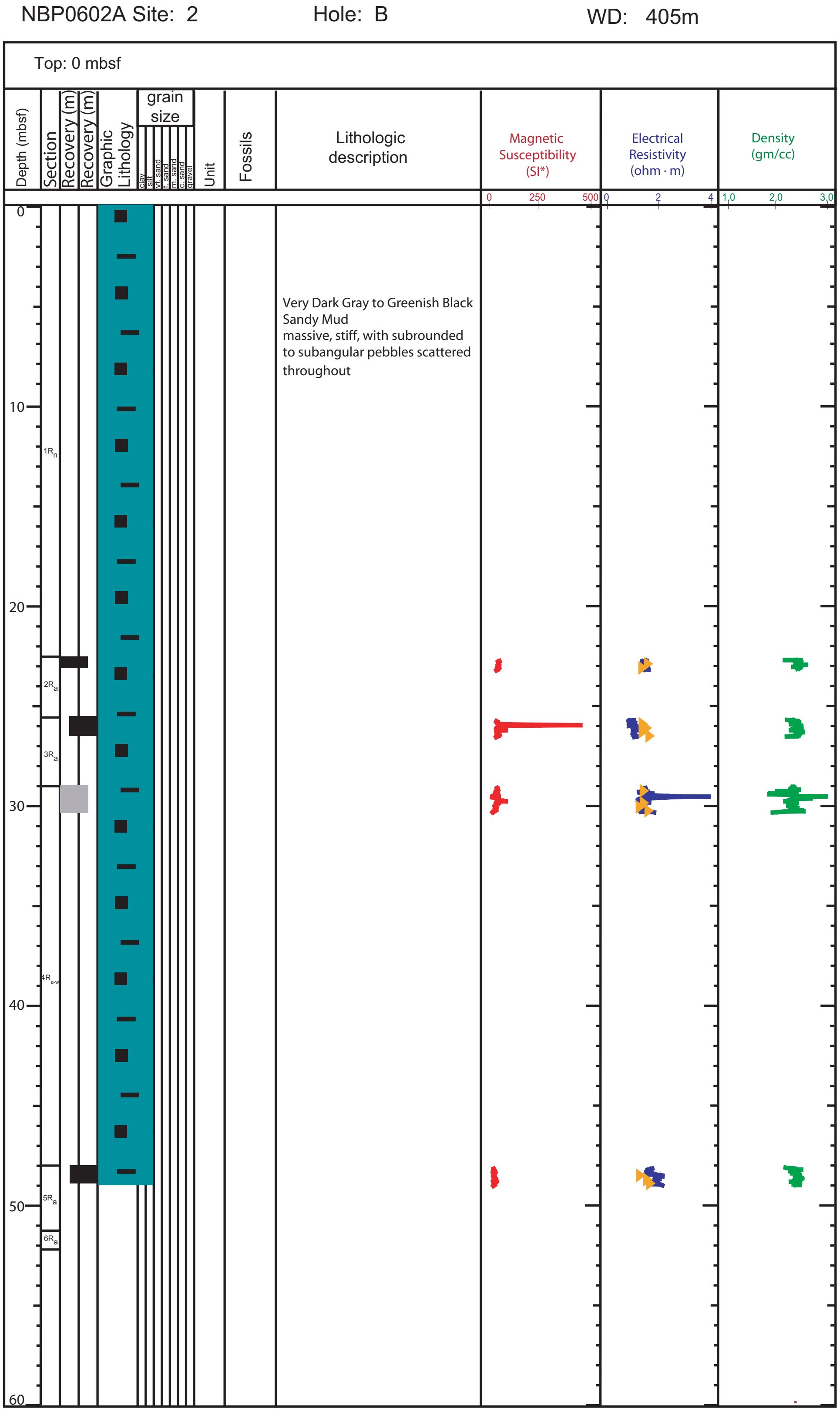


Figure 3-7. Lithologic log for Hole NBP0602A-2A.

Figure 3-8. Summary lithologic log of Hole NBP0602A-2B.



Very Dark Gray to Greenish Black Sandy Mud
massive, stiff, with subrounded to subangular pebbles scattered throughout

Table 3-4. Drilling and coring recovery log for Holes NBP0602A-2A, -2B, and -2C. A labeling error during coring resulted in the non-cored intervals of Holes 2B and 2C being designated with a core number, which is contrary to normal core-labeling procedures.

NBP0602A SHALDRIL II Site 2 (Proposed Site JRB4)

Multibeam Water Depth: 384 m @ A; 341 m @ B; 385 m @ C

Station Number/Hole	Core Number	Core Type	Top (mbsf)	Bottom (mbsf)	Interval Cored (m)	"Push Distance" (m)	Recovery: total (m)	Recovery: competent (m)	Recovery: disturbed (m)	Gaps (m)	Recovery Corrected (m)	Total Recovery (%)	Recovery Corrected (%)	Section Number	Section Lengths (cm)	Date (JD)	Time on Deck (GMT)	Initials	Comments
2A	1	Ra-w	0	5.7	n/a	0	0	0	0	0	0	0.0%	0.0%	n/a	n/a	67	1349	JSW	No recovery
2A	2	Ra	5.7	9.24	6.5-9.24	2.74	3.33	3.33	0	0	3.33	121.5%	121.5%	1 2 3	0-150 150-242 242-333	67	1515	JSW	5.7-6.5 still very soft; drilling began at 6.5 m; site ended due to ice
2B	1	Rn	0	22.66	n/a	0	0	0	0	0	0	0.0%	0.0%	n/a	n/a	67	2130	JSW	Soft sediment, relatively little resistance
2B	2	Ra	22.66	25.66	25.66-22.66	3	0.51	0.51	0	0	0.51	17.0%	17.0%	1	0-57.5	67	2431	CLD	Bottom section of core tube full of water
2B	3	Ra	25.66	29.0	29-25.66	3.3	0.86	0.86	0	0	0.86	25.7%	25.7%	1	0-91.5	68	0030	CLD	Bottom section of core tube full of water
2B	4	Ra-w	29.0	48.0	washed	19.0	1.3	0	1.3	0	0	6.8%	0.0%	1	0-130 [0-135.5]*	68	0340	JFC	Wash core; top of section has a gap
2B	5	Ra	48.0	51.3	51.3-48	3.3	0.92	0.92	0	0	0.92	27.9%	27.9%	1	0-92* [0-94]*	68	0433	JFC	Top of core has a gap
2B	6	Ra	51.3	52.2	52.2-51.3	0.9	0	0	0	0	0	0.0%	0.0%	n/a	baggie	68	0615	JSW	Bagged core catcher
2C	1	Rn	0	10.5	n/a	0	0	0	0	0	0	0.0%	0.0%	n/a	n/a	68	1515	JSW	
2C	2	Ra	10.5	11.2	11.2-10.5	0.7	0	0	0	0	0	0.0%	0.0%	n/a	baggie	68	1615	JSW	

* Liner measurement from helo hanger may contain gap at top or botoom. Core and foam should equal original measurement. As long as this extra is from top or bottom of core (not middle) do not count in total core length.

Table 3-5. Smear-slide data for Holes NBP0602A-2A, -2B, and -2C.

		Components											Grain Size						
		Minerals									Biogenic								
Sample	Approximate Depth (mbsf)	Clay	Feldspar	Glauconite	Heavy Minerals	Hornblende	Mica	Microcline	Quartz	Volcanic Glass	Diatoms	Sponge Spicules	Sand	Silt	Clay	Sorting	Roundness	Lithology	Comments
Hole 2A																			
NBP0602A-2A-2R$_a$, base	5.7	60	2	tr	2	tr	2		33		1	tr	7	30	63	P	a-sr	Mud	Hematite-stained quartz grains (more rounded)
NBP0602A-2A-2R$_a$, 326 cm	9.0	51	15	tr	7	tr	1		25		1	tr	5	40	55	P	a-sr	Mud	Bright, long, spiny-looking things (not sponge spicules)
NBP0602A-2A-2R$_a$, CC	9.2	57	7	tr	5	tr	2		28	tr	1	tr	7	33	60	P	a-sr	Mud	Hematite-stained quartz grains (more rounded)
Hole 2B																			
NBP0602A-2B-2R$_a$, top	22.7	62	7	tr	3	tr	1		28		2	tr	5	30	65	P	a-sr	Mud	Hematite-stained quartz grains (more rounded)
NBP0602A-2B-2R$_a$, 20 cm	22.9	47	15	1	5	tr	2	tr	30		tr	tr	10	40	50	P	a-sa	Mud	
NBP0602A-2B-2R$_a$, CC	23.2	65	5	tr	3	tr	1	tr	25		1	tr	5	30	65	P	a-sr	Mud	Hematite-stained quartz grains (more rounded)
NBP0602A-2B-3R$_a$, top	25.7	60	5	tr	3	tr	1		30	tr	1	tr	5	35	60	P	a-sr	Mud	Hematite-stained quartz grains (more rounded)
NBP0602A-2B-3R$_a$, CC	26.6	62	3	tr	5		3		27		tr	tr	3	30	67	P	a-sr	Mud	Hematite-stained quartz grains (more rounded)
NBP0602A-2B-4R$_{a\text{-}w}$, top	(29.0-48.0)	55	10	tr	2	tr			33		tr	tr	5	40	55	P	a, sr	Mud	Hematite-stained quartz grains (more rounded)
NBP0602A-2B-4R$_{a\text{-}w}$, base	(29.0-48.0)	50	15	tr	5				30			tr	10	35	55	P	a, sr	Mud	Hematite-stained quartz grains (more rounded)
NBP0602A-2B-5R$_a$, top	48.0	50	15	tr	5	tr	tr		30		tr	tr	7	40	53	P	a-sr	Mud	Hematite-stained quartz grains (more rounded)
NBP0602A-2B-5R$_a$, base	48.9	50	10	tr	5	tr	tr		35			tr	5	45	50	P	a-sr	Mud	Hematite-stained quartz grains (more rounded)
NBP0602A-2B-6R$_a$, CC	52.2	53	10	tr	7	tr	tr	tr	30				10	40	50	P	a-sr	Mud	Hematite-stained quartz grains (more rounded)
Hole 2C																			
NBP0602A-2C-2R$_a$, CC	(10.5-11.2)	50	15	tr	10	tr	tr		25				10	40	50	P	a-sa	Mud	Pebbles present in sample

Notes: Sample: R$_a$ = cored using alien coring bit; R$_{a\text{-}w}$ = wash cored using alien coring bit; Components/Grain Size: Numbers represent percentages, tr = trace; Sorting: P = poor; Roundness: a = angular, sa = subangular, sr = subrounded.

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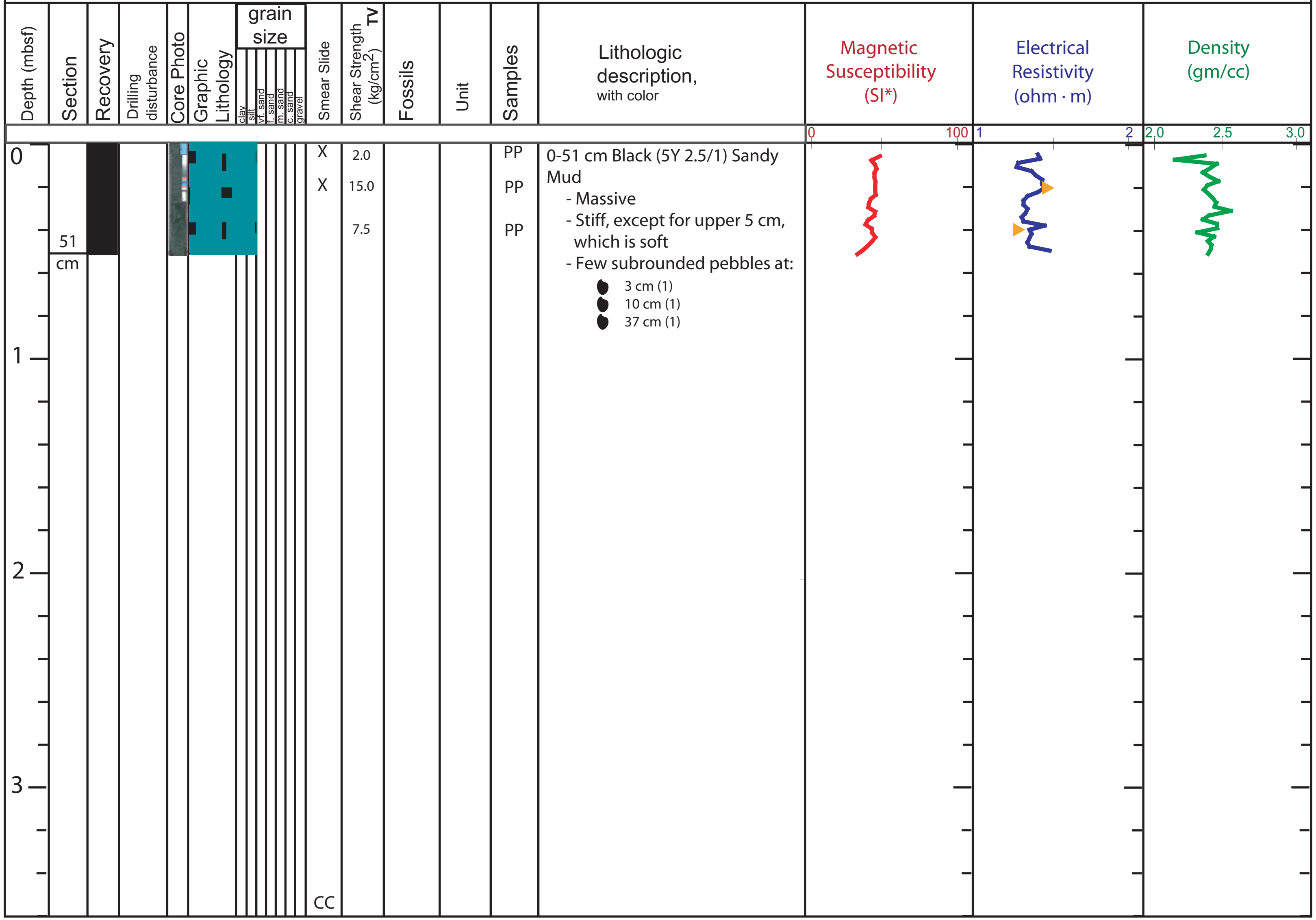
APPENDIX 3-1 LITHOLOGIC LOGS HOLE NBP0602A-2B

NBP0602A Site: 2 Hole: B

Water Depth: 405m

Core Number: 2 Top 22.66 mbsf Core Type: R_a



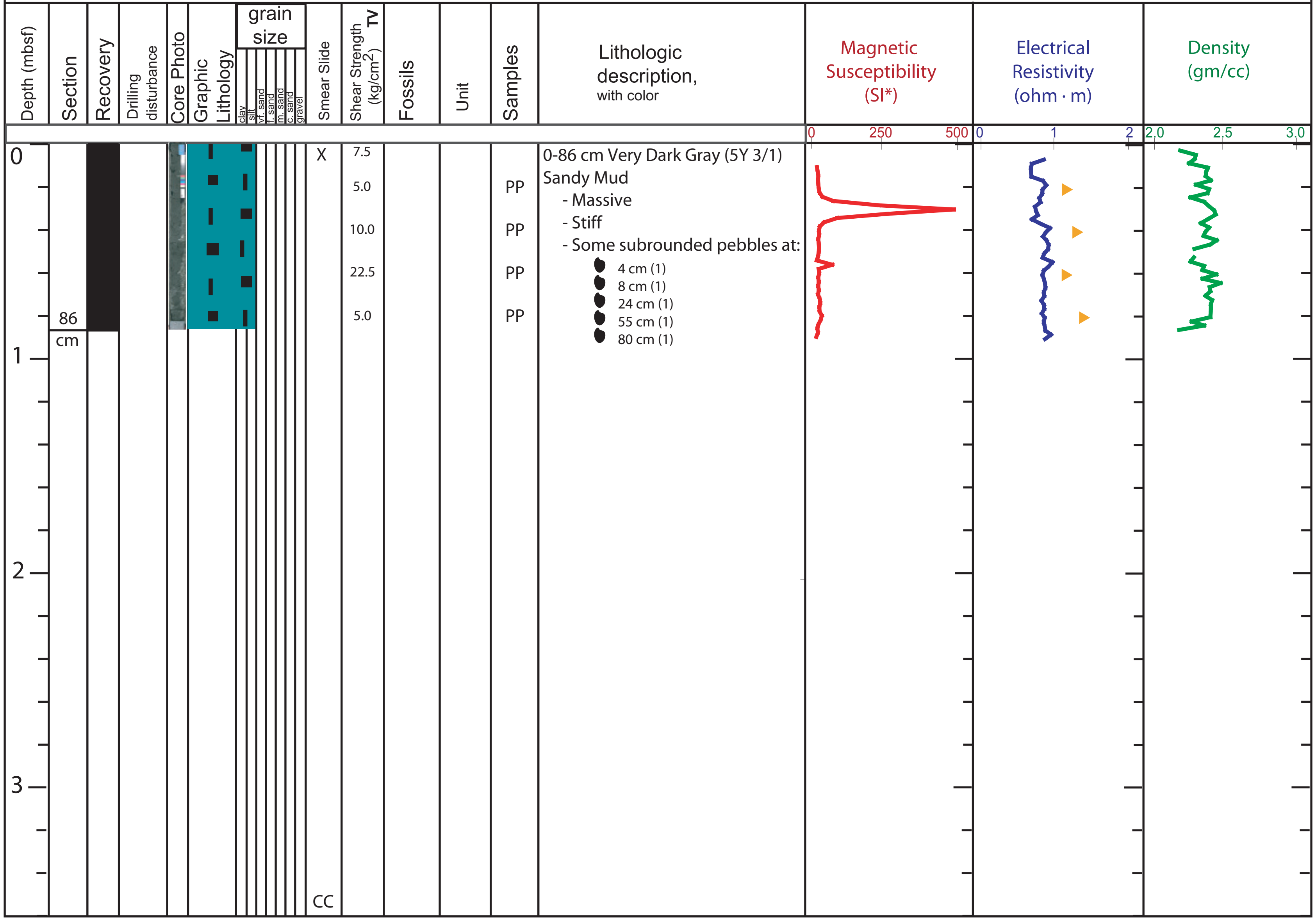
0-51 cm Black (5Y 2.5/1) Sandy Mud

- Massive
- Stiff, except for upper 5 cm, which is soft
- Few subrounded pebbles at:
  - ● 3 cm (1)
  - ● 10 cm (1)
  - ● 37 cm (1)

NBP0602A Site: 2 Hole: B

Water Depth: 405m

Core Number: 3 Top 25.66 mbsf Core Type: R_a

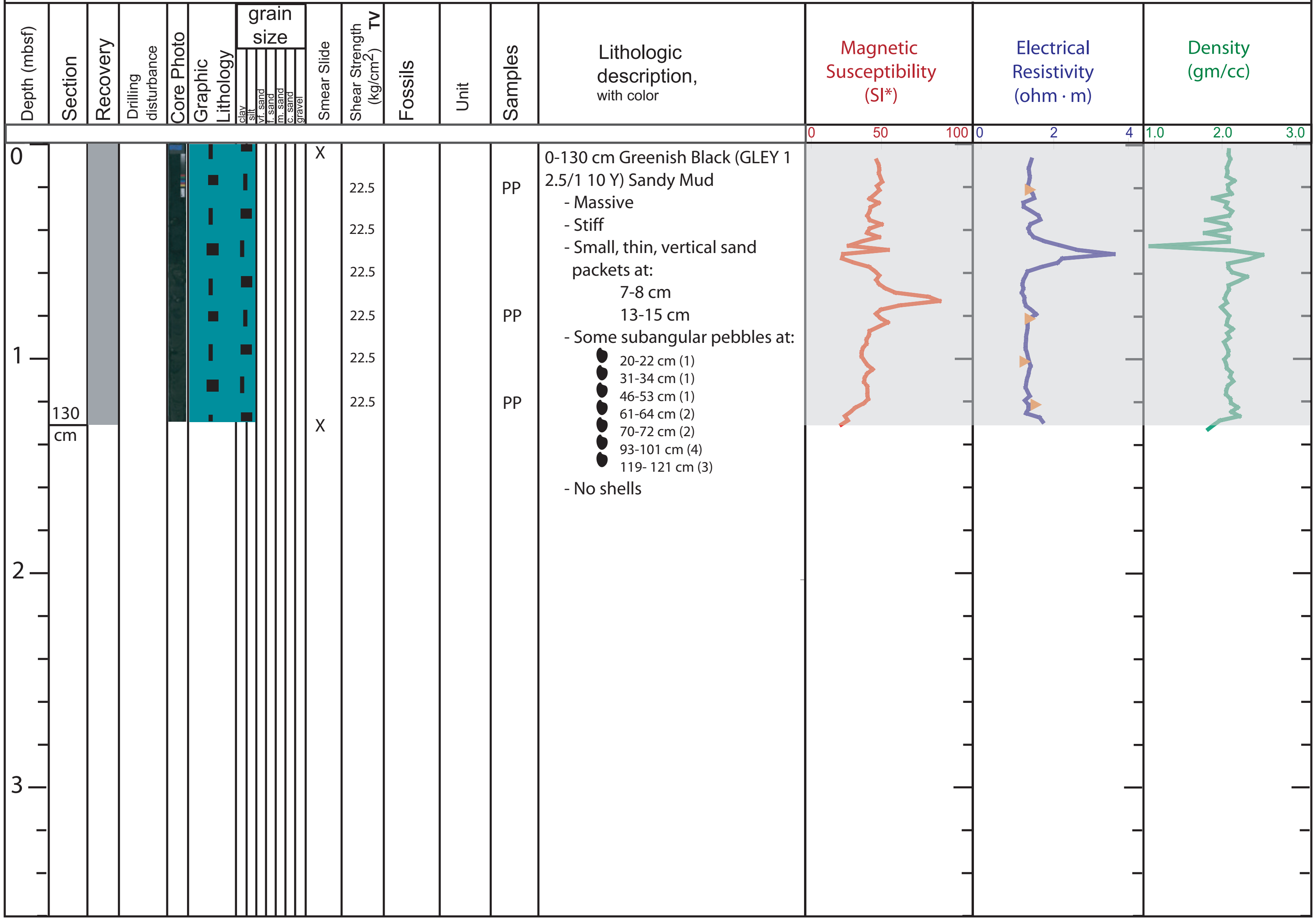


0-86 cm Very Dark Gray (5Y 3/1)
Sandy Mud
- Massive
- Stiff
- Some subrounded pebbles at:
  - ● 4 cm (1)
  - ● 8 cm (1)
  - ● 24 cm (1)
  - ● 55 cm (1)
  - ● 80 cm (1)

NBP0602A Site: 2 Hole: B

Water Depth: 405m

Core Number: 4 Top 29.00 mbsf Core Type: $R_{a\text{-}w}$



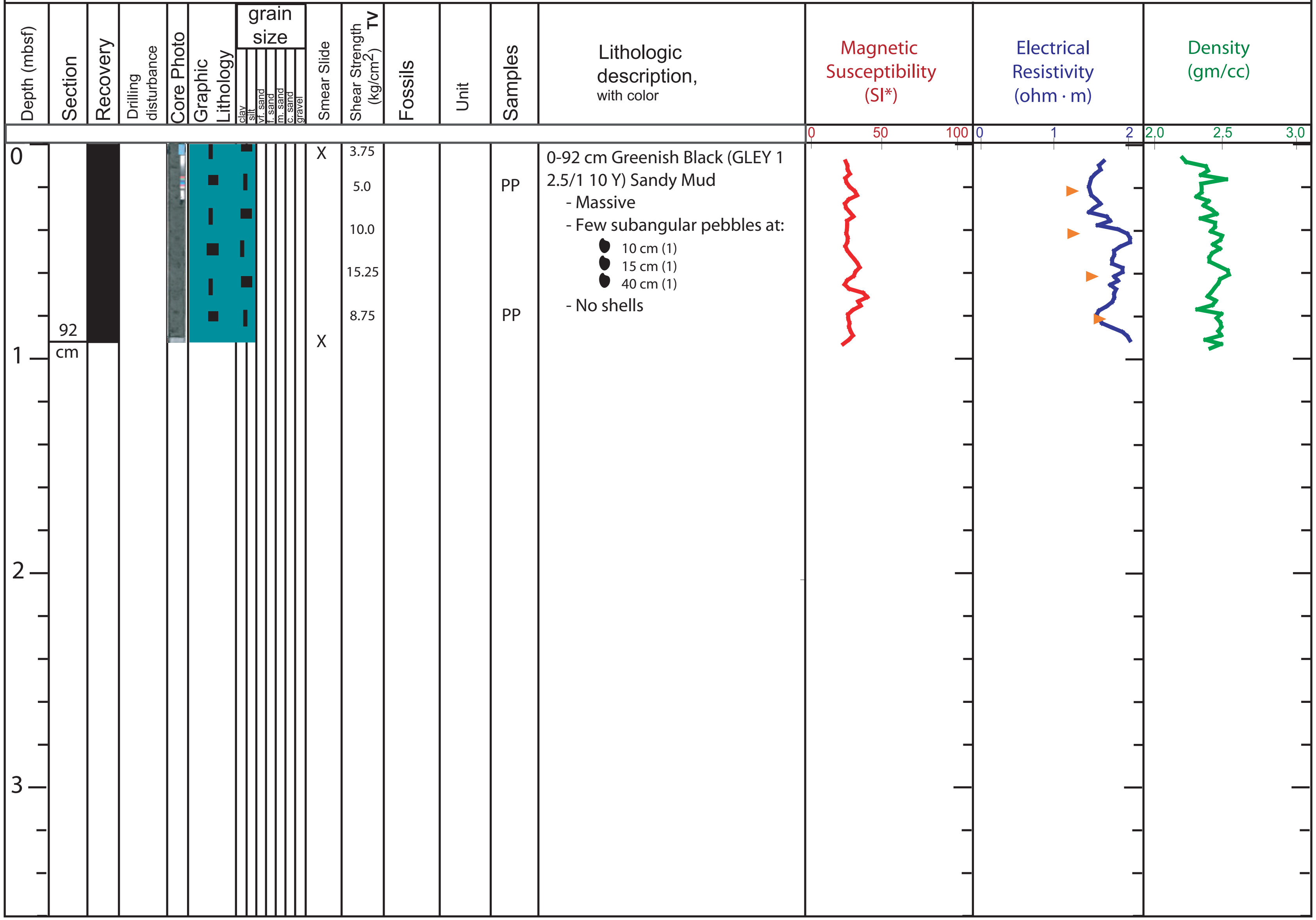
0-130 cm Greenish Black (GLEY 1 2.5/1 10 Y) Sandy Mud

- Massive
- Stiff
- Small, thin, vertical sand packets at:
  - 7-8 cm
  - 13-15 cm
- Some subangular pebbles at:
  - ● 20-22 cm (1)
  - ● 31-34 cm (1)
  - ● 46-53 cm (1)
  - ● 61-64 cm (2)
  - ● 70-72 cm (2)
  - ● 93-101 cm (4)
  - ● 119- 121 cm (3)
- No shells

NBP0602A Site: 2 Hole: B

Water Depth: 405m

Core Number: 5 Top 48.00 mbsf Core Type: R_a



0-92 cm Greenish Black (GLEY 1 2.5/1 10 Y) Sandy Mud

- Massive
- Few subangular pebbles at:
  - ● 10 cm (1)
  - ● 15 cm (1)
  - ● 40 cm (1)
- No shells

CHAPTER 4: SITES 3 and 4
Table of Contents

HOLES NBP0602A-3A-KC, -3B-KC, -3C

Date/time occupied (date; Julian Day; GMT): 12 March 2006; 071; 1115

Date/time departed: 13 March 2006; 072; 0445

Time on station: 17 hr, 30 min

Geographic area: Northern edge of the James Ross Basin

Ice coverage during station: $^1/_{10}$ to $^3/_{10}$

Kasten Cores: 63° 50.861' S, 54° 39.207' W; 341 mbsl (A), 340 mbsl (B)

NBP0602A-3A-KC: 32 cm of pebbly sand, Quaternary
NBP0602A-3B-KC: No recovery

Drill Hole 3C: 63° 50.861' S, 54° 39.207' W

Water depth (multibeam, m): 340

Water depth (drill-pipe measurement from sea level, m): 340

Total penetration (m): 20

Number of drill runs: 8

Total length of cored section (m): 17

Total drill core recovered (m): 6.31

Drill-core recovery (%): 37.1

Oldest sediment drilled:
Depth sub-bottom (m): 17
Nature: Muddy fine sand
Age: Late Eocene-early Oligocene

Principal Results: Upon leaving Site NBP0602A-2, we sought suitable openings in the omnipresent multiyear sea ice to allow drilling in the neighborhoods of Proposed Sites JRB3 and JRB4 and our previous Site NBP0602A-1 (near Proposed Site JRB6), but to no avail. Having exhausted all possibilities of drilling our primary sites for the moment, we elected to trace the basin margin northward toward more open water. A seismic survey revealed promising new sites where the older sediments of Seismic Units S5 and S4 onlap the edge of the basin. Site NBP0602A-3 was selected where these units crop out at or near the surface.

Two Kasten cores achieved little or no penetration in Quaternary pebbly sands, but the alien bit provided 65-79% recovery between 7.5 and 13.5 mbsf in stiff, fine Paleogene sand in Hole NBP0602A-3C. Numerous whole mollusc shells (gastropods and bivalves) and shell fragments are distributed throughout the cores. Silty muds and muddy, silty fine sands in the top 1.6 m of the section yielded the highest readings in MS, ER, and GRAPE bulk density for the entire hole, this despite the expected downhole increase in physical properties due to compaction.

Diatoms from Kasten Core NBP0602A-3A-KC and the upper part of Core NBP0602A-3C-1R_a are well preserved, modern (Holocene) sea-ice assemblages, whereas all subjacent floras represent a neritic Eocene-Oligocene shelf biofacies that improves in terms of preservation and diversity toward the bottom of the hole. Their age is conservatively estimated between ~37 to 32 Ma (late Eocene to earliest Oligocene), whereas a more restricted interpretation is late Eocene (~37 to 34 Ma). Calcareous nannofossils are rare to locally abundant in the older sediments of Hole NBP0602A-3C. Occasional coccospheres of the nearshore, salinity tolerant species *Braarudosphaera bigelowii* and some small placoliths are a sign of diminished bioturbation in the organic-rich sediments. The discolith *Transversopontis* spp. limits the age of the assemblage to the earliest Oligocene or older, whereas single pristine specimens of *Crucicribrum reticulatum* and *Chiasmolithus expansus* indicate late or middle Eocene, respectively; however, Cretaceous and Paleocene taxa were also noted, hence any of these isolated pre-Oligocene specimens could be reworked.

After penetrating to 20 mbsf in Hole NBP0602A-3C, the core barrel became stuck in the pipe, and the hole had to be terminated. An excursion of the vessel 28 m off station to “side step” moving sea ice may have contributed to the inability to retrieve the stuck tool.

HOLES NBP0602A-4A-KC, -4B-KC, -4C

Date/time occupied (date; Julian Day; GMT): 13 March 2006; 072; 0645

Date/time departed: 13 March 2006; 072; 2100

Time on station: 14 hr, 15 min

Geographic area: Northern edge of the James Ross Basin

Ice coverage during station: $^{2}/_{10}$ to $^{7}/_{10}$

Kasten Cores: 63° 51.6' S, 54° 26.95' W; 363 mbsl

NBP0602A-4A-KC: No recovery
NBP0602A-4B-KC: No recovery

Drill Hole 4C: 63° 49.685' S, 54° 28.098' W

Water depth (multibeam, m): 322

Water depth (drill-pipe measurement from sea level, m): 319

Total penetration (m): 10

Number of drill runs: 3

Total length of cored section (m): 5

Total drill core recovered (m): 0.27

Drill-core recovery (%): 5

Oldest sediment drilled:
Depth sub-bottom (m): 10
Nature: Sandy mud
Age: Quaternary?

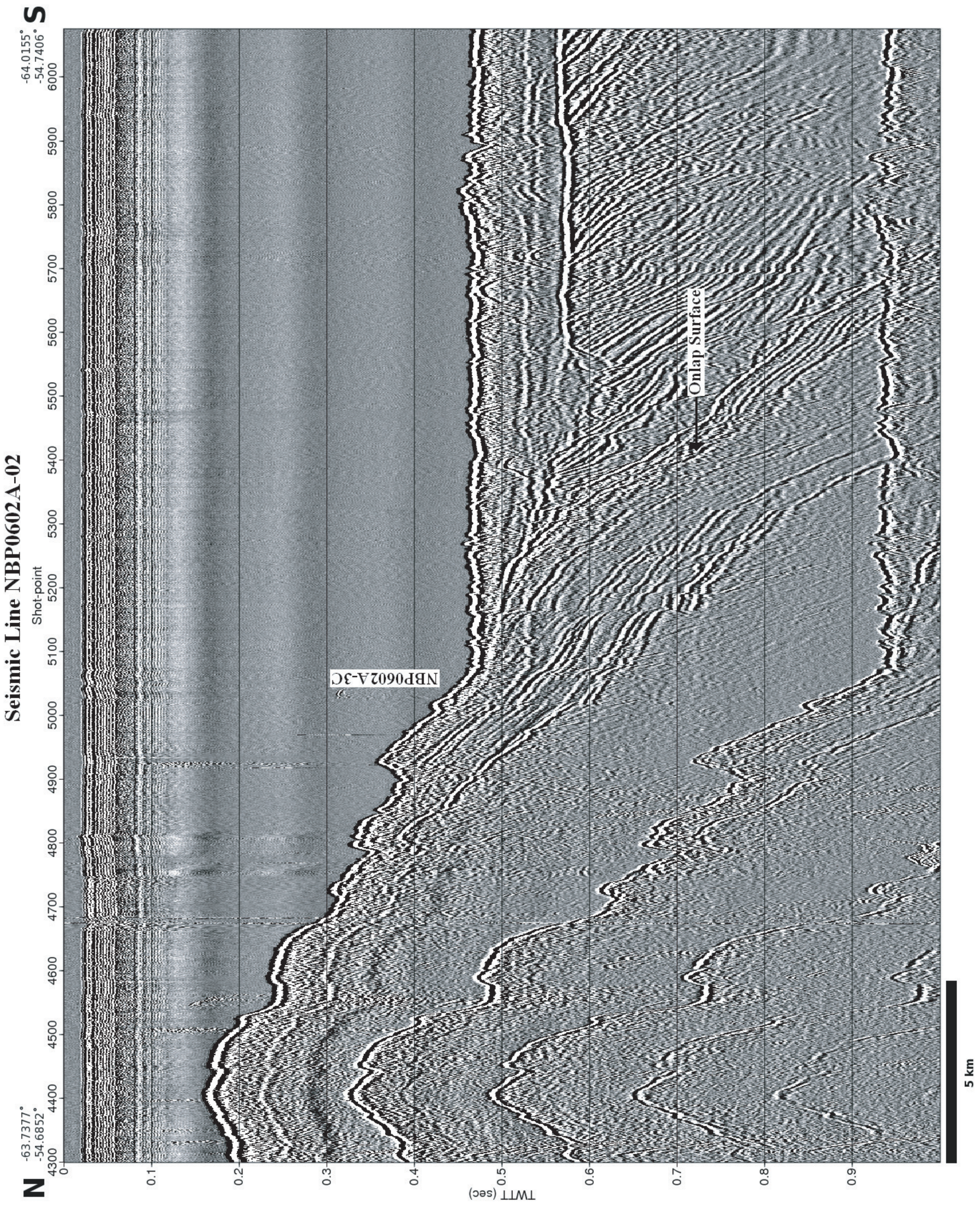
Principal Results: Having successfully cored the uppermost Eocene to lower Oligocene section, the vessel was moved east in the downdip direction where we believed upper Oligocene strata should crop out near the surface. Here a promising acoustically laminated interval was calculated to lie some 60 m stratigraphically higher in the section than the Paleogene sampled at Site NBP0602A-3. Two Kasten core attempts at Site NBP0602A-4 failed to return any sediment.

After one false start at running pipe due to ice and a subsequent relocation of the vessel, a new drill hole was spudded. After the first core barrel was washed to 5 mbsf, the second of the three cores attempted yielded 27 cm of disturbed, dark gray sandy mud with a mixture of diatom and coccolith species of various ages. Rare, moderate to well preserved calcareous nannofossils include reworked Cretaceous and Paleogene taxa, an indication that the 10 m of total penetration in the hole may well have been approaching the intended target. At that point, however, ice forced a 50-foot offset of the vessel, well beyond the 10% of water depth operational limits, thereby causing abandonment of the site. No apparent damage was done to any equipment.

SEISMIC STRATIGRAPHY

Initial attempts to drill the primary James Ross Basin sites selected for SHALDRIL II were hampered by extensive ice cover. Scattered areas of open water were encountered, but these tended to close within hours due to multiyear ice drifting at rates of 0.5 to 0.8 kn. After several attempts to drill the original proposed sites met with little success, we were forced to search for alternative sites. On 10 March we undertook a seismic survey of the northern edge of the basin where more open waters were encountered. The survey showed that the stratigraphic succession onlaps acoustic basement, dips to the south, and strikes more or less east to west along the basin edge (Fig. 4-1). We were able to trace the prominent onlap surface that separates Seismic Units S5 and S4 along the edge of the basin. The section thins to the east where Seismic Lines NBP0602A-06 and -07 cross the section.

Figure 4-1. Seismic Line NBP0602A-02 showing the onlap surface where the stratigraphic succession onlaps acoustic basement and the location of Hole NBP0602A-3C.



SITE 3

A. OBJECTIVES

Site NBP0602A-3 (Fig. 4-2) was drilled in the northern edge of the James Ross Basin where Seismic Lines NBP0602A-01 and -02 cross (Fig. 4-3). The objective of this site was to sample the older part of the section (Fig. 4-1), which, according to our seismic stratigraphic age model, is late Eocene to early Oligocene in age. The target horizon was reached and latest Eocene to early Oligocene strata were sampled.

B. OPERATIONS

During the interval of time between drilling at Sites NBP0602A-2 and -3, a station near Proposed Site JRB6 and Site NBP0602A-1 was occupied. The objective of the site was to reach the sedimentary section that was never sampled at Hole NBP0602A-1C because of early termination due to ice. Unfortunately, this attempt was terminated even earlier and the mudline was never reached.

Two Kasten cores and one drill hole were taken at Site NBP0602A-3 (Table 4-1), which were all located at 63° 50.861' S, 54° 39.207' W. The first Kasten core was retrieved in 341 m of water, while the second Kasten core and drill hole occurred in 340 m of water. The first Kasten core, NBP0602A-3A-KC, filled the nose of the core barrel, representing about 32 cm of penetration. This material was bagged but no core sections were recovered. NBP0602A-3B-KC recovered no material. Drilling operations at this site were begun simultaneously with Kasten coring, and mudline was reached after three hours on station.

Hole NBP0602A-3C was begun using the alien bit. Core recovery was not needed from the surface; however, when the seafloor consists of relatively loose or uncompacted sediment, using the alien bit to penetrate the overburden proved to be just as fast as using the non-coring bit. The hole was intentionally washed to 3.01 mbsf and then coring was attempted. A total of eight core runs were made, recovering a combined total of 6.31 m of sediment. The hole was terminated at 20 mbsf due to the tool being stuck in the pipe. There was no recovery in the last core barrel.

While drilling Hole NBP0602A-3C, the *NB Palmer* moved off station by 28 m in order to maneuver around ice. While this distance kept the vessel within the 10% of water depth limit set as the absolute maximum deviation, it may have been the cause of the stuck tool. They were coincident in time. A review of dynamic positioning practices after pulling out of the hole highlighted the fact that the drill collars, representing the first 35 m of pipe during normal SHALDRIL operations, are not as flexible as the rest of the drill pipe. Therefore, the collars cannot take the same deviation as the pipe that is strung later. From the mudline until all of the collars are buried, i.e., until 35 mbsf, a 5% of water depth limit needs to be followed to ensure that drilling can continue.

C. LITHOSTRATIGRAPHY

Site NBP0602A-3 consists of three holes, two Kasten cores and one drill hole. Kasten Core NBP0602A-3A-KC extends from 0 to 0.32 mbsf (Fig. 4-4). Sediment from this hole consists of greenish black (GLEY 1 2.5/ 10Y), poorly sorted sand to sandy diatomaceous mud with packets of sandy silt and small to coarse pebbles. Many of the pebbles are composed of fine, well-sorted sandstone and some of the larger pebbles are encrusted with bryozoa. Other macrofauna found include intact and segmented brittle stars, one small yellow gastropod, and several large sponges up to 2 cm in diameter. Smear-slide analysis of the <250 µm fraction (Table 4-2) was completed for two samples, one from the top and one from the base of the core. Overall, the two analyses are similar, indicating the sediment consists mostly of clay (35-48%) with slightly less quartz and feldspar (26-30%). Minor constituents of the sediment include calcite and heavy minerals (5%), as well as mica (2%). Hornblende, glauconite, and volcanic glass appear as trace amounts in both samples. The only significant difference is that up to 25% of the sediment at the base is composed of diatoms as opposed to 10% at the top. Radiolarians and sponge spicules occur in trace amounts in both samples. Some hematite stained quartz also occurs. The second Kasten core (NBP0602A-3B-KC) had no recovery.

Hole NBP0602A-3C reached a depth of 20.0 mbsf, although no recovery occurred below 17.0 mbsf (Fig. 4-5; Appendix 4-1). The sediment from this hole mostly consists of poorly sorted, muddy, silty, very fine to fine sand with a few subangular to subrounded pebbles. One cobble (>15 cm) was found at 12.3 mbsf. This cobble is angular and composed of hard, calcite-cemented sandstone with one large bivalve embedded in it. In addition to the cobble, some of the larger pebbles also contain shell fragments. The upper portion of the hole (0-7.5 mbsf) is greenish black (GLEY 1 2.5/1 10Y) and the lower portion (7.5-20.0 mbsf) is very dark gray (5Y 3/1) to very dark greenish gray (GLEY 1 3/ 10Y). There is no evidence of bioturbation; however, there are numerous whole shells (gastropods and bivalves) and shell fragments distributed throughout the hole. Smear-slide analysis of the <250 µm fraction (Table 4-2) does indicate variability from top to bottom. Much of the sediment from this hole is predominantly composed of clay minerals (40-50%), although the clay fraction decreases to 13% just below 10.5 mbsf before increasing again. Quartz typically comprises 20-30%, while feldspars comprise 5-20%. Calcite varies from 0-40%, and increases significantly toward the middle of the hole, coincident with where the clay fraction decreases. Heavy minerals typically comprise a few percent, while hornblende, glauconite, mica, and volcanic glass make up only 1-2% of the sediment. Siliceous and calcareous biogenics are present in all samples examined. Diatoms are the most abundant microfossil, comprising 1-10% of the assemblage throughout the hole. Sponge spicules (typically pyritized) also occur as traces to 1% in every sample, while trace numbers of silicoflagellates and radiolarians are found sporadically. Calcareous nannofossils are present as traces throughout the hole.

D. BIOSTRATIGRAPHY

Introduction

Site NBP0602A-3 targeted the Paleogene section of seaward dipping strata located northeast of Seymour Island. Initial shipboard paleontological work included smear-slide examination of diatom and calcareous nannofossil assemblages. Qualitative census data for these microfossil groups are recorded in Tables 4-3 and 4-4. Zonal assignments and age estimates for Hole NBP0602A-3C are summarized in Figure 4-6.

Diatoms

Diatoms from Kasten Core NBP0602A-3A-KC and the upper part of Core NBP0602A-3C-1R$_a$ are well preserved and represent a modern sea-ice assemblage (Table 4-3). The samples are dominated by *Chaetoceros* spp. and *Fragilariopsis curta* with secondary abundances of *Fragilariopsis cylindrus, Thalassiosira antarctica, Fragilariopsis sublinearis,* and *F. obliquecostata.* This interval from the uppermost part of the drilled section is presumed to be Holocene in age, but diatom biostratigraphy only constrains the age of the samples to ~140 ka or younger based on the absence of *Rouxia leventerae* (Zielinski et al., 2002).

A distinct downcore change in diatom assemblages occurs in the lower part of Core NBP0602A-3C-1R$_a$. Sample NBP0602A-3C-1R$_a$-CC contains a rare, poorly preserved diatom assemblage, but the presence of *Pterotheca* spp., *Biddulphia* spp., and large, heavily silicified *Stephanopyxis* spp. (Table 4-3) clearly indicates that older (Paleogene) strata were penetrated at very shallow depths (~4.0 mbsf) in the hole. Below this level, a relatively uniform diatom assemblage is present down to the base of the recovered interval in Core NBP0602A-3C-7R$_a$ (~14.1 mbsf). Diatoms are rare and poorly preserved in the upper part of this interval (Core NBP0602A-3C-1R$_a$ to -3R$_a$; ~4.0 to 9.0 mbsf), whereas diatoms in the lower interval are few to common and moderately well preserved (Cores NBP0602A-3C-4R$_a$ to -7R$_a$; ~9.0 to 14.1 mbsf). Diatom assemblages from Cores NBP0602A-3C-6R$_a$ and -7R$_a$ are particularly diverse and well preserved. In all of the Paleogene samples, the diatom assemblages are dominated by neritic-planktic taxa such as *Radialiplicata clavigera*, *Stephanopyxis* spp., and *Biddulphia* spp. (Table 4-3). These groups are characteristic of Eocene-Oligocene shelf facies from the Antarctic margin (e.g., Harwood, 1989).

Although the Eocene-Oligocene diatom assemblages from Cores NBP0602A-3C-1R$_a$ to -7R$_a$ are dominated by numerous shelfal taxa that are not biostratigraphically useful, several less abundant taxa can be used to provide a general age constraint for the section. These taxa include *Distephanosira architecturalis*, *Eurossia irregularis, Hemiaulus caracteristicus, H. dissimilis, H. reflexispinosus, Kisseleviella gaster, Pterotheca danica,* and *Pyxilla* spp. (Table 4-3). The known stratigraphic ranges of these taxa and the absence of a few key taxa provide a general age assignment of late Eocene to early Oligocene for the older Hole NBP0602A-3C section. An approximate minimum age of early Oligocene is provided by the presence of *Pyxilla* spp., which typically only occur as rare or reworked specimens in sediments of late Oligocene age or younger in the Antarctic region. The maximum age for Hole 3C is indicated by the absence of *Triceratium inconspicuum* var. *trilobata,* which is characteristic of middle Eocene diatom assemblages in the southern high latitudes. Its absence suggests a late Eocene age or younger.

Although the Eocene-Oligocene diatom assemblages from Hole NBP0602A-3C are diverse, the age constraints are relatively coarse due to the fact that very few sections of similar age have been recovered from the Antarctic shelf, and thus, the age ranges for most taxa are not well calibrated. The presence or absence of several additional taxa does allow further refinement of the age estimate. The first occurrence datums of *Kisseleviella cicatricata* and early forms of *Cavitatus jouseanus* are near 32.0 Ma, based on the age calibration for the base of the diatom-bearing interval of the Cape Roberts Project (CRP) drill core CRP-3 (Harwood and Bohaty, 2001; Olney et al., 2005). The absence of these two distinctive taxa in Hole 3C, therefore, indicates an age older than ~32.0 Ma. *Kisseleviella gaster*, which is present in several Hole 3C samples, has a documented first occurrence in the early late Eocene in cores recovered during Ocean Drilling Program (ODP) Leg 189 on the South Tasman Rise and East Tasman Rise (C. Stickley, pers. comm., 2005). This information provides a maximum age constraint of ~37 Ma. Combining these minimum and maximum age control points, diatom stratigraphy provides a conservative age estimate of late Eocene to earliest Oligocene (~37 to 32 Ma) for the Hole 3C section. This interval corresponds to the *Rhizosolenia oligocaenica* (syn. with *R. gravida*) to *Rylandsia inaequiradiata* Zones of Gombos and Ciesielski (1983), although the primary zonal markers have not been identified in Hole 3C samples.

Several characteristic early Oligocene diatom taxa are missing in the Hole NBP0602A-3C diatom assemblage, including *R. oligocaenica*, *Skeletonemopsis mahoodii,* and *Stephanopyxis splendidus.* All of these taxa have first occurrence datums near the Eocene-Oliogocene boundary (at ~34 Ma) (Gombos and Ciesielski, 1983; Roberts et al., 2003). If their absence is considered to be biostratigraphically significant, then a more restricted Eocene age of ~37 to 34 Ma can be interpreted for the Hole 3C section. Alternatively, *R. oligocaenica* is typically rare in shelf sediments, so its absence may be due to environmental factors and not be biostratigraphically significant. *Skeletonemopsis mahoodii* and *S. splendidus,* however, are relatively common in early Oligocene shelf sediments (Barron and Mahood, 1993; Sims, 1994; Scherer et al., 2000; Harwood and Bohaty, 2001), which indicates that their absence is not environmentally controlled, thus suggesting an Eocene age for the Hole 3C section.

Another diatom taxon with possible biostratigraphic significance in the Eocene-Oligocene boundary interval is *Pterotheca aculeifera.* This species occurs in all of the lower Hole NBP0602A-3C samples (Table 4-3). Its biostratigraphic range is not well constrained, but it is documented from middle and late Eocene age sediments of DSDP Holes 511 and 512 (Gombos, 1983; Gombos and Ciesielski, 1983) and is not present in early Oligocene age strata of the CIROS-1, CRP-2A, CRP-3, and ODP Hole 739C drill cores (Harwood, 1989; Barron and Mahood, 1993; Scherer et al., 2000; Harwood and Bohaty, 2001). Thus, the presence of *P. aculeifera* in Hole 3C also hints at an Eocene age for the section.

Calcareous Nannofossils

A minimum of three samples per core from Hole NBP0602A-3C were prepared and examined for calcareous nannofossils. Most samples were prepared as smear slides, although several settled slides were made since much of the recovered sediment is very sandy. Rare to abundant, generally well-preserved calcareous nannofossils were observed in every sample examined (Table 4-4). Small- to medium-size reticulofenestrids (*Reticulofenestra minuta*, *R. minutula*, and/or *R. daviesii*) are consistently present in nearly every sample. Well preserved *Braarudosphaera bigelowii* is also found throughout the section, typically in low numbers, although it is abundant in Sample NBP0602A-3C-7R$_a$, 30cm. This species is a salinity-tolerant encystment form common to continental margin environments. Coccospheres of *B. bigelowii* and *R. minutula* occur in several samples, indicating low bioturbation rates. Reworked Cretaceous species are found sporadically in the upper 9 m of the hole. Additionally, *Markalius apertus* and *Toweius pertusus*, characteristic of the Paleocene and Paleocene-early Eocene, respectively, occur sporadically throughout the hole, indicative of the presence of early Paleogene reworked material.

The low abundance of calcareous nannofossils makes it difficult to establish a precise age for the section. The presence of *R. daviesii*, *Zygrhablithus bijugatus*, and *Cyclicargolithus floridanus* together are indicative of the late Eocene to Oligocene, which is consistent with the late Eocene-early Oligocene age based on diatoms. A single pristine specimen of *Cribrocentrum reticulatum* from Sample NBP0602A-3C-3R$_a$, 10cm narrows the age to early late Eocene or older (>36 Ma) assuming it is not reworked. A single pristine specimen of *Chiasmolithus expansus* was also observed in Sample NBP0602A-3C-6R$_a$, 87cm, which is characteristic of the early to middle Eocene. The presence of these older taxa, coupled with only finding isolated, single specimens, indicates they may be reworked and therefore not reliable for dating the section. Wise (1983) recorded the last occurrence of *Transversopontis pulcheroides* in the lowermost Oligocene *Blackites spinosus* Zone at Deep Sea Drilling Project (DSDP) Site 511 on the Falkland Plateau. This event was used as a regional top for correlation at that level in the CRP-3 drill core (Watkins, et al., 2002). At Site NBP0602A-3, rare to few *T. pulcheroides* are present in samples from Cores NBP0602A-6R$_a$ and -7R$_a$, further indication that the age at the bottom of the hole is early Oligocene or older.

Age Summary

The combined information provided by diatom and calcareous nannofossil biostratigraphy from Hole NBP0602A-3C allows an age assignment of late Eocene or earliest Oligocene (~37 to 32 Ma) for Cores NBP0602A-3C-2R$_a$ to -7R$_a$ (Fig. 4-6). Given the great thickness of the total sediment package at this site (as interpreted from seismic profiles), the ~10 m-thick section sampled in Hole 3C, is presumed to represent a very short interval of time within the assigned age range. At present, however, neither microfossil group can definitively place the section in the Eocene or Oligocene. Further characterization the diatom and nannofossil assemblages in Hole 3C and calibration of diatom ranges in the Eocene-Oligocene boundary interval at other sites, such as those drilled during ODP Leg 189, may help further constrain the age of the Hole 3C section. Additionally, the occurrence of numerous well-preserved bivalve and gastropod fragments throughout the recovered core material will provide ample material for strontium isotope dating.

E. PHYSICAL PROPERTIES

Holes NBP0602A-3A-KC, -3B-KC, and -3C differed in their depth, coring method, and core recovery. Holes 3A-KC and 3B-KC were Kasten cores, with 32 cm of recovery in Hole 3A-KC and none in Hole 3B-KC. No physical properties were run on the former. Hole 3C reached approximately 20 mbsf and physical property measurements were made by the multisensor core logger (MSCL), the Middlebury College electrical resistivity (MCER) probe at 2-cm intervals, and discrete samples taken every 20 cm. As at the previous site, the discrete samples (normally 5 cc, using a syringe sampling system) are not processed onboard. These samples are stored in weighed vials and kept in the cooler for transport back to Middlebury College.

One lithologic unit is described in Hole NBP0602A-3C (see "**Lithostratigraphy**"); however, the physical properties show a distinct difference between the top 1.6 m of core and the remainder of the core. The top 0.3 m consists of silty mud with pebbles, and the next 1.3 m consists of muddy, silty fine sand. These two intervals together show the highest readings in magnetic susceptibility (MS), electrical resistivity (ER), and density for the entire hole. The bottom portion of the hole consists of silty fine sand. This slight change in lithology is noticeable in the physical properties. Measured densities range from 2.3-2.7 g/cm^3 for the top of the recovered section, whereas density drops in the fine sand to 1.7-2.5 g/cm^3. Density also shows the characteristic increase with depth in the lower sections of the hole. The same pattern is observed in ER measurements. For the top segment, ER measurements are around 1 ohm-m (1.1-1.3 ohm-m for the MCER probe) but drop to 0.7-0.9 ohm-m (0.6-1.1 ohm-m for MCER probe) for the lower segments. Magnetic susceptibility is the least affected. The upper section yields values around 40 SI units, with a large peak (147 SI) associated with a pebble (see Lithostratigraphic Log NBP0602A-3C-2R$_a$ at 38 cm). For the lower sections, MS drops to around 15 SI units for the remainder of the core.

Core disturbances such as gaps and edge effects produced by the core ends are removed from the physical properties data. Since ER measurements vary with porosity, a conversion using Boyce's (1968) equation indicates that porosities range between 40-

50% for these sediments, the upper section having lower porosity than the fine sands of the lower sections.

The shift from higher MS, ER, and gamma-ray attenuation porosity evaluator (GRAPE) density in the upper 1.3 m to lower values in the rest of the hole can be attributed to the higher percent of clay in these units. The well-sorted clean sand of the lower sections shows a downhole increase in physical properties but the values never reach those observed in the upper section.

F. SITE SUMMARY

Upon leaving Site NBP0602A-2, we sought suitable openings in the multiyear sea ice to allow drilling in the neighborhoods of Proposed Sites JRB3 and JRB4. Finally an attempt was made to lower pipe in the vicinity of our previous Site NBP0602A-1 (near Proposed Site JRB6). Before the pipe reached mudline, the wind had picked up to 25 kn, the current had changed direction, and the string had to be retrieved as ice closed in. Since drilling our primary sites was not possible at that time, we elected to complete a seismic survey to trace the basin margin northward toward more open water. The survey yielded sites where the older (Eocene to Oligocene) sediments of Seismic Units S4 and S5 onlap the edge of the basin. Site NBP0602A-3 was selected where these units crop out near the surface.

Two Kasten cores achieved little or no penetration in Quaternary pebbly sands, but in Hole NBP0602A-3C the alien bit provided 65-79% recovery between 7.5 and 13.5 mbsf in stiff greenish to dark greenish gray, fine Paleogene sand. Numerous whole mollusc shells (gastropods and bivalves) and shell fragments are distributed throughout the cores, some of which were sampled for strontium isotope dating.

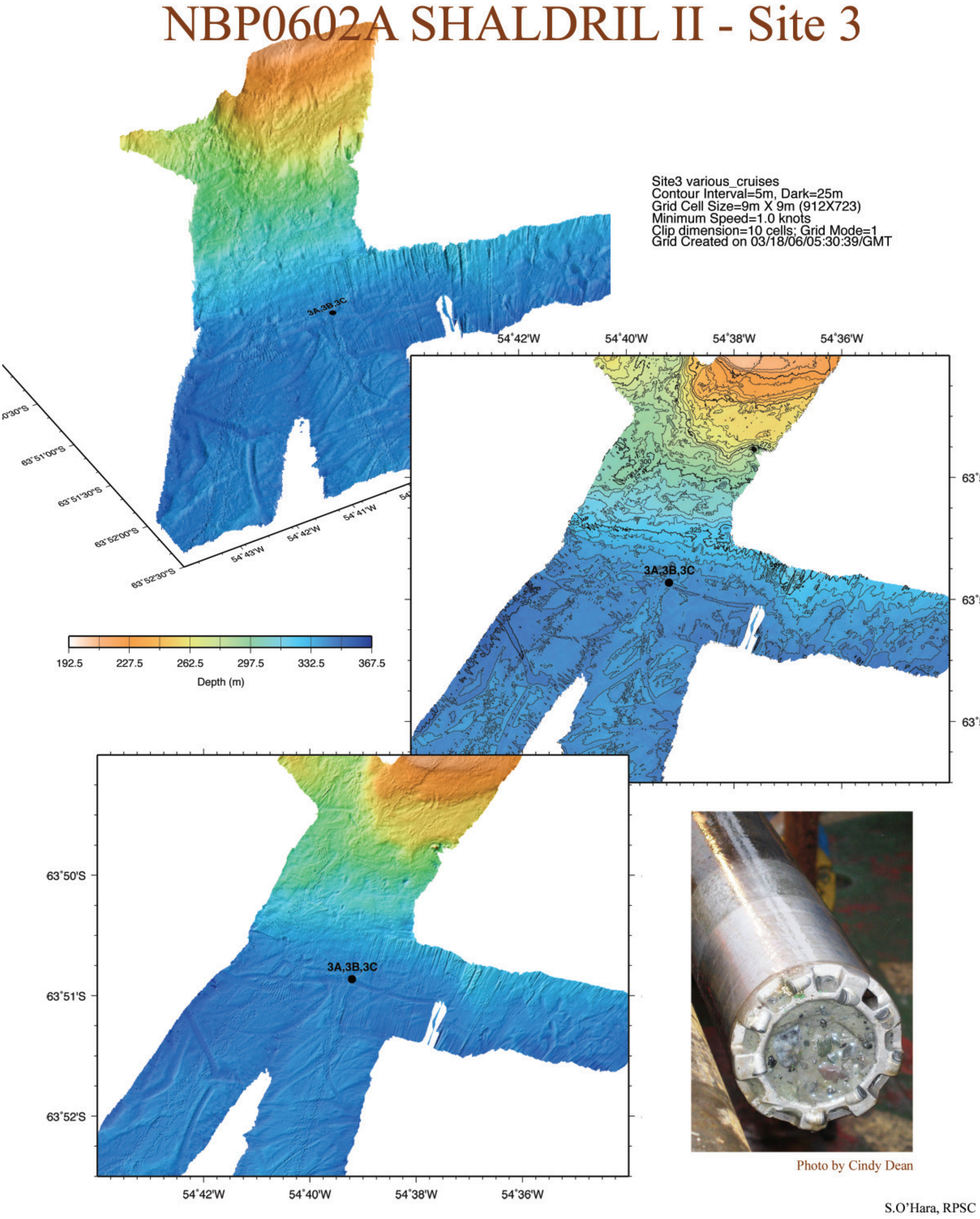
Diatoms from Kasten Core NBP0602A-3A-KC and the upper part of Core NBP0602A-3C-1R_a are well preserved and represent a modern (Holocene) sea-ice assemblage. A distinct change to rare, poorly preserved diatoms is seen in the lower portion of Core NBP0602A-3C-1R_a, where the assemblage is characterized by an Eocene-Oligocene shelf biofacies including *Pterotheca* spp., *Biddulphia* spp., and large, heavily silicified *Stephanopyxis* spp. Preservation and abundance improves toward the bottom of the hole, particularly in Cores NBP0602A-3C-6R_a and -7R_a, where the flora are diverse and well preserved. These dominantly neritic, tychopelagic diatoms are not biostratigraphically useful; however, several less abundant forms provide general age constraints on this short section, including *Distephanosira architecturalis*, *Eurossia irregularis, Hemiaulus caracteristicus, H. dissimilis, H. reflexispinosus, Kisseleviella gaster, Pterotheca danica,* and *Pyxilla* spp. The age ranges of these species are not well calibrated by the few available sections along the Antarctic shelf; however, by taking into account the absence of other index taxa, a conservative age for the assemblage is ~37 to 32 Ma (late Eocene to earliest Oligocene), whereas a more restricted interpretation places the section entirely within the upper Eocene (~37 to 34 Ma).

Calcareous nannofossils, although present in only trace amounts from a lithologic standpoint, are generally well preserved and are rare to locally abundant from a paleontologic point of view. Most conspicuous are rare to abundant but pristine specimens of the nearshore, salinity tolerant *Braarudosphaera bigelowii*, sometimes in complete coccospheres. A background of small placoliths also contains some coccospheres, a sign of diminished bioturbation in the organic-rich sediments. In Antarctic waters, the presence of *Transversopontis* limits the age of the assemblage to the earliest Oligocene or older, whereas single pristine specimens of *Crucicribrum reticulatum* and *Chiasmolithus expansus* indicate late or middle Eocene respectively. Cretaceous and Paleocene taxa were also noted, hence any of these isolated pre-Oligocene specimens could be reworked.

Physical properties show a distinct difference between the top 1.6 m of the section compared to that below. The top 0.3 m consists of silty mud with pebbles and the next 1.3 m is muddy, silty fine sand, which together yielded the highest readings in MS, ER, and GRAPE bulk density for the entire hole. These higher values are attributed to increased clay content compared to that found in the well-sorted, clean sands of the lower sections.

After penetrating to 20 mbsf the core barrel became stuck in the pipe, and the hole had to be terminated. During drilling, the vessel moved 28 m off station to “side step” moving sea ice, a distance within the 34-m prescribed operational limits, but this may have contributed to our inability to retrieve the stuck tool by putting a slight bend into the collars.

Figure 4-2. Multibeam images of Site NBP0602A-3.



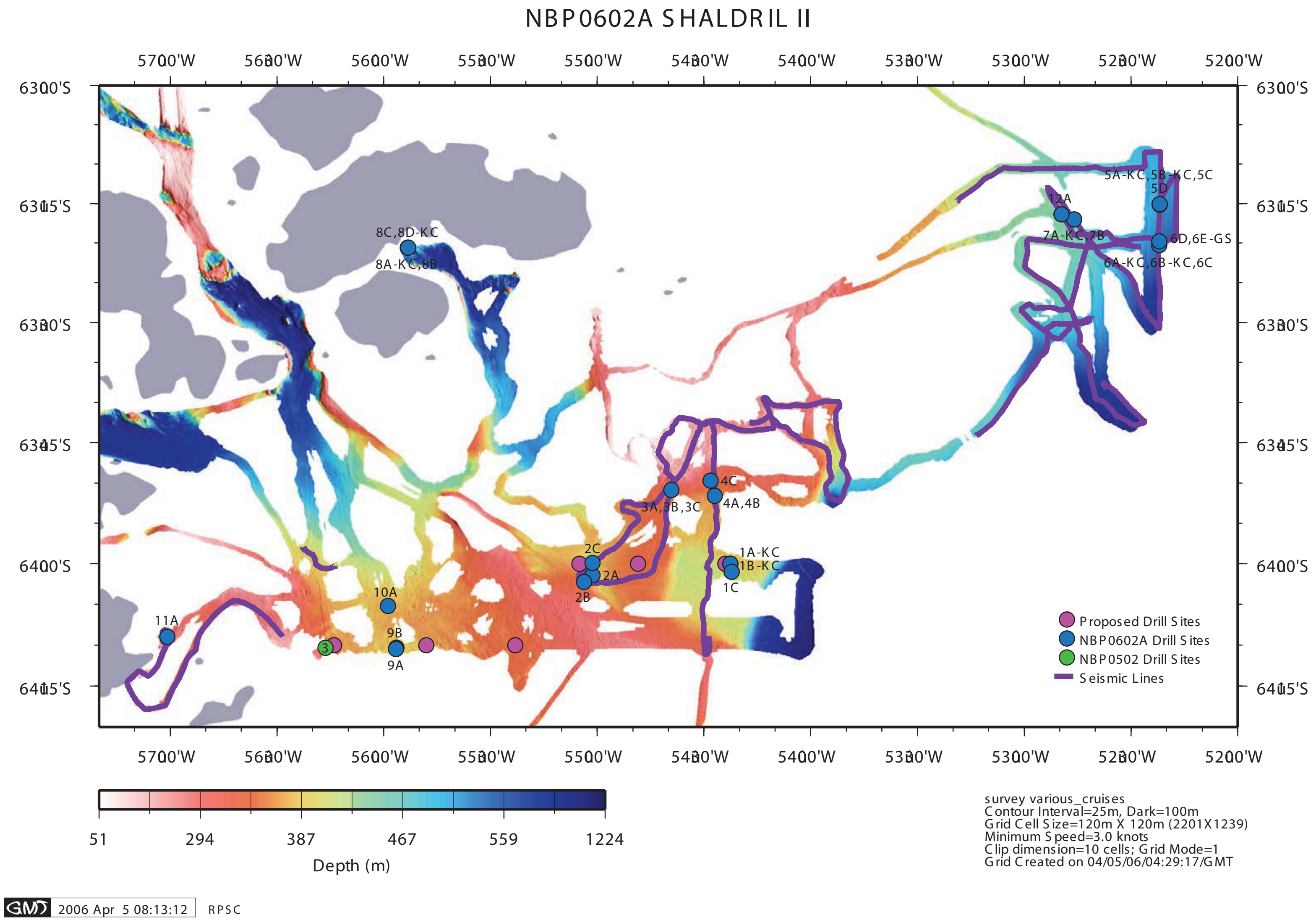
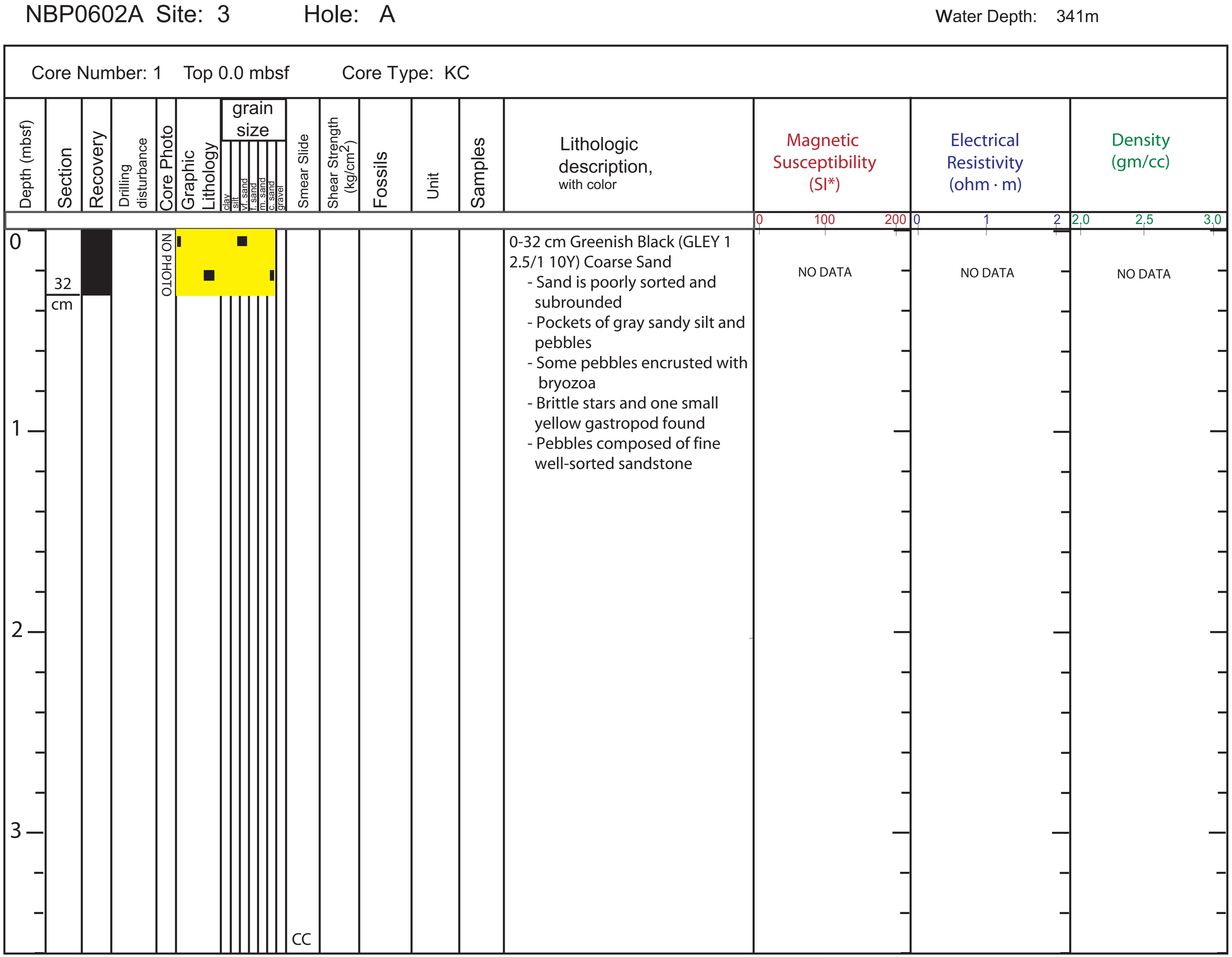


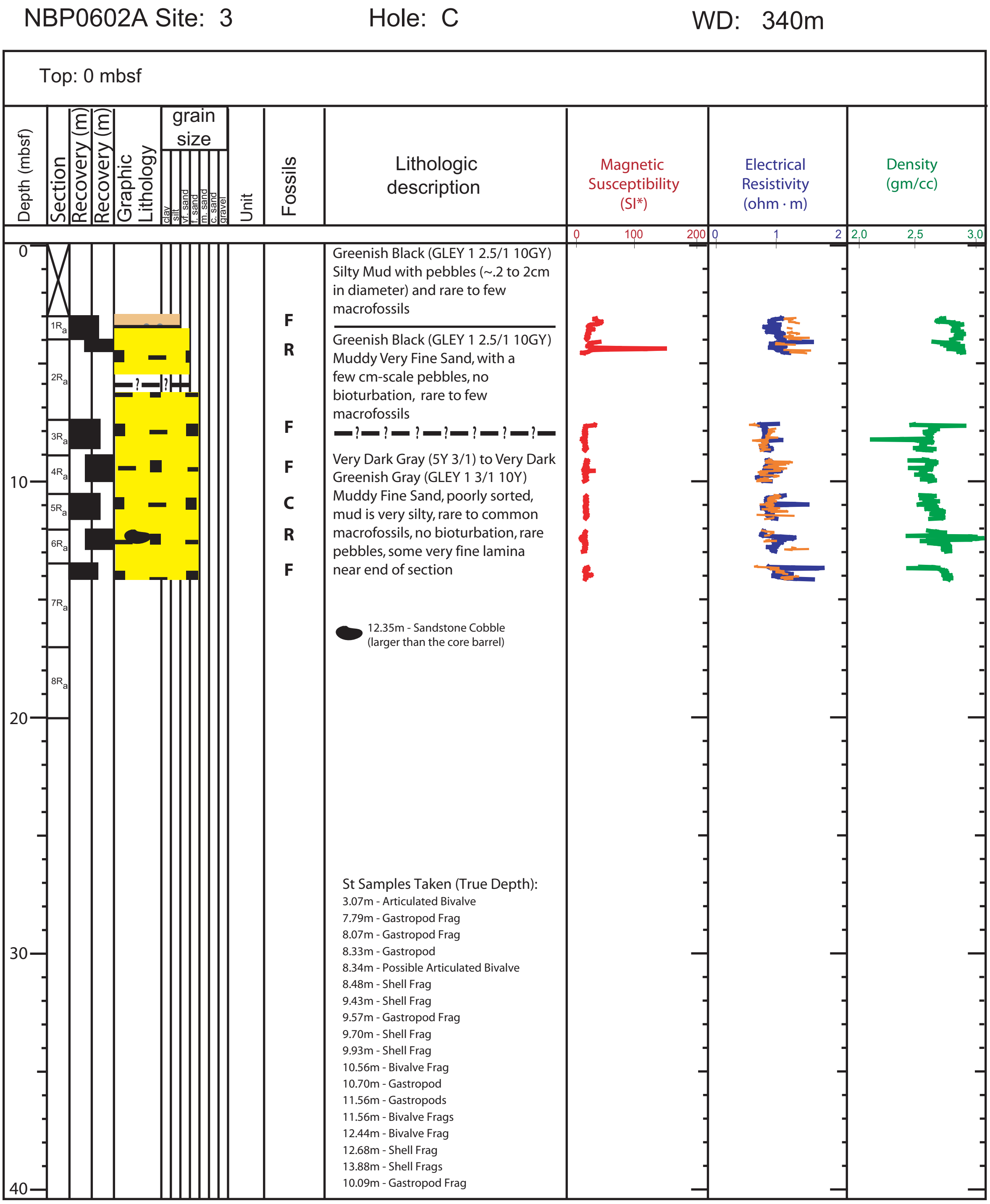
Figure 4-3. Trackline map of Cruise NBP0602A showing seismic lines and the positions of drill sites from Cruise NBP0502 (SHALDRIL I), proposed drill sites for SHALDRIL II, and drill sites for SHALDRIL II Cruise NBP0602A.



0-32 cm Greenish Black (GLEY 1 2.5/1 10Y) Coarse Sand
- Sand is poorly sorted and subrounded
- Pockets of gray sandy silt and pebbles
- Some pebbles encrusted with bryozoa
- Brittle stars and one small yellow gastropod found
- Pebbles composed of fine well-sorted sandstone

Figure 4-4. Lithologic log for Kasten Core NBP0602A-3A-KC.

Figure 4-5. Summary lithologic log of Hole NBP0602A-3C.



Greenish Black (GLEY 1 2.5/1 10GY) Silty Mud with pebbles (~.2 to 2cm in diameter) and rare to few macrofossils

Greenish Black (GLEY 1 2.5/1 10GY) Muddy Very Fine Sand, with a few cm-scale pebbles, no bioturbation, rare to few macrofossils

Very Dark Gray (5Y 3/1) to Very Dark Greenish Gray (GLEY 1 3/1 10Y) Muddy Fine Sand, poorly sorted, mud is very silty, rare to common macrofossils, no bioturbation, rare pebbles, some very fine lamina near end of section

12.35m - Sandstone Cobble (larger than the core barrel)

St Samples Taken (True Depth):
3.07m - Articulated Bivalve
7.79m - Gastropod Frag
8.07m - Gastropod Frag
8.33m - Gastropod
8.34m - Possible Articulated Bivalve
8.48m - Shell Frag
9.43m - Shell Frag
9.57m - Gastropod Frag
9.70m - Shell Frag
9.93m - Shell Frag
10.56m - Bivalve Frag
10.70m - Gastropod
11.56m - Gastropods
11.56m - Bivalve Frags
12.44m - Bivalve Frag
12.68m - Shell Frag
13.88m - Shell Frags
10.09m - Gastropod Frag

Figure 4-6. Diatom zonal assignments and age interpretation for Hole NBP0602A-3C

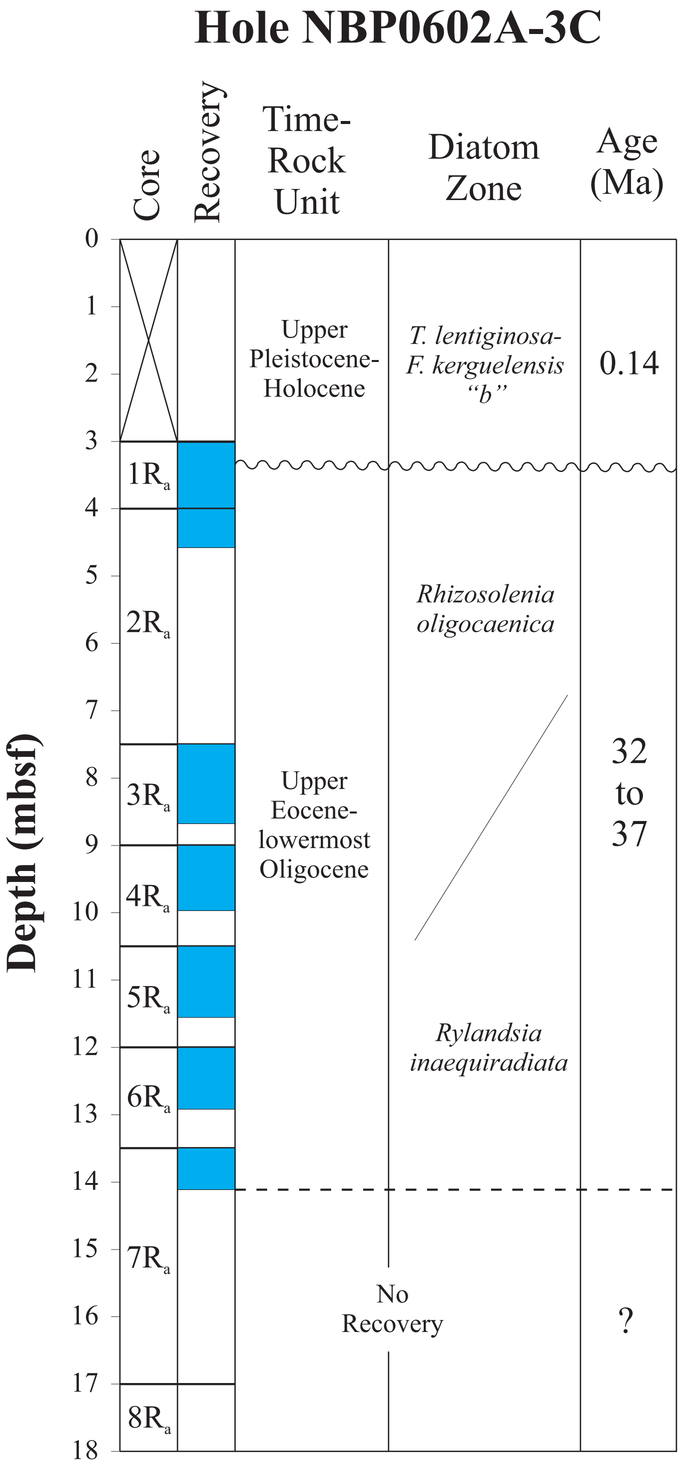


Table 4-1. Drilling and coring recovery log for Holes NBP0602A-3A-KC, -3B-KC, and -3C.

NBP0602A SHALDRIL II Site 3 (SE of Joinville Island)

Multibeam Water Depth: 341m @ A, 340m @ B, 340m @ C

Station Number/Hole	Core Number	Core Type	Top (mbsf)	Bottom (mbsf)	Interval Cored (m)	"Push Distance" (m)	Recovery: total (m)	Recovery: competent (m)	Recovery: disturbed (m)	Gaps (m)	Recovery Corrected (m)	Total Recovery (%)	Recovery Corrected (%)	Section Number	Section Lengths (cm)	Date (JD)	Time on Deck (GMT)	Initials	Comments
3A	1	KC	0.0	CC	0-0.32	0.32	0	0	0	0	0	0.0%	0.0%	0	baggie	71	1215	JSW	
3B	2	KC	0.0	0.0	0	0	0	0	0	0	0	0.0%	0.0%	0	0	71	1307	JSW	No recovery
3C	1	Ra	3.0	4.0	3.0-4.0	0.99	0.99	0.99	0	0	0.99	100.0%	100.0%	1	0.99	71	1225	JSW	0-3 mbsf washed
3C	2	Ra	4.0	7.5	4-7.5	3.5	0.57	0.57	0	0	0.57	16.3%	16.3%	1	0.57	71	1747	JSW	
3C	3	Ra	7.5	9.0	7.5-9.0	1.5	1.18	1.18	0	0	1.18	78.7%	78.7%	1	1.18	71	1838	CD	Some drilling mud in core
3C	4	Ra	9.0	10.5	9-10.5	1.5	0.97	0.97	0	0	0.97	64.7%	64.7%	1	0.97	71	1915	CD	
3C	5	Ra	10.5	12.0	10.5-12	1.5	1.06	1.06	0	0	1.06	70.7%	70.7%	1	106	71	1959	CD	Some drilling mud in core
3C	6	Ra	12.0	13.5	12-13.5	1.5	0.92	0.92	0	0	0.92	61.3%	61.3%	1	94.5	71	2042	CD	
3C	7	Ra	13.5	17.0	13.5-17	3.5	0.62	0.62	0	0	0.62	17.7%	17.7%	1	63	71	2216	CD	1.5 cm of foam at end of core; 62 cm of recovery
3C	8	Ra	17.0	20.0	0	0.0	0	0	0	0	0	0.0%	0.0%	0	0	72	0003	CD	No recovery; Hole terminated due to stuck pipe
TOTALS:							6.31												

Table 4-2. Smear slide data for Holes NBP0602A-3A-KC and -3C.

Sample	Approximate Depth (mbsf)	Components																	Grain Size			Sorting	Roundness	Lithology	Comments
		Minerals											Biogenic					Rock							
		Calcite	Clay	Feldspar	Glauconite	Heavy Minerals	Hornblende	Mica	Microcline	Quartz	Volcanic Glass	Zircon	Calcareous Nannofossils	Diatoms	Radiolarians	Silicoflagellates	Sponge Spicules	Fragments	Sand	Silt	Clay				
Hole 3A-KC																									
NBP0602A-3A-KC, top	surface	5	48	10	1	5	tr	1	tr	20	tr			10	tr	tr			20	15	30	P	a-sr	Mud with diatoms and sand	Hematite-stained quartz grains
NBP0602A-3A-KC-CC	0.32	5	35	10	tr	7	tr	2		16	tr			25	tr	tr			15	30	55	P	sa-sr	Sandy diatomaceous mud	Hematite-stained quartz grains; carbonate cemented sand (mostly quartz); chloritic mica
Hole 3C																									
NBP0602A-3C-1R_a, 15 cm	3.15	5	33	20	tr	5	tr	1		35			tr	2			1	tr	30	30	40	P	a-sr	Sandy mud	
NBP0602A-3C-1R_a, 55 cm	3.55	20	53	7	1	7	1			10			tr	1			tr		13	30	57	P	a-sr	Mud	Pyritized sponge spicules
NBP0602A-3C-2R_a, 10 cm	4.10	5	31	20	2	5		tr		35			tr	2			tr		22	40	38	P	a-sr	Sandy mud	
NBP0602A-3C-2R_a, 30 cm	4.30	15	42	10	1	5	1	tr		25		tr	tr	1			tr	tr	10	40	50	P	a-sr	Sandy mud	Pyritized sponge spicules
NBP0602A-3C-3R_a, 10 cm	7.60	25	20	5	1	3		1		40			tr	5			tr		60	25	15	P	a	Muddy sand	Diatoms and sponge spicules highly fragmented
NBP0602A-3C-3R_a, 60 cm	8.10	15	44	7	1	5	tr	tr		20			tr	7			1		17	30	53	P	a-sr	Sandy mud	Pyritized sponge spicules
NBP0602A-3C-4R_a, 10 cm	9.10	38	15	2	1	2	1	3		35			tr	3			tr		70	10	20	M	a-sa	Muddy sand	Diatoms and sponge spicules highly fragmented
NBP0602A-3C-4R_a, 50 cm	9.50		30	17	tr	3	1			30			tr	3			1	15	35	25	40	P	a-sa	Sandy mud	Pyritized sponge spicules and diatoms
NBP0602A-3C-5R_a, 10 cm	10.60	35	10	4	3	2	3	3		35			tr	5		tr	tr		80	5	15	M	sa	Clayey Sand	Diatoms and sponge spicules highly fragmented; large pieces of glauconite; fecal pellets
NBP0602A-3C-5R_a, 55 cm	11.05		20	15	tr	3	tr	tr		20			tr	2		tr	tr	40	20	50	30	P	a-sr	Sandy mud	Pyritized sponge spicules
NBP0602A-3C-6R_a, 10 cm	12.10	14	40	8	1	3	1	3		20			tr	10	tr		tr		35	10	55	P	sa-sr	Sandy mud	Diatoms and sponge spicules highly fragmented; large pieces of glauconite; fecal pellets
NBP0602A-3C-6R_a, 50 cm	12.50		29	20	2	3	1	tr		15			tr	10			tr	20	20	50	30	P	a-sr	Sandy mud	Pyritized sponge spicules
NBP0602A-3C-7R_a, 5 cm	13.55	20	30	4	2	2	1	2		35	1		tr	3		tr	tr		45	20	35	P	a-sa	Sandy mud	
NBP0602A-3C-7R_a, 30 cm	13.80		45	8	tr	5	tr	2		35			tr	5			tr		15	35	50	P	a-sr	Sandy mud	Pyritized sponge spicules

Notes: Sample: R_a = cored using alien coring bit; R_{a-w} = wash cored using alien coring bit; Components/Grain Size: Numbers represent percentages, tr = trace; Sorting: M = moderate, P = poor; Roundness: a = angular, sa = subangular, sr = subrounded.

Table 4-3. Stratigraphic occurrence and relative abundance of diatom taxa in Holes NBP0602A-3A-KC and -3C.

						Diatoms																													
Cruise/Hole/Core/Interval	**Depth (mbsf)**	**Slide Preparation**	**Diatom Abundance**	**Preservation**	**Fragmentation**	*Actinocyclus actinochilus*	*Actinocyclus ingens*	*Actinoptychus* spp.	*Arachnoidiscus* spp.	*Biddulphia* sp. 1	*Biddulphia* spp.	*Cavitatus miocenicus*	*Chaetoceros* spp. (small veg. cells & resting spores)	*Chaetoceros* spp. (large spores, decorated)	*Chaetoceros panduraeformis*	*Cocconeis* spp. (several taxa)	*Coscinodiscus bulliens*	*Coscinodiscus* spp.	*Denticulopsis simonsenii / vulgaris*	*Distephanosira architecturalis* (small diameter)	*Eucampia antarctica* var. *recta*	*Eurossia irregularis* var. *irregularis*	*Fragilariopsis angulata*	*Fragilariopsis curta*	*Fragilariopsis cylindrus*	*Fragilariopsis obliquecostata*	*Fragilariopsis ritscheri*	*Fragilariopsis sublinearis*	*Goniothecium odontella*	*Hemiaulus caracteristicus*	*Hemiaulus dissimilis*	*Hemiaulus polycystinorum*	*Hemiaulus reflexispinosus*	*Hemiaulus* sp. 1	"*Hemiaulus* sp." (of Gombos & Ciesielski, 1983)
Hole 3A-KC																																			
NBP0602A-3A-KC-CC	0.32	smear	F	M	M-H	X							F			fr(X)		fr(X)	X		X		X	F	R	R	X	R							
Hole 3C																																			
NBP0602A-3C-1R$_a$, 0 cm	3.01	smear	C	M	M	X							C					fr(X)			X			F	R										
NBP0602A-3C-1R$_a$, 55 cm	3.56	smear	X	P	H								X																						
NBP0602A-3C-1R$_a$-CC	4.00	smear & >10	X	P	H						X		R																						
NBP0602A-3C-2R$_a$, 0 cm	4.01	smear	R	P	H	*d?*	*d?*						X																						
NBP0602A-3C-2R$_a$-CC	4.57	smear	X	P	H								X																						
NBP0602A-3C-3R$_a$-CC	8.68	smear	R	P	H					X	X		X					X		X		X									X				
NBP0602A-3C-4R$_a$-CC	9.97	smear & >10	F	M	H			X		X	X		R	X	X	X		X		X		R									X	X			
NBP0602A-3C-5R$_a$-CC	11.56	smear	R	P	H					X	R	?	R	X				X		X															
NBP0602A-3C-6R$_a$-CC	14.42	smear & >10	F	M	M			X		X	R		R	X	X		?	X		R		R							R	X	X	X	X	X	
NBP0602A-3C-7R$_a$, 10 cm	13.60	smear & >10	C	M	M			X		R	R		F	X		X	?	fr(X)		X		X							R		X	X	R		
NBP0602A-3C-7R$_a$-CC	14.12	smear & >10	C	M	M			X	X	X	R		R	X		X	X	X													X	X	R	X	X

Notes: Abundance: C = common, F = few, R = rare, X = present, fr = fragments; Preservation: M = moderate, P = poor; Fragmentation: M = moderate, H = high.

Table 4-3 (continued).

Cruise/Hole/Core/Interval	Depth (mbsf)	Slide Preparation	Diatom Abundance	Preservation	Fragmentation	Diatoms																															
						Hemiaulus spp.	*Hyalodiscus* sp.1 (very small diameter)	*Ikebea* sp. A (of Scherer et al., 2000)	*Isthmia* spp.	*Kisseleviella gaster*	*Paralia crenulata*	*Poretzkia* ? sp.	*Porosira* spp.	*Proboscia alata*	*Pseudammodochium lingii*	*Pseudammodochium sphericum*	*Pseudopyxilla americana*	*Pterotheca aculeifera*	*Pterotheca danica*	*Pterotheca* sp. 1	*Pterotheca* sp. 2	*Pyxilla reticulata*	*Radialiplicata clavigera*	*Rhabdonema* spp.	*Rhizosolenia* spp.	*Rocella praenitida*	*Stellarima microtrias*	*Stephanopyxis* spp. (small to med. diameter, mod. silicified	*Stephanopyxis* spp. (large, heavily silicified)	*Stictodiscus* spp.	*Thalassiosira antarctica* var. *antarctica*	*Thal. gracilis* var. *gracilis / expecta*	*Thlassiosira tumida*	*Thalassiothrix/Trichotoxon* spp.	*Triceratium unguiculatum* group	*Trinacria excavata* group	*Trochosira spinosus*
Hole 3A-KC																																					
NBP0602A-3A-KC-CC	0.32	smear	F	M	M-H									X											X		X				F	X		fr(X)			
Hole 3C																																					
NBP0602A-3C-1R$_a$, 0 cm	3.01	smear	C	M	M								X																		R	X	X	fr(X)			
NBP0602A-3C-1R$_a$, 55 cm	3.56	smear	X	P	H																		R						fr(R)								
NBP0602A-3C-1R$_a$-CC	4.00	smear & >10	X	P	H															X			F						X								
NBP0602A-3C-2R$_a$, 0 cm	4.01	smear	R	P	H															X		X	R		X				X	X	d?						
NBP0602A-3C-2R$_a$-CC	4.57	smear	X	P	H													X		X		X	R						X								
NBP0602A-3C-3R$_a$-CC	8.68	smear	R	P	H					X								X				X	R	X		X			R	X							X
NBP0602A-3C-4R$_a$-CC	9.97	smear & >10	F	M	H			X		R							?	X		R		X	F	X		X	X		F								R
NBP0602A-3C-5R$_a$-CC	11.56	smear	R	P	H					X								X		R		R	F	X		X			R	X						X	R
NBP0602A-3C-6R$_a$-CC	14.42	smear & >10	F	M	M					X	X							R	X	R		R	F	R		R	X		F						X		R
NBP0602A-3C-7R$_a$, 10 cm	13.60	smear & >10	C	M	M		R	R	X	R	R	X						R		R	R	R	F	X		R	X		F						X		R
NBP0602A-3C-7R$_a$-CC	14.12	smear & >10	C	M	M			R	X		R	X						X	X			X	F	X		R			F	X							R

Notes: Abundance: C = common, F = few, R = rare, X = present, fr = fragments; Preservation: M = moderate, P = poor; Fragmentation: M = moderate, H = high.

Table 4-3 (continued).

						Silicoflagellates, Ebridians, Etc.														
Cruise/Hole/Core/Interval	**Depth (mbsf)**	**Slide Preparation**	**Diatom Abundance**	**Preservation**	**Fragmentation**	*Ammodochium rectangulare* (single)	*Ammodochium rectangulare* (double, non-loricate)	*Archaeosphaeridium australensis* (with spines)	*Archaeosphaeridium tasmaniae*	*Corbisema triacantha*	*Craniopsis octo*	*Ebrinula paradoxa*	*Ebriopsis crenulata* (non-loricate)	*Ebriopsis crenulata* (loricate)	*Distephanus speculum speculum*	*Dist. spec. speculum* ("pseudofibula" morphology)	*Distephanus speculum pentagonus*	*Falsebria ambigua*	*Pseudammodochium dictyoides* (single)	*Pseudammodochium dictyoides* (double)
Hole 3A-KC																				
NBP0602A-3A-KC-CC	0.32	smear	F	M	M-H															
Hole 3C																				
NBP0602A-3C-1R_a, 0 cm	3.01	smear	C	M	M															
NBP0602A-3C-1R_a, 55 cm	3.56	smear	X	P	H															
NBP0602A-3C-1R_a-CC	4.00	smear & >10	X	P	H													X		
NBP0602A-3C-2R_a, 0 cm	4.01	smear	R	P	H															
NBP0602A-3C-2R_a-CC	4.57	smear	X	P	H															
NBP0602A-3C-3R_a-CC	8.68	smear	R	P	H	X		X			X									
NBP0602A-3C-4R_a-CC	9.97	smear & >10	F	M	H	X		X	X				X	X				X	X	
NBP0602A-3C-5R_a-CC	11.56	smear	R	P	H													X		
NBP0602A-3C-6R_a-CC	14.42	smear & >10	F	M	M	X		X						R				X	X	
NBP0602A-3C-7R_a, 10 cm	13.60	smear & >10	C	M	M		X	R	X			X		X					X	X
NBP0602A-3C-7R_a-CC	14.12	smear & >10	C	M	M	X		X	X	X			X							

Notes: Abundance: C = common, F = few, R = rare, X = present, fr = fragments; Preservation: M = moderate, P = poor; Fragmentation: M = moderate, H = high.

Table 4-4. Stratigraphic occurrence and relative abundance of calcareous nannofossil taxa for Hole NBP0602A-3C.

			Paleogene																								Cretaceous	
Sample	**Total Abundance**	**Preservation**	*Braarudosphaera bigelowii*	*Chiasmolithus expansus*	*Coccolithus pelagicus*	*Coronocyclus prionion*	*Cribrocentrum reticulatum*	*Cyclicargolithus floridanus*	*Cyclicargolithus cf. floridanus*	*Dictyococcites productus*	*Markalius apertus*	*Pontosphaera cf. latoculata*	*Pontosphaera pectinata*	*Pontosphaera* spp.	*Reticulofenestra ampla*	*Reticulofenestra daviesii*	*Reticulofenestra haqii (3-5)*	*Reticulofenestra minuta*	*Reticulofenestra minutula*	*Reticulofenestra* spp.	*Thoracosphaera heimii*	*Thoracosphaera* spp.	*Toweius pertusus*	*Transversopontis pulcheroides*	Unknown spp.	*Zygrhablithus bijugatus*	*Ellipsagelosphaera britannica*	*Watznaueria barnesae*
NBP06-02A-3C-1R$_a$, 15 cm	R	G						?																			*	
NBP06-02A-3C-1R$_a$, 55 cm	F	M-G														F			R			R			R			
NBP06-02A-3C-1R$_a$-CC			x														x	x			x							
NBP06-02A-3C-2R$_a$, 10cm	R	M								R																		
NBP06-02A-3C-2R$_a$, 30 cm	F	G	R							F									F			F						*
NBP06-02A-3C-2R$_a$-CC																		x			x							
NBP06-02A-3C-3R$_a$, 10 cm	C	M-G	F				R			R	*			R		F		C	C			F	*			F		*
NBP06-02A-3C-3R$_a$, 60 cm	C	G	F			?		R								F			C			F						
NBP06-02A-3C-3R$_a$-CC			x															x	x	x								
NBP06-02A-3C-4R$_a$, 10 cm	R	G																	R									
NBP06-02A-3C-4R$_a$, 50 cm	C	G														F			C									
NBP06-02A-3C-4R$_a$-CC			x													x		x										
NBP06-02A-3C-5R$_a$, 10 cm	C	G	R		R														C			R						
NBP06-02A-3C-5R$_a$, 55 cm	F	G																	F									
NBP06-02A-3C-5R$_a$-CC			x					x								x		x			x							
NBP06-02A-3C-6R$_a$, 10 cm	C	M-G	F		R											F		F	C			R						
NBP06-02A-3C-6R$_a$, 50 cm	F	G																	F			F						
NBP06-02A-3C-6R$_a$, 87 cm	A	G	F	R				R					?	R	F	C	R	C	A					F	F	R		
NBP06-02A-3C-6R$_a$-CC			x					x								x		x										
NBP06-02A-3C-7R$_a$, 5 cm	F	G	F													R			R			F						
NBP06-02A-3C-7R$_a$, 10 cm			x		x														x									
NBP06-02A-3C-7R$_a$, 30 cm	A		A							?	*					F		C	C									
NBP06-02A-3C-7R$_a$, 34 cm	F	G														R			F									
NBP06-02A-3C-7R$_a$, 40 cm	A	M-G	F							C	*				R	F		F	A						F			
NBP06-02A-3C-7R$_a$, 51.5 cm	C							R	R							F	F		C									
NBP06-02A-3C-7R$_a$-CC	C		C					F				R			?	F		F/C	F		F			R		R		

Notes: Abundance: A = abundant, C = common, F = few, R = rare, x = present, ? = questionable, * = reworked; Preservation: M = moderate, G = good.

SITE 4

A. OBJECTIVES

Site NBP0602A-4 (Fig. 4-7) intended to sample Oligocene strata situated approximately 60 m above the uppermost Eocene to lower Oligocene strata sampled at Site NBP0602A-3 (Fig. 4-8). The site targeted an acoustically laminated interval. Drifting sea ice caused us to abandon the site before the target horizon was reached.

B. OPERATIONS

Site NBP0602A-4 consists of two Kasten cores and one drill hole. Holes NBP0602A-4A-KC and -4B-KC are located at 63° 51.6' S, 54° 26.95' W in 363 m of water. Neither Kasten core had any recovery.

Hole NBP0602A-4C is located at 63° 49.685' S, 54° 28.098' W in 322 m of water. Pipe was run into the water while at the Kasten core site but ice forced the drill site to be moved before the mudline was reached. After relocating the site to shallower water, the hole was begun using the alien bit (Table 4-5). The first 5 m were intentionally washed, retrieving 26.8 cm of washed core. The second core run retrieved 27 cm of core from a 2 m run, and the last run, to a depth of 10 mbsf, retrieved only a bag of sediment. During the last coring run, the *NB Palmer* began to drift off station due to ice conditions. There were 4 m of collars remaining below the mudline when the vessel left the 10% of water depth radius, eventually stopping at approximately a 50-foot offset. The drill pipe and collars came out of the hole during this excursion but there was no apparent damage to any equipment.

C. LITHOSTRATIGRAPHY

Site NBP0602A-4 consists of three holes, two Kasten cores and one drill hole. There was no recovery from the two Kasten cores. Hole NBP0602A-4C extends from 0 to 10.0 mbsf (Fig. 4-9; Appendix 4-2). Sediment from the upper half of the hole is disturbed and sediment from the bottom 3 m came from the core catcher. Sediment from this hole consists of very dark greenish black (GLEY 1 3/ 10Y), muddy, silty, pebbly sand at the top to greenish black (GLEY 1 2.5/ 10Y), stiff, silty, sandy mud with many pebbles in the middle. One of the pebbles from the middle of the hole is composed of pink granite. Toward the bottom of the core the sediment becomes very dark gray (5Y 3/1), very poorly sorted, soupy, pebbly, sandy mud. The pebbles are medium size and angular. Smear-slide analysis of the <250 μm fraction (Table 4-6) indicates that clay is dominant (36-49%), with slightly less quartz (30-35%) and even less feldspar (10-20%) present. Both calcite and heavy mineral percentages are similar (2-5%), and mica abundances range from trace amounts to 1%. Hornblende, glauconite, and volcanic glass generally occur in trace amounts. Diatoms occur throughout the hole, although they decrease in abundance from 2% to traces downhole. Sponge spicules are also present in trace amounts throughout the hole, whereas traces of calcareous nannofossils are found only in the 5- to 7-mbsf interval. The sponge spicules that are present in the upper portion of the hole are pyritized.

D. BIOSTRATIGRAPHY

Site NBP0602A-4 was chosen with the goal of penetrating a thin uppermost unit of glacial diamicton overlying dipping sedimentary units of Miocene age. Initial shipboard paleontological work included smear-slide preparations for diatom and calcareous nannofossil analysis.

All diatom taxa identified in the uppermost part of Core NBP0602A-4C-1R_a (Sample NBP0602A-4C-1R_a, 22 cm) are modern (extant) species (Table 4-7). The presence of rare specimens of *Actinocyclus actinochilus, Fragilariopsis curta, F. cylindrus,* and *Thalassiosira antarctica* indicates deposition in a sea-ice influenced environment and a late Pliocene or younger age (≤ 3.0 Ma) for this sample.

Samples below the uppermost section of Hole NBP0602A-4C (from ~5 to 10 mbsf) contain only very rare and poorly preserved diatoms (Table 4-7). Most taxa identified in this interval have very little biostratigraphic utility. The presence of *Actinocyclus ingens* in Samples NBP0602A-4C-1R_a-CC and -2R_a, 7 cm constrains the very top of the section (5.07 mbsf and above) to an age of ~16 Ma or younger, although these specimens are most likely reworked into latest Pleistocene age strata. Below 5.07 mbsf, the only biostratigraphically useful diatom species identified is *Actinocyclus actinochilus* from the "bit face" sample of Core NBP0602A-4C-3R_a. The "bit face" material may represent a sampling of the lowermost sediment penetrated in Hole 4C (at ~10 mbsf). If interpreted as *in situ*, the presence of *A. actinochilus* would constrain the age of the drilled section to ≤ 3.0 Ma. Downhole contamination in this sample cannot be ruled out, thus this age estimate should be taken with caution.

Smear slides made from the core catcher samples of the three cores from Hole NBP0602A-4C were examined for calcareous nannofossils. Cores NBP0602A-4C-1R_a and -3R_a were both barren. Core NBP0602A-4C-2R_a contained few moderately to well-preserved calcareous nannofossils. The assemblage consists of reticulofenestrids (*Reticulofenestra minuta*, *R. minutula*, and *R. daviesii*), *Braarudosphaera bigelowii*, and *Thoracosphaera spp*. Additionally, the Cretaceous species *Watznaueria barnesae* was observed. Without further recovery, the presence of reworked material makes it impossible to interpret an age for the sediment based on calcareous nannofossils.

E. PHYSICAL PROPERTIES

Site NBP0602A-4 consists of three holes. Holes NBP0602A-4A-KC and -4B-KC were Kasten cores with no recovery. Hole NBP0602A-4C was drilled but with little recovery.

The 26.5 cm recovered in Core NBP0602A-4C-1R_a consists of muddy, silty, pebbly sand, whereas sediment from Core NBP0602A-4C-2R_a was recovered from the core catcher and is silty, sandy mud. Both small cores have density ranges between 2.4-3.0 g/cm^3 and ER values are also high at 1-2 ohm-m. High MS values correlate with the large number of pebbles found in both cores.

Since Core NBP0602A-4C-1R_a is disturbed and NBP0602A-4C-2R_a came from the core catcher, little can be gleaned from analyses of the physical properties.

F. SITE SUMMARY

Site NBP0602A-4 was drilled along the northern edge of the James Ross Basin. The objective of this site was to sample Oligocene strata that occur at shallow sub-bottom depths in the area. Two Kasten cores were attempted without recovery. Hole NBP0602A-4C was drilled to a depth of 10 mbsf, retrieving 26.8 cm of washed core from the upper 5 m, 27 cm from the second core run, and sediment from the core catcher of the third (final) core run.

Sediment from the upper 5 m of Hole NBP0602A-4C consists of very dark greenish gray, muddy, pebbly sand that contains a modern sea-ice influenced diatom assemblage indicating the section is late Pliocene or younger (≤ 3.0 Ma) in age. Sediment below 5 mbsf is greenish black, silty, sandy mud with common pebbles and rare macrofossils. Diatoms are rare and poorly preserved. *Actinocyclus ingens* constrains the age to <16 Ma, although the presence of *A. actinochilus* in sediment from the last core run would restrict that age to ≤ 3.0 Ma if not downhole contamination. Calcareous nannofossils also occur in one sample below 5 mbsf. Athough the reticulofenestrid assemblage could indicate the target was reached, the presence of an obviously reworked Cretaceous species precludes a reliable age estimate.

Hole NBP0602A-4C was terminated when the *NB Palmer* began to drift off station due to approaching ice. The ship left the 10% of water depth radius while 4 m of drill collars remained in the hole; however, no apparent damage occurred.

Figure 4-7. Multibeam images of Site NBP0602A-4.

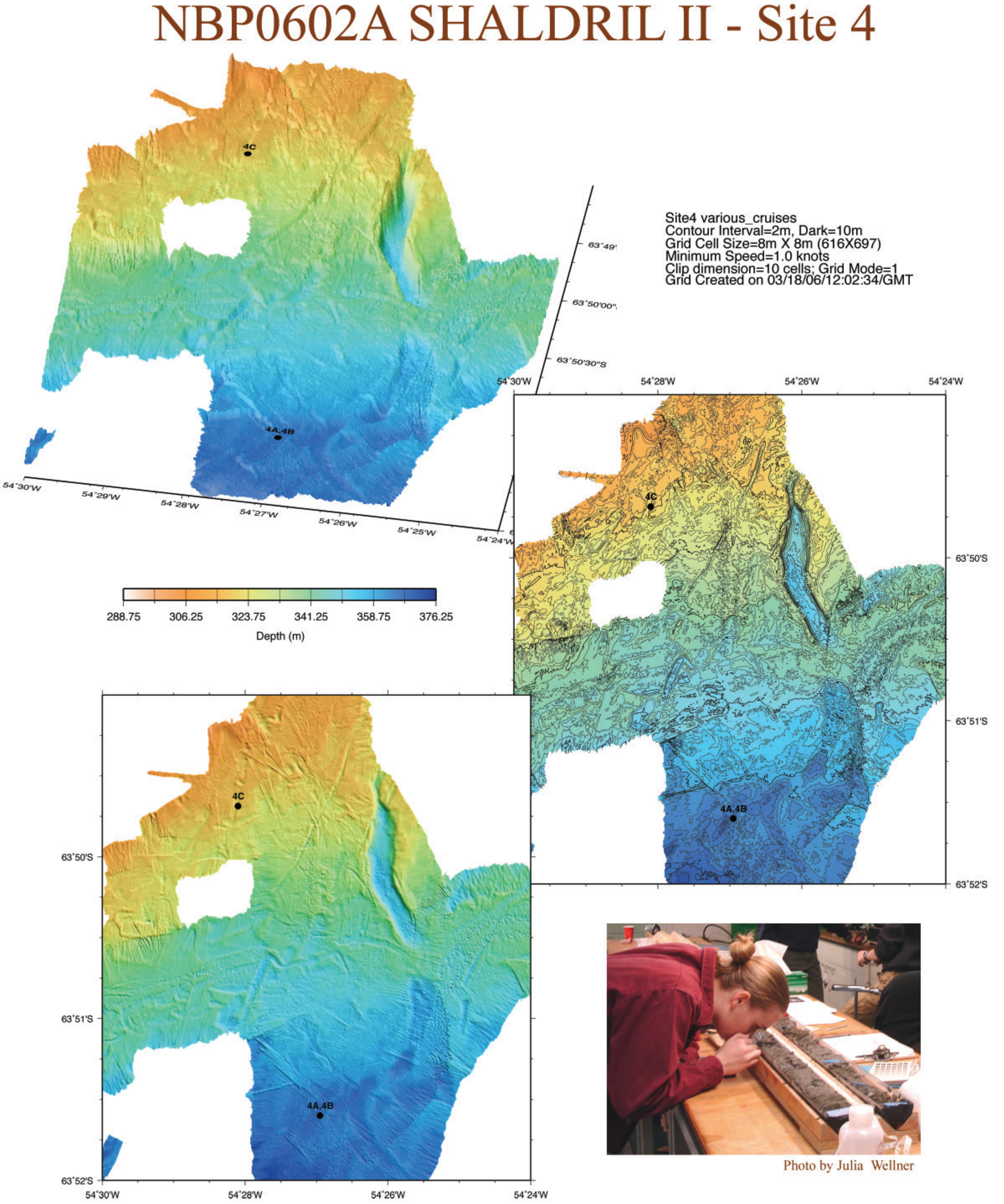


Figure 4-8. Locations of Holes NBP0602A-4A-KC, -4B-KC, and -4C on Seismic Line NBP0602A-01.

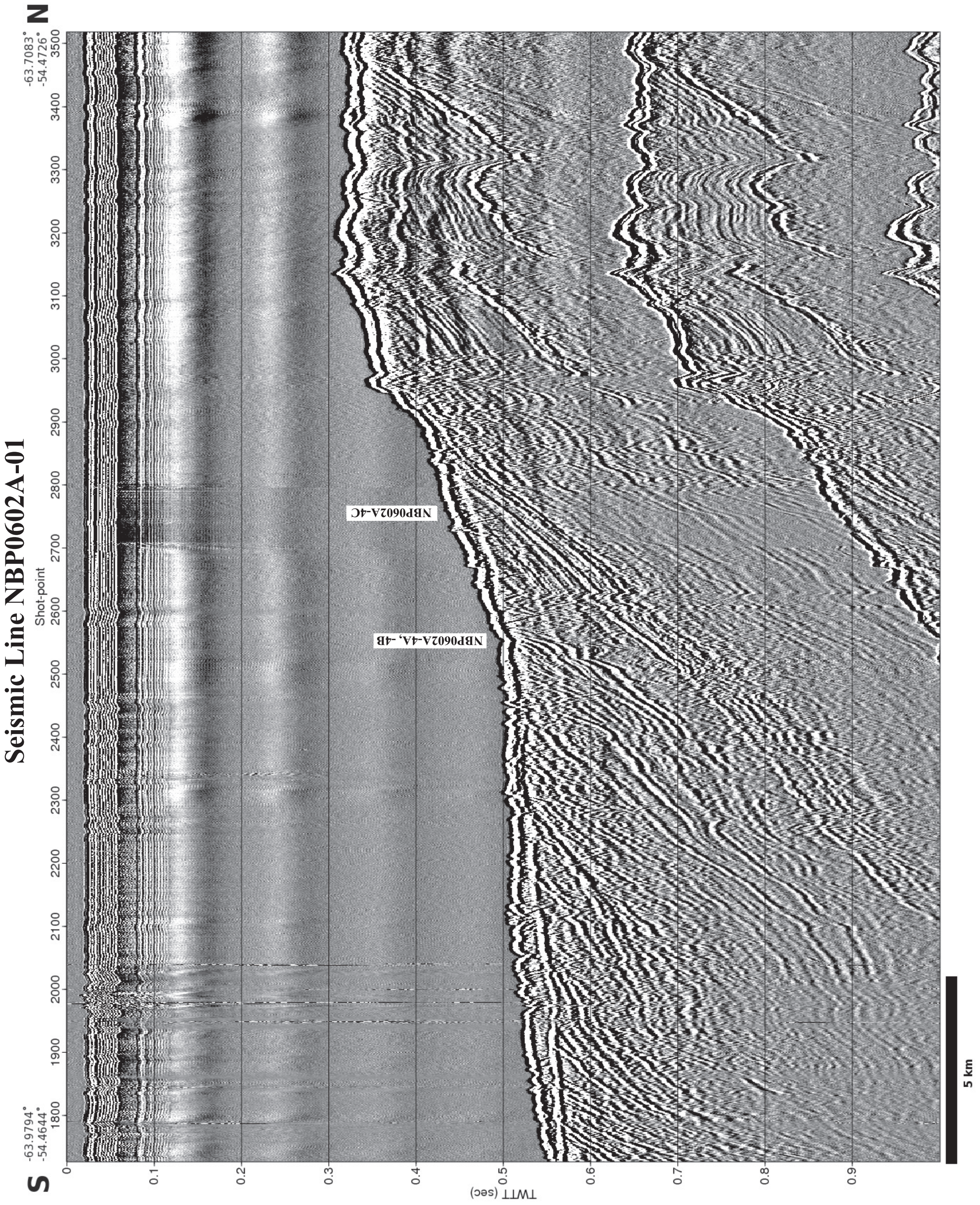


Figure 4-9. Summary lithologic log of Hole NBP0602A-4C.

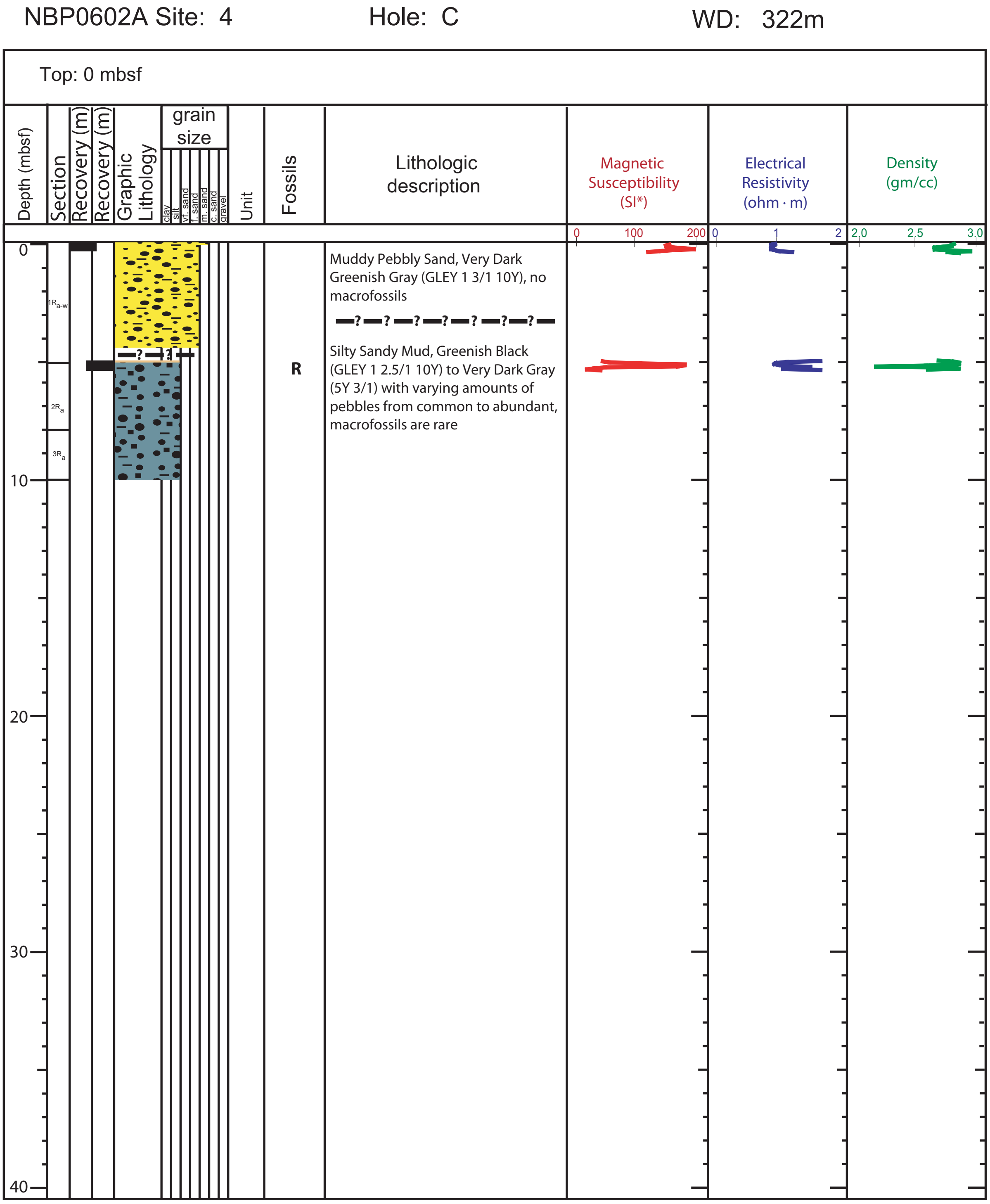


Table 4-5. Drilling and coring recovery log for Holes NBP0602A-4A-KC, -4B-KC, and -4C.

NBP0602A SHALDRIL II Site 4 (SE of Joinville Island)

Multibeam Water Depth: 363m @ A, 363m @ B, 322 @ C

Station Number/Hole	Core Number	Core Type	Top (mbsf)	Bottom (mbsf)	Interval Cored (m)	"Push Distance" (m)	Recovery: total (m)	Recovery: competent (m)	Recovery: disturbed (m)	Gaps (m)	Recovery Corrected (m)	Total Recovery (%)	Recovery Corrected (%)	Section Number	Section Lengths (cm)	Date (JD)	Time on Deck (GMT)	Initials	Comments
4A	1	KC	0.0	0.0	0	0.0	0	0	0	0	0	0.0%	0.0%	0	0.0	72	0730	JSW	No Recovery
4B	1	KC	0.0	0.0	0	0.0	0	0	0	0	0	0.0%	0.0%	0	0.0	72	0800	JSW	No Recovery
4C	1	Ra-w	0.0	5.0	washed	0.0	0.268	0	0.268	0	0	5.4%	0.0%	1	26.8	72	1555	CD	Disturbed core
4C	2	Ra	5.0	7.0	5.0-7.0	2.0	0.27	0.22	0.05	0	0.22	13.5%	11.0%	1	27.0	72	1658	CD	Core disturbed at top
4C	3	Ra	7.0	10.0	7.0-10.0	3.0	0	0	0	0	0	0.0%	0.0%	1	baggie	72	1845	CD	Drifted off station, 50 m off w/ 4 m in ground, no damage to pipe, appears to have pulled out of ground

Table 4-6. Smear-slide data for Hole NBP0602A-4C.

		Components											**Grain Size**						
		Minerals								**Biogenic**									
Sample	**Approximate Depth (mbsf)**	Calcite	Clay	Feldspar	Glauconite	Heavy Minerals	Hornblende	Mica	Quartz	Calcareous Nannofossils	Diatoms	Sponge Spicules	Sand	Silt	Clay	Sorting	Roundness	**Lithology**	**Comments**
Hole 4C																			
NBP0602A-4C-1$R_{a\text{-}w}$-CC	0-5.0	5	36	20	tr	3	tr	1	35		2	tr	30	40	30	P	a-sr	Sandy mud	Pyritized sponge spicules
NBP0602A-4C-2R_a-CC	5.27	2	48	10	tr	5	tr	tr	35	tr	1	tr	7	45	48	P	a-sr	Mud	Pyritized sponge spicules
NBP0602A-4C-3R_a-CC	7-10.0	5	49	10	1	4	1	tr	30		tr	tr	10	41	49	P	a-sr	Mud	

Notes: Sample: R_a = cored using alien coring bit; $R_{a\text{-}w}$ = wash cored using alien coring bit; Components/Grain Size: Numbers represent percentages, tr = trace; Sorting: P = poor; Roundness: a =

Table 4-7. Stratigraphic occurrence and relative abundance of diatom taxa in Hole NBP0602A-4C.

Cruise/Hole/Core/Interval	**Depth (mbsf)**	**Slide Preparation**	**Diatom Abundance**	**Preservation**	**Fragmentation**	**Diatoms**																				**Ebridians**
						Actinocyclus actinochilus	*Actinocyclus ingens*	*Actinoptychus* spp.	*Chaetoceros* spp. (small veg. cells & resting spores)	*Cocconeis* spp. (several taxa)	*Coscinodiscus* spp.	*Denticulopsis simonsenii / vulgaris*	*Fragilariopsis curta*	*Fragilariopsis cylindrus*	*Fragilariopsis kerguelensis*	*Fragilariopsis obliquecostata*	*Paralia* spp.	*Proboscia alata*	*Radialiplicata clavigera*	*Rhizosolenia* spp.	*Stellarima microtrias*	*Stephanopyxis* spp. (large, heavily silicified)	*Thalassiosira antarctica* var. *antarctica*	*Thal. gracilis* var. *gracilis / expecta*	*Thalassiothrix/Trichotoxon* spp.	*Falsebria ambigua*
Hole 4C																										
NBP0602A-4C-1R$_{a-w}$, 22 cm	0.0-5.0	smear	R	P	H	fr(X)		X	F	fr(X)		X	R	X	X	R		X		X	fr(X)		fr(X)	X		
NBP0602A-4C-1R$_{a-w}$-CC	0.0-5.0	smear	X	P	H		fr(X)		X			X									X			X	fr(X)	X
NBP0602A-4C-2R$_{a}$, 7 cm	5.07	smear	X	P	H		fr(X)												fr(X)			fr(X)				
NBP0602A-4C-2R$_{a}$, 13 cm	5.13	smear	X	P	H						fr(X)															
NBP0602A-4C-2R$_{a}$, 21 cm	5.21	smear	X	P	H														fr(X)							
NBP0602A-4C-2R$_{a}$-CC	5.27	smear	X	P	H				X		fr(X)											X				
NBP0602A-4C-3R$_{a}$-CC	7.0-10.0	smear	X	P	H				X								X		fr(X)			X				
NBP0602A-4C-3R$_{a}$, "bit face"	7.0-10.0	smear	X	P	H	fr(?)			X	fr(X)										X						

Notes: Abundance: R = rare, X = present, fr = fragment; Preservation: P = poor; Fragmentation: H = high.

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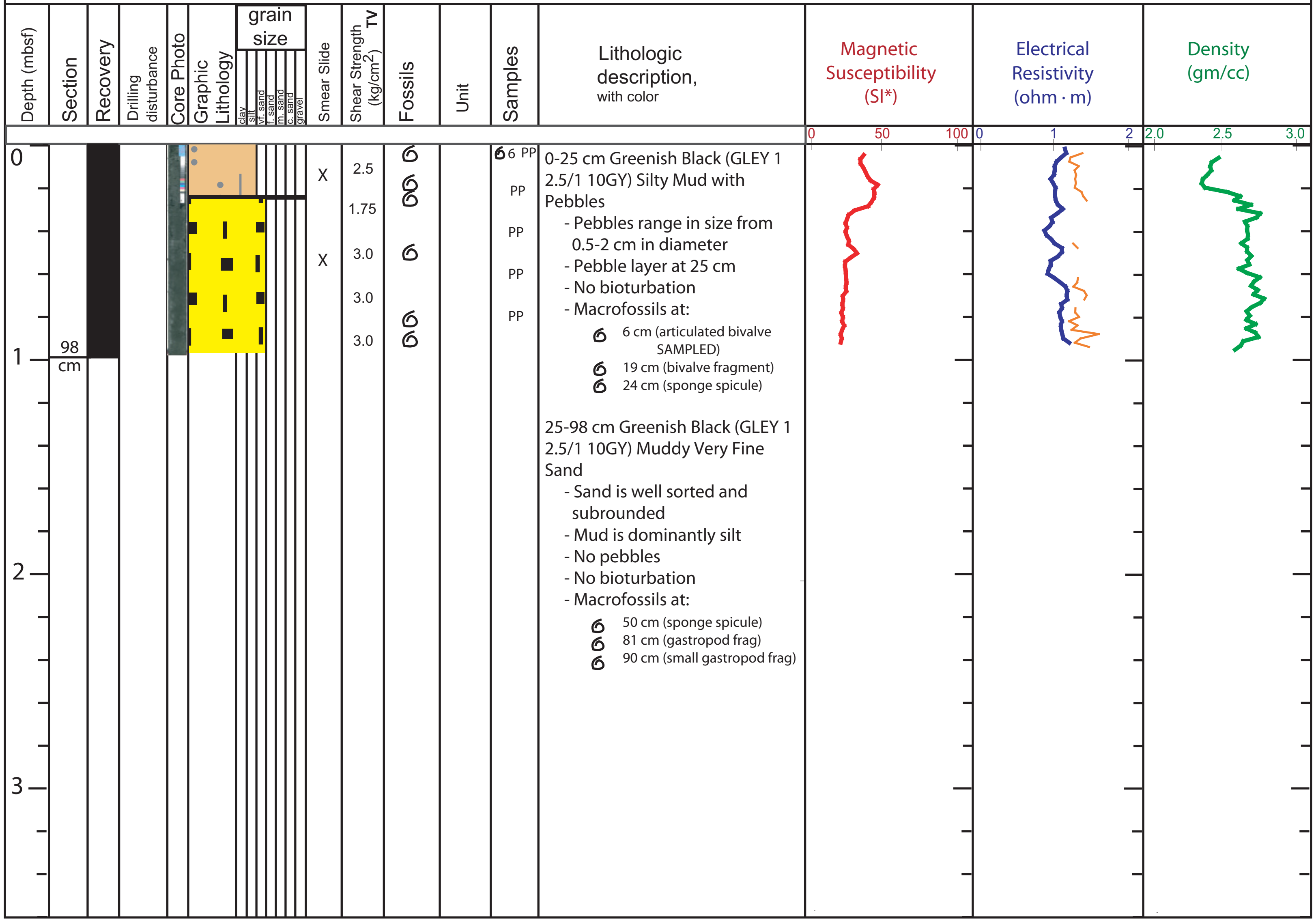
NBP0602A Site: 3 Hole: C Water Depth: 340m

Core Number: 1 Top 3.01 mbsf Core Type: R_a



0-25 cm Greenish Black (GLEY 1 2.5/1 10GY) Silty Mud with Pebbles

- Pebbles range in size from 0.5-2 cm in diameter
- Pebble layer at 25 cm
- No bioturbation
- Macrofossils at:
  - 6 cm (articulated bivalve SAMPLED)
  - 19 cm (bivalve fragment)
  - 24 cm (sponge spicule)

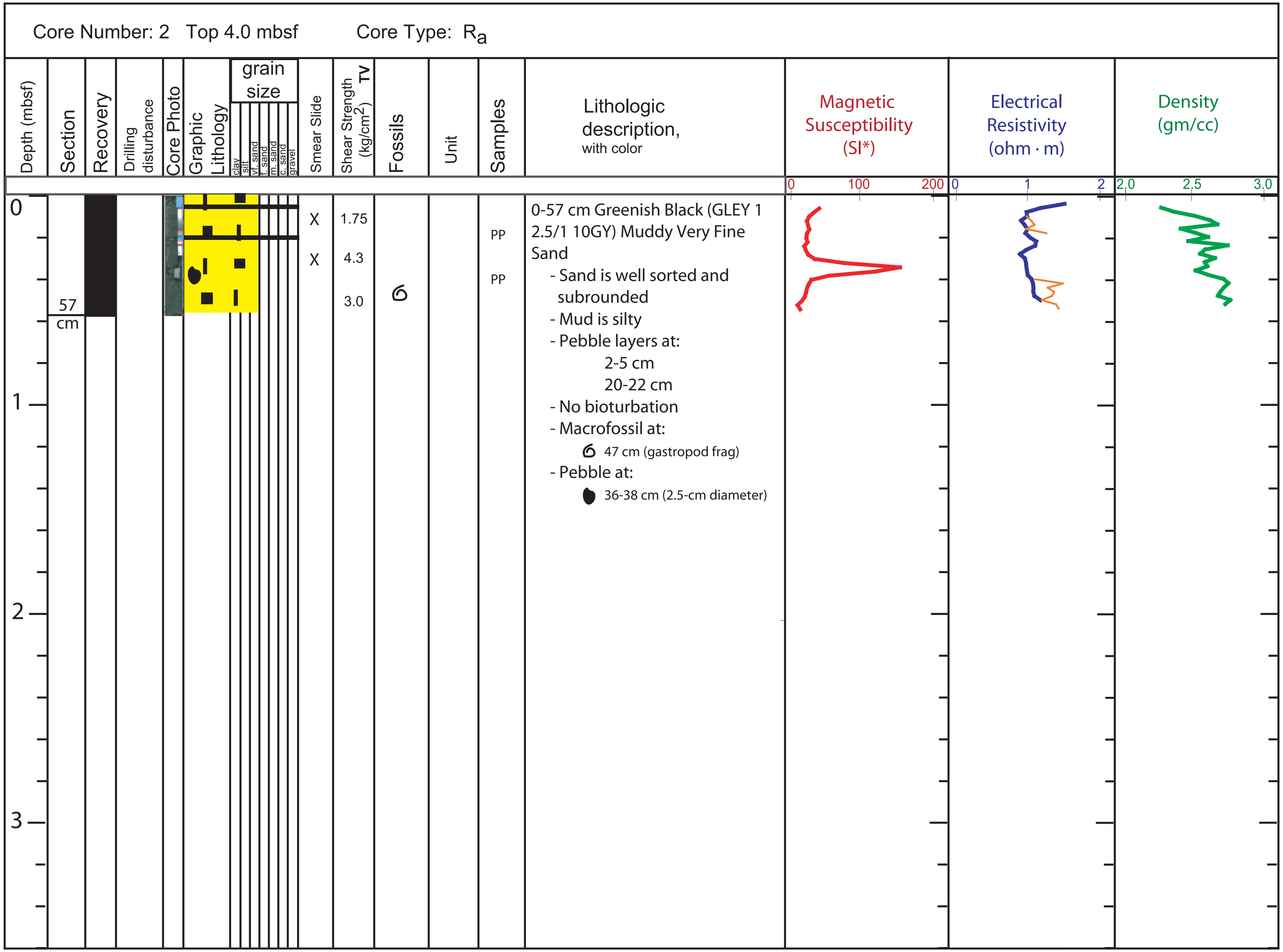
25-98 cm Greenish Black (GLEY 1 2.5/1 10GY) Muddy Very Fine Sand

- Sand is well sorted and subrounded
- Mud is dominantly silt
- No pebbles
- No bioturbation
- Macrofossils at:
  - 50 cm (sponge spicule)
  - 81 cm (gastropod frag)
  - 90 cm (small gastropod frag)

NBP0602A Site: 3 Hole: C

Water Depth: 340m

Core Number: 2 Top 4.0 mbsf Core Type: R_a



0-57 cm Greenish Black (GLEY 1 2.5/1 10GY) Muddy Very Fine Sand

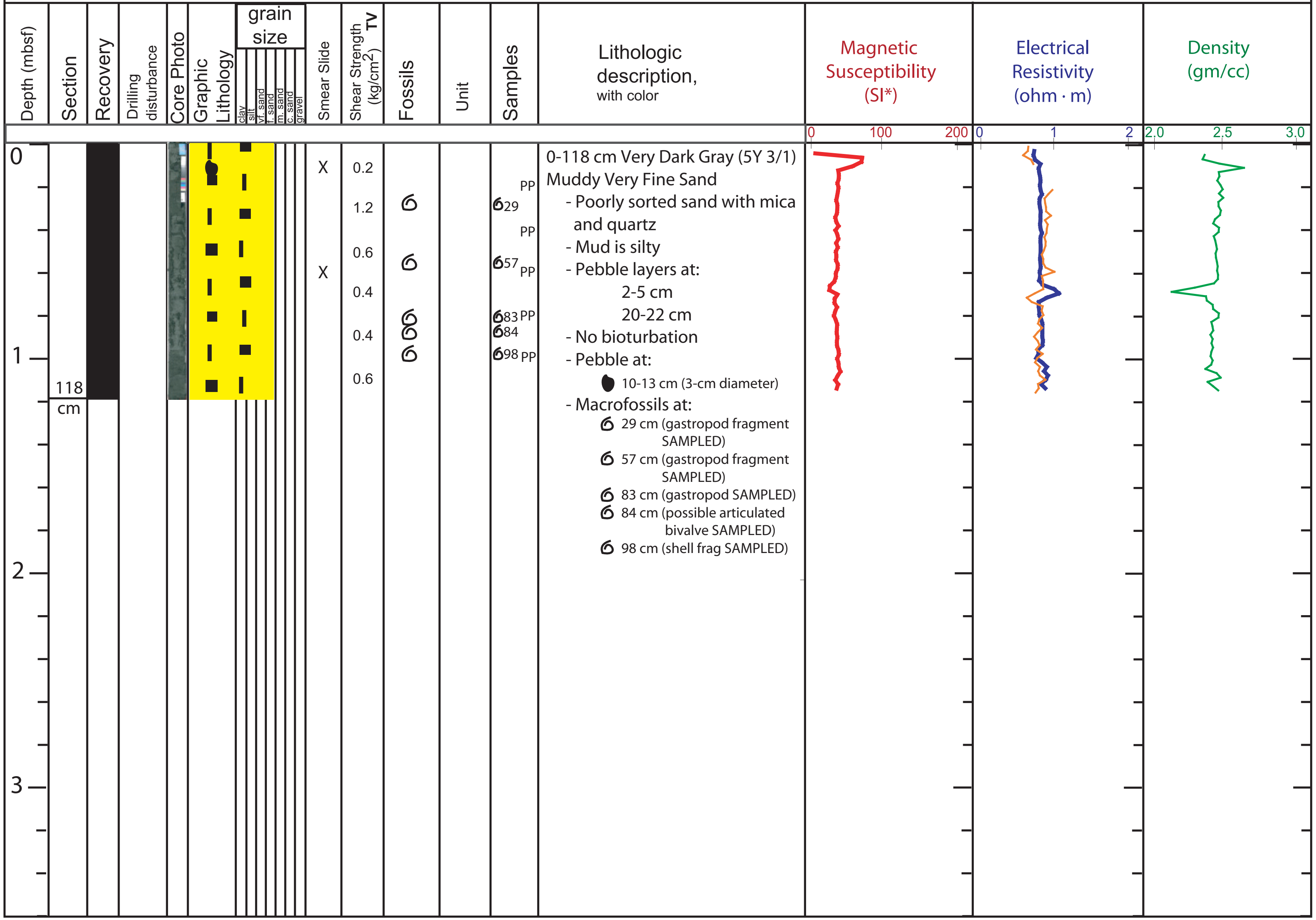
- Sand is well sorted and subrounded
- Mud is silty
- Pebble layers at:
  - 2-5 cm
  - 20-22 cm
- No bioturbation
- Macrofossil at:
  - 47 cm (gastropod frag)
- Pebble at:
  - ● 36-38 cm (2.5-cm diameter)

NBP0602A Site: 3 Hole: C

Water Depth: 342m

Core Number: 3 Top 7.5 mbsf

Core Type: R_a

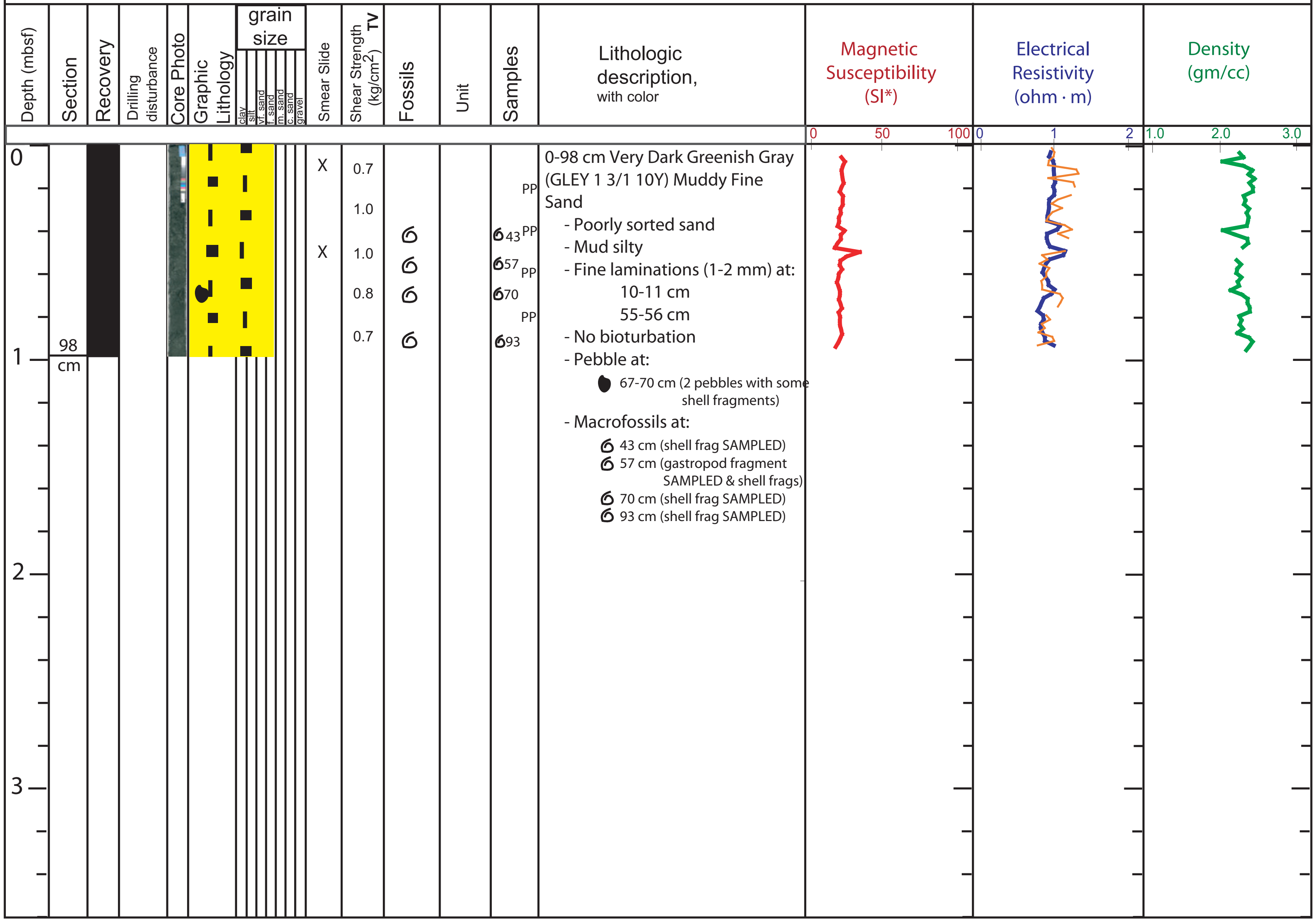


0-118 cm Very Dark Gray (5Y 3/1) Muddy Very Fine Sand
- Poorly sorted sand with mica and quartz
- Mud is silty
- Pebble layers at:
  - 2-5 cm
  - 20-22 cm
- No bioturbation
- Pebble at:
  - ● 10-13 cm (3-cm diameter)
- Macrofossils at:
  - 29 cm (gastropod fragment SAMPLED)
  - 57 cm (gastropod fragment SAMPLED)
  - 83 cm (gastropod SAMPLED)
  - 84 cm (possible articulated bivalve SAMPLED)
  - 98 cm (shell frag SAMPLED)

NBP0602A Site: 3 Hole: C

Water Depth: 340m

Core Number: 4 Top 9.0 mbsf Core Type: R_a

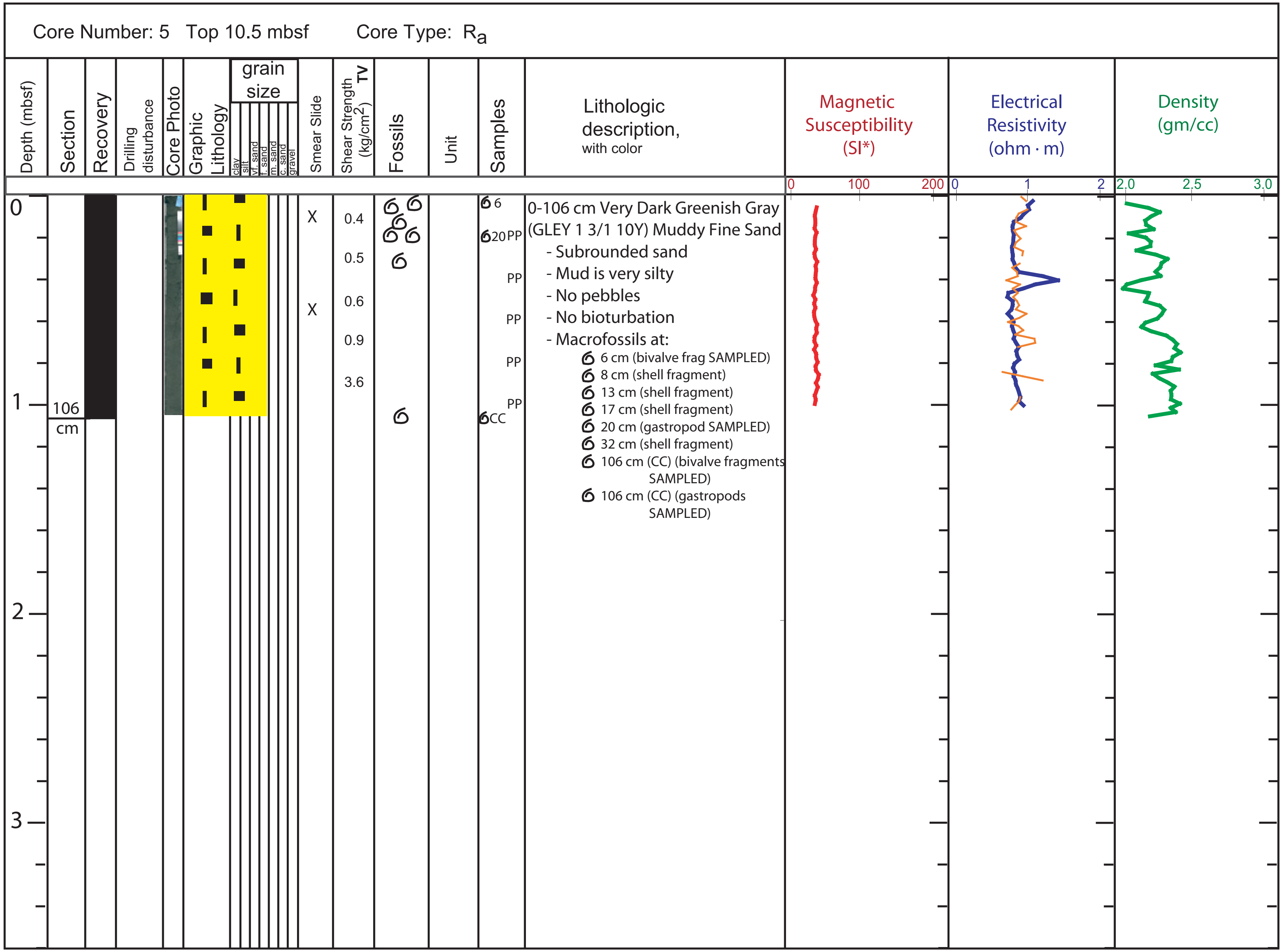


0-98 cm Very Dark Greenish Gray (GLEY 1 3/1 10Y) Muddy Fine Sand

- Poorly sorted sand
- Mud silty
- Fine laminations (1-2 mm) at:
  - 10-11 cm
  - 55-56 cm
- No bioturbation
- Pebble at:
  - ● 67-70 cm (2 pebbles with some shell fragments)
- Macrofossils at:
  - 🐚 43 cm (shell frag SAMPLED)
  - 🐚 57 cm (gastropod fragment SAMPLED & shell frags)
  - 🐚 70 cm (shell frag SAMPLED)
  - 🐚 93 cm (shell frag SAMPLED)

NBP0602A Site: 3 Hole: C

Water Depth: 340m



Core Number: 5 Top 10.5 mbsf Core Type: R_a

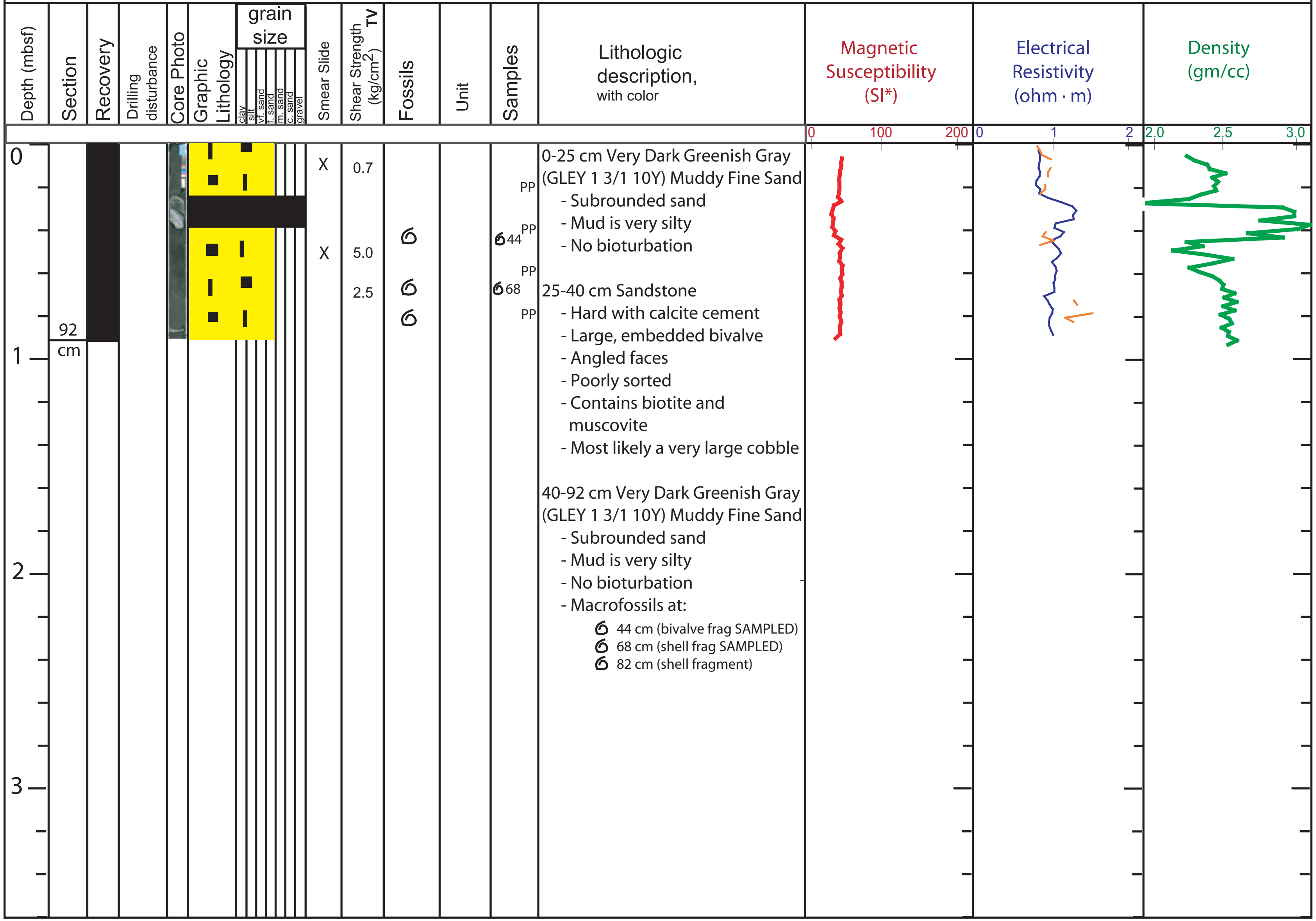
0-106 cm Very Dark Greenish Gray (GLEY 1 3/1 10Y) Muddy Fine Sand

- Subrounded sand
- Mud is very silty
- No pebbles
- No bioturbation
- Macrofossils at:
  - 6 cm (bivalve frag SAMPLED)
  - 8 cm (shell fragment)
  - 13 cm (shell fragment)
  - 17 cm (shell fragment)
  - 20 cm (gastropod SAMPLED)
  - 32 cm (shell fragment)
  - 106 cm (CC) (bivalve fragments SAMPLED)
  - 106 cm (CC) (gastropods SAMPLED)

NBP0602A Site: 3 Hole: C

Water Depth: 340m

Core Number: 6 Top 12.0 mbsf Core Type: R_a



0-25 cm Very Dark Greenish Gray (GLEY 1 3/1 10Y) Muddy Fine Sand
- Subrounded sand
- Mud is very silty
- No bioturbation

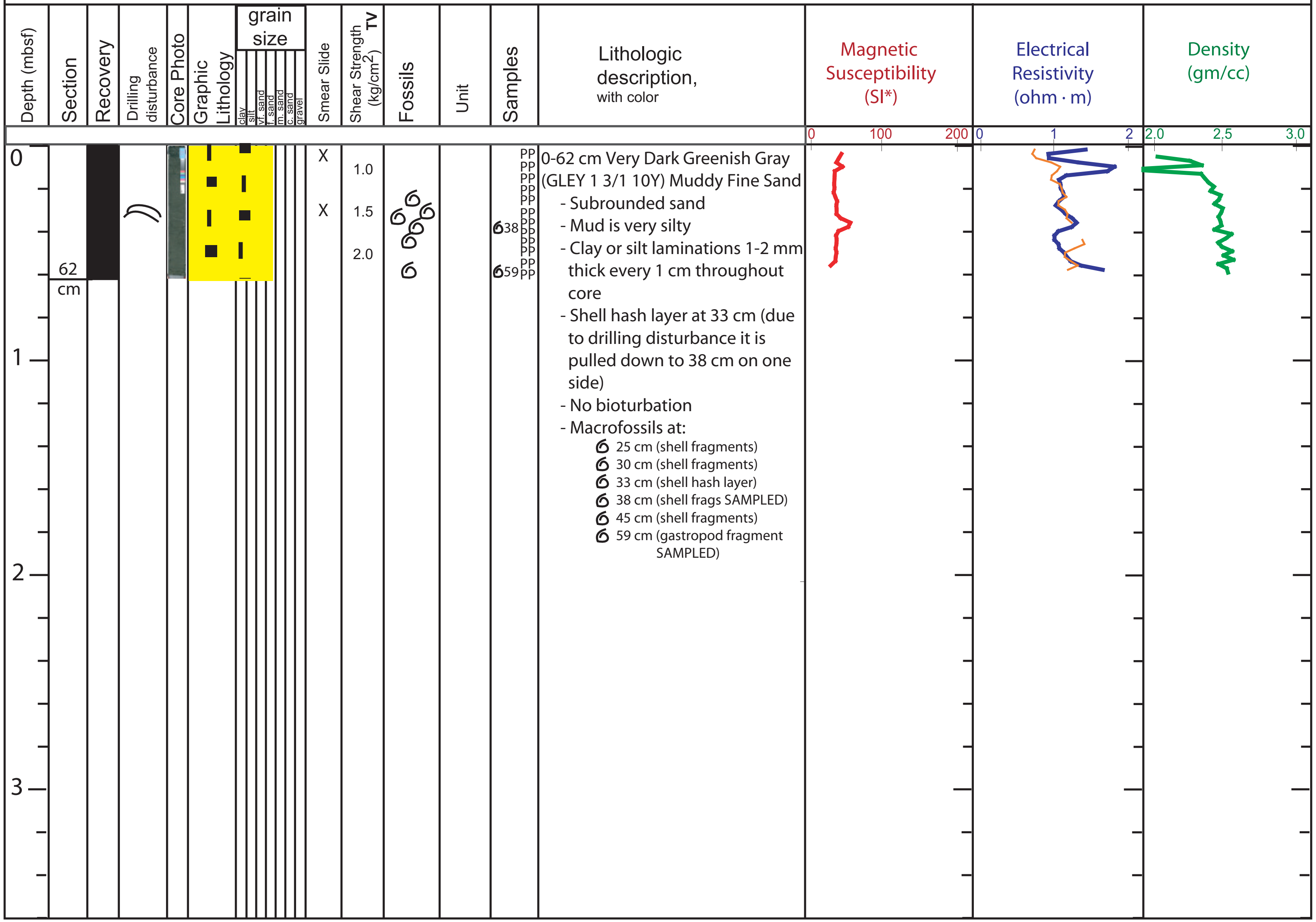
25-40 cm Sandstone
- Hard with calcite cement
- Large, embedded bivalve
- Angled faces
- Poorly sorted
- Contains biotite and muscovite
- Most likely a very large cobble

40-92 cm Very Dark Greenish Gray (GLEY 1 3/1 10Y) Muddy Fine Sand
- Subrounded sand
- Mud is very silty
- No bioturbation
- Macrofossils at:
  - 44 cm (bivalve frag SAMPLED)
  - 68 cm (shell frag SAMPLED)
  - 82 cm (shell fragment)

NBP0602A Site: 3 Hole: C

Water Depth: 340m

Core Number: 7 Top 13.5 mbsf Core Type: R_a

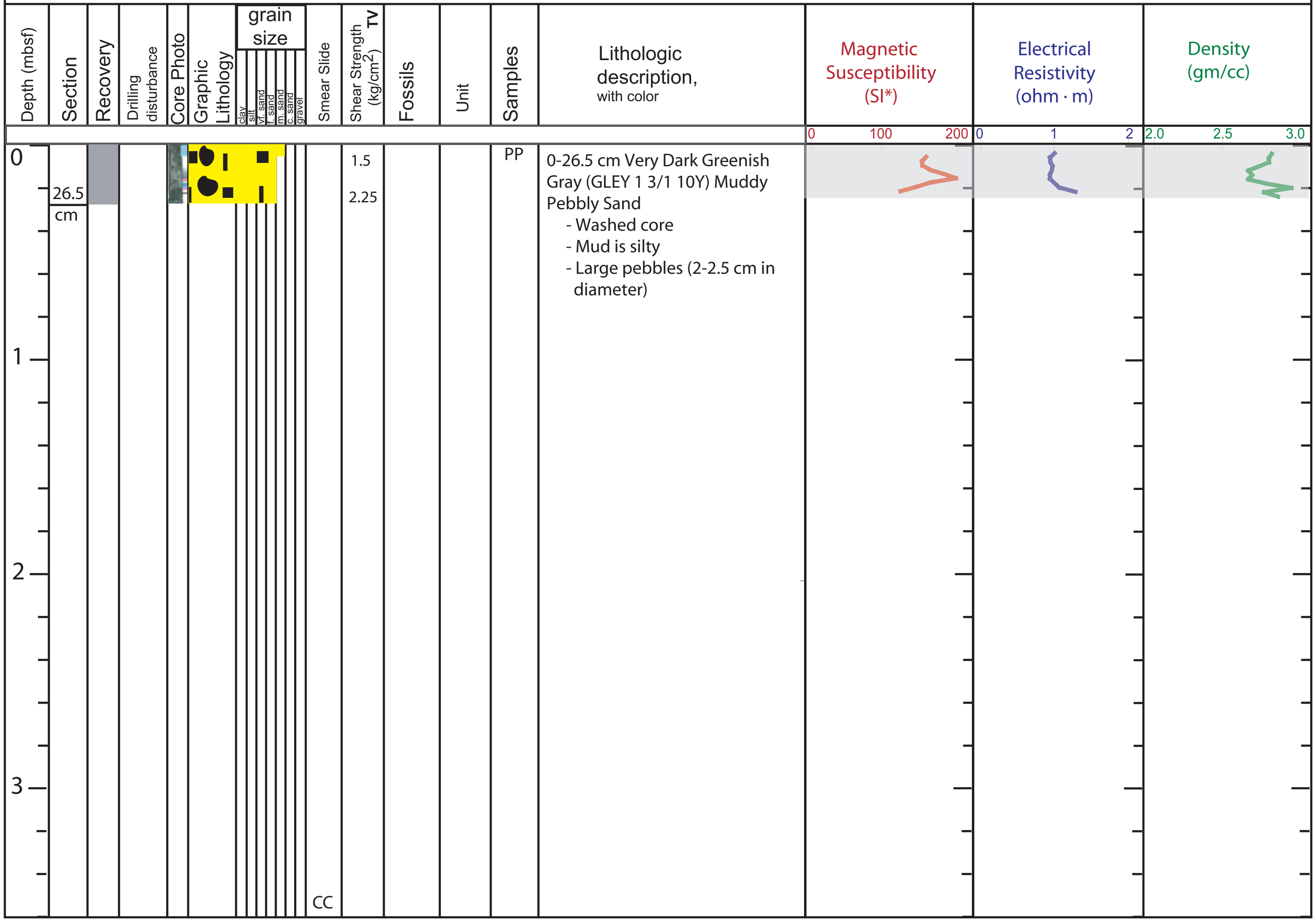


0-62 cm Very Dark Greenish Gray (GLEY 1 3/1 10Y) Muddy Fine Sand

- Subrounded sand
- Mud is very silty
- Clay or silt laminations 1-2 mm thick every 1 cm throughout core
- Shell hash layer at 33 cm (due to drilling disturbance it is pulled down to 38 cm on one side)
- No bioturbation
- Macrofossils at:
  - 25 cm (shell fragments)
  - 30 cm (shell fragments)
  - 33 cm (shell hash layer)
  - 38 cm (shell frags SAMPLED)
  - 45 cm (shell fragments)
  - 59 cm (gastropod fragment SAMPLED)

NBP0602A Site: 4 Hole: C Water Depth: 322m

Core Number: 1 Top 0.0 mbsf Core Type: R_a

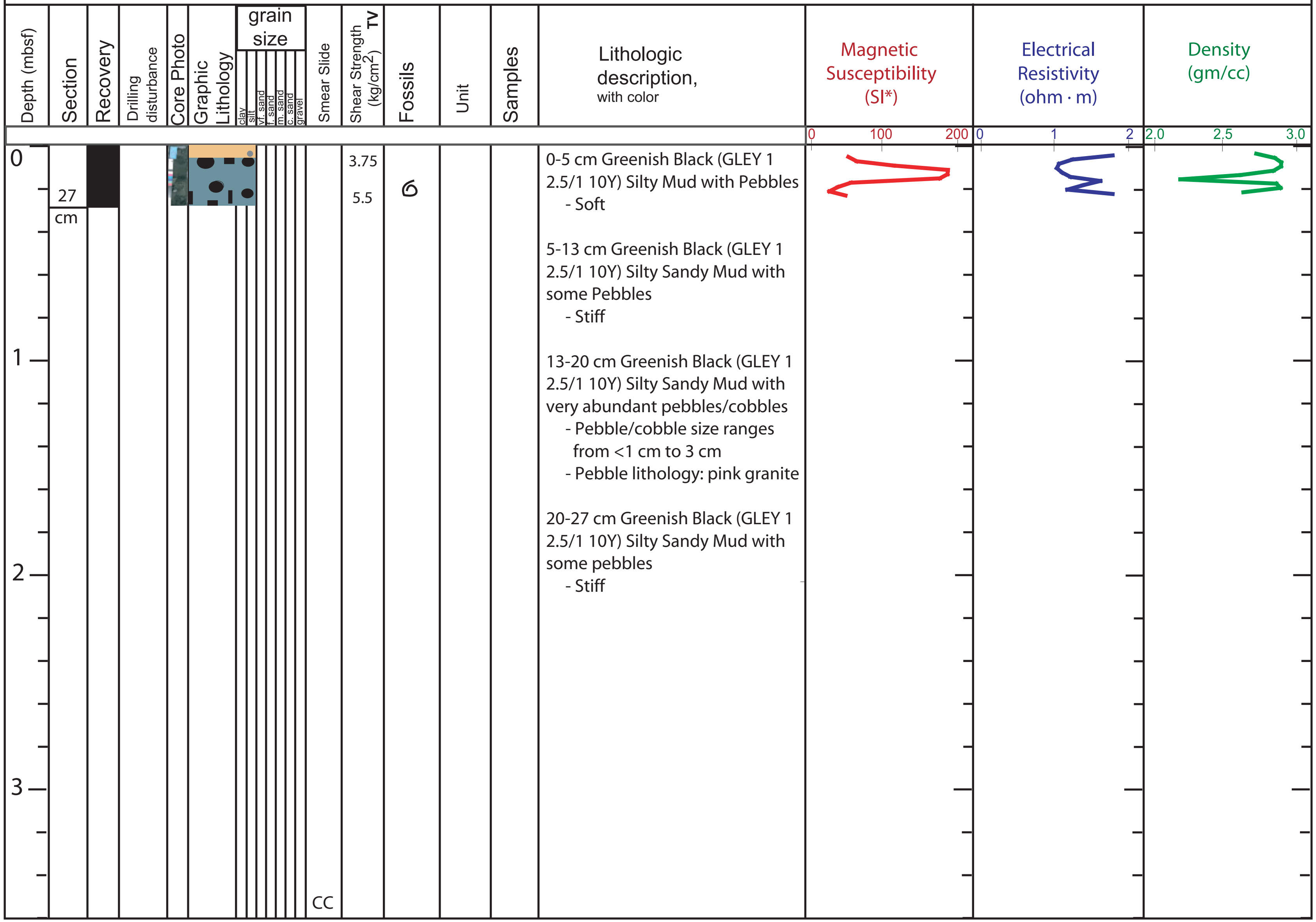


0-26.5 cm Very Dark Greenish Gray (GLEY 1 3/1 10Y) Muddy Pebbly Sand
- Washed core
- Mud is silty
- Large pebbles (2-2.5 cm in diameter)

NBP0602A Site: 4 Hole: C

Water Depth: 322m

Core Number: 2 Top 5.0 mbsf Core Type: R_a



0-5 cm Greenish Black (GLEY 1 2.5/1 10Y) Silty Mud with Pebbles
- Soft

5-13 cm Greenish Black (GLEY 1 2.5/1 10Y) Silty Sandy Mud with some Pebbles
- Stiff

13-20 cm Greenish Black (GLEY 1 2.5/1 10Y) Silty Sandy Mud with very abundant pebbles/cobbles
- Pebble/cobble size ranges from <1 cm to 3 cm
- Pebble lithology: pink granite

20-27 cm Greenish Black (GLEY 1 2.5/1 10Y) Silty Sandy Mud with some pebbles
- Stiff

CHAPTER 5: SITES 5, 6, and 7
Table of Contents

HOLES NBP0602A-5A-KC, -5B-KC, -5C

Date/time occupied (date; Julian Day; GMT): 15 March 2006; 074; 0700

Date/time departed: 15 March 2006; 074; 1630

Time on station: 9 hr, 30 min

Geographic area: Joinville Plateau

Ice coverage during station: $^{1}/_{10}$

Kasten Cores: 63° 15.110' S, 52° 21.908' W; 506 meters below sealevel (mbsl)

NBP0602A-5A-KC: No recovery
NBP0602A-5B-KC: No recovery

Drill Hole 5C: 63° 15.110' S, 52° 21.908' W

Water depth (multibeam, m): 506

Water depth (drill-pipe measurement from sea level, m): 510

Total penetration (m): 11.97[1]

Number of drill runs: 2

Total length of cored section (m): 3.47

Total drill core recovered (m): 0

Drill-core recovery (%): 0

Oldest sediment drilled: N/A

HOLE NBP0602A-5D

Date/time occupied (date; Julian Day; GMT): 15 March 2006; 074; 1630

Date/time departed: 17 March 2006; 076; 0215

Time on station: 33 hr, 45 min

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[1] Sub-bottom depths for Hole NBP0602A-5C are based on the multibeam depth. See Site 5 "**Operations**" for discussion.

Geographic area: Joinville Plateau

Ice coverage during station: $^1/_{10}$

Position: 63° 15.090' S, 52° 21.939' W

Water depth (multibeam, m): 506

Water depth (drill-pipe measurement from sea level, m): 510

Total penetration (m): 31.4[2]

Number of drill runs: 13

Total length of cored section (m): 23.4

Total drill core recovered (m): 12.56

Drill-core recovery (%): 40

Oldest sediment drilled:
  Depth sub-bottom (m): 31.4
  Nature: Silty mud
  Age: Late middle Miocene

Principal Results: After experiencing the hazards of drilling within striking distance of moving sea ice at our first four sites, we elected to seek comparable drilling targets along the southern margin of the Joinville Plateau, well north of the sea-ice front. After a seismic survey, Site NBP0602A-5 was selected to sample the older part of the Cenozoic section in an area with $^1/_{10}$ or less ice coverage.

When two Kasten cores failed to return sediment, a surface gravel lag formed by bottom currents was suspected to be the culprit. With the initiation of Hole NBP0602A-5C, the driller felt bottom with the drill pipe at a depth 4.15 m below that given by multibeam. When the second core run reached 11.97 mbsf, shear pins in the overshot tool sheared. After fishing out the overshot and retrieving the core barrel, the ship was offset 20 m to drill Hole NBP0602A-5D. Again, the driller did not sense bottom until 4.15 m below the depth indicated by multibeam; however, 13 consecutive core runs between 8.0-31.4 mbsf yielded 40% recovery, primarily through lower Pliocene and middle Miocene clastic sediments.

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[2] Sub-bottom depths for Hole NBP0602A-5D are based on the multibeam depth. See Site 5 “**Operations**” for discussion.

The lithologic succession from Hole NBP0602A-5D is divided into five sedimentary units. Lithologic Unit I includes sediment retrieved from the first core run, which spans 8.0-12.15 mbsf after washing to 8 mbsf. Unit I includes two subunits: Subunit IA consists of sand and diamicton containing a modern diatom assemblage between 8.0-8.80 mbsf; Subunit IB, which extends from 8.80-12.15 mbsf, is muddy fine sand, distinguished from Subunit IA by the lack of pebbles and Pliocene-aged diatoms. Litholologic Unit II (12.15-15.0 mbsf) is firm sandy, silty diatomaceous mud of early Pliocene age. Lithologic Unit III (15.0-22.18 mbsf) is stiff, black to dark greenish gray, fine to medium muddy sand with 5-7% diatoms. The Miocene/Pliocene boundary appears to be represented by a disconformity within this unit between 16.25 and 16.45 mbsf; lower Pliocene diatoms above this boundary are poorly preserved and highly fragmented. The markedly finer grained Lithologic Unit IV (22.18-25.07 mbsf) is virtually devoid of sand, but a return to a sandier lithology distinguishes Lithologic Unit V (25.07-31.40 mbsf), a stiff middle Miocene, greenish black, sandy, silty mud with pebbles.

Much of Lithologic Units II, III, and V smelled of hydrogen sulfide. Additionally, soft, white layers (possibly gypsum) occur in Units III and V, and an interval of small (≤10 μm) authigenic dolomite rhombs that comprise up to 50% of the sediment occurs near the base of Core NBP0602A-5D-5$R_{a.}$ All of these indicate relatively high organic content within the sediment. Deposition in an oxygen-deficient environment is further suggested by a lack of bioturbation throughout the section, the lack of shell material except in Unit I, and the preservation of small, dark fragments thought to be wood near the base of Unit III.

According to diatom biostratigraphy, the lower Pliocene diatom assemblages from 8.85 to 16.00 mbsf are between 4.4-5.1 Ma in age. These are separated by a hiatus of ~6.7 m.y. from subjacent middle Miocene strata that are between 11.8-12.7 Ma in age.

Most variations in physical properties in Hole NBP0602A-5D are attributed to cobbles and pebbles scattered throughout the section. Density, MS, and ER measurements decrease concurrently at the 7 cm, white, non-effervescent layer thought to be gypsum. There is little downhole increase in physical properties, which suggests the sands have been reworked and winnowed, thereby allowing grain-to-grain contact that prevents downhole compaction.

When the 13th core run reached 31.4 mbsf, the pipe twisted off just above the mudline, leaving the drill collars and bottom hole assembly in the ground. Throughout the operation the bit or pipe sometimes jammed. The consistent 4.15 m discrepancy between the mudline depth measured by pipe and multibeam in both Holes NBP0602A-5C and -5D suggests that the pipe, under the influence of bottom currents, may have entered the hole at an angle, thereby producing stresses that caused the failure.

HOLES NBP0602A-6A-KC, -6B-KC, -6C

Date/time occupied (date; Julian Day; GMT): 17 March 2006; 076; 0330

Date/time departed: 18 March 2006; 077; 0745

Time on station: 28 hr, 15 min

Geographic area: Joinville Plateau

Ice coverage during station: $^{1}/_{10}$

Kasten Cores: 63° 20.268' S, 52° 22.032' W; 532 mbsl

NBP0602A-6A-KC: No recovery
NBP0602A-6B-KC: No recovery

Drill Hole 6C: 63° 20.268' S, 52° 22.032' W

Water depth (multibeam, m): 532

Water depth (drill-pipe measurement from sea level, m): 531

Total penetration (m): 20.5

Number of drill runs: 9

Total length of cored section (m): 16.5

Total drill core recovered (m): 5.882

Drill-core recovery (%): 28

Oldest sediment drilled:
Depth sub-bottom (m): 20.5
Nature: Pebbly, muddy sand
Age: Early Pliocene

HOLE NBP0602A-6D, -6E-GS

Date/time occupied (date; Julian Day; GMT): 18 March 2006; 077; 0745

Date/time departed: 18 March 2006; 077; 2200

Time on station: 14 hrs, 15 min

Geographic area: Joinville Plateau

Ice coverage during station: $^{1}/_{10}$ to $^{2}/_{10}$

Grab Sample 6E-GS: 63° 19.746' S, 52° 22.040' W; 528 mbsl

NBP0602A-6E-GS: Holocene sandy diatomaceous mud

Drill hole 6D: 63° 19.746' S, 52° 22.040' W

Water depth (multibeam, m): 528

Water depth (drill-pipe measurement from sea level, m): 529

Total penetration (m): 10

Number of drill runs: 3

Total length of cored section (m): 4.8

Total drill core recovered (m): 2.27

Drill-core recovery (%): 47

Oldest sediment drilled:
Depth sub-bottom (m): 10
Nature: Sandy mud
Age: Early Pliocene

Principal Results: After the drill string parted just above the collars in Hole NBP0602A-5D, the vessel was repositioned down dip 5.5 nautical miles to the south in order to sample section approximately 150 m above the middle Miocene strata successfully sampled at Site NBP0602A-5.

Two Kasten cores yielded no sediment although a surface grab sample taken after the previous drill hole returned full of Holocene sandy diatomaceous mud. Eight core runs in Hole NBP0602A-6C penetrated to 20.5 mbsf with 28% recovery in lower Pliocene dark pebbly and muddy sands. Diatoms comprise from 7 to 10% of the <250 µm fraction. The sandy units are interpreted as traction current deposits.

Variations observed in the MSCL-MS, -ER, and -density measurements are attributed to pebbles and rocks throughout the core. Many of the pebbles are basaltic lithologies that give large increases in MS. As observed at Site NBP0602A-5, there is little downhole increase in physical properties, again suggesting that these sediments have undergone some physical sorting.

Cores NBP0602A-6C-2R_a to -7R_a (~4.0 to 17.0 mbsf) contain few to common, moderately well preserved, but generally highly fragmented diatoms. Those in Cores 2R_a to 6R_a (~4.0 to 15.0 mbsf) belong to the *Fragilariopsis barronii* Zone (~3.8 and 4.4 Ma), whereas those in Core 7R_a (~16.0 to 17.0 mbsf) are tentatively placed in the *Thalassiosira inura* Zone (~4.4 to 5.1 Ma). Diatoms are very rare and poorly preserved in the remainder of the hole and are given a broad age assignment of ~4.0 to 9.0 Ma.

Despite the fact that ice coverage remained below $^1/_{10}$ as Hole NBP0602A-6C was drilled, during the pre-dawn hours in heavy fog the ship's radar showed a large solitary iceberg on course with the ship. The pipe was pulled above the mudline and the ship offset approximately 0.5 km, where Hole NBP0602A-6D was drilled in an effort to penetrate through the Pliocene cover to the older dipping strata below. After three cores this hole was also terminated due to another solitary iceberg.

HOLES NBP0602A-7A-KC, -7B

Date/time occupied (date; Julian Day; GMT): 19 March 2006; 078; 1115

Date/time departed: 20 March 2006; 079; 0030

Time on station: 13 hr, 15 min

Geographic area: Joinville Plateau

Ice coverage during station: $^1/_{10}$ to $^2/_{10}$

Kasten Core: 63° 17.016' S, 52° 46.020' W; 448 mbsl

NBP0602A-7A-KC: 48 cm of Quaternary pebbly, muddy sand

Drill Hole 6C: 63° 17.016' S, 52° 46.020' W

Water depth (multibeam, m): 448

Water depth (drill-pipe measurement from sea level, m): 447

Total penetration (m): 6

Number of drill runs: 1

Total length of cored section (m): 6 (washed)

Total drill core recovered (m): 0.31

Drill-core recovery (%): N/A

Oldest sediment drilled:
Depth sub-bottom (m): 0 to 6
Nature: Sandy mud
Age: Plio-Pleistocene

Principal Results: After encroaching solitary icebergs terminated both drill holes at Site NBP0602A-6, a seismic survey along the Joinville Plateau helped locate a site where lower Miocene units could be sampled below the middle Miocene recovered at Site NBP0602A-5. A Kasten core recovered 48 cm of poorly sorted, pebbly, muddy sand with a gravel lag at the top; it yielded a modern sea-ice diatom assemblage. Hole NBP0602A-7B drilled rather slowly and with some difficulty in firm sediment. A wash core to 6 mbsf returned 31 cm of disturbed sediment with rare, poorly preserved Plio-Pleistocene diatoms.

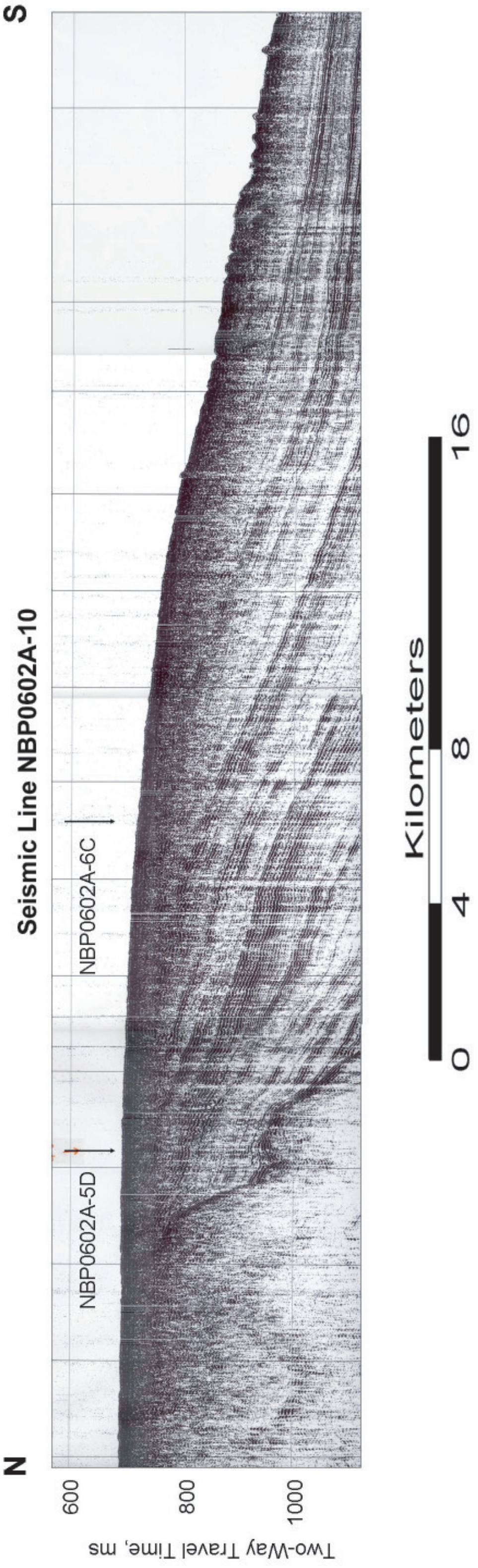
During the second core run, the drill string became stuck. While efforts were made to free it, the locking coupling of the bottom hole assembly (BHA) sheared, leaving the alien bit and most of the BHA in the hole. The failure may be related at least in part to the design and/or manufacture of the coupling; however, the pull on the BHA should not have been sufficient to break it unless it was at an angle.

SEISMIC STRATIGRAPHY

The Joinville Plateau study area is bounded north and south by 63° 10' S and 63° 30' S, and east and west by 52° 17' W and 52° 54' W (Fig. 4-3). The area is characterized by a thick, southward dipping succession of sedimentary strata (Fig. 5-1). The contact between acoustic basement and sedimentary deposits trends roughly east to west and is characterized by onlap of the section against basement. The sedimentary section is at least 1.5 seconds thick and is virtually undeformed, except for minor normal faults near the basement contact. The basement is mostly non-reflective, although there are some layered intervals suggesting either a volcanic or sedimentary origin. The acoustic character of the overlying stratigraphic section is highly laminated, with strongly reflective units alternating with less reflective units in cyclic fashion. Individual reflectors are continuous.

The overall stratigraphic architecture of the area differs from that offshore Seymour Island in that it lacks the alternating progradational and aggradational units and bounding unconformities described by Anderson et al. (1992) and Sloan et al. (1995). There is no distinct shelf break. Rather, the margin has a ramp-like character. There is a prominent seafloor unconformity that truncates topset beds and offlap breaks, so the upper half of the stratigraphic section can be sampled within a few meters of the seafloor.

Figure 5-1. Seismic Line NBP0602A-10 showing the locations of Holes NBP0602A-5D and -6C.



SITE 5

A. OBJECTIVES

Site NBP0602A-5 (Fig. 5-2) was the first site drilled on the Joinville Island Plateau margin (Fig. 4-3). The stratigraphic architecture of the sedimentary package in this area is markedly different from that to the west, so we were not able to apply our seismic stratigraphic age model when selecting drill sites. Thus, the site was selected to sample the oldest part of the section situated within a few tens of meters of the seafloor (Fig. 5-1). The target interval was penetrated at 21 mbsf and found to be middle Miocene in age. We were able to sample approximately 12 m of the section before the drill pipe broke, forcing us to abandon the hole.

B. OPERATIONS

Site NBP0602A-5 consists of two Kasten cores and two drill holes. Holes NBP0602A-5A-KC, -5B-KC, and -5C are located at 63° 15.110' S, 52° 21.908' W in 506 m of water. Hole NBP0602A-5D is located at 63° 15.090' S, 52° 21.939' W in 506 m of water. The two Kasten cores were taken immediately after arriving onsite to help determine the seafloor characteristics. Neither returned any sediment so the bottom was assumed to have a gravel lag preventing penetration of the Kasten corer.

Hole NBP0602A-5C was begun at the same location as the Kasten cores using the alien bit. The driller could not tell that the mudline had been reached until a calculated depth, based on the multibeam, of 4.15 mbsf (Table 5-1). The hole was intentionally washed to a depth of 8.5 mbsf (based on the multibeam) before coring was attempted. Drilling in the hole reached a maximum depth of 11.97 mbsf and an attempt was then made to retrieve core from this interval. The overshot tool, which is used to pick up the coring tool, was lowered into the hole. When retrieval was attempted, the shear pins at the top of the overshot sheared, leaving the coring tool and the overshot in the hole. An *ad hoc* fishing tool was made and hammered over the top of the overshot. These two pieces were retrieved and then a spare overshot was used to pick up the coring tool. For safety, the hole was abandoned after this retrieval process and was restarted at an offset of about 20 m.

Hole NBP0602A-5D was begun using the alien bit and intentionally washed to 8 mbsf. Thirteen coring runs were completed reaching a maximum depth of 31.4 mbsf. A total of 12.56 m of core was recovered, representing 40% total recovery. It should be noted that several of the core runs (Table 5-1) actually had over 100% recovery. This excess material likely represents material that dropped out of the previous core run. Throughout the time spent at this hole the drillers felt that it was caving in and jamming with cobbles, making it hard to keep open. They thought it might be difficult to pull the pipe when the hole was completed; however, it still came as a surprise, when the pipe sheared off just above the mudline after the 31.4 mbsf core run (Fig. 5-3). All of the collars and the bottom hole assembly (BHA) were left in the ground. The alien bit was stuck at the break in the pipe and retrieved.

Analysis after retrieving the broken pipe did little to give a final explanation for the cause of the parting. The prevailing theory for the source of the problems in both holes is that currents in the area forced the pipe to become offset before hitting the mudline. Such a deviation would indicate the hole was begun at an angle, putting too much stress on the pipe where it angled into the ground. The acoustic Doppler current profiler (ADCP) data indicates some current in the area and the cobbly bottom also indicates fast flow near the seafloor. The ADCP is not accurate all the way to the bottom of the water column, so the exact current speeds are not known. At both Holes NBP0602A-5C and -5D the driller estimated to have reached the mudline at about 4.15 m deeper than indicated by the multibeam; at all previous holes the pipe found mudline within 1 m of the multibeam reading. In 506 m of water, a difference of 4.15 m to find bottom indicates on offset of 65 m, which is greater than the acceptable deviation between the moonpool and the hole location. It seems obvious now that a hole should not be started with such an offset; however, drilling from other vessels often occurs with depth soundings that are only accurate to 20 m or more. Thus, in beginning the hole with such a discrepancy in depth to mudline, the drillers did not take full advantage of the ability to measure so accurately the true depth with sonar, rather than with pipe. In the future, not only do currents need to be more carefully monitored, but also any discrepancy in depth to mudline needs to be analyzed before proceeding. While this is the main hypothesis for why the pipe broke, there are others. They include metal fatigue in the pipe, lack of transition joints between the collars and drill pipe, and potentially turning the pipe too fast.

C. LITHOSTRATIGRAPHY

Site NBP0602A-5 consists of four holes, including two Kasten cores and two drill holes. There was no recovery from the two Kasten cores, and only a bag of sediment recovered from the first drill hole. This hole, NBP0602A-5C, extends to 11.97 mbsf with sediment retrieved from the core catcher of the last drill run. The sediment is very dark greenish gray (GLEY 1 3/1 10Y), muddy fine to very fine sand with coarse pebbles to cobbles. Smear-slide analysis of the <250 µm fraction (Table 5-2) indicates that the sediment is sandy diatomaceous mud. Quartz grains are dominant (30%), with lesser amounts of clay (18%) and feldspar (10%). Calcite (7%) and heavy minerals (3%) are minor constituents, while hornblende, mica, and glauconite occur in trace amounts. Biogenic components include abundant diatoms (30%), with lesser amounts of sponge spicules (2%), and silicoflagellates occur in trace amounts. Some of the sponge spicules are pyritized.

Hole NBP0602A-5D extends from 8.0-31.4 mbsf (Fig. 5-4; Appendix 5-1). This hole is divided into five lithologic units. Lithologic Unit I extends from 8.0-12.15 mbsf and is divided into Subunits IA and IB. Sediment from Subunit IA consists of very dark greenish gray (GLEY 1 3/1 10Y) medium to coarse sand from 8.0-8.09 mbsf, and very dark greenish gray (GLEY 1 3/1 10Y), poorly sorted diamicton between 8.09-8.60 mbsf. The diamicton contains grain sizes ranging from clay through coarse sand, with intermittent gravel layers and some large shell fragments. At the base of this subunit (8.60-8.80 mbsf) is very dark gray (GLEY 1 3/ N), muddy fine sand with pebbles. Smear-slide analysis of the <250 µm fraction (Table 5-2) indicates that clay is the dominant constituent (45%), with less quartz (22%) and feldspar (18%) present. Calcite, heavy minerals, glauconite, and rock fragments each compose about 1-2%, and mica and hornblende are found only in trace amounts. Diatoms compose 10% of the fine fraction, and sponge spicules are found in trace amounts. Fecal pellets are also present. Sediment from Subunit IB (8.80-12.15 mbsf) consists of much stiffer, very dark gray (GLEY 1 3/ N), muddy very fine sand with no pebbles.

Lithologic Unit II extends from 12.15-15.0 mbsf and much of it smells of hydrogen sulfide. The lithology of this unit is firm, sandy, silty diatomaceous mud that ranges from olive (5Y 4/3) at the top, to black (GLEY 1 2.5/ N), very dark gray (GLEY 1 3/ N), and then to very dark greenish gray (GLEY 1 3/ 10Y) at the base of the unit. Barely perceptible layering exists between 12.15-12.42 mbsf. Smear-slide analysis of the <250 µm fraction (Table 5-2) indicates that clay is slightly more abundant (29-33%) than quartz (25%), with even less feldspar (15-16%) and calcite (5-12%) present. Lesser amounts of heavy minerals (2%) and glauconite (trace amounts to 1%) occur, while hornblende and mica are found sporadically in trace amounts. Diatoms constitute 17-22% and sponge spicules are found in trace amounts to 1%.

Lithologic Unit III extends from 15.0-22.18 mbsf and is composed entirely of stiff, pebbly, muddy sand with a few local variations. The sand is mostly fine to medium. Overall the color of this unit varies from black (GLEY 1 2.5/ N) at the top, to very dark greenish gray (GLEY 1 3/ 10Y), back to black (GLEY 1 2.5/ N), very dark gray (GLEY 1 3/ N), and then to greenish black (GLEY 1 2.5/ 10Y). Smear-slide analysis of the <250 µm fraction (Table 5-2) indicates that clay is dominant (45%) with slightly less quartz (25%) and even less feldspar (12-16%) present. In the upper part of this unit the sediment contains small amounts of heavy minerals (3%), calcite (2%), mica (1%), and rock fragments (1%), while hornblende and volcanic glass are found in trace amounts. In the lower part the percentages are similar, although heavy minerals compose up to 7% of the fine fraction. Overall, diatoms compose 5-7% and sponge spicules occur in trace amounts throughout the unit, except for a noted absence of biogenics and a large increase in clay minerals (up to 94%) at 16.45 mbsf. One small horizon of interest starts at 16.24 mbsf and extends to 16.28 mbsf. At this depth, the muddy sand is cleaner than it is above and below, with a noted absence of pebbles and a slight color change. This interval is the contact between the lower Pliocene and middle Miocene based on diatom biostratigraphy (See "**Biostratigraphy**").

Lithologic Unit IV is markedly finer grain and extends from 22.18-25.07 mbsf, denoted by the absence of sand grains, with the exception of one lens of moderately sorted fine sand between 23.78-23.82 mbsf. The section between 23.71-23.86 mbsf is very dark gray (GLEY 1 3/ N), silty mud. A dark gray (GLEY 1 4/ N) layer of clay occurs between 23.86-24.96 mbsf. The unit coarsens again between 25.02-25.07 mbsf, and for this section becomes very dark gray (GLEY 1 3/ N) silty mud. Smear-slide analysis of the <250 µm fraction (Table 5-2) indicates that clay is very pervasive (≥63%), with slightly less quartz (23%) and even less feldspar (6%) present. Heavy minerals comprise 3%, calcite and hornblende 2% each, glauconite 1%, with mica occurring in trace amounts. Diatoms, sponge spicules, and silicoflagellates all occur in trace numbers.

Lithologic Unit V is marked by a return to a sandier lithology. It extends from 25.07-31.40 mbsf. This unit is mostly greenish black (GLEY 2 2.5/ 5BG or GLEY 1 2.5/1 10Y), stiff, sandy, silty mud with pebbles, transitioning to sandy diatomaceous mud below 28.83 mbsf. The sand is almost uniformly fine to very fine. Some black mottling occurs.

Much of Lithologic Units II, III, and V smell of hydrogen sulfide, with several thin white layers (possibly gypsum) occurring in Lithologic Units III and V. Small, dark fragments, thought to be wood, occur towards the base of Lithologic Unit III. There is a lack of visible shell material and no evidence for bioturbation throughout the entire section, with the exception of the modern sediment in Lithologic Unit I.

D. BIOSTRATIGRAPHY

Initial shipboard paleontological work for Site NBP0602A-5 was limited to diatom analysis of smear slides. Samples were prepared from both Holes NBP0602A-5C and -5D, with the primary focus on the longer core recovered in Hole 5D. A checklist of observed diatom taxa is presented in Table 5-3, and diatom zonal assignments and age estimates for Hole 5D are shown in Figure 5-5.

Diatoms are well preserved and moderately abundant in the uppermost part of NBP0602A-5D-1R$_a$ (Sample NBP0602A-5D-1R$_a$, 50 cm; 8.5 mbsf). All taxa observed in this sample are extant species (Table 5-3), and the presence of *Actinocyclus actinochilus, Fragilariopsis curta, F. cylindrus, F. vanheurckii,* and *Thalassiosira antarctica* indicates deposition in a sea-ice influenced environment. Although this upper interval of the core may be Holocene in age, diatom biostratigraphy only constrains the age to ≤ 140 ka based on the absence of *Rouxia leventerae*. This interval is assigned to the *Thalassiosira lentiginosa-Fragilariopsis kerguelensis* "b" Zone (Fig. 5-5).

Lower Pliocene diatom assemblages occur in the bagged sample from Core NBP0602A-5C-2R$_a$ and in a ~7 m-thick interval of Hole NBP0602A-5D from Sample NBP0602A-5D-1R$_a$, 85 cm to -5R$_a$, 25 cm (8.85-16.0 mbsf). Diatoms in these samples are poorly preserved and highly fragmented, but several characteristic Pliocene taxa are present, including *Fragilariopsis praeinterfrigidaria, Rouxia diploneides, Thalassiosira fasciculatus, T. complicata,* and *T. inura* (Table 5-3). The presence of *T. inura* and the absence of *Fragilariopsis barronii* place this interval of Hole 5D in the *Thalassiosira* *inura* Zone (Fig. 5-5). Calibration of the zonal datums for the *T. inura* Zone constrains the depositional age to between 4.4 and 5.1 Ma. Most samples in the Pliocene interval of Hole 5D contain poorly preserved diatoms in relatively low abundances. The apparent absence of *F. barronii* may, therefore, not be biostratigraphically significant. Further examination of samples from this interval will confirm the absence of *F. barronii* and provide more confidence in the current diatom zonal assignment.

A significant hiatus is present within or just below Core NBP0602A-5D-5R_a. Below this level, a ~12 m-thick interval containing middle Miocene diatom assemblages occurs (Samples NBP0602A-5D-6R_a, 0 cm to -13R_a-CC; 18.80-30.36 mbsf). Diatoms are moderately well preserved in most samples in this interval and rare to common in abundance (Table 5-3). Characteristic diatom taxa observed in this section include *Actinocyclus ingens, Denticulopsis delicata, D. dimorpha* var. *areolata*, *D. praedimorpha*, *D. simonsenii,* and *Thalassionema nitzschioides*. Core NBP0602A-5D-6R_a is assigned to the *Denticulopsis ovata-Nitzschia denticuloides* Zone based on the presence of both *D. ovata* and *N. denticuloides* (Fig. 5-5). Although *N. denticuloides* is very rare in Hole NBP0602A-5D samples, *D. praedimorpha* is relatively common (Table 5-3), and it has a last occurrence near the last occurrence of *N. denticuloides.* Thus, the presence of *D. praedimorpha* provides additional support for the zonal assignment of Core 6R_a. Below Core 6R_a, *D. ovata* was not observed; consequently, the interval between Cores NBP0602A-5D-7R_a and -13R_a is assigned to the *Denticulopsis dimorpha* Zone based on the presence of *D. dimorpha* and the absence of *D. ovata* (Fig. 5-5). Age calibration of the diatom datums for these combined zones places deposition of the middle Miocene interval of Hole 5D between 11.8 and 12.7 Ma.

The position of the hiatus between the lower Pliocene and middle Miocene sections of Hole NBP0602A-5D cannot be precisely determined. The lowermost sample that contains Pliocene diatoms is Sample NBP0602A-5D-5R_a, 25 cm (16.25 mbsf), and the uppermost sample that contains Miocene diatoms is Sample NBP0602A-5D-6R_a, 0 cm (18.80 mbsf). Samples from the lower interval of Core NBP0602A-5D-5R_a (between the two diatom-bearing samples) contain abundant silt-sized dolomite rhombs with only very rare diatom fragments. Thus, no age information can be derived for these samples.

One additional note concerning the middle Miocene diatom assemblages of Hole NBP0602A-5D is the presence of *Fragilariopsis praecurta* (Table 5-3). In deep-sea sections in the circum-Antarctic region, this taxon has a documented first occurrence at ~11.4 Ma, and is used to mark the base of the *F. praecurta* Zone. Its apparent presence in older strata of Hole 5D suggests that it has a diachronous first occurrence, appearing in shelf regions prior to open-ocean (deep-sea) sections.

E. PHYSICAL PROPERTIES

At Site NBP0602A-5 only Hole NBP0602A-5D had significant recovery, reaching approximately 31 mbsf. Physical property measurements were made with the multisensor core logger (MSCL) at 2-cm intervals, the Middlebury College electrical resistivity (MCER) probe at 5-cm intervals, and discrete samples taken every 10-20 cm and stored for future analyses.

Five lithologic units were defined in Hole NBP0602A-5D (see "**Lithostratigraphy**"). These units are described as pebbly muddy sand, pebbly sandy mud, or sandy mud. One core recovered a small amount of gray clay. Most of the variation observed in the MSCL magnetic susceptibility (MS), electrical resistivity (ER), and density can be attributed to the presence of cobbles or pebbles strewn throughout various sections of the hole. In general where there is a high peak in MS, a corresponding decrease occurs in density and resistivity. MS ranges between 20 SI to over 500 SI. The largest MS spikes are correlated to individual rocks, gravel layers, or a series of closely spaced rocks (e.g., Lithology Log NPB0602A-5D-10R_a at 50-80 cm). In some instances, MS peaks do not correlate to any visible rock, and x-rays will be needed to determine the source (e.g., Lithology Log NBP0602A-5D-4R_a at 55 cm).

Density varies between 1.5 and 3 g/cm^3 throughout the hole, averaging around 2.68 g/cm^3. This is higher than the average 2.33 g/cm^3 observed at Site NBP0602A-3. The difference is in the sediment constituency. Hole NBP0602A-3C is predominantly muddy, silty fine sands, whereas Hole NBP0602A-5D has more fine to medium sands with a larger proportion of pebbles and rocks randomly found throughout. Large offsets in density (e.g., Lithology Log NBP0602A-5D-9R_a) are attributed to changes in lithology (in this case from a clay to silty mud with a change in density from 1.7 g/cm^3 to 2.5 g/cm^3, respectively). Other large variations occur where cracks exist in the sediment or the sediment is disturbed near a large pebble or rock. These disturbances usually lower the density from 2.2 to 1.5 g/cm^3 (e.g., Lithology Log NBP0602A-5D-11R_a at 0-20 cm). This decrease in density is a common effect when using the gamma-ray attenuation porosity-evaluator (GRAPE) sensor in cracked or disturbed sections of core. An exception to this occurs in Lithologic Log NPB0602A-5D-11R_a at ~180 cm. At this depth, density drops to 1.87 g/cm^3, MS shows a significant drop to ~10 SI units, and the MSCL-ER measurements also show a decrease. These concurrent decreases are related to the 7-cm white layer inferred to be gypsum.

Electrical resistivity measurements using the MCER probe were not easily obtained; the probe was not always in good contact with the sediment due to the uneven nature of the split core surface. Large variance of the averaged voltages was recorded and only those averages with a variance under 1.0 ohm were converted to resistivity.

There is little downhole increase in physical properties, especially in density. This suggests that these sands have possibly been deposited and reworked. If most of the fines have been winnowed away (due to contourite currents) then grain-to-grain contact might prevent downhole compaction until a much thicker overburden section occurs. In comparison, Hole NBP0602A-3C, which also consists of sands, shows a downcore increase due to compaction within the top 10 m.

F. SITE SUMMARY

After minimal success drilling within the sea-ice front, we elected to relocate further north, acquiring new seismic data along the southern margin of the Joinville Plateau. The survey revealed a thick, undeformed succession of basinal sediments onlapping acoustic basement from the south along a roughly east-west trend. The overall stratigraphic architecture suggests a hemipelagic section truncated by a prominent unconformity within a few meters of the seafloor. Since we could not tie our seismic stratigraphic age model to this new area, Site NBP0602A-5 was selected to sample the oldest part of the section located close to the seafloor. Two Kasten cores failed to return sediment, and a gravel lag was suspected of preventing their penetration.

With the initiation of Hole NBP0602A-5C, the driller did not detect bottom at the depth given by multibeam (506 mbsl), but rather felt resistance 4.15 m below that. After washing to 8.5 mbsf, the section was cored to 11.97 m, at which point an attempt to retrieve the core barrel failed when shear pins in the overshot tool sheared, leaving that device and the core barrel in the hole. A fishing tool was improvised that successfully extracted the overshot and core barrel. A small amount of sandy diatomaceous mud in the core catcher contained a lower Pliocene diatom assemblage. The ship was then offset 20 m and a new drill hole begun.

As Hole NBP0602A-5D was spudded in, the driller again did not sense bottom until 4.15 m below the depth indicated by multibeam. Nevertheless, after washing to 8 mbsf, 13 consecutive core runs to 31.4 mbsf yielded 40% recovery, primarily through lower Pliocene and middle Miocene clastic sediments. The lithologic succession was divided into five sedimentary units.

Lithologic Subunit IA (8.0-8.80 mbsf) primarily consists of diamicton with a modern diatom assemblage. Subunit IB (8.80-12.15 mbsf) is stiff muddy sand with no pebbles and Pliocene diatoms.

Litholologic Unit II (12.15-15.0 mbsf) is firm sandy, silty diatomaceous mud of early Pliocene age.

Lithologic Unit III (15.0-22.18 mbsf) is stiff, black to dark greenish gray, fine to medium muddy sand with 5-7% diatoms. The Miocene/Pliocene boundary appears to be represented by a disconformity within this unit between 16.25 and 16.45 mbsf.

Lithologic Unit IV (22.18-25.07 mbsf) is markedly finer grain, with 63% clay or more. It is virtually devoid of sand except for one lens, and diatoms occur only in trace numbers.

Lithology V (25.07-31.40 mbsf) is sandier, consisting primarily of middle Miocene stiff, greenish black, sandy, silty mud to diatomaceous mud with pebbles.

When the cores were opened, much of Lithologic Units II, III, and V smelled of hydrogen sulfide, and soft, white layers (possibly gypsum) occur in Units III and V. An interval with authigenic dolomite rhombs comprises up to 50% of the sediment at some levels in Core NBP0602A-5D-5R$_a$. All of these indicate relatively high organic content within the sediment. Deposition in an oxygen-deficient environment is further suggested by a lack of bioturbation throughout the section, a lack of shell material except in Unit I, and preservation of small, dark fragments thought to be wood near the base of Unit III.

Diatoms in the diamicton of Lithologic Subunit IA indicate deposition in a sea-ice influenced environment. This interval is assigned to the *T. lentiginosa-F. kerguelensis* "b" Zone (age ≤ 0.14 Ma) based on the absence of *R. leventerae*. Below that poorly preserved and highly fragmented lower Pliocene diatom assemblages from 8.85-16.00 mbsf are assigned to the *T. inura* Zone (4.4-5.1 Ma). A disconformity representing a hiatus of ~6.7 m.y. within or just below Core NBP0602A-5D-5R$_a$ separates Pliocene from subjacent middle Miocene sediments represented by the diatom *D. ovata-N. denticuloides* and *D. dimorpha* Zones (11.8-12.7 Ma); the latter extends to the bottom of the hole.

Most of the variation in physical properties in Hole NBP0602A-5D can be attributed to the presence of cobbles and pebbles scattered throughout the section. Large offsets in density are attributed to changes in lithology, e.g., from clay to silty mud. An exception to this occurs in Core NBP0602A-5D-11R$_a$ at ~180 cm where the density, MS, and ER measurements decrease concurrently at the 7-cm, white, non-effervescent layer inferred to be gypsum. Interestingly, there is little downhole increase in physical properties, especially in density, which suggests the sands may have been deposited and reworked. If most of the fines have been winnowed out, then grain-to-grain contact might prevent downhole compaction until a much thicker overburden section is imposed.

Hole NBP0602A-5D terminated at 31.4 mbsf when the pipe twisted off just above the mudline, leaving the BHA and drill collars in the hole. Throughout the operation material caving into the hole sometimes jammed the bit or pipe, and it was often difficult to flush cuttings out of the hole. In addition, excess materials had been recovered in some cores. Multiple hypotheses abound as to the possible cause of the pipe failure, but the consistent 4.15 m discrepancy between the mudline depth measured by pipe and multibeam in both Holes NBP0602A-5C and -5D may implicate a significant offset between the position of the hole and that of the ship’s moonpool caused by bottom currents.

Figure 5-2. Multibeam images of Site NBP0602A-5.

NBP0602A SHALDRIL II - Site 5

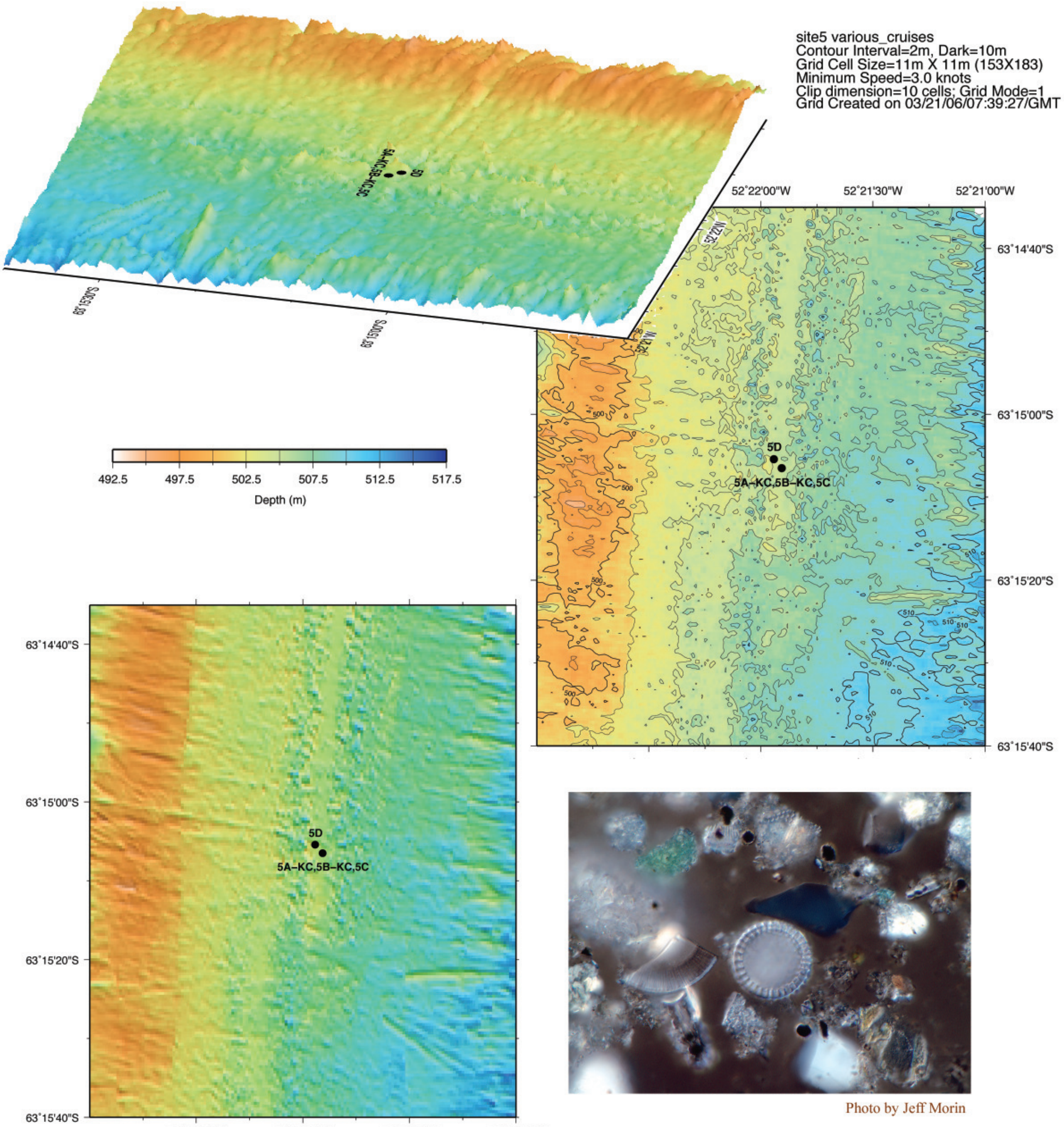


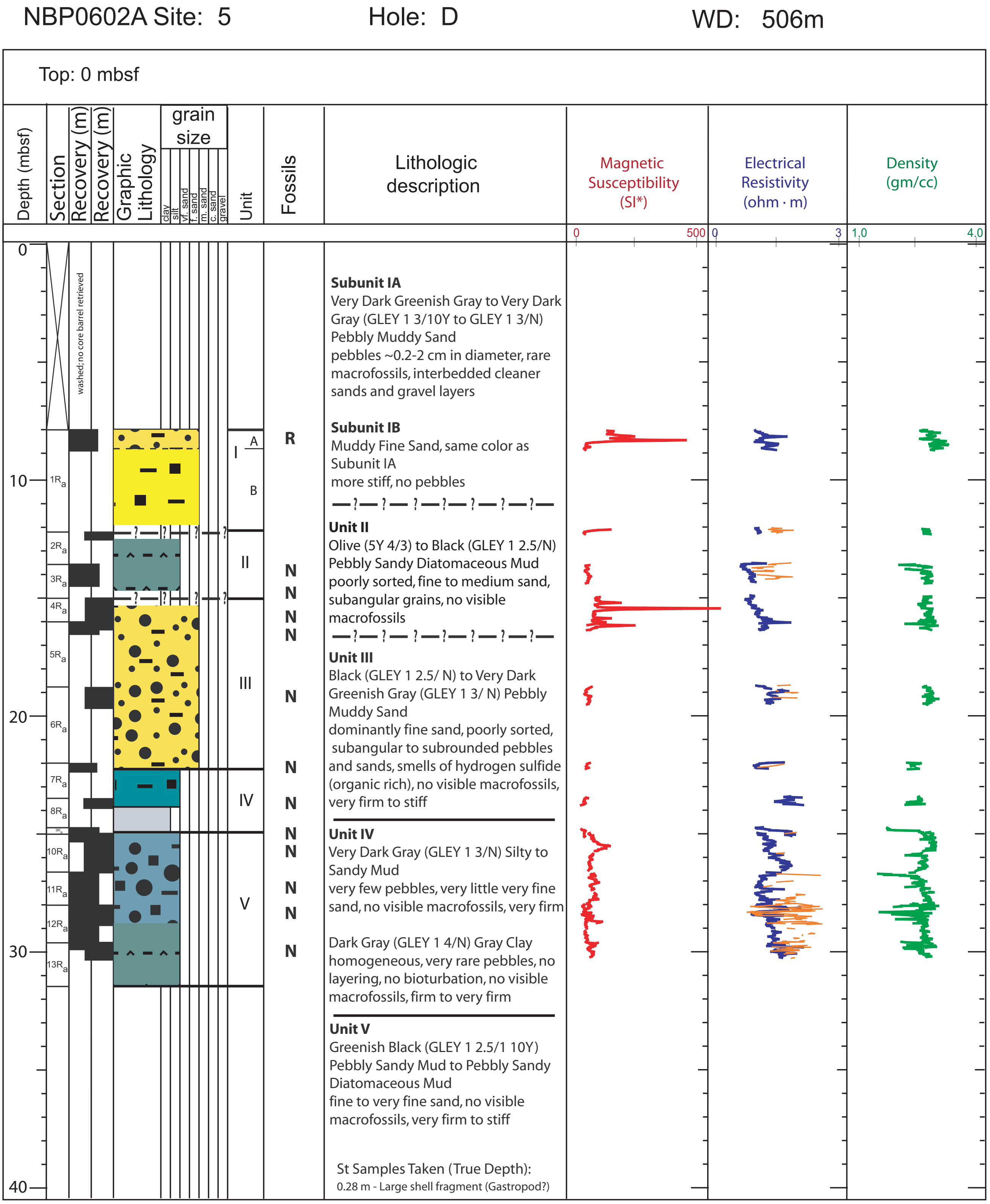
Photo by Jeff Morin

S.O'Hara, RPSC

Figure 5-3. Photograph illustrating the broken pipe from Hole NBP0602A-5D.

Photo by Jesse Doren

Figure 5-4. Summary lithologic log of Hole NBP0602A-5D.



Subunit IA
Very Dark Greenish Gray to Very Dark Gray (GLEY 1 3/10Y to GLEY 1 3/N)
Pebbly Muddy Sand
pebbles ~0.2-2 cm in diameter, rare macrofossils, interbedded cleaner sands and gravel layers

Subunit IB
Muddy Fine Sand, same color as Subunit IA
more stiff, no pebbles

—?—?—?—?—?—?—

Unit II
Olive (5Y 4/3) to Black (GLEY 1 2.5/N)
Pebbly Sandy Diatomaceous Mud
poorly sorted, fine to medium sand, subangular grains, no visible macrofossils

—?—?—?—?—?—?—

Unit III
Black (GLEY 1 2.5/ N) to Very Dark Greenish Gray (GLEY 1 3/ N) Pebbly Muddy Sand
dominantly fine sand, poorly sorted, subangular to subrounded pebbles and sands, smells of hydrogen sulfide (organic rich), no visible macrofossils, very firm to stiff

Unit IV
Very Dark Gray (GLEY 1 3/N) Silty to Sandy Mud
very few pebbles, very little very fine sand, no visible macrofossils, very firm

Dark Gray (GLEY 1 4/N) Gray Clay
homogeneous, very rare pebbles, no layering, no bioturbation, no visible macrofossils, firm to very firm

Unit V
Greenish Black (GLEY 1 2.5/1 10Y)
Pebbly Sandy Mud to Pebbly Sandy Diatomaceous Mud
fine to very fine sand, no visible macrofossils, very firm to stiff

St Samples Taken (True Depth):
0.28 m - Large shell fragment (Gastropod?)

Figure 5-5. Diatom zonal assignments and age interpretation for Hole NBP0602A-5D.

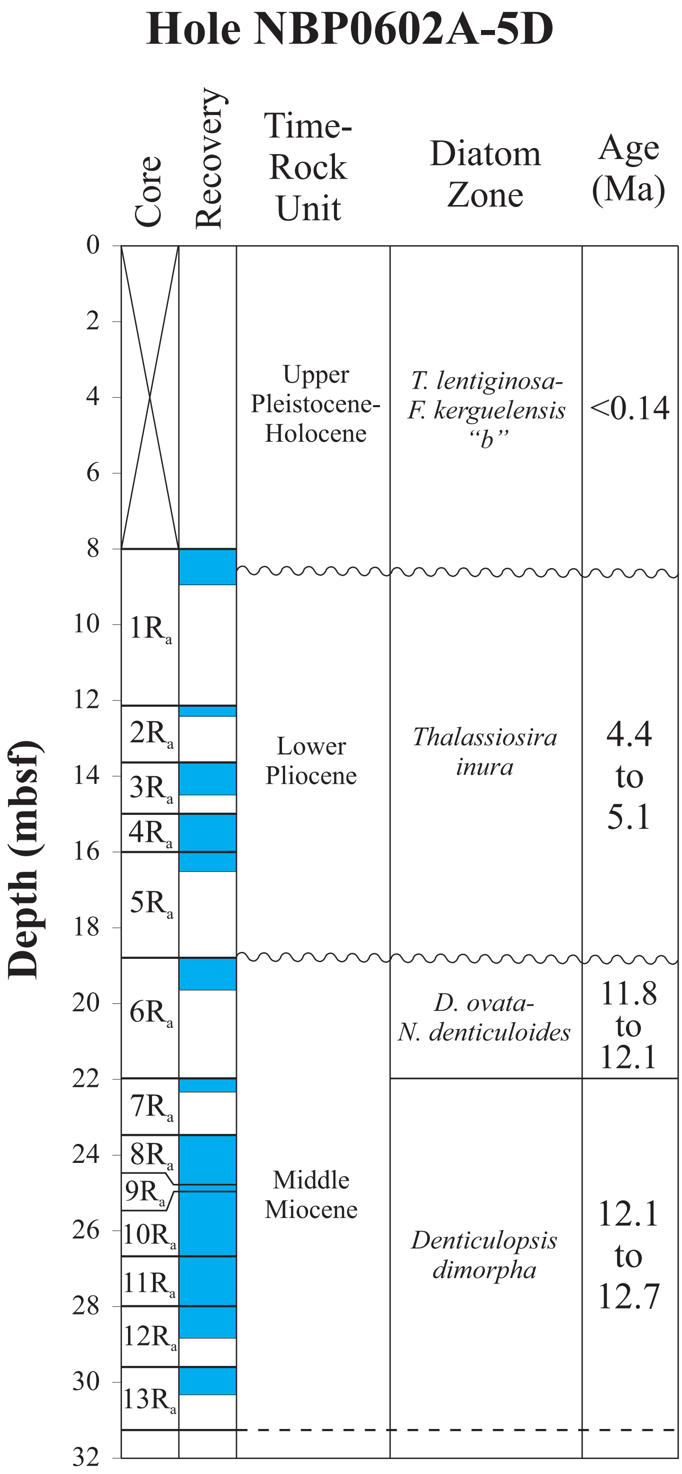


Table 5-1. Drilling and coring recovery log for Holes NBP0602A-5A-KC, -5B-KC, -5C, and -5D.

NBP0602A SHALDRIL II Site 5 (Danger Islands)

Multibeam Water Depth: 506m at A, B, C, and D

Station Number/Hole	Core Number	Core Type	Top (mbsf)	Bottom (mbsf)	Interval Cored (m)	"Push Distance" (m)	Recovery: total (m)	Recovery: competent (m)	Recovery: disturbed (m)	Gaps (m)	Recovery Corrected (m)	Total Recovery (%)	Recovery Corrected (%)	Section Number	Section Lengths (cm)	Date (JD)	Time on Deck (GMT)	Initials	Comments
5A	1	KC	0.0	0.0	0	0.0	0	0	0	0	0	0.0%	0.0%	0	0.0	74	0748	JSW	No Recovery; Nose a bit bent
5B	1	KC	0.0	0.0	0	0.0	0	0	0	0	0	0.0%	0.0%	0	0.0	74	0825	JSW	No Recovery
5C	1	Ra-w	0.0	8.5	washed	0.0	0	0	0	0	0	0.0%	0.0%	1	0.0	74	1130	JSW	No Recovery; Mudline not obvious?; 4.15 m added to depth for all 5C values
5C	2	Ra	8.5	11.97	8.5-11.97	0.0	0	0	0	0	0	0.0%	0.0%	1	baggie	74	1215-1642	JSW	Needed to use custom made fishing tool to recover - overshot pins sheared
5D	1	Ra	8.0	12.15	8.0-12.15	4.15	0.95	0.95	0	0	0.95	22.9%	22.9%	1	95.0	74	1938	CD	Hole washed to 8.0 mbsf
5D	2	Ra	12.15	13.65	12.15-13.65	1.5	0.295	0.27	0.025	0	0.27	19.7%	18.0%	1	29.5	74	2303	CD	
5D	3	Ra	13.65	15.0	13.65-15.0	1.35	0.86	0.86	0	0	0.86	63.7%	63.7%	1	85.5	75	0006	CD	
5D	4	Ra	15.0	16.0	15.0-16.0	1.0	1.28	1.28	0	0.02	1.28	128.0%	128.0%	1	128.0	75	0330	CAC	Smelly Diamicton; Pliocene?
5D	5	Ra	16.0	18.8	16.0-18.8	2.8	0.51	0.51	0	0	0.51	18.2%	18.2%	1	52.0	75	0605	CAC	Dolomite crystals
5D	6	Ra	18.8	22.0	18.8-22.0	3.2	0.85	0.85	0	0	0.85	26.6%	26.6%	1	83.0	75	0820	JSW	Miocene?
5D	7	Ra	22.0	23.48	22.0-23.48	1.48	0.335	0.335	0	0	0.335	22.6%	22.6%	1	38.0	75	0930	JSW	Stopped by cobble (hard to remove from barrel); Miocene?
5D	8	Ra	23.48	24.78	23.48-24.78	1.3	0.43	0.43	0	0	0.43	33.1%	33.1%	1	41.0	75	1123	JSW	Soft clay! Barren?
5D	9	Ra	24.78	24.98	24.78-24.98	0.2	0.46	0.46	0	0	0.46	230.0%	230.0%	1	46.0	75	1155	JM	Hard; Excess core is from previous run; Middle/Late Miocene?
5D	10	Ra	24.98	26.68	24.98-26.68	1.7	1.7	1.7	0	0	1.7	100.0%	100.0%	1	87.0	75	1410	JM	
5D	10	Ra												2	85.0	75	1410	JM	
5D	11	Ra	26.68	28.00	26.68-28.00	1.32	3.24	3.24	0	0	3.24	245.5%	245.5%	1	81.3	75	1750	CD	
5D	11	Ra												2	81.2	75	1750	CD	
5D	11	Ra												3	81.0	75	1750	CD	
5D	11	Ra												4	79.9	75	1750	CD	
5D	12	Ra	28.0	29.6	28.0-29.6	1.60	0.895	0.865	0.03	0	0.865	55.9%	54.1%	1	89.5	75	1919	CD	
5D	13	Ra	29.6	31.4	29.6-31.4	1.8	0.755	0.755	0	0	0.755	41.9%	41.9%	1	75.5	75	2035	CD	Hole abandoned - pipe above collars sheared- BHA left in hole
Total							**12.56**				**12.51**	**40%**	**40%**						

Table 5-2. Smear-slide data for Holes NBP0602A-5C and -5D.

Sample	Approximate Depth (mbsf)	Components															Grain Size			Sorting	Roundness	Lithology	Comments
		Minerals														Rock							
		Calcite	Clay	Dolomite	Feldspar	Glauconite	Heavy Minerals	Hornblende	Mica	Quartz	Volcanic Glass	Zircon	Diatoms	Silicoflagellates	Sponge Spicules	Fragments	Sand	Silt	Clay				
Hole 5C																							
NBP0602A-5C-2R$_a$-CC	(8.5-11.97)	7	18		10	tr	3	tr	tr	30			30	tr	2		22	51	27	P	sa-r	Sandy diatomaceous mud	Some pyritized sponge spicules
Hole 5D																							
NBP0602A-5D-1R$_a$, 50 cm	(0.50-12.15)	1	45		18	1	2	tr	tr	22			10		tr	1	20	30	50	P	a-sr	Sandy mud	Fragmented diatoms; rutilated quartz; fecal pellets
NBP0602A-5D-2R$_a$, 18 cm	12.33	12	33		10	tr	2	tr	tr	25			17		1		20	40	40	P	a-sr	Sandy diatomaceous mud	Pyritized sponge spicules
NBP0602A-5D-3R$_a$, 44 cm	14.09	5	29		15	1	2			25			22		1		21	41	38	P	a-sr	Sandy diatomaceous mud	Pyritized sponge spicules; diatoms highly fragmenteded
NBP0602A-5D-4R$_a$, 65 cm	15.65	2	44		16		3	tr	1	26	tr		7		tr	1	20	32	48	P	sr	Sandy mud	
NBP0602A-5D-5R$_a$, 45 cm	16.45		94		2	tr				4							4	2	94	M	a-sr	Clay	Very fine-grained
NBP0602A-5D-6R$_a$, 43 cm	19.23	3	44		12	1	7	1	1	25			5		tr	1	25	30	45	P	a-sr	Sandy mud	Rutilated quartz
NBP0602A-5D-7R$_a$, 30 cm	22.30	5	45		15	1	2	1	tr	20			10		1		20	30	50	P	sa-sr	Sandy mud	
NBP0602A-5D-8R$_a$, 37 cm	23.85	2	63		6	1	3	2	tr	23			tr	tr	tr		6	30	64	P	sa-sr	Mud	
NBP0602A-5D-9R$_a$, 43 cm	(24.78-24.98)	3	49		15	tr	1	1	tr	20			10		1		25	20	55	P	sa-sr	Sandy mud	
NBP0602A-5D-10R$_a$, 43 cm	25.41	6	42		17	2	3	2	tr	20			7		tr		15	40	45	P	a-wr	Sandy mud	
NBP0602A-5D-11R$_a$, 63 cm	27.31	3	44		15	1	2	1	tr	27			6	tr	1		9	44	47	P	a-sr	Mud	
NBP0602A-5D-12R$_a$, 83 cm	28.83	3	31		5	tr	5	tr	3	35			15		tr	3	20	44	36	P	sa-sr	Sandy diatomaceous mud	Hematite-stained quartz grains
NBP0602A-5D-13R$_a$, 64 cm	30.24	1	41		7	tr	5	tr	3	20	tr	tr	20	tr	tr	3	15	34	51	P	sa-sr	Sandy diatomaceous mud	Hematite-stained quartz grains

Notes: Sample: R$_a$ = cored using alien coring bit; R$_{a\text{-}w}$ = wash cored using alien coring bit; Components/Grain Size: Numbers represent percentages, tr = trace; Sorting: P = poor; Roundness: a = angular, sa = subangular, sr = subrounded, r = rounded, wr = well-rounded.

Table 5-3. Stratigraphic occurrence and relative abundance of diatom taxa in Holes NBP0602A-5C and -5D.

						Diatoms																							
Cruise	**Depth (mbsf)**	**Slide Preparation**	**Diatom Abundance**	**Preservation**	**Fragmentation**	*Actinocyclus actinochilus*	*Actinocyclus* cf. *fryxellae*	*Actinocyclus ingens*	*Actinocyclus maccollumi*	*Actinocyclus* spp.	*Arachnoidiscus* spp.	*Azpeitia tabularis*	*Chaetoceros bulbosum*	*Chaetoceros* spp. (small veg. cells & resting spores)	*Chaetoceros* spp. (large spores, decorated)	*Cocconeis* spp. (several taxa)	*Coscinodiscus* spp.	*Dactyliosolen antarcticus* (girdle bands)	*Denticulopsis crassa*	*Denticulopsis delicata*	*Denticulopsis dimorpha* var. *areolata*	*Denticulopsis maccollumii*	*Denticulopsis ovata*	*Denticulopsis praedimorpha*	"*Denticulopsis* cf. *praedimorpha*" (of Harwood & Maruyama, 1992, pl. 6, figs. 11, 18-20)	*Denticulopsis simonsenii / vulgaris*	*Eucampia antarctica* var. *recta*	*Eucampia antarctica* "var. *planus*"	*Fragilariopsis aurica*	*Fragilariopsis curta*
Hole 5C																														
NBP0602A-5C-2R$_a$-CC	11.97	smear & >10	C	P	H	R			X					F			fr(X)			fr(X)							X			
Hole 5D																														
NBP0602A-5D-1R$_a$, 50 cm	8.50	smear	A	M	M	F							X	F													R			F
NBP0602A-5D-1R$_a$, 85 cm	8.85	smear	X	P	H																									
NBP0602A-5D-1R$_a$, 95 cm	8.95	smear & >10	C	P	H									F						fr(X)							X			
NBP0602A-5D-2R$_a$, 18 cm	12.33	smear	F	P	H									R			fr(R)	X		X										
NBP0602A-5D-2R$_{a\text{-CC}}$	12.43	smear	X	P	H									X			fr(X)													
NBP0602A-5D-3R$_a$, 44 cm	14.09	smear	F	P	H									R			fr(R)	X		R										
NBP0602A-5D-3R$_{a\text{-CC}}$	14.51	smear	R	P	H									X			fr(X)			fr(X)							X			
NBP0602A-5D-4R$_a$, 65 cm	15.65	smear	R	P	H									X			fr(X)			fr(X)										
NBP0602A-5D-4R$_a$, 128 cm	15.98	smear	X	P	H									X			fr(X)													
NBP0602A-5D-5R$_a$, 0 cm	16.00	smear	R	P	H									R			fr(R)			fr(X)										
NBP0602A-5D-5R$_a$, 25 cm	16.25	smear&strewn	F	M	H						fr(X)		X	F		X	fr(F)	X		F						R	X		X	
NBP0602A-5D-5R$_a$-CC	16.51	smear	B	-	-																									
NBP0602A-5D-6R$_a$, 0 cm	18.80	smear	C	M	M		R							F			fr(F)	X		F	F		R			X		X		
NBP0602A-5D-6R$_a$-CC	19.05	smear	C	M	M		X							F	R		fr(R)			F	R		X	X	X	X	X			
NBP0602A-5D-7R$_a$, 16 cm	22.16	smear	R	P	H		X	R						F	X		fr(R)			fr(R)		R		X		X				
NBP0602A-5D-7R$_a$, 34 cm	22.34	smear	F	P	H									R	X		fr(F)			F	X	X		R		X	X			
NBP0602A-5D-8R$_a$, 20 cm	23.68	smear	X	P	H			fr(X)						R			fr(R)				X									
NBP0602A-5D-8R$_a$, 29 cm	23.77	smear	B	-	-																									
NBP0602A-5D-8R$_a$, 41 cm	23.89	smear	B	-	-																									
NBP0602A-5D-9R$_a$, 46 cm	25.24	smear	F	P-M	H			X		fr(X)				X			fr(R)			X				X	X					
NBP0602A-5D-10R$_a$, 87 cm	25.85	smear	F	P-M	H			R						X			fr(X)	X		fr(R)						X				
NBP0602A-5D-10R$_a$-CC	26.68	smear	R	P-M	H			R						R			fr(X)									fr(?)				
NBP0602A-5D-11R$_a$, middle	~27	smear	F	P	H		X	R						R			fr(X)	X		F				R-F		R				
NBP0602A-5D-11R$_a$, 324 cm	~28	smear	F	P	H			R						R			fr(F)			fr(X)						X				
NBP0602A-5D-11R$_a$-CC	~28	smear	C	M	H		X	R				X		R	R		fr(F)	X	X	F				F	X	R	X			
NBP0602A-5D-12R$_a$, 83 cm	28.83	smear	C	M	M-H			F				X		X			fr(F)	X		F	X			F	X	R	X			
NBP0602A-5D-12R$_a$, 87 cm	28.87	smear	R	P	H			X						R	R		fr(R)		X	fr(R)				X		R				
NBP0602A-5D-13R$_a$, 44 cm	30.04	smear	F	M	M			F		X				F			fr(F)	X		F	R			F		R	F			
NBP0602A-5D-13R$_a$, 75 cm	30.35	smear	F	M	M			R		X				R	F		fr(F)	R	X	F	R			R	X	F		X		
NBP0602A-5D-13R$_a$-CC	30.36	smear	C	M	M		X	R		X				F			fr(F)	X	X	F	R			F	X	R	X			

Notes: Abundance: A = abundant, C = common, F = few, R = rare, X = present, B = barren, fr = fragments; Preservation: M = moderate, P = poor; Fragmentation: M = moderate, H = high.

Table 5-3 (continued).

						Diatoms																								
Cruise	**Depth (mbsf)**	**Slide Preparation**	**Diatom Abundance**	**Preservation**	**Fragmentation**	*Fragilariopsis cylindrus*	*Fragilariopsis kerguelensis*	*Fragilariopsis obliquecostata*	*Fragilariopsis vanheurckii*	*Fragilariopsis praecurta*	*Fragilariopsis praeinterfrigidaria*	*Hemiaulus* spp.	*Isthmia* spp.	*Navicula directa*	*Nitzschia denticuloides*	*Nitzschia grossepunctata*	*Nitzschia maleinterpretaria*	*Paralia* spp.	*Pinnularia quadratarea*	*Proboscia alata*	*Pseudotriceratium radiosoreticulatum*	*Pyxilla reticulata*	*Rhiz. hebetata f. hiemalis* (coarse & fine punctation)	*Rhizosolenia* spp.	*Rouxia antarctica*	*Rouxia diploneides*	*Rouxia isopolica*	*Rouxia naviculoides*	*Rouxia* spp.	*Stellarima microtrias*
Hole 5C																														
NBP0602A-5C-2R$_a$-CC	11.97	smear & >10	C	P	H							fr(X)												X	fr(X)	fr(X)			fr(F)	X
Hole 5D																														
NBP0602A-5D-1R$_a$, 50 cm	8.50	smear	A	M	M	R	X	R	R					X						X		X								X
NBP0602A-5D-1R$_a$, 85 cm	8.85	smear	X	P	H																									
NBP0602A-5D-1R$_a$, 95 cm	8.95	smear & >10	C	P	H					fr(X)			X											X	fr(X)	fr(X)			fr(X)	X
NBP0602A-5D-2R$_a$, 18 cm	12.33	smear	F	P	H						X													X	X				fr(R)	
NBP0602A-5D-2R$_{\text{a-CC}}$	12.43	smear	X	P	H																									
NBP0602A-5D-3R$_a$, 44 cm	14.09	smear	F	P	H																					fr(X)		X		
NBP0602A-5D-3R$_{\text{a-CC}}$	14.51	smear	R	P	H					fr(X)														X			fr(X)			fr(X)
NBP0602A-5D-4R$_a$, 65 cm	15.65	smear	R	P	H					X																				
NBP0602A-5D-4R$_a$, 128 cm	15.98	smear	X	P	H																									
NBP0602A-5D-5R$_a$, 0 cm	16.00	smear	R	P	H																							X		fr(X)
NBP0602A-5D-5R$_a$, 25 cm	16.25	smear&strewn	F	M	H					X	fr(X)													X	X				fr(R)	X
NBP0602A-5D-5R$_a$-CC	16.51	smear	B	-	-																									
NBP0602A-5D-6R$_a$, 0 cm	18.80	smear	C	M	M					X														F						X
NBP0602A-5D-6R$_a$-CC	19.05	smear	C	M	M					X					X									F						X
NBP0602A-5D-7R$_a$, 16 cm	22.16	smear	R	P	H											X	X	R						X						fr(X)
NBP0602A-5D-7R$_a$, 34 cm	22.34	smear	F	P	H											X								X						
NBP0602A-5D-8R$_a$, 20 cm	23.68	smear	X	P	H										X			X				X								
NBP0602A-5D-8R$_a$, 29 cm	23.77	smear	B	-	-																									
NBP0602A-5D-8R$_a$, 41 cm	23.89	smear	B	-	-																									
NBP0602A-5D-9R$_a$, 46 cm	25.24	smear	F	P-M	H																			X						X
NBP0602A-5D-10R$_a$, 87 cm	25.85	smear	F	P-M	H							X					fr(X)				X	X		X						
NBP0602A-5D-10R$_a$-CC	26.68	smear	R	P-M	H																			X						X
NBP0602A-5D-11R$_a$, middle	~27	smear	F	P	H																			R						X
NBP0602A-5D-11R$_a$, 324 cm	~28	smear	F	P	H					X														X						X
NBP0602A-5D-11R$_a$-CC	~28	smear	C	M	H					X					X								X	X						
NBP0602A-5D-12R$_a$, 83 cm	28.83	smear	C	M	M-H																			F						
NBP0602A-5D-12R$_a$, 87 cm	28.87	smear	R	P	H																			X						
NBP0602A-5D-13R$_a$, 44 cm	30.04	smear	F	M	M					X														R						X
NBP0602A-5D-13R$_a$, 75 cm	30.35	smear	F	M	M					X														R						X
NBP0602A-5D-13R$_a$-CC	30.36	smear	C	M	M					X					X				X				X	F						X

Notes: Abundance: A = abundant, C = common, F = few, R = rare, X = present, B = barren, fr = fragments; Preservation: M = moderate, P = poor; Fragmentation: M = moderate, H = high.

Table 5-3 (continued).

						Diatoms																				Silico-flagellate
Cruise	**Depth (mbsf)**	**Slide Preparation**	**Diatom Abundance**	**Preservation**	**Fragmentation**	*Stephanopyxis* spp. (small to med. diameter, mod. silicified)	*Stephanopyxis* spp. (large, heavily silicified)	*Synedropsis* sp. 1 (long, capitate, constricted in middle)	*Synedropsis* sp. 2 (lanceolate with rounded apices, medium size)	*Synedropsis* sp. 3 (stubby w/ capitate apices)	*Thalassionema nitzschioides*	*Thalassiosira antarctica* var. *antarctica*	*Thalassiosira complicata*	*Thalassiosira fasciculatus*	*Thalassiosira gersondei-mahoodii* group	*Thal. gracilis* var. *gracilis / expecta*	*Thalassiosira inura*	*Thalassiosira jacksonii*	*Thalassiosira oestrupii* (small, fine areolation)	*Thalassiosira oliverana*	*Thalassiosira torokina* ("late form")	*Thalassiosira torokina* ("early form")	*Thalassiosira* spp. (very small forms)	*Thalassiothrix/Trichotoxon* spp.	*Trinacria excavata* group	*Distephanus speculum speculum*
Hole 5C																										
NBP0602A-5C-2R_a-CC	11.97	smear & >10	C	P	H	F						R		fr(X)			X				F	fr(X)		fr(X)		
Hole 5D																										
NBP0602A-5D-1R_a, 50 cm	8.50	smear	A	M	M							F				F								fr(X)		X
NBP0602A-5D-1R_a, 85 cm	8.85	smear	X	P	H																			fr(X)		
NBP0602A-5D-1R_a, 95 cm	8.95	smear & >10	C	P	H	fr(F)	X						fr(X)		X		X					X	R	fr(X)		
NBP0602A-5D-2R_a, 18 cm	12.33	smear	F	P	H	X		X							X		X	X	X					fr(R)		
NBP0602A-5D-2$R_{a\text{-}CC}$	12.43	smear	X	P	H	fr(X)																		fr(X)		
NBP0602A-5D-3R_a, 44 cm	14.09	smear	F	P	H	fr(R)					fr(F)													fr(X)		
NBP0602A-5D-3$R_{a\text{-}CC}$	14.51	smear	R	P	H	fr(X)																fr(X)		fr(X)		
NBP0602A-5D-4R_a, 65 cm	15.65	smear	R	P	H	X																fr(X)	X	X		
NBP0602A-5D-4R_a, 128 cm	15.98	smear	X	P	H																			X		
NBP0602A-5D-5R_a, 0 cm	16.00	smear	R	P	H	fr(X)																fr(X)		fr(X)		
NBP0602A-5D-5R_a, 25 cm	16.25	smear&strewn	F	M	H	X		X			fr(F)		X		X		R		X	X		X	X	fr(R)		X
NBP0602A-5D-5R_a-CC	16.51	smear	B	-	-																					
NBP0602A-5D-6R_a, 0 cm	18.80	smear	C	M	M	R			X		fr(F)													fr(X)	fr(X)	
NBP0602A-5D-6R_a-CC	19.05	smear	C	M	M	X					fr(F)													fr(X)	R	
NBP0602A-5D-7R_a, 16 cm	22.16	smear	R	P	H	X					fr(F)													fr(X)	fr(X)	X
NBP0602A-5D-7R_a, 34 cm	22.34	smear	F	P	H	R					fr(R)													fr(X)	fr(X)	
NBP0602A-5D-8R_a, 20 cm	23.68	smear	X	P	H	fr(R)																		fr(X)	fr(X)	
NBP0602A-5D-8R_a, 29 cm	23.77	smear	B	-	-																					
NBP0602A-5D-8R_a, 41 cm	23.89	smear	B	-	-																					
NBP0602A-5D-9R_a, 46 cm	25.24	smear	F	P-M	H						fr(X)														fr(X)	
NBP0602A-5D-10R_a, 87 cm	25.85	smear	F	P-M	H	X					fr(X)													fr(X)	fr(X)	
NBP0602A-5D-10R_a-CC	26.68	smear	R	P-M	H	fr(X)					X														X	
NBP0602A-5D-11R_a, middle	~27	smear	F	P	H					X	fr(F)														R	
NBP0602A-5D-11R_a, 324 cm	~28	smear	F	P	H						fr(R)														X	
NBP0602A-5D-11R_a-CC	~28	smear	C	M	H			X			fr(F)														R	
NBP0602A-5D-12R_a, 83 cm	28.83	smear	C	M	M-H						fr(F)													fr(R)	R	
NBP0602A-5D-12R_a, 87 cm	28.87	smear	R	P	H						fr(R)														fr(X)	
NBP0602A-5D-13R_a, 44 cm	30.04	smear	F	M	M					X	fr(X)													fr(R)	fr(X)	
NBP0602A-5D-13R_a, 75 cm	30.35	smear	F	M	M						fr(F)														X	
NBP0602A-5D-13R_a-CC	30.36	smear	C	M	M	X		X			fr(R)													fr(F)	fr(X)	

Notes: Abundance: A = abundant, C = common, F = few, R = rare, X = present, B = barren, fr = fragments; Preservation: M = moderate, P = poor; Fragmentation: M = moderate, H = high.

SITE 6

A. OBJECTIVES

Site NBP0602A-6 (Fig. 5-6) was selected to sample the section approximately 150 m above the middle Miocene strata (Fig. 5-1) sampled at Site NBP0602A-5. This site targeted an acoustically laminated unit assumed to be of hemipelagic origin; however, the targeted interval was not reached. The overburden to the primary target was cored and consists of Pliocene sand.

B. OPERATIONS

Site NBP0602A-6 consists of two Kasten cores, two drill holes, and one grab sample. Holes NBP0602A-6A-KC, -6B-KC, and -6C are located at 63° 20.268' S, 52° 22.032' W in 532 m of water. Holes NBP0602A-6D and -6E-GS are located at 63° 19.746' S, 52° 22.040' W in 528 m of water. Neither Kasten core had any recovery.

Hole NBP0602A-6C completed nine core runs using the alien bit and reached a maximum depth of 20.5 mbsf. Core recovery was moderate to good throughout the hole, even though the goal was simply to get through the section (Table 5-4). The hole was terminated due to an approaching iceberg. Hole NBP0602A-6D was begun at an offset distance of about 0.5 km. It completed three core runs with the alien bit and reached a maximum depth of 10 mbsf. Core recovery was similar to that in Hole 6C, with relatively good recovery even though that was not the primary goal. Both holes were made using the 8.5-diameter hybrid bit rather than the smaller bit that had been used for the holes at Site NBP0602A-5. This change was made with the idea that cutting a larger hole may reduce the problems associated with drilling through gravel and sand. It is not clear if such a result was achieved or not. The hole was terminated due to approaching ice.

NBP0602A-6E-GS was collected as pipe was being pulled from Hole NBP0602A-6D in order to obtain a sample of the bottom, both to understand the drilling conditions and to obtain a biological sample of a modern assemblage. It returned a full grab bucket.

C. LITHOSTRATIGRAPHY

Site NBP0602A-6 consists of five holes, including two Kasten cores, two drill holes, and one grab sample. Neither Kasten core had any recovery.

Hole NBP0602A-6C sampled to 20.5 mbsf (Fig. 5-7; Appendix 5-2). The first core run washed to 4.0 mbsf but recovered cobbles and gravel with a small amount of mud. From 4.0 mbsf to at least 5.5 mbsf, and potentially to as deep as 8.0 mbsf, dark greenish gray (GLEY 1 4/1 5GY) pebbly sand was recovered. The sand contains a few clay laminations, and no bioturbation or macrofossils. Smear-slide analysis of the <250 μm fraction (Table 5-5) indicates the sediment consists of poorly sorted, angular to subrounded grains predominantly composed of clay (53%), with lesser amounts of quartz (20%) and feldspar (15%). Minor constituents include calcite (2%), heavy minerals (1%), hornblende (1%), and trace amounts of glauconite. Biogenic components include diatoms (7%) and pyritized sponge spicules (1%). From 8.0 mbsf to the base of the section at 20.5 mbsf, the sediment is pebbly, muddy sand with color varying from dark gray (GLEY 1 4/1 10Y) to very dark greenish gray (GLEY 1 3/1 10Y). The material is firmer than the section above 8.0 mbsf and contains rounded to subrounded grains. There is no evidence of bioturbation, and no macrofossils were found. Smear-slide analysis of the <250 μm fraction indicates poorly sorted, subangular to rounded grains composed primarily of clay (35-75%), quartz (13-23%), and feldspar (7-28%). Calcite and heavy minerals typically comprise several percent of the sediment, while mica, hornblende, and glauconite occur in trace amounts to 1%. Diatoms compose up to 10% of the sediment, with traces of sponge spicules also present. Silicoflagellates, rutilated quartz, and fecal pellets occur sporadically. These sandy units are interpreted to be traction current deposits.

Hole NBP0602A-6D reached 10.0 mbsf (Fig. 5-8; Appendix 5-3). The surface sample is very dark greenish gray (GLEY 1 3/1 10Y) pebbly sand and sandy mud. The unit from 5.5 to almost 9 mbsf is dark greenish gray (GLEY 1 4/1 10Y) to dark olive gray (GLEY 1 3/2 5Y), muddy fine to medium sand and no macrofossils or bioturbation. Smear-slide analysis of the <250 μm fraction indicates the sediment consists of poorly sorted subangular to subrounded sandy mud with diatoms. Clay (35%), quartz (31%), and feldspar (17%) are the dominant constituents, while calcite, heavy minerals, mica, hornblende, and glauconite occur in trace amounts to 3%. Sediment from 8.94 mbsf to the base of the hole is dark greenish gray (GLEY 1 4/1 10Y) pebbly, muddy sand. The sand is fine to medium with no bioturbation, no macrofossils, and mixed pebble lithologies. Smear-slide analysis of the <250 μm fraction (Table 5-5) indicates poorly sorted, subangular to subrounded grains. The sediment is predominantly clay (64%), with lesser amounts of quartz (13%) and feldspar (8%), and minor constituents similar to the section above. Diatoms compose 10% of the sediment in both units, while sponge spicules occur in trace amounts to 1%. These two units are also interpreted to be traction current deposits.

D. BIOSTRATIGRAPHY

Initial shipboard paleontological work for Site NBP0602A-6 focused on diatom analysis of smear slides from Holes NBP0602A-6C and -6D. A table of observed diatom taxa is presented in Table 5-6 and diatom zonal assignments and age estimates are shown in Figure 5-9.

In both Holes NBP0602A-6C and -6D, the first cores were washed to approximately 4.0 mbsf and no core was recovered in the uppermost sections of the holes. Below this level, samples from Cores NBP0602A-6C-2R_a to -7R_a (~4.0 to 17.0 mbsf) and Cores NBP0602A-6D-1R_a to -3R_a (~5.0 to 10 mbsf) contain few to common, moderately well preserved diatoms. Common diatom taxa in this interval include *Chaetoceros* spp. (small spores), *Denticulopsis delicata, Rouxia antarctica, Stephanopyxis* spp., *Thalassiosira nitzschioides,* and *T. torokina* (Table 5-6). Many of the samples in this interval are very rich in diatomaceous material, but all diatoms are highly fragmented. Even with a high degree of fragmentation, a number of biostratigraphically useful taxa could be identified, including *Fragilariopsis barronii, F. praeinterfrigidaria, Rouxia diploneides, Thalassiosira inura*, and *T. torokina* (Table 5-6). Using the overlapping ranges of these taxa, a broad age of early Pliocene can be interpreted for the cores, and, if the presence/absence of several taxa is considered, the age can be further narrowed using the established Southern Ocean zonal scheme for the Pliocene (see "**Explanatory Notes**"). Cores NBP0602A-6C-2R_a to -6R_a (~4.0 to 15.0 mbsf) and Cores NBP0602A-6D-1R_a to -3R_a (~5.0 to 10.0 mbsf) are assigned to the *F. barronii* Zone (Fig. 5-9) based on the presence of *F. barronii* and the absence of *Fragilariopsis interfrigidaria.* Age calibration of these datums places deposition of this section between ~3.8 and 4.4 Ma. Core NBP0602A-6C-7R_a (~16.0 to 17.0 mbsf) is tentatively placed in the *T. inura* Zone (~4.4 to 5.1 Ma) based on the presence of *T. inura* and the absence of *F. barronii*. The absence of *F. barronii* in this core may be due to other factors, such as poor preservation or environmental exclusion; therefore, Core 7R_a may also represent deposition during the *F. barronii* Zone interval, and 5.1 Ma (i.e., the first occurrence of *T. inura*) should be considered the maximum age for this core.

Diatoms are very rare and poorly preserved in the lowermost section of Hole NBP0602A-6C (Cores NBP0602A-6C-8R_a and -9R_a; ~19.1 to 20.5 mbsf). This interval has not been given a zonal assignment, although the presence of rare fragments of *D. delicata* and *T. torokina* does constrain the age of this section to late Miocene or early Pliocene. As such, diatom biostratigraphy does not provide a precise age estimate for the lowermost sediments penetrated at this site, as the overlapping ranges of *D. delicata* and *T. torokina* only provide a broad age assignment of ~4.0 to 9.0 Ma. More detailed postcruise sampling of these cores may identify intervals with higher diatom content, and therefore provide better age constraint for this section of the hole.

Many samples from Cores NBP0602A-6C-4R_a to -7R_a contain very abundant diatom fragments, with lithologies approaching diatomaceous sand. The predominant diatom group in these samples is *Stephanopyxis* spp. This diatom group is composed of several neritic-planktonic taxa that are rare in the modern sea-ice flora. Thus, the abundance of this group in Pliocene sediments of Holes NBP0602A-6C and -6D may indicate the local presence of open-water neritic areas during the summer months (with minimal sea-ice cover and turbidity). Increased opal (diatom) accumulation rates in continental-rise drift sediments on the western side on the Antarctic Peninsula (Hillenbrand and Fütterer, 2002) may provide support for regionally reduced sea-ice cover in the early Pliocene. Alternatively, diatom fragmentation and the high concentration of *Stephanopyxis* spp. in these sandy sediments could be the result of winnowing. The presence of abundant small diatom fragments and numerous small taxa, however, does not support intense winnowing.

In previous drilling and outcrop sampling efforts, lower Pliocene sediments have been obtained from only a few locations on the Antarctic shelf. On the western side of the Antarctic Peninsula, a ~150 m-thick section of lower Pliocene strata was drilled at Ocean Drilling Program (ODP) Site 1097 (Iwai and Winter, 2002). In the Site 1097 holes, Seismic Unit S2 and the upper part of S3 were determined to be early Pliocene in age, but limited depositional facies and paleoenvironmental interpretations could be made from the cores due to very poor recovery (Barker and Camerlenghi, 2002). Other lower Pliocene sections include the Dry Valley Drilling Project (DVDP) 10, DVDP 11, CIROS-2 drill cores in the Ross Sea (Winter and Harwood, 1997), and the Sørsdal Formation that outcrops in the Vestfold Hills (Pickard et al., 1988; Harwood et al., 2000; Whitehead et al., 2001). The Sørsdal Formation is composed of sandy diatomite and diatomaceous sands deposited in a coastal area of East Antarctica, and diatom biostratigraphy places the entire formation within the *F. barronii* Zone. Deposition of diatomaceous sands of the Sørsdal Formation and the lower Pliocene section of Holes NBP0602A-6C and -6D, therefore, are roughly contemporaneous. This suggests the intriguing possibility of a distant climatic connection influencing deposition at both sites.

During ODP Leg 113, a ~110 m-thick section of lower Pliocene muds and sands was drilled in deep waters of the Weddell Sea abyssal plain at Site 694 (Barker et al., 1988). These sediments are interpreted as high-energy turbidity currents composed of material at least partly sourced from the Antarctica Peninsula (Barker et al., 1988). In Hole 694B, a diatom-rich sample from the uppermost section of the turbiditic muds and sands (at ~13 mbsf) is assigned to the *F. barronii* Zone (Gersonde et al., 1990), indicating that deposition of at least the uppermost portion of the turbidite section is contemporaneous with the section recovered in Holes NBP0602A-6C and -6D. Below this level in Hole 694B, a thick section (from ~20 to 110 mbsf) of coarse to fine lithic quartz sands is present. These sands are poorly recovered and unfossiliferous, but are interpreted to extend down to the Miocene/Pliocene boundary (Gersonde et al., 1990). An interesting line of future research will be to determine whether there is a link between early Pliocene sand deposition in shelf areas of the eastern Antarctic Peninsula (Holes 6C and 6D) and the Weddell Sea abyssal plain (ODP Site 694).

E. PHYSICAL PROPERTIES

At Site NBP0602A-6 two Kasten cores (NBP0602A-6A-KC and NBP0602A-6B-KC) were taken but had no recovery. Hole NBP0602A-6C reached a depth of 20.5 mbsf and NBP0602A-6D drilled to a depth of 10 mbsf. Site NBP0602A-6 has similar lithologies and physical properties as those reported for Site NBP0602A-5. Cores from both holes were run through the MSCL, obtaining measurements every 2 cm, MCER probe obtained ER measurements every 5 cm, and discrete samples were taken every 10 to 20 cm and stored for future analyses.

Two lithologic subdivisions are informally distinguished in Hole NBP0602A-6C (see "**Lithostratigraphy**"). These units are described as pebbly sand and pebbly sand with a silty mud matrix. Variations observed in MSCL-MS, -ER, and -density can be attributed to the presence of pebbles and rocks throughout the various sections of the hole. A high peak in MS is correlated to individual rocks or a series of closely spaced rocks (e.g., Lithology Log NPB0602A-6C-6R_a at 30 to 35 cm). Many of the rocks and pebbles found in the cores tend to be basaltic in nature, thus giving a large increase in MS. Background values of MS are generally around 30-50 SI units with large peaks having values between 200-600 SI units. Density varies between 1.5-3 g/cm^3 throughout the hole, averaging around 2.76 g/cm^3. This is slightly higher than the average 2.68 g/cm^3 observed at Hole NBP0602A-5B. Electrical resistivity measurements using the MCER probe were not easily obtained due to the uneven nature of the split core surface. Large variance of the averaged voltages was recorded since the probe was not always in good contact with the sediment. Only those averages with a variance under 1.0 ohm were converted to resistivity. The ER measurements vary between 0.7-1.4 ohm-m using the MSCL, whereas the MCER probe gives slightly higher values ranging from 0.9-2.5 ohm-m. As observed at Site NBP0602A-5 there is little downhole increase in physical properties, again suggesting these sediments have undergone some physical sorting.

Two lithologic subdivisions are also informally distinguished in Hole NBP0602A-6D (see "**Lithostratigraphy**"). These units are described as a muddy sand and pebbly muddy sand. Only two cores were recovered so the interpretation gleaned from physical properties is minimal. High peaks in MS can be correlated to rocks (e.g., Lithology Log NPB0602A-6D-3R_a at 60 to 70 cm); however, other peaks (e.g., Lithology Log NPB0602A-6D-2R_a at 75 to 80 cm) do not appear to be related to anything observed on the surface of the split core. Density varies between 1.5-3 g/cm^3 throughout the hole, averaging around 2.79 g/cm^3, comparable to the average density obtained from Hole NPB0602A-6C. Electrical resistivity measurements using the MCER probe were again not easily obtained due to the uneven nature of the split core surface. The ER measurements vary between 0.76-1.1 ohm-m using the MSCL, and the MCER probe gives slightly higher values ranging from 0.76-2 ohm-m. These values are slightly lower than those observed at Hole NPB0602A-6C. No downhole comparisons can be made due to limited recovery.

F. SITE SUMMARY

Site NBP0602A-6 intended to sample approximately 150 m above the middle Miocene strata successfully sampled at Site NBP0602A-5. The target was an acoustically laminated unit assumed to be hemipelagic in origin. Two Kasten cores yielded no sediment, although a surface grab sample taken while pulling pipe at the end of the last drill hole returned full of Holocene sandy diatomaceous mud.

After washing to 4 mbsf, Hole NBP0602A-6C penetrated to 20.5 mbsf with 28% recovery. The sediment consists of dark greenish gray to dark gray pebbly sand to pebbly, muddy sand of early Pliocene age. Diatoms comprise from 7 to 10% of the fine fraction, whereas clay ranges from 35 to 70%, and angular to subangular quartz and feldspar from 10 to 30%. The sandy units are interpreted as traction current deposits.

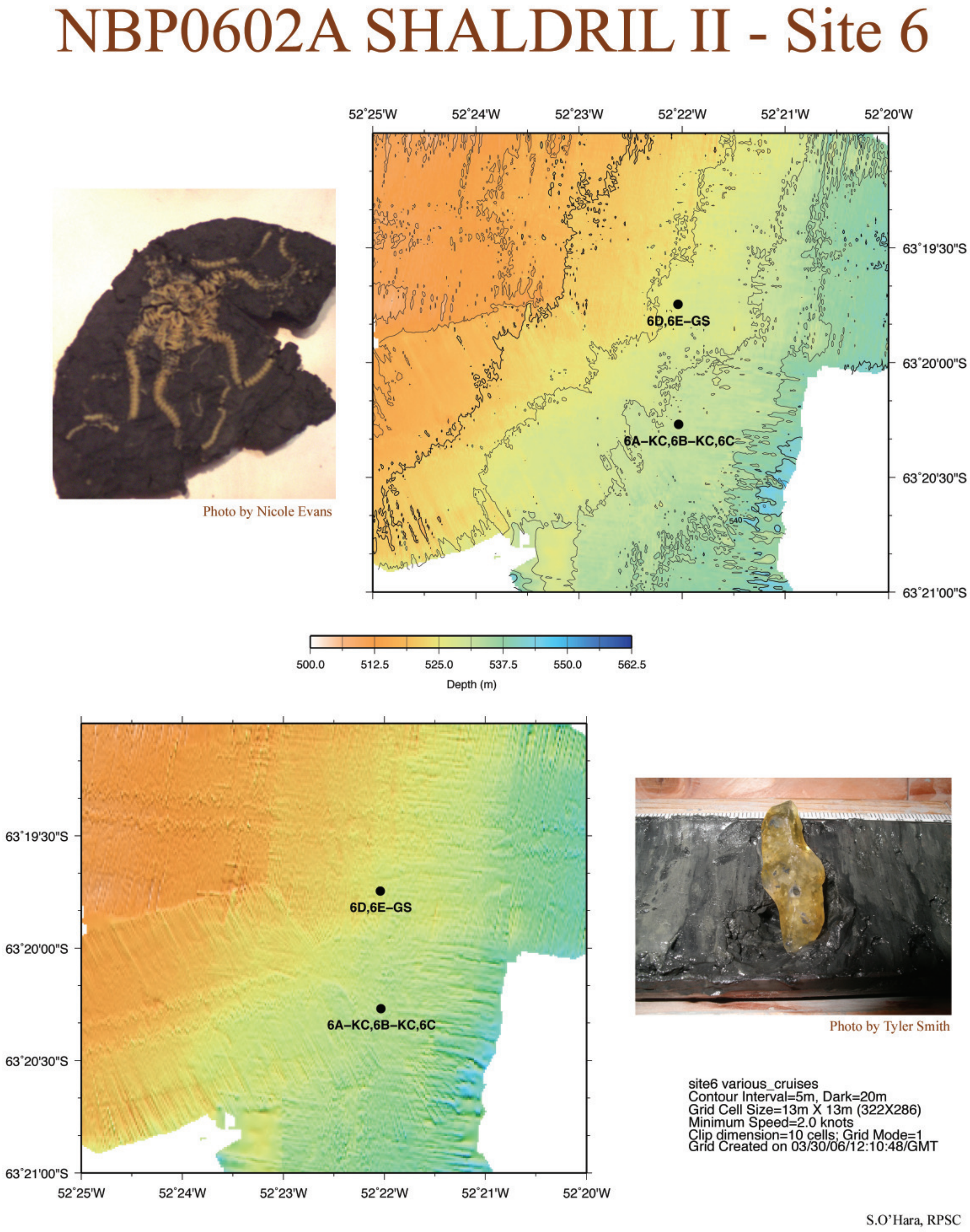
Samples from Cores NBP0602A-6C-2R_a to -7R_a (~4.0 to 17.0 mbsf) contain few to common, moderately well preserved diatoms that are highly fragmented. Nevertheless, biostratigraphically useful taxa could be identified, allowing Cores NBP0602A-6C-2R_a to -6R_a (~4.0 to 15.0 mbsf) to be assigned to the *F. barronii* Zone (~3.8 and 4.4 Ma). Core NBP0602A-6C-7R_a (~16.0 to 17.0 mbsf) is tentatively placed in the *T. inura* Zone (~4.4 to 5.1 Ma) based in part on the absence of *F. barronii*, which could be due to other factors such as poor preservation or environmental exclusion. Diatoms are very rare and poorly preserved in the remainder of this hole; however, fragments in Cores NBP0602A-6C-8R_a and -9R_a (~19.1 to 20.4 mbsf) suggest a broad age assignment of ~4.0 to 9.0 Ma.

Diatom fragments in Cores NBP0602A-6C-4R_a to -7R_a are highly abundant, approaching diatomaceous sand. The predominant group therein is *Stephanopyxis* spp, which may indicate the local presence of open-water neritic areas during the summer months (with minimal sea-ice cover and turbidity). Alternatively, diatom fragmentation in these sandy sediments could result from winnowing, although the presence of numerous small taxa does not support intense winnowing.

Variations observed in the MSCL-MS, -ER, and -density are attributed to pebbles and rocks throughout the cores. Many of the rocks/pebbles are basaltic in nature, thus giving a large increase in MS. As observed at Site NBP0602A-5, there is little downhole increase in physical properties, again suggesting these sediments have undergone some physical sorting.

Although ice coverage remained below $^{1}/_{10}$ as Hole NBP0602A-6C was drilled, a large, solitary iceberg on course for the ship threatened the operation. The pipe was pulled above mudline and the ship offset approximately 0.5 km to drill a new hole. Hole NBP0602A-6D penetrated to 10 mbsf in three core runs, with 48% recovery after the initial wash core. It penetrated well into the lower Pliocene sandy muds seen previously in Hole NBP0602A-6C when yet another iceberg terminated the operation.

Figure 5-6. Multibeam images of Site NBP0602A-6.



NBP0602A SHALDRIL II - Site 6

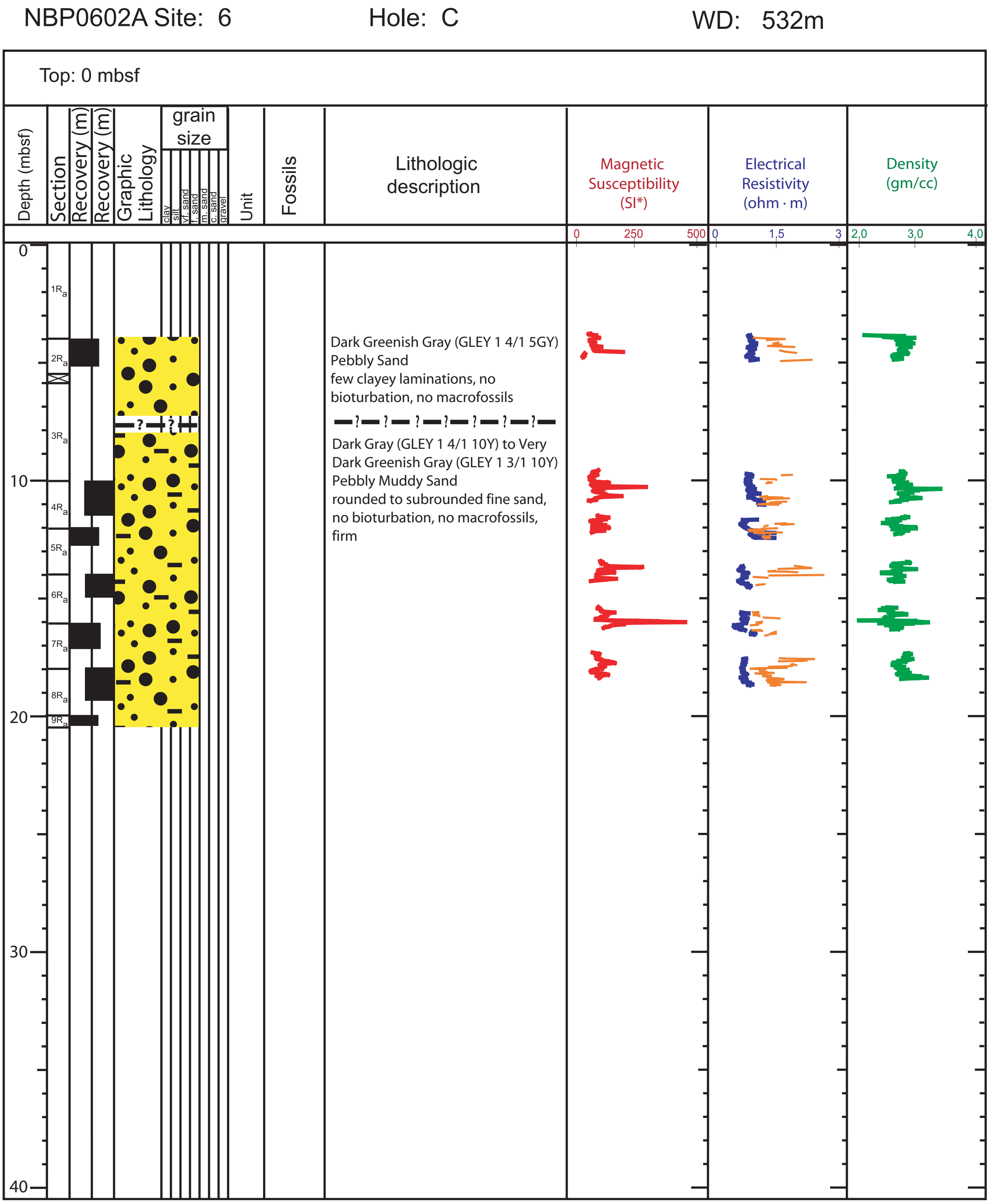
Photo by Nicole Evans

Photo by Tyler Smith

site6 various_cruises
Contour Interval=5m, Dark=20m
Grid Cell Size=13m X 13m (322X286)
Minimum Speed=2.0 knots
Clip dimension=10 cells; Grid Mode=1
Grid Created on 03/30/06/12:10:48/GMT

S.O'Hara, RPSC

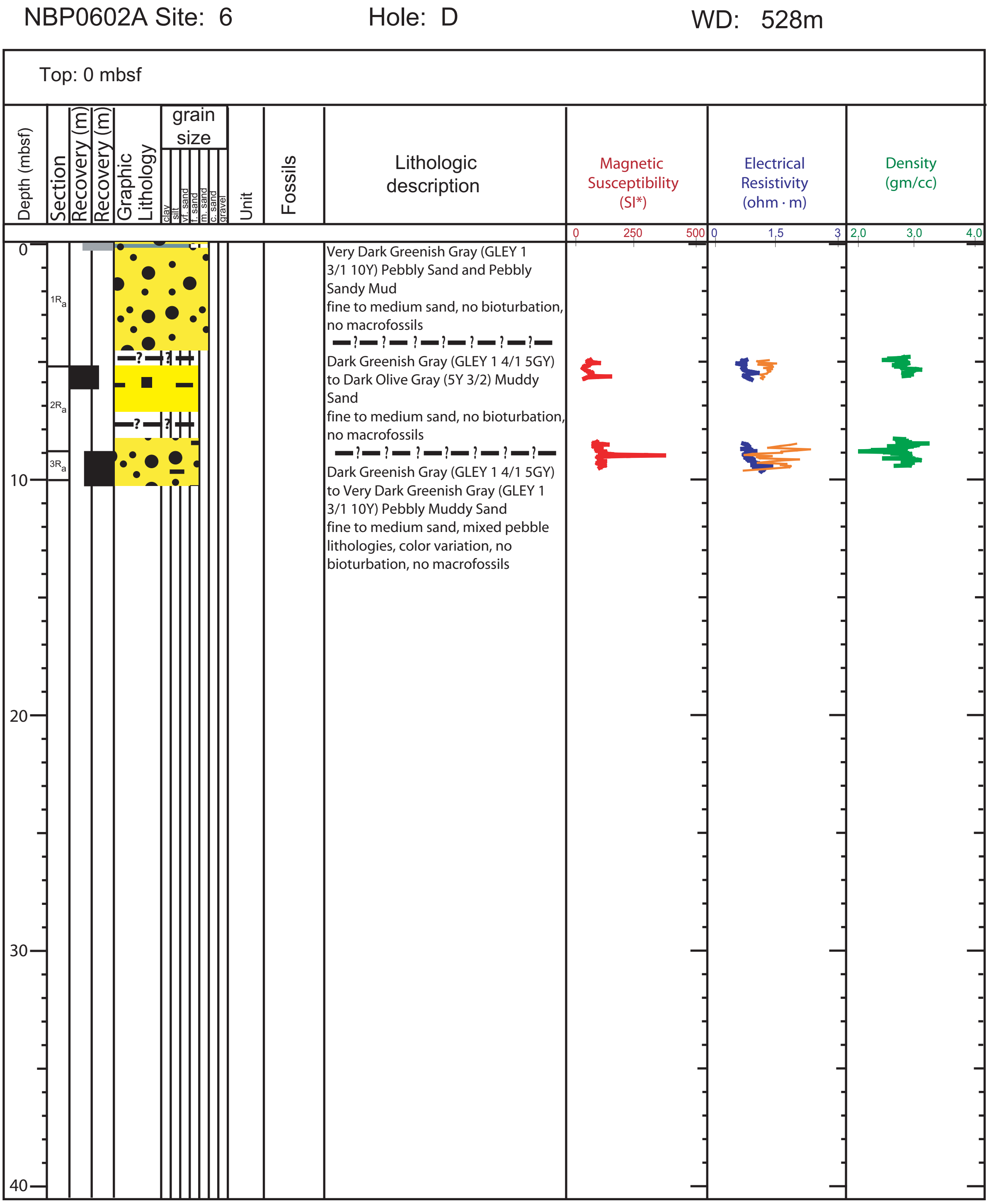
Figure 5-7. Summary lithologic log of Hole NBP0602A-6C.



Dark Greenish Gray (GLEY 1 4/1 5GY)
Pebbly Sand
few clayey laminations, no bioturbation, no macrofossils

Dark Gray (GLEY 1 4/1 10Y) to Very Dark Greenish Gray (GLEY 1 3/1 10Y)
Pebbly Muddy Sand
rounded to subrounded fine sand, no bioturbation, no macrofossils, firm

Figure 5-8. Summary lithologic log of Hole NBP0602A-6D.



Very Dark Greenish Gray (GLEY 1 3/1 10Y) Pebbly Sand and Pebbly Sandy Mud
fine to medium sand, no bioturbation, no macrofossils

Dark Greenish Gray (GLEY 1 4/1 5GY) to Dark Olive Gray (5Y 3/2) Muddy Sand
fine to medium sand, no bioturbation, no macrofossils

Dark Greenish Gray (GLEY 1 4/1 5GY) to Very Dark Greenish Gray (GLEY 1 3/1 10Y) Pebbly Muddy Sand
fine to medium sand, mixed pebble lithologies, color variation, no bioturbation, no macrofossils

Figure 5-9. Diatom zonal assignments and age interpretation for Holes NBP0602A-6C and -6D.

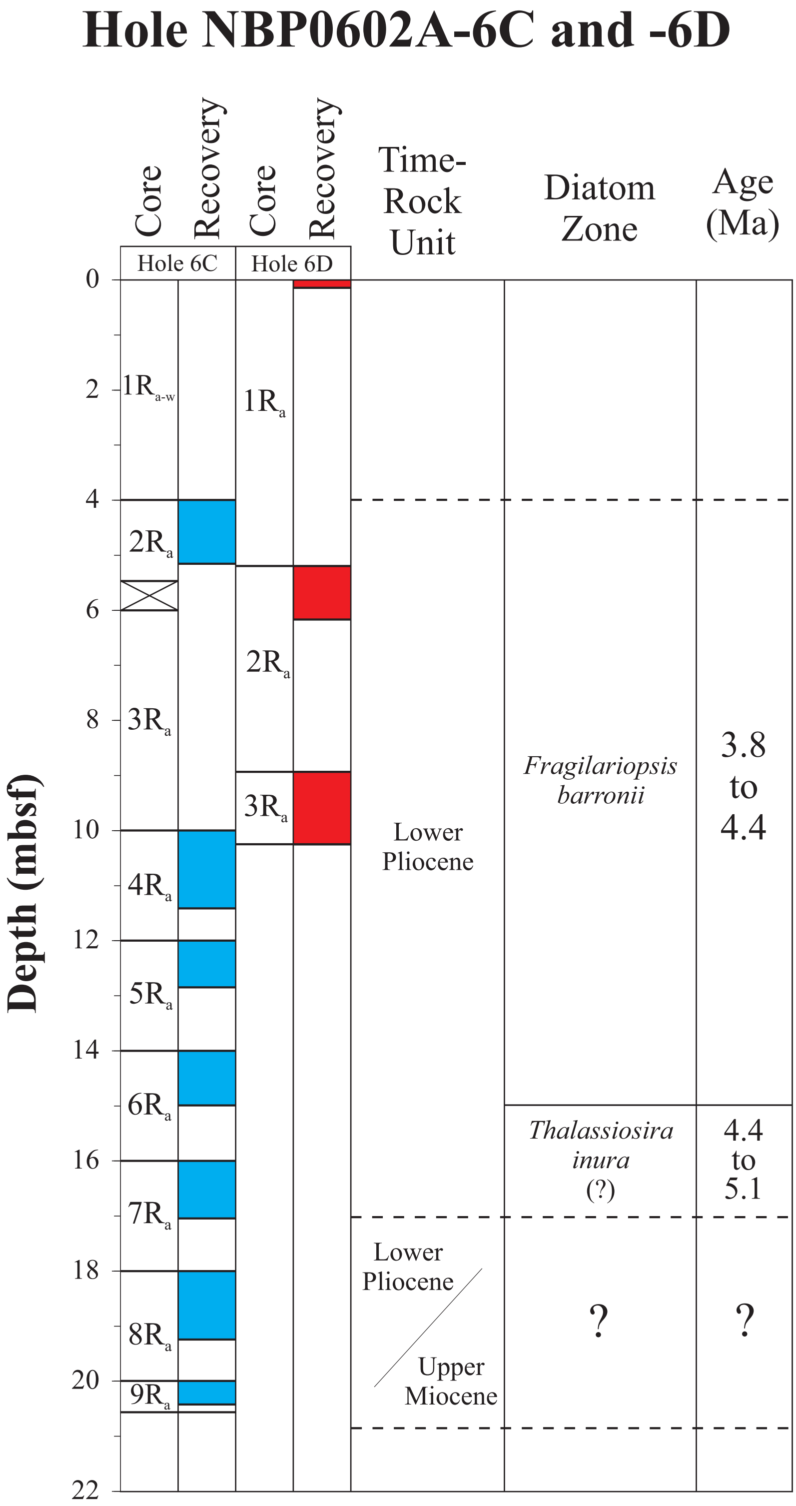


Table 5-4. Drilling and coring recovery log for Holes NBP0602A-6A-KC, -6B-KC, -6C, -6D, and -6E-GS.

NBP0602A SHALDRIL II Site 6

Multibeam Water Depth: 530 m at A, B; 532 m at C; 528 m at D, E

Station Number/Hole	Core Number	Core Type	Top (mbsf)	Bottom (mbsf)	Interval Cored (m)	"Push Distance" (m)	Recovery: total (m)	Recovery: competent (m)	Recovery: disturbed (m)	Gaps (m)	Recovery Corrected (m)	Total Recovery (%)	Recovery Corrected (%)	Section Number	Section Lengths (cm)	Date (JD)	Time on Deck (GMT)	Initials	Comments
6A	1	KC	0.0	0.0	0	0.0	0	0	0	0	0	0.0%	0.0%	0	0.0	76	0815	CAC	No Recovery
6B	1	KC	0.0	0.0	0	0.0	0	0	0	0	0	0.0%	0.0%	0	0.0	76	0900	CAC	No Recovery
6C	1	Ra-w	0.0	4.0	washed	0	0	0	0	0	0	0.0%	0.0%	1	baggie	76	1806	CD	Cobbles with some mud
6C	2	Ra	4.0	5.5	4.0-5.5	1.5	1.165	1.165	0	0	1.165	77.7%	77.7%	1	116.4	76	1945	CD	Sandy, traction current deposit
6C	3	Ra	6.0	10.0	8.0-10.0	2.0	0	0	0	0	0.000	0.0%	0.0%	1	baggie (4)	76	2211	CD	Bagged four sections, include core catcher
6C	4	Ra	10.0	12.0	10.0-12.0	2.0	1.42	1.42	0	0	1.42	71.0%	71.0%	1	143.0	76	2347	CD	Drill run
6C	5	Ra	12.0	14.0	12.0-14.0	2.0	0.855	0.855	0	0	0.855	42.8%	42.8%	1	85.9	77	0120	CD	
6C	6	Ra	14.0	16.0	14.0-16.0	2.0	0.99	0.99	0	0	0.990	49.5%	49.5%	1	99.1	77	0258	CD	
6C	7	Ra	16.0	18.0	16.0-18.0	2.0	1.05	1.05	0	0	1.050	52.5%	52.5%	1	103.0	77	0510	JM	
6C	8	Ra	18.0	20.0	18.0-20.0	2.0	1.25	1.25	0	0	1.250	62.5%	62.5%	1	125.0	77	0610	JM	
6C	9	Ra	20.0	20.5	20.0-20.5	0.5	0.43	0.43	0	0	0.430	86.0%	86.0%	1	40.0	77	0804	JM	Pliocene; Terminated due to ice
Total											**7.160**								
6D	1	Ra	0.0	5.2	0-5.2	5.2	0.2	0	0.2	0	0.000	3.8%	0.0%		20.0	77	1140	CAC	Mostly gravel
6D	2	Ra	5.2	8.94	5.2-8.94	3.7	0.975	0.975	0	0	0.975	26.4%	26.4%		97.5	77	1320	CAC	Hole terminated due to ice
6D	3	Ra	8.94	10	8.94-10	1.06	1.32	1.32	0	0	1.320	124.5%	124.5%		132.0	77	1702	CD	Final recovery while pulling pipe; hole terminated due to ice
6E	1	GS	0	0	surface	0	0	0	0	0	0	100%	100%	1	bucket	77	2100	JSW	
Total							**8.335**				**2.295**	**27%**	**7%**						

Table 5-5. Smear-slide data for Holes NBP0602A-6C and -6D.

Sample	Approximate Depth (mbsf)	Components												Grain Size			Sorting	Roundness	Lithology	Comments
		Minerals										Rock								
		Calcite	Clay	Feldspar	Glauconite	Heavy Minerals	Hornblende	Mica	Quartz	Diatoms	Silicoflagellates	Sponge Spicules	Fragments	Sand	Silt	Clay				
Hole 6C																				
NBP0602A-6C-2R_a, 58 cm	4.58	2	53	15		1	1	tr	20	7		1		15	23	62	P	a-sr	Mud	Pyritized sponge spicules
NBP0602A-6C-3R_a, base	(6.0-10.0)	2	40	20	tr	3	1	1	28	3		tr	2	30	30	40	P	r	Sandy mud	Rutilated quartz
NBP0602A-6C-4R_a, 142 cm	11.42	2	42	20	1	2	1	1	18	10		tr	2	25	30	45	P	sa	Sandy mud	Rutilated quartz; fecal pellets
NBP0602A-6C-5R_a, 23 cm	12.23		75	7	tr	1	tr		15	1		1		7	16	77	P	a-sr	Clay	
NBP0602A-6C-6R_a, 44 cm	14.44	2	55	13	1	1	1	tr	23	3	tr	1		16	25	59	P	a-sr	Sandy mud	
NBP0602A-6C-7R_a, 80 cm	16.80	3	72	8	tr	1	tr		13	2		tr		20	5	75	P	sa-sr	Sandy clay	
NBP0602A-6C-8R_a, 10 cm	18.10	3	35	23	1	3	1	1	26	4		tr	3	40	25	35	P	sr	Sandy mud	Fecal pellets
NBP0602A-6C-9R_a, 30 cm	20.30	5	59	12	tr	3	2	tr	18	1		tr		25	15	60	P	sa-sr	Sandy mud	
Hole 6D																				
NBP0602A-6D-2R_a, 48 cm	5.68	3	35	17	tr	2	2	tr	31	10		tr		35	20	45	P	sa-sr	Sandy mud	
NBP0602A-6D-3R_a, 65 cm	9.59	2	64	8	tr	1	1	tr	13	10		1		10	15	75	P	sa-sr	Silty clay	

Notes: Sample: R_a = cored using alien coring bit; Components/Grain Size: Numbers represent percentages, tr = trace; Sorting: P = poor; Roundness: a = angular, sa = subangular, sr = subrounded.

Table 5-6. Stratigraphic occurrence and relative abundance of diatom taxa in Holes NBP0602A-6C and -6D.

						Diatoms																								
Cruise	**Depth (mbsf)**	**Slide Preparation**	**Diatom Abundance**	**Preservation**	**Fragmentation**	"*Actinocyclus actinochilus* early form"	*Actinocyclus ingens*	*Actinocyclus* spp.	*Azpeitia tabularis*	*Chaetoceros* spp. (small veg. cells & resting spores)	*Cocconeis* spp. (several taxa)	*Coscinodiscus* spp.	*Dactyliosolen antarcticus* (girdle bands)	*Denticulopsis delicata*	*Denticulopsis simonsenii / vulgaris*	*Eucampia antarctica* var. *recta*	*Fragilariopsis aurica*	*Fragilariopsis barronii*	*Fragilariopsis praecurta*	*Fragilariopsis praeinterfrigidaria*	*F. praeinterfrigidaria-interfrigidaria* (int. form)	*Fragilariopsis* cf. *sublinearis*	*Fragilariopsis vanheurckii*	*Paralia* spp.	*Rhizosolenia* spp.	*Rouxia antarctica*	*Rouxia diploneides*	*Rouxia isopolica*	*Rouxia naviculoides*	*Rouxia* spp.
Hole 6C																														
NBP0602A-6C-1R_a, bit face	3.90	smear	B	-	-																									
NBP0602A-6C-1R_a, 58 cm	4.58	smear	F	P	H					R	fr(X)	fr(R)							?						X	fr(X)	fr(X)			
NBP0602A-6C-2R_a-CC	5.17	smear	F	P	H				X	R		fr(R)	X			X		R	R	X			X			X	fr(X)			
NBP0602A-6C-3R_a, bit face	10.00	strewn	F	M	H					F	X	fr(X)	X			R		R		X			X			R	fr(X)	fr(X)		
NBP0602A-6C-4R_a, 38 cm	10.38	strewn	C	M	M			X		F		fr(X)				X		R-F	X	X		fr(F)	X			F	X			
NBP0602A-6C-4R_a-CC	11.42	smear	F	P	H		X	X		F	X	fr(X)				X				X			X		R	X				
NBP0602A-6C-5R_a-CC	12.86	strewn	C	M	M-H	X				F		fr(X)		R-F		X		X	X	?	X		X		R	X	X			
NBP0602A-6C-6R_a-CC	14.99	smear	C	M	H			X		R	X	fr(X)	X	X		X		X	X	X	X		X		X	R	X		X	
NBP0602A-6C-7R_a, 100 cm	17.00	strewn	F	P	H			R		X	X	fr(R)		F			X		R					X	X	fr(R)				
NBP0602A-6C-8R_a, 108 cm	19.08	strewn	X	P	H			fr(X)		X	fr(X)	fr(X)																		
NBP0602A-6C-8R_a, 125 cm	19.25	strewn	X-R	P	H					X	X	fr(X)													X					fr(X)
NBP0602A-6C-9R_a, 30 cm	20.30	strewn	X	P	H					X	X	fr(X)		fr(X)	X															
NBP0602A-6C-9R_a-CC	20.43	strewn	X	P	H																									
Hole 6D																														
NBP0602A-6D-1R_a-CC	~5.0	smear	F	P	H					R	X								X	X						R			X	
NBP0602A-6D-2R_a, 98 cm	6.18	strewn	C	M	H					F		R	X	X		X		X		X	X	R				R	fr(X)	fr(X)		
NBP0602A-6D-3R_a-CC	10.26	smear	F	P	H					F	X					X		X	X				X			fr(F)		fr(X)		

Notes: Abundance: C = common, F = few, R = rare, X = present, B = barren, fr = fragments, d = downcore contamination, ? = questionable; Preservation: M = moderate, P = poor; Fragmentation: M = moderate, H = high.

Table 5-6 (continued).

						Diatoms															Silico-flagellate
Cruise	**Depth (mbsf)**	**Slide Preparation**	**Diatom Abundance**	**Preservation**	**Fragmentation**	*Stellarima microtrias*	*Stephanopyxis* spp.	*Synedropsis* sp. 1	*Synedropsis* sp. 3	*Thalassionema nitzschioides*	*Thalassiosira antarctica* var. *antarctica*	*Thalassiosira complicata*	*Thalassiosira fasciculatus*	*Thalassiosira inura*	*Thalassiosira oestrupii* (small, fine areolation)	*Thalassiosira oliverana*	*Thalassiosira torokina* ("early form")	*Thalassiosira* spp. (very small forms)	*Thalassiothrix/Trichotoxon* spp.	*Trinacria excavata* group	*Distephanus speculum speculum*
Hole 6C																					
NBP0602A-6C-1R_a, bit face	3.90	smear	B	-	-																
NBP0602A-6C-1R_a, 58 cm	4.58	smear	F	P	H	fr(X)	fr(R)							R			fr(R)	X	fr(R)		
NBP0602A-6C-2R_a-CC	5.17	smear	F	P	H	X	R			fr(X)			X	X		R	fr(X)	X	fr(X)		X
NBP0602A-6C-3R_a, bit face	10.00	strewn	F	M	H	X	R	X		fr(F)				X		X	fr(X)	X	fr(F)		X
NBP0602A-6C-4R_a, 38 cm	10.38	strewn	C	M	M	fr(X)	F	X	X	fr(X)		X		X	X	X	fr(X)	R	fr(R)		X
NBP0602A-6C-4R_a-CC	11.42	smear	F	P	H	X	fr(C)	X				X		X	X		X	X	fr(R)		
NBP0602A-6C-5R_a-CC	12.86	strewn	C	M	M-H	R	fr(C)	X		fr(F)				X	X	X	X	X	fr(F)		
NBP0602A-6C-6R_a-CC	14.99	smear	C	M	H	fr(X)	fr(C)	X		fr(R)					X		fr(X)		fr(R)		
NBP0602A-6C-7R_a, 100 cm	17.00	strewn	F	P	H		fr(F)			fr(R)		X		X	R	X	fr(X)		fr(F)		X
NBP0602A-6C-8R_a, 108 cm	19.08	strewn	X	P	H	fr(X)	fr(X)			fr(R)											
NBP0602A-6C-8R_a, 125 cm	19.25	strewn	X-R	P	H		fr(X)										fr(X?)		fr(R)		
NBP0602A-6C-9R_a, 30 cm	20.30	strewn	X	P	H	fr(X)	fr(X)				*d*						fr(X?)			fr(X)	
NBP0602A-6C-9R_a-CC	20.43	strewn	X	P	H		fr(X)												fr(X)		
Hole 6D																					
NBP0602A-6D-1R_a-CC	~5.0	smear	F	P	H	fr(X)	fr(R)		X					R	X	X	X		fr(F)		
NBP0602A-6D-2R_a, 98 cm	6.18	strewn	C	M	H	fr(R)	fr(F)		X	fr(R)		X		R			R	R	fr(F)		
NBP0602A-6D-3R_a-CC	10.26	smear	F	P	H	fr(R)	fr(F)							X	X		fr(X)	X	fr(R)		

Notes: Abundance: C = common, F = few, R = rare, X = present, B = barren, fr = fragments, d = downcore contamination, ? = questionable; Preservation: M = moderate, P = poor; Fragmentation: M = moderate, H = high.

SITE 7

A. OBJECTIVES

Site NBP0602A-7 (Fig. 5-10) was drilled to sample lower Miocene strata (Fig. 5-11) approximately 150 m below the middle Miocene section targeted at Site NBP0602A-5. The target interval is an acoustically laminated interval where the reflectors appear to come very close to the seafloor. The target interval was not reached.

B. OPERATIONS

Site NBP0602A-7 is located at 63° 17.016' S, 52° 46.020' W in 448 m of water. One Kasten core and one drill hole were accomplished at this site (Table 5-7). Kasten Core NBP0602A-7A-KC had 48 cm of total recovery and was the first Kasten core in the northern Joinville study area to have any recovery.

Hole NBP0602A-7B was begun using the alien bit. The first core run was from the seafloor to 6 mbsf, returning 31 cm of washed core. The targeted interval at the site is below about 15 or 20 m of overburden and thus the top of the core was intentionally washed. Another run with the alien bit was then attempted. During this attempt, the locking coupling of the BHA sheared apart. The alien bit and the majority of the BHA were lost. The reasons for this failure are not clear. There is no evidence that this hole was started at an angle; mudline was reached one meter above the depth indicated by multibeam. The tear appears to have begun at the point where slots were cut in the wall of the locking coupling (Fig. 5-12). A new design or manufacturing process for this piece may be considered in the future.

C. LITHOSTRATIGRAPHY

Site NBP0602A-7 includes one Kasten core and one drill hole. Kasten Core NBP0602A-7A-KC sampled from 0 to 0.48 mbsf (Fig. 5-13). The sediment recovered is greenish black (GLEY 1 2.5/ 10Y), poorly sorted, pebbly, muddy sand. The sand is very fine to coarse and subangular to subrounded. A layer of pebbles was concentrated at the core top (Fig. 5-14) and is interpreted as a lag deposit. The biota in the core includes krill, worms, and a clam.

Hole NBP0602A-7B recovered 0.31 cm of sediment after washing to 6.0 mbsf (Fig. 5-15). The sediment consists of very dark greenish gray (GLEY 1 3/1 5GY) sand, sandy gravel, and pebbly sandy mud. No macrofossils or bioturbation are present.

D. BIOSTRATIGRAPHY

Three samples from Site NBP0602A-7 were prepared for diatom analysis. The observed diatom taxa are presented in Table 5-8.

The base of Kasten Core NBP0602A-7A-KC (0.48 mbsf) yielded common moderately preserved diatoms. The assemblage represents a modern sea-ice assemblage, and characteristic taxa include *Actinocyclus actinochilus, Chaetoceros* spp., *Fragilariopsis curta, F. vanheurckii,* and *Thalassiosira antarctica* (Table 5-8). The recovered sediment is most likely Holocene in age, but diatom biostratigraphy only constrains the age to < 140 ka based on the absence of *Rouxia leventerae.*

Diatoms in the base of Core NBP0602A-7B-1R$_a$ (Samples NBP0602A-7B-1R$_a$, 30 cm and -1R$_a$-CC) are rare and poorly preserved. The few identifiable taxa present include both late Pliocene-Pleistocene species, as well as a few fragments of older, reworked taxa such as *Trinacria excavata* (Table 5-8). Due to low abundance and poor preservation, diatom biostratigraphy only provides an age of late Pliocene or younger for these samples.

E. PHYSICAL PROPERTIES

Site NBP0602A-7 consists of a Kasten core and a drill hole, both having little recovery. The 48 cm recovered in Kasten Core NBP0602A-7A-KC consists of poorly sorted, pebbly, muddy sand and only the MCER probe was used. Electrical resistivity values range from 0.8-1.5 ohm-m. Core NBP0602A-7B recovered 31 cm of similar material and no data was collected on this core. Due to limited recovery little can be gleaned from the analyses of the physical properties.

F. SITE SUMMARY

After isolated icebergs terminated both drill holes at Site NBP0602A-6, seismic gear was deployed and a supplemental line shot to the northeast to locate a site where lower Miocene units could be sampled. These were calculated to lie some 150 m below the middle Miocene recovered at Site NBP0602A-5. Site NBP0602A-7 was selected where these lower Miocene reflectors occur close to the seafloor.

Kasten Core NBP0602A-7A-KC recovered 48 cm of poorly sorted, pebbly, muddy sand with a gravel lag at the top; the sediment yielded a modern sea-ice diatom assemblage. Hole NBP0602A-7B drilled rather slowly and with some difficulty in firm sediment. A wash core to 6 mbsf returned 31 cm of disturbed sediment with rare, poorly preserved Plio-Pleistocene diatoms.

During the next core run, the drill string became stuck and efforts were made to free it; however, within 10 minutes, the locking coupling of the BHA sheared, leaving the alien bit and most of the BHA in the hole. Although multiple hypotheses for the failure abound, a crack appears to have begun where slots had been cut into the wall of the locking coupling. The failure, therefore, may be related at least in part to the design and/or manufacture of the coupling. Other factors may have played a role as well, as the damage to the BHA was not consistent with the 20 tons of overpull being used at the time of failure.

Figure 5-10. Multibeam images of Site NBP0602A-7.

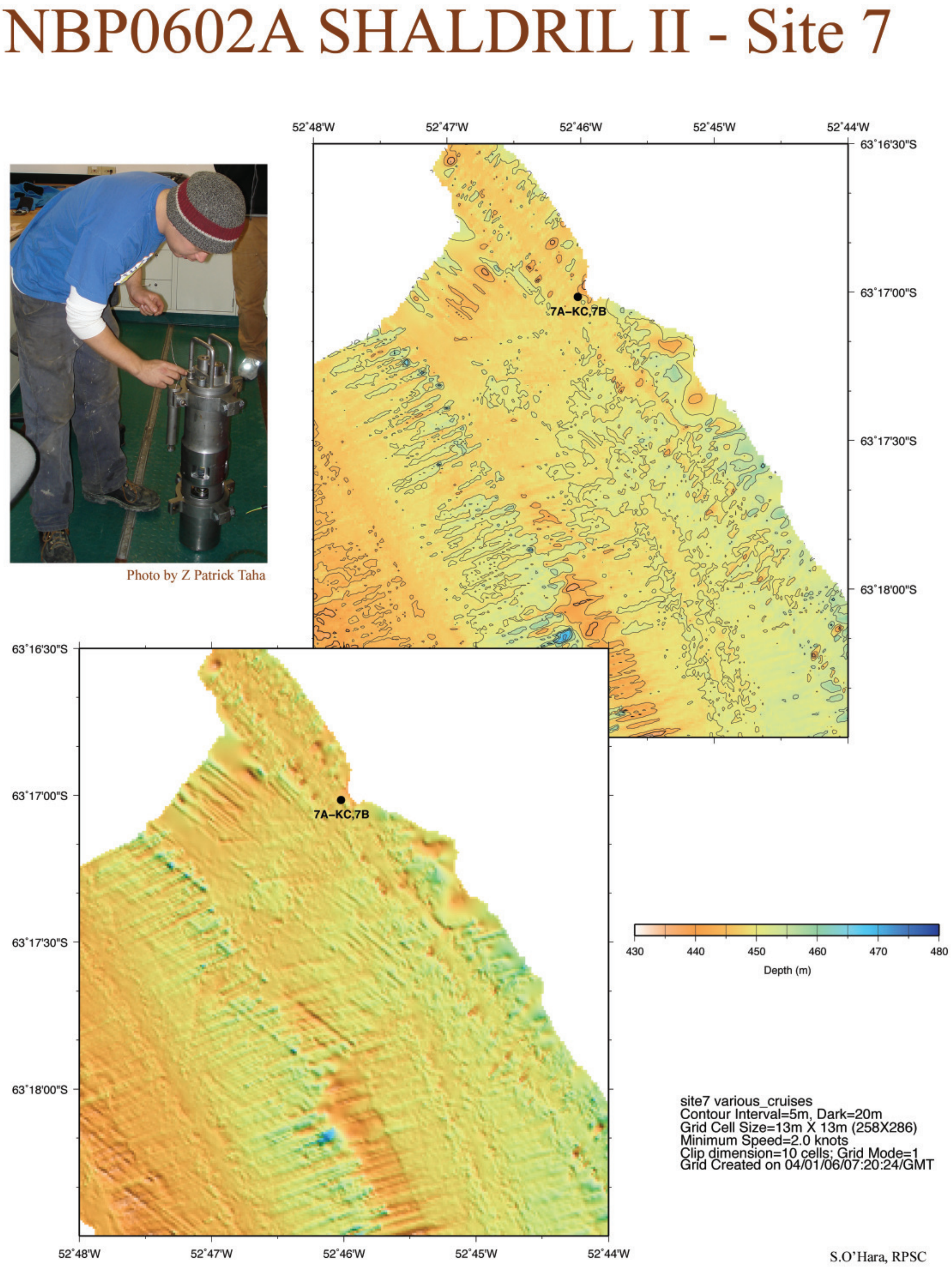


Figure 5-11. Seismic Line NBP0602A-10 showing the location of Hole NBP0602A-7B.

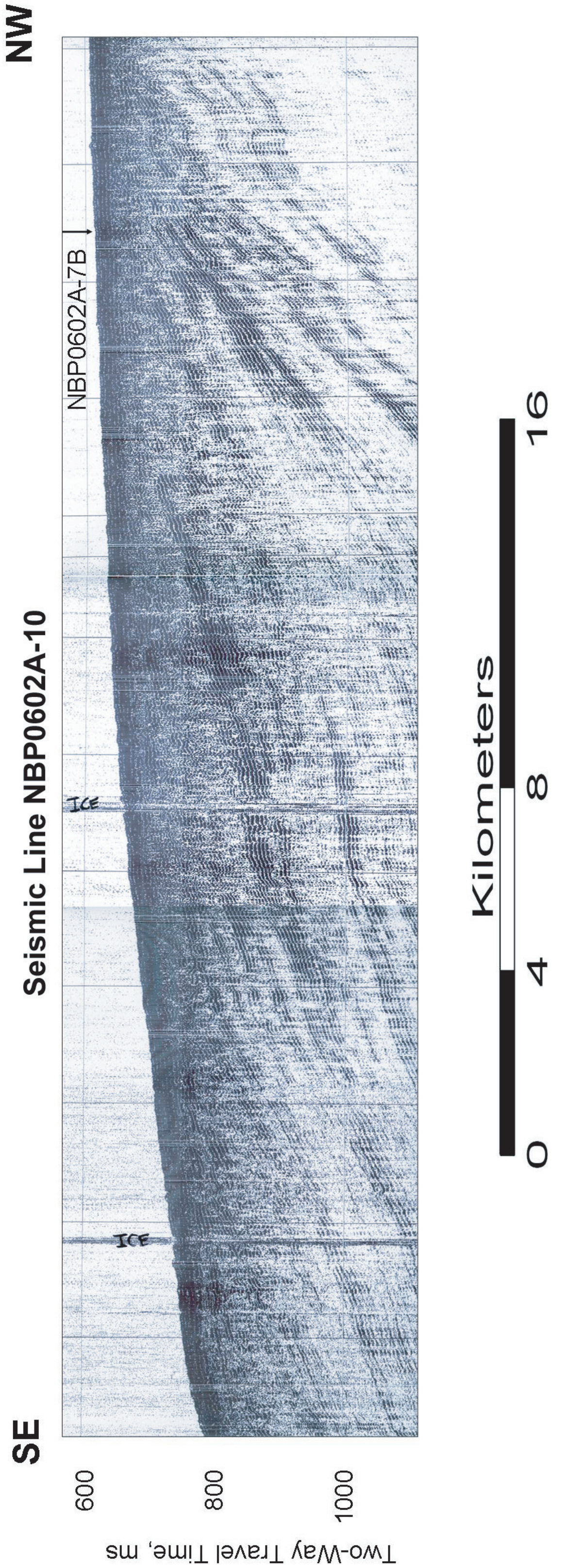
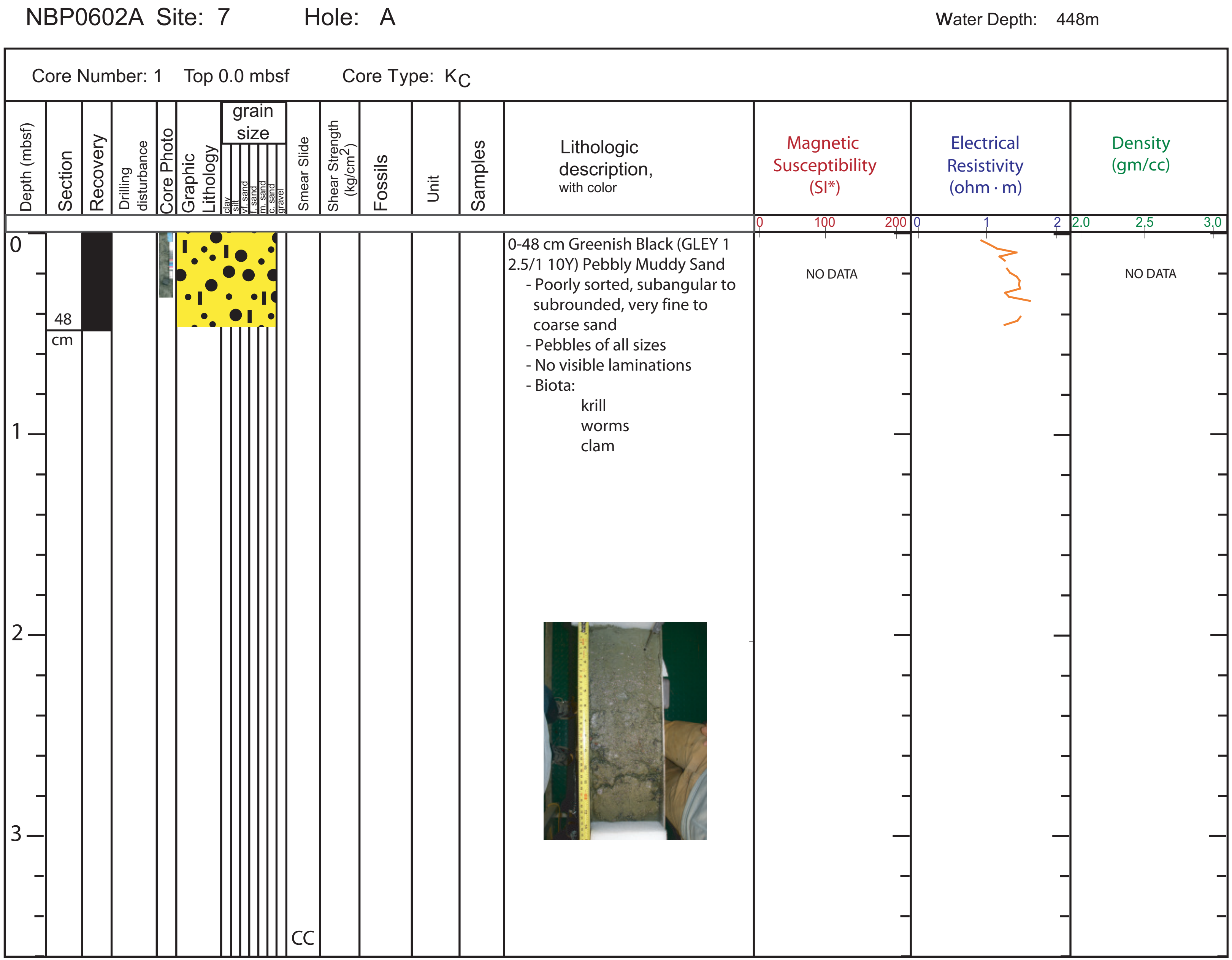


Figure 5-12. Photograph showing details of broken pipe from Hole NBP0602A-7B.

Photo by Julia Smith Wellner



0-48 cm Greenish Black (GLEY 1 2.5/1 10Y) Pebbly Muddy Sand

- Poorly sorted, subangular to subrounded, very fine to coarse sand
- Pebbles of all sizes
- No visible laminations
- Biota:
  - krill
  - worms
  - clam

Figure 5-13. Lithologic log for Kasten Core NBP0602A-7A-KC.

Figure 5-14. Photograph of Kasten Core NBP0602A-7A-KC.

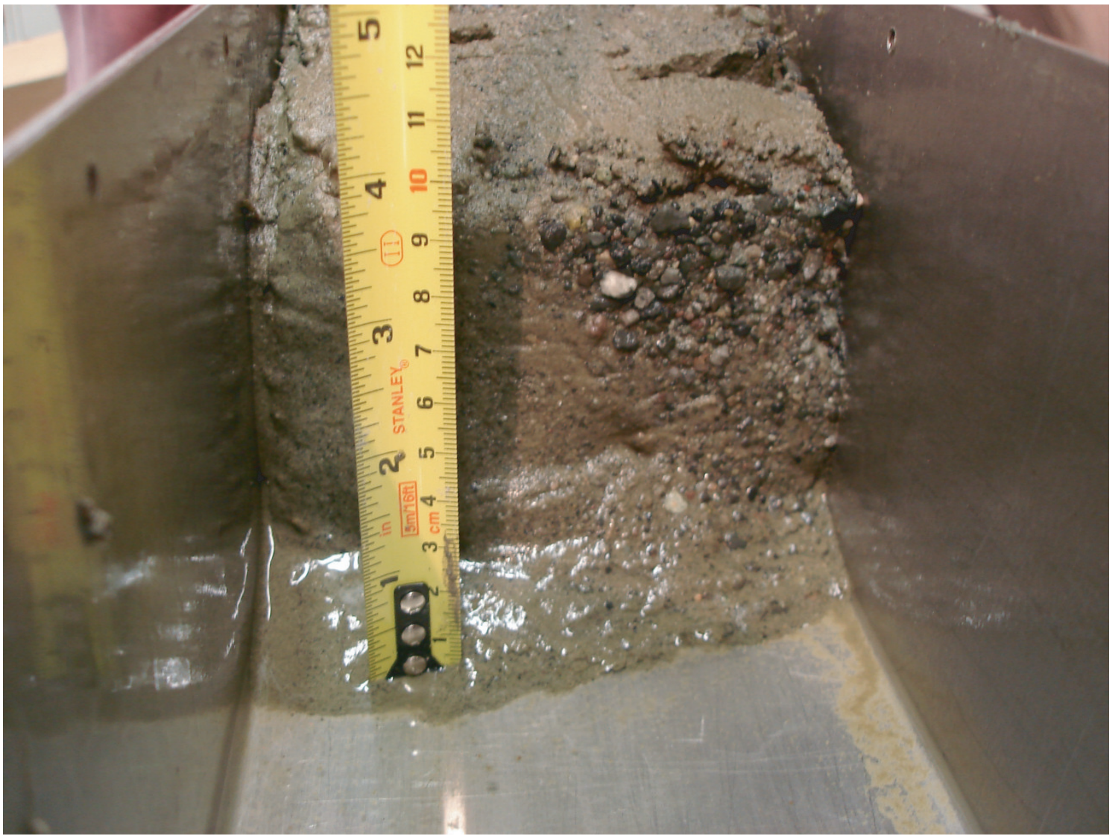
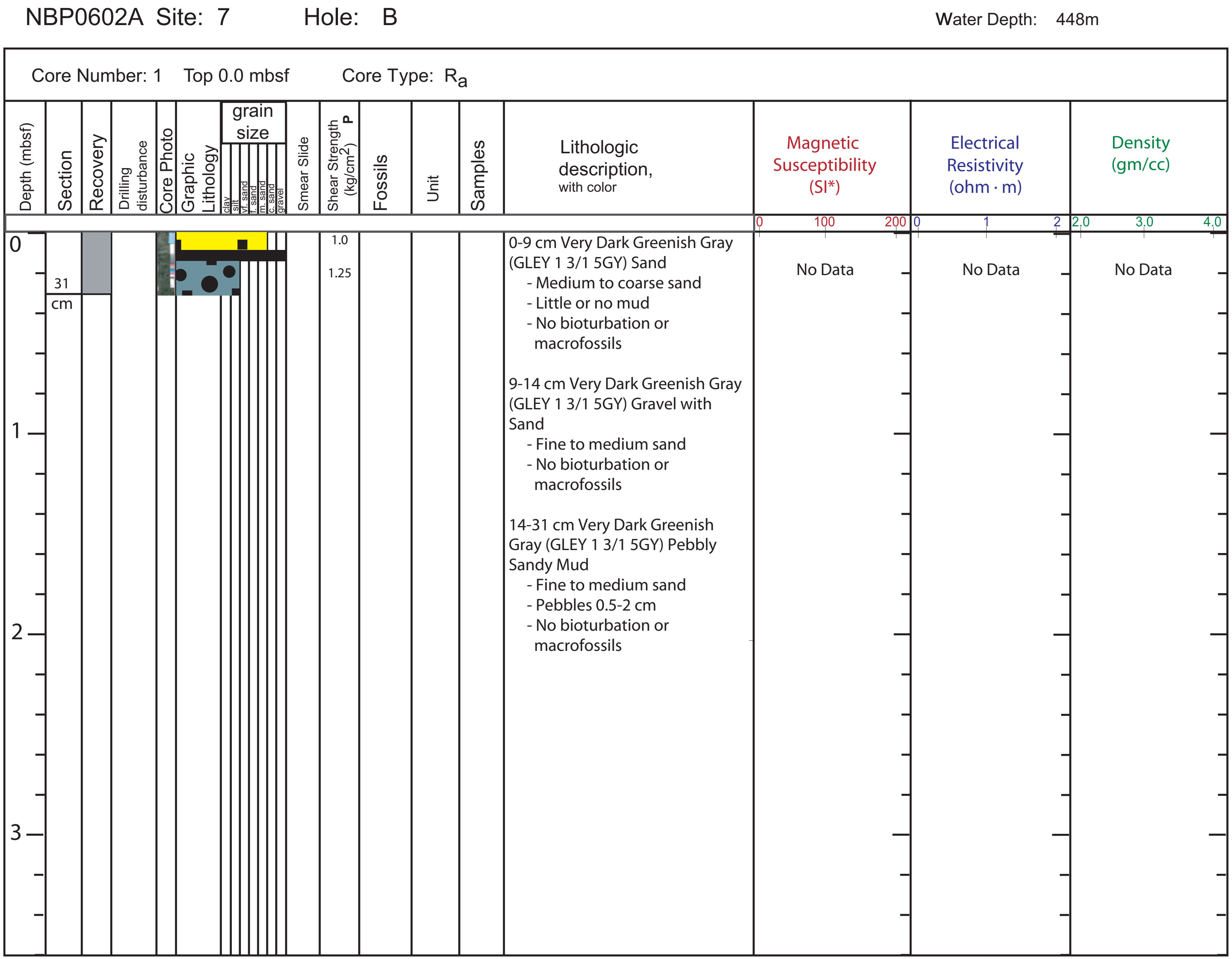


Photo by Patrick Taha



0-9 cm Very Dark Greenish Gray (GLEY 1 3/1 5GY) Sand
- Medium to coarse sand
- Little or no mud
- No bioturbation or macrofossils

9-14 cm Very Dark Greenish Gray (GLEY 1 3/1 5GY) Gravel with Sand
- Fine to medium sand
- No bioturbation or macrofossils

14-31 cm Very Dark Greenish Gray (GLEY 1 3/1 5GY) Pebbly Sandy Mud
- Fine to medium sand
- Pebbles 0.5-2 cm
- No bioturbation or macrofossils

Figure 5-15. Lithologic log for Hole NBP0602A-7B.

Table 5-7. Drilling and coring recovery log for Holes NBP0602A-7A-KC and -7B.

NBP0602A SHALDRIL II Site 7 (Danger Islands)

Multibeam Water Depth: 448 m

Station Number/Hole	Core Number	Core Type	Top (mbsf)	Bottom (mbsf)	Interval Cored (m)	"Push Distance" (m)	Recovery: total (m)	Recovery: competent (m)	Recovery: disturbed (m)	Gaps (m)	Recovery Corrected (m)	Total Recovery (%)	Recovery Corrected (%)	Section Number	Section Lengths (cm)	Date (JD)	Time on Deck (GMT)	Initials	Comments
7A	1	KC	0.0	0.48	0-0.48	0.48	0.48	0.48	0	0	0.48	100.0%	100.0%	1	36.0	78	1230	JSW	
7B	1	Ra	0.0	6.0	0-6.0	6.0	0.311	0	0	0	0	5.2%	0.0%	1	31.1	78	1804	CD	Bagged bottom 5 cm of core; Hole lost - BHA torn apart, lower portion and alien gone

Table 5-8. Stratigraphic occurrence and relative abundance of diatom taxa in Holes NBP0602A-7A-KC and -7B.

						Diatoms																			Silico-flagellate
Cruise	**Depth (mbsf)**	**Slide Preparation**	**Diatom Abundance**	**Preservation**	**Fragmentation**	*Actinocyclus actinochilus*	*Chaetoceros* spp. (small veg. cells & resting spores)	*Cocconeis* spp. (several taxa)	*Coscinodiscus* spp.	*Eucampia antarctica* var. *recta*	*Fragilariopsis curta*	*Fragilariopsis cylindrus*	*Fragilariopsis kerguelensis*	*Fragilariopsis ritscheri*	*Fragilariopsis sublinearis*	*Fragilariopsis vanheurckii*	*Paralia* spp.	*Porosira* spp.	*Radialiplicata clavigera*	*Stellarima microtrias*	*Stephanopyxis* spp.	*Thalassiosira antarctica* var. *antarctica*	*Thal. gracilis* var. *gracilis / expecta*	*Thalassiothrix/Trichotoxon* spp.	*Trinacria excavata* group	*Distephanus speculum speculum*
Hole 7A-KC																										
NBP0602A-7A-KC-CC	0.48	smear	C	M	M	R	F	R	fr(X)	R	F	X	fr(X)	R		F	X			R	fr(X)	F		fr(R)	X	X
Hole 7B																										
NBP0602A-7B-1R_a-CC	0.30	smear	X	P	H	X	X			fr(X)					fr(X)	fr(X)		fr(X)	fr(X)			X	X		X	
NBP0602A-7B-1R_a, 30 cm	0.31	smear	X	P	H		X																			

Notes: Abundance: C = common, F = few, R = rare, X = present, fr = fragments; Preservation: M = moderate, P = poor; Fragmentation: M = moderate, H = high.

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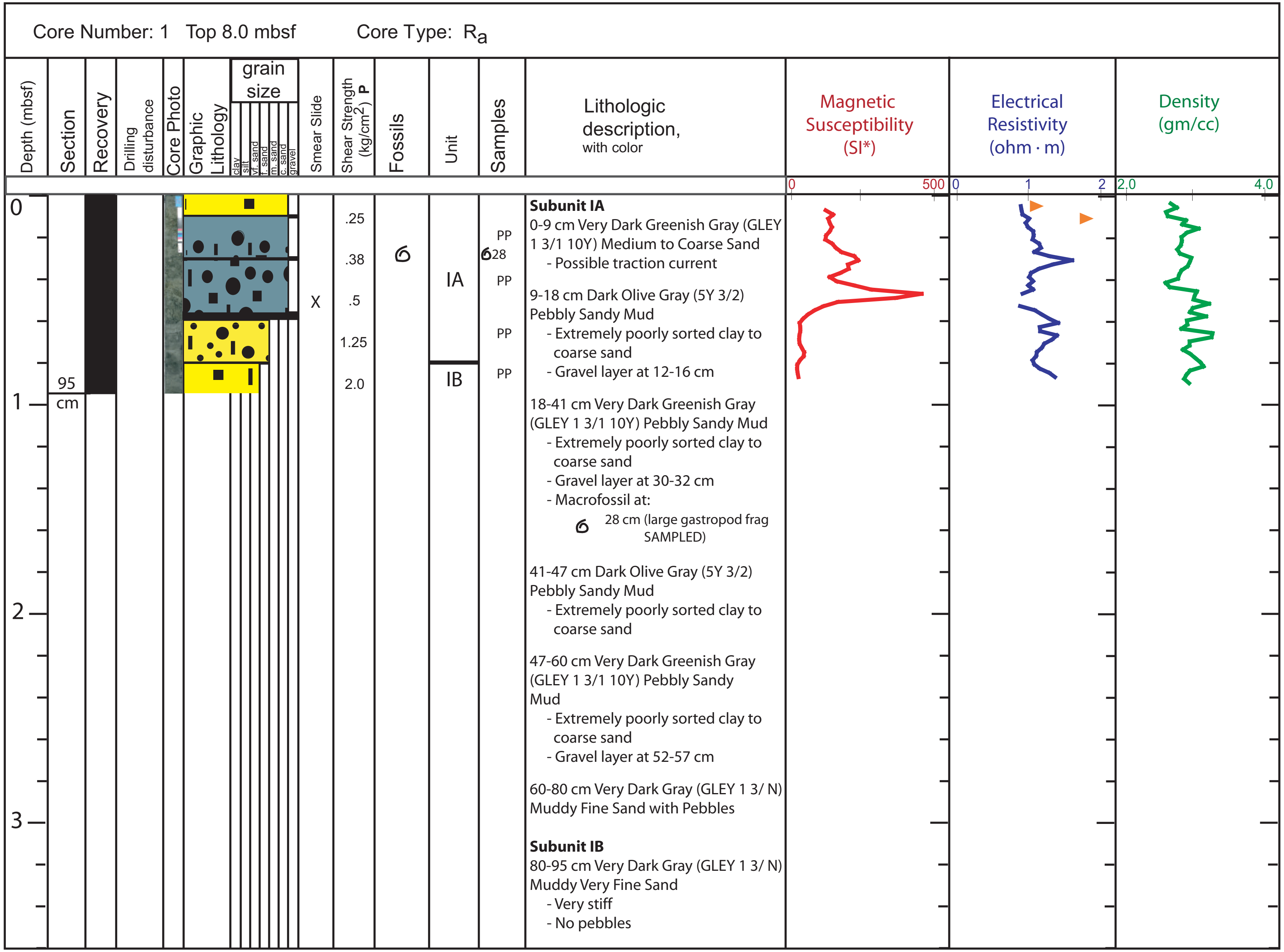
APPENDIX 5-1 LITHOLOGIC LOGS HOLE NBP0602A-5D

NBP0602A Site: 5 Hole: D Water Depth: 506m

Core Number: 1 Top 8.0 mbsf Core Type: R_a



Subunit IA

0-9 cm Very Dark Greenish Gray (GLEY 1 3/1 10Y) Medium to Coarse Sand
- Possible traction current

9-18 cm Dark Olive Gray (5Y 3/2) Pebbly Sandy Mud
- Extremely poorly sorted clay to coarse sand
- Gravel layer at 12-16 cm

18-41 cm Very Dark Greenish Gray (GLEY 1 3/1 10Y) Pebbly Sandy Mud
- Extremely poorly sorted clay to coarse sand
- Gravel layer at 30-32 cm
- Macrofossil at:
  - 28 cm (large gastropod frag SAMPLED)

41-47 cm Dark Olive Gray (5Y 3/2) Pebbly Sandy Mud
- Extremely poorly sorted clay to coarse sand

47-60 cm Very Dark Greenish Gray (GLEY 1 3/1 10Y) Pebbly Sandy Mud
- Extremely poorly sorted clay to coarse sand
- Gravel layer at 52-57 cm

60-80 cm Very Dark Gray (GLEY 1 3/ N) Muddy Fine Sand with Pebbles

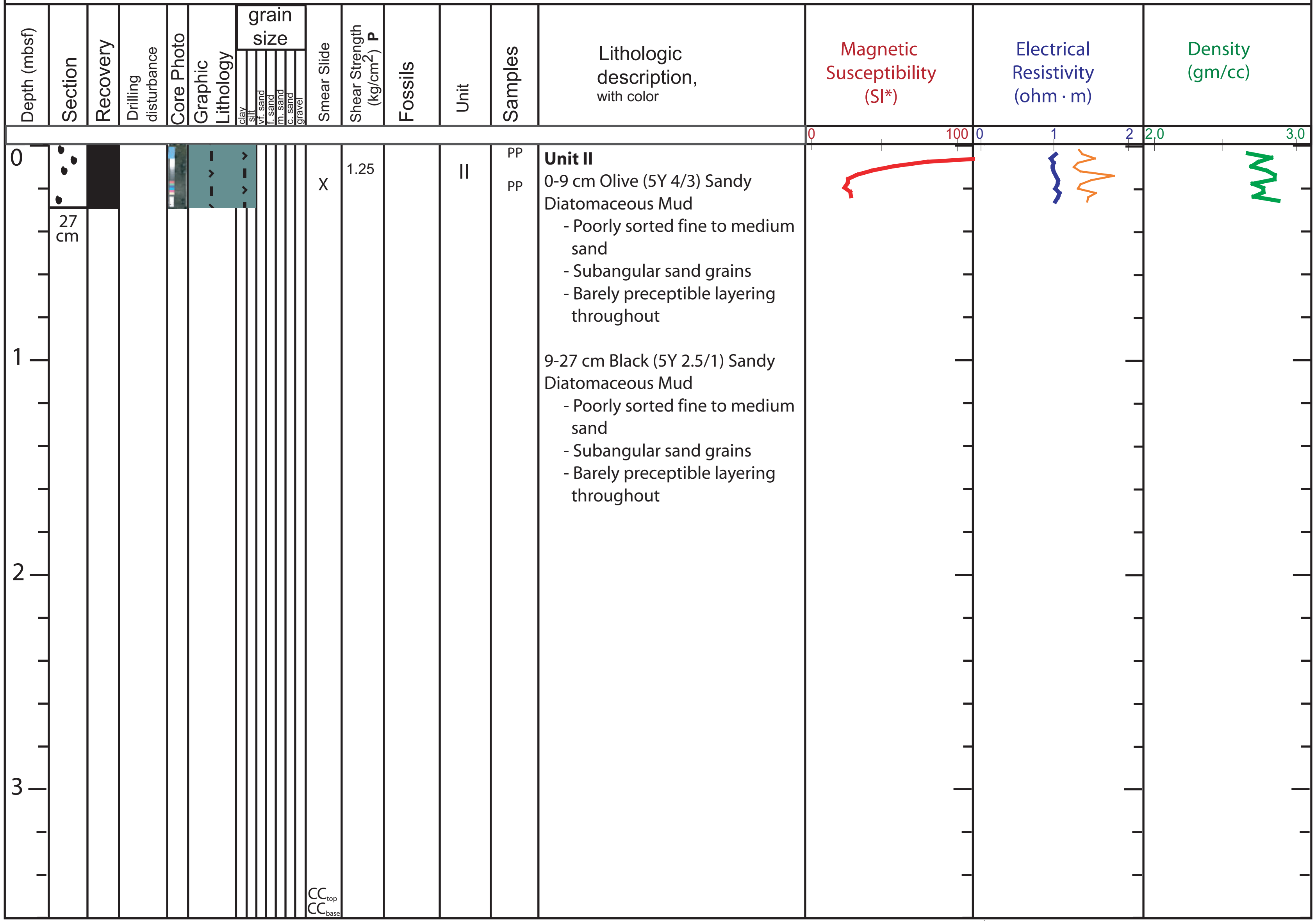
Subunit IB

80-95 cm Very Dark Gray (GLEY 1 3/ N) Muddy Very Fine Sand
- Very stiff
- No pebbles

NBP0602A Site: 5 Hole: D

Water Depth: 506m

Core Number: 2 Top 12.15 mbsf Core Type: R_a



Unit II

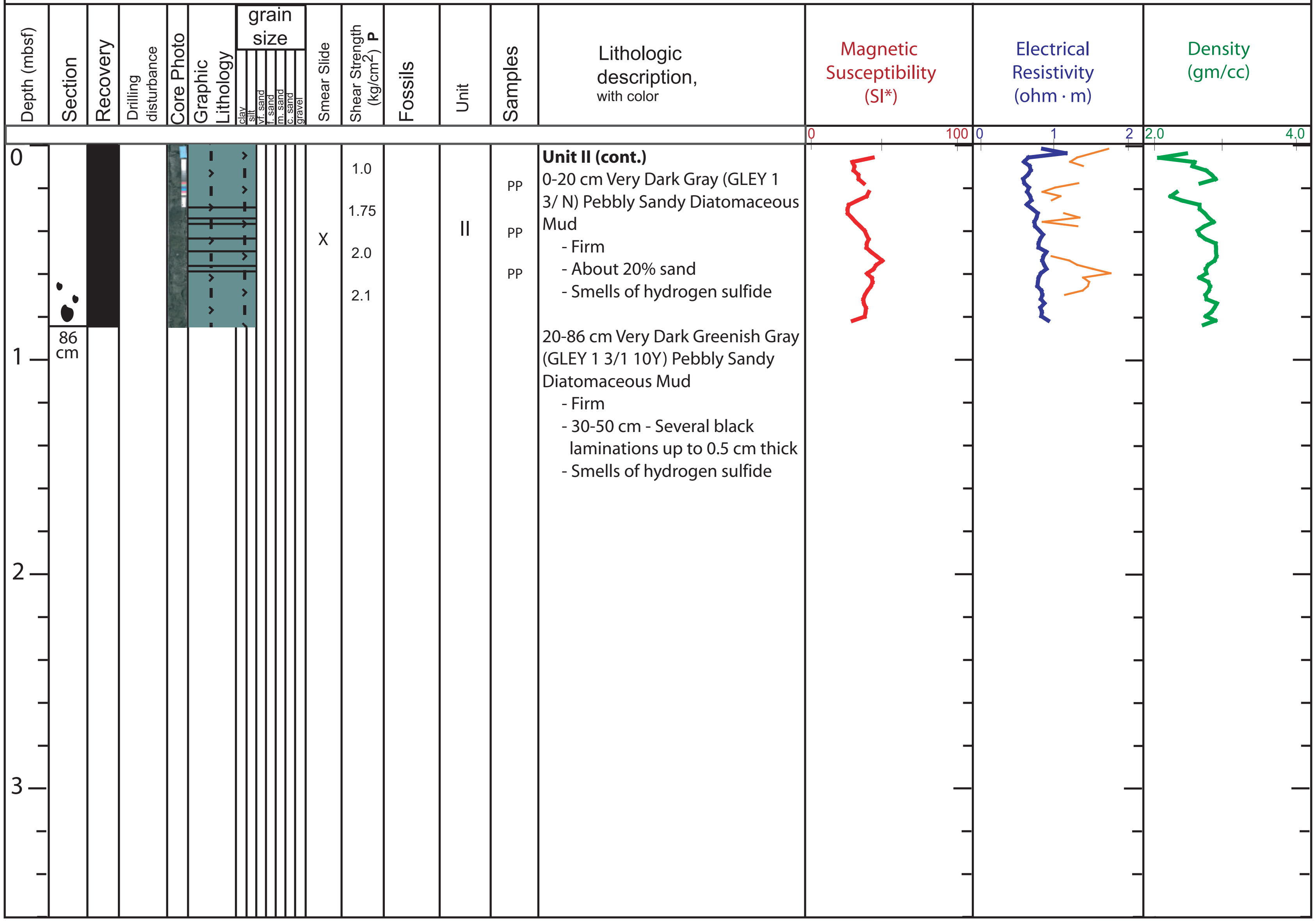
0-9 cm Olive (5Y 4/3) Sandy Diatomaceous Mud
- Poorly sorted fine to medium sand
- Subangular sand grains
- Barely preceptible layering throughout

9-27 cm Black (5Y 2.5/1) Sandy Diatomaceous Mud
- Poorly sorted fine to medium sand
- Subangular sand grains
- Barely preceptible layering throughout

NBP0602A Site: 5 Hole: D

Water Depth: 506m

Core Number: 3 Top 13.65 mbsf Core Type: R_a



Unit II (cont.)

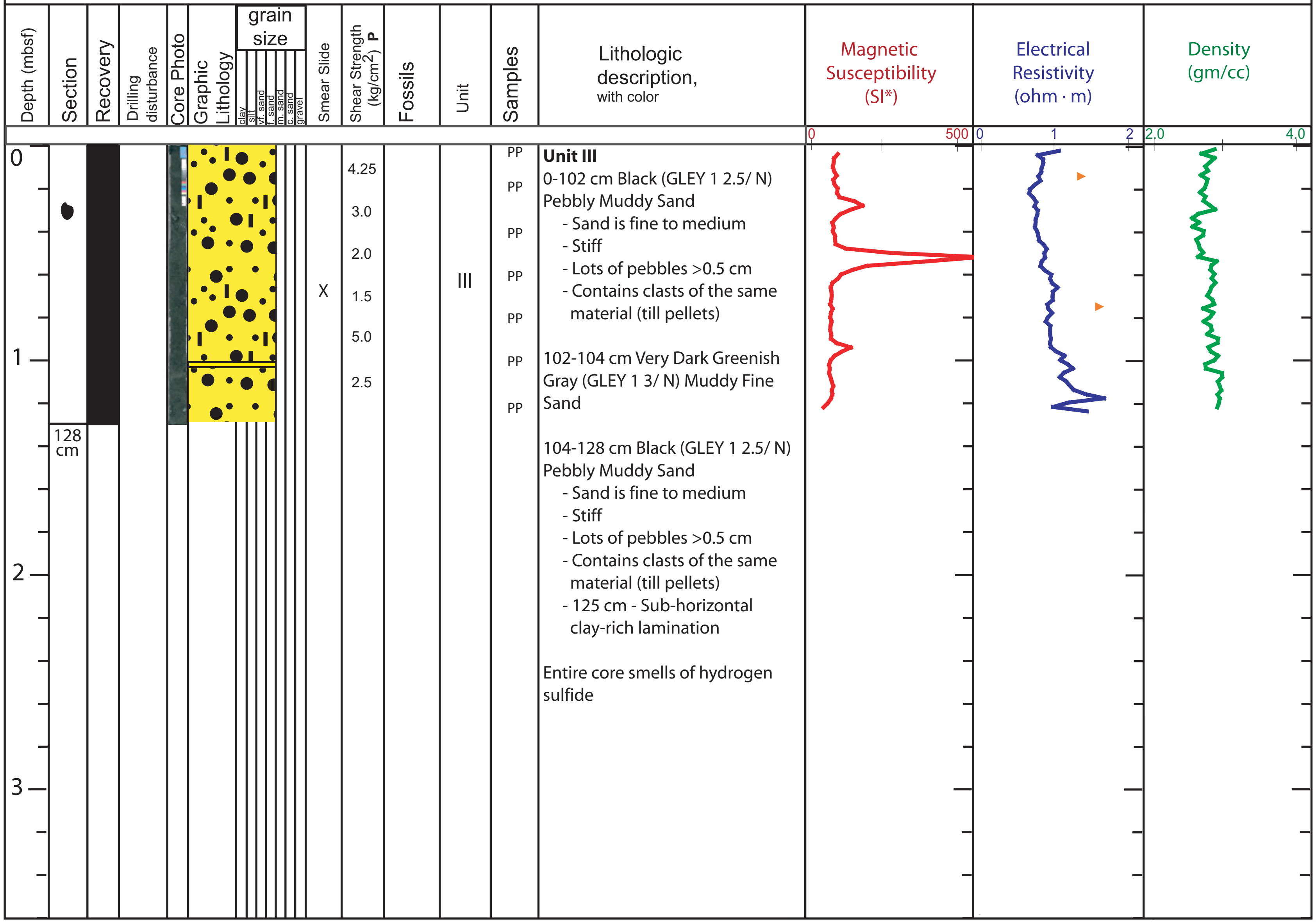
0-20 cm Very Dark Gray (GLEY 1 3/ N) Pebbly Sandy Diatomaceous Mud
- Firm
- About 20% sand
- Smells of hydrogen sulfide

20-86 cm Very Dark Greenish Gray (GLEY 1 3/1 10Y) Pebbly Sandy Diatomaceous Mud
- Firm
- 30-50 cm - Several black laminations up to 0.5 cm thick
- Smells of hydrogen sulfide

NBP0602A Site: 5 Hole: D

Water Depth: 506m

Core Number: 4 Top 15 mbsf Core Type: R_a



Unit III

0-102 cm Black (GLEY 1 2.5/ N) Pebbly Muddy Sand
- Sand is fine to medium
- Stiff
- Lots of pebbles >0.5 cm
- Contains clasts of the same material (till pellets)

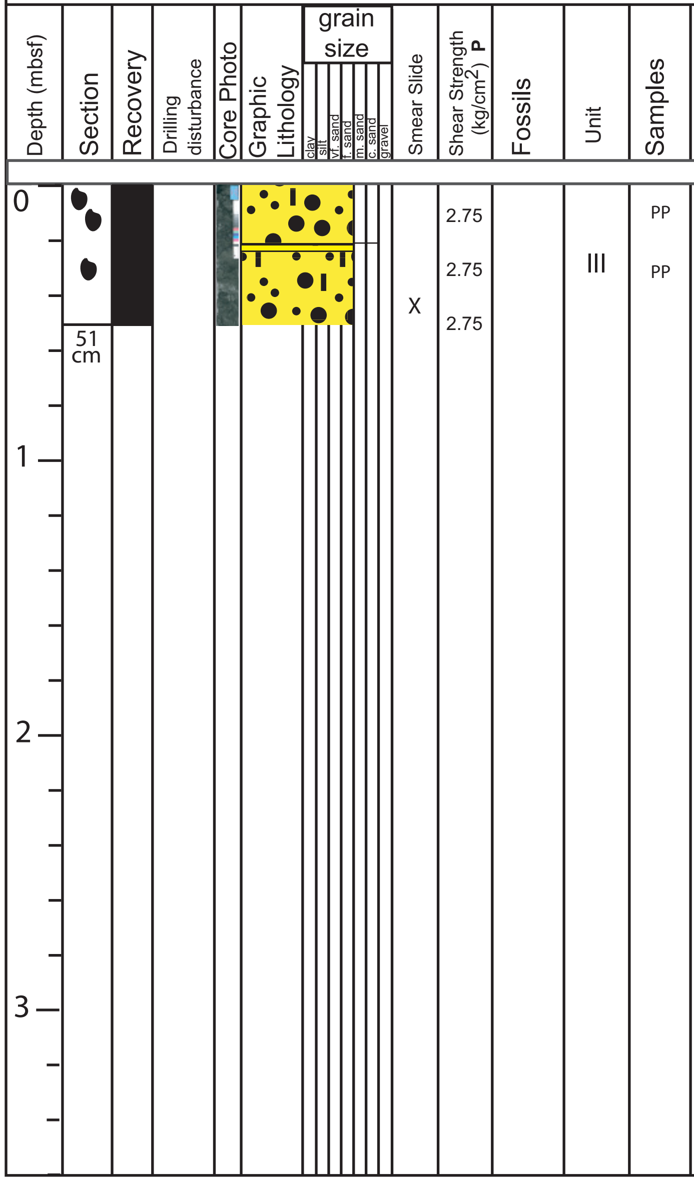
102-104 cm Very Dark Greenish Gray (GLEY 1 3/ N) Muddy Fine Sand

104-128 cm Black (GLEY 1 2.5/ N) Pebbly Muddy Sand
- Sand is fine to medium
- Stiff
- Lots of pebbles >0.5 cm
- Contains clasts of the same material (till pellets)
- 125 cm - Sub-horizontal clay-rich lamination

Entire core smells of hydrogen sulfide

NBP0602A Site: 5 Hole: D Water Depth: 506m

Core Number: 5 Top 16.0 mbsf Core Type: R_a



Lithologic description,
with color

Unit III (cont.)

0-23 cm Black (GLEY 1 2.5/ N) Pebbly Muddy Sand
- Stiff
- Fine to medium sand
- Lots of pebbles >0.5 cm, mixed lithologies
- Contains clasts of the same material (till pellets)

23-24 cm Black (GLEY 1 2.5/ N) Muddy Coarse Sand

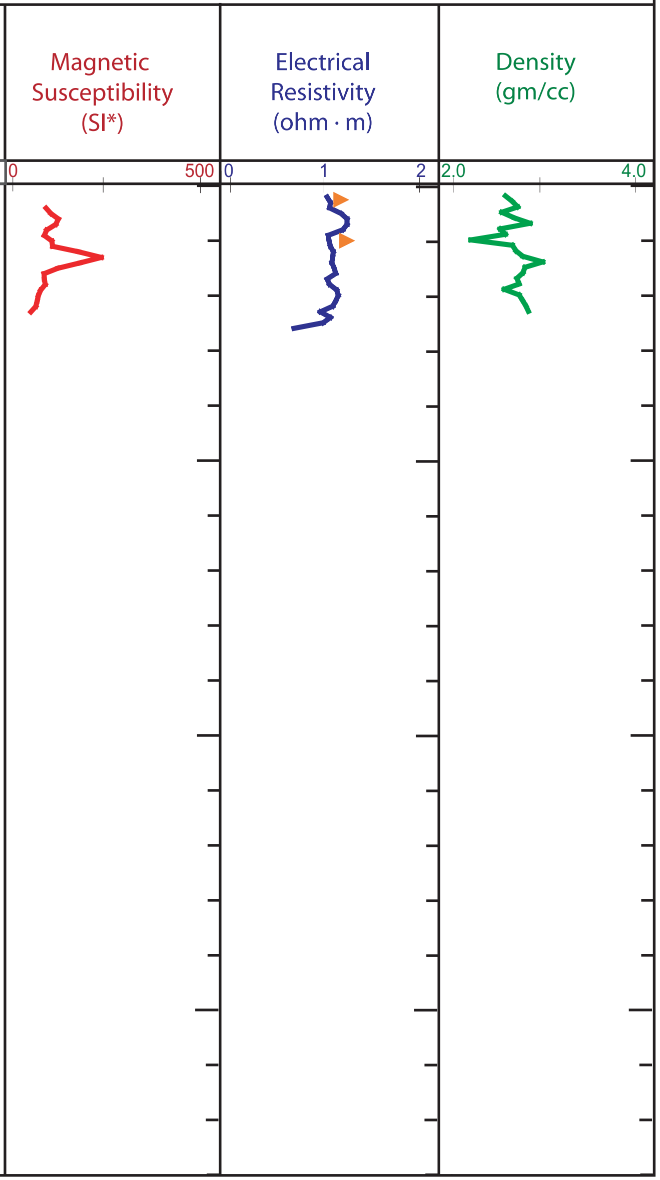
24-28 cm Black (GLEY 1 2.5/ N) Muddy Sand
- Cleaner than upper and lower sections, no pebbles

28-35 cm Black (GLEY 1 2.5/ N) Pebbly Muddy Sand
- Stiff
- Fine to medium sand
- Lots of pebbles >0.5 cm, mixed lithologies
- Contains clasts of the same material (till pellets)

35-42 cm Very Dark Gray (GLEY 1 3/ N) Pebbly Muddy Sand with whitish powder
- Very stiff

42-51 cm Black (GLEY 1 2.5/ N) Pebbly Muddy Sand
- Stiff
- Fine to medium sand
- Lots of pebbles >0.5 cm, mixed lithologies
- Contains clasts of the same material (till pellets)

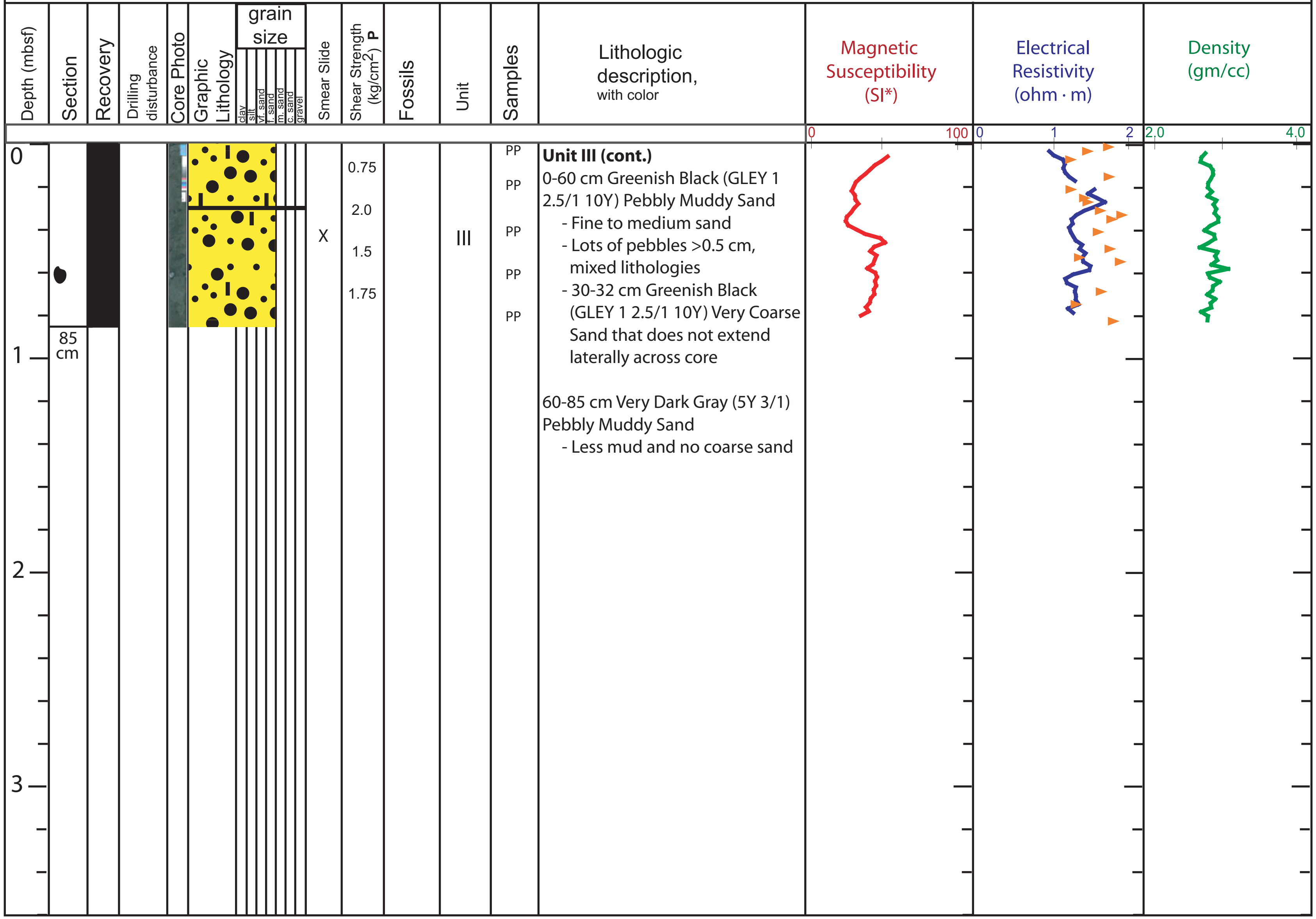
Entire core smells of hydrogen sulfide



NBP0602A Site: 5 Hole: D

Water Depth: 506m

Core Number: 6 Top 18.8 mbsf Core Type: R_a



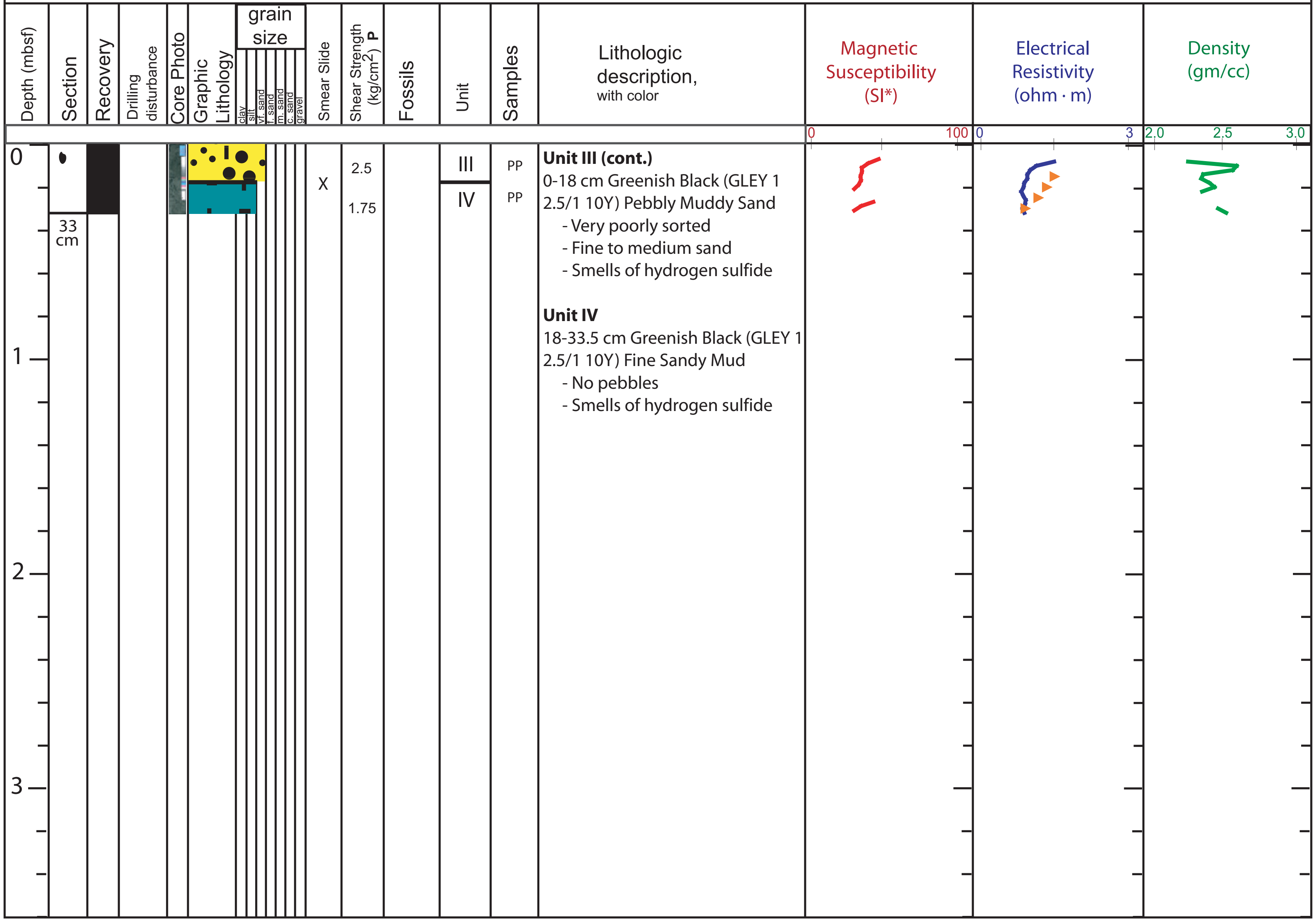
Unit III (cont.)

0-60 cm Greenish Black (GLEY 1 2.5/1 10Y) Pebbly Muddy Sand
- Fine to medium sand
- Lots of pebbles >0.5 cm, mixed lithologies
- 30-32 cm Greenish Black (GLEY 1 2.5/1 10Y) Very Coarse Sand that does not extend laterally across core

60-85 cm Very Dark Gray (5Y 3/1) Pebbly Muddy Sand
- Less mud and no coarse sand

NBP0602A Site: 5 Hole: D Water Depth: 506m

Core Number: 7 Top 22.0 mbsf Core Type: R_a



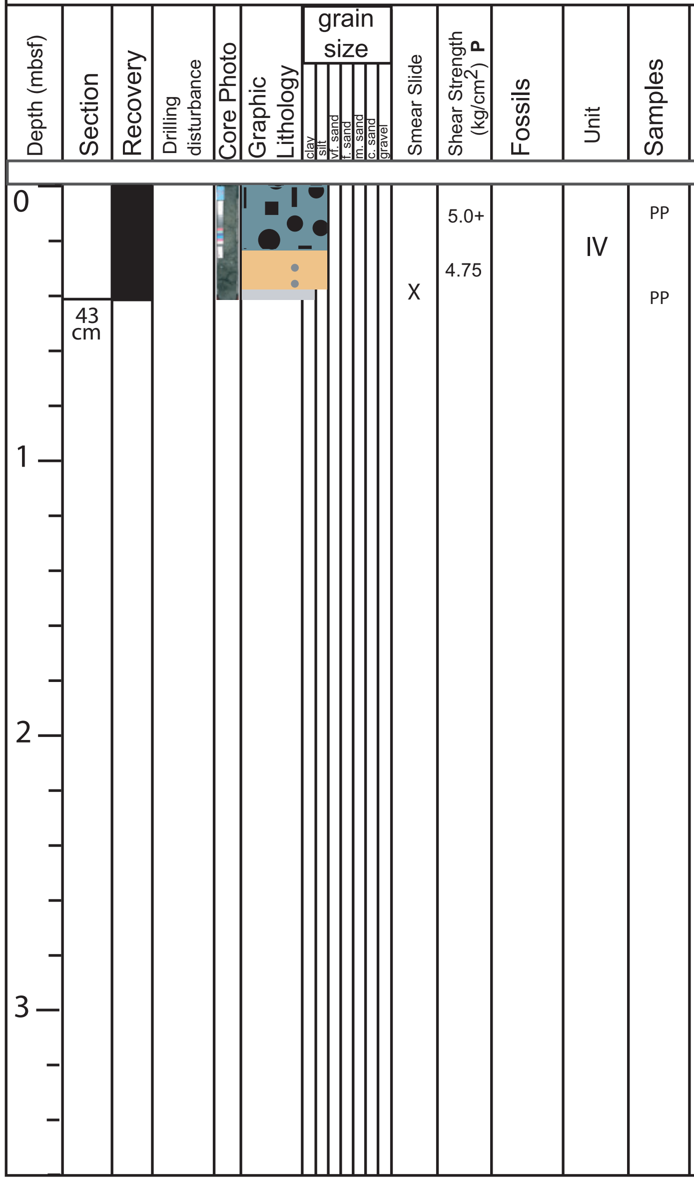
Unit III (cont.)
0-18 cm Greenish Black (GLEY 1 2.5/1 10Y) Pebbly Muddy Sand
- Very poorly sorted
- Fine to medium sand
- Smells of hydrogen sulfide

Unit IV
18-33.5 cm Greenish Black (GLEY 1 2.5/1 10Y) Fine Sandy Mud
- No pebbles
- Smells of hydrogen sulfide

NBP0602A Site: 5 Hole: D

Water Depth: 506m

Core Number: 8 Top 23.48 mbsf Core Type: R_a



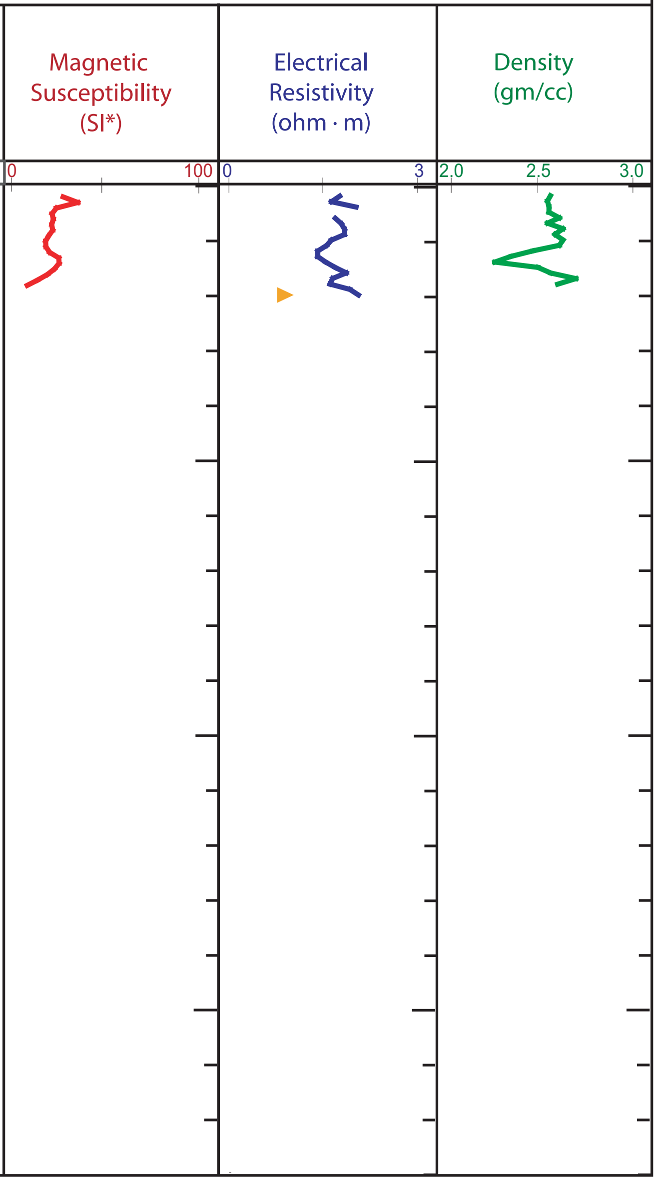
Lithologic description, with color

Unit IV (cont.)

0-23 cm Greenish Black (GLEY 1 3/1 10 Y) Pebbly Sandy Mud
- Small amount of fine to very fine sand
- Small dark brown fragments (possibly wood) at:
  - 7 cm
  - 10 cm

23-38 cm Very Dark Gray (GLEY 1 3/ N) Silty Mud
- 30-34 cm - Moderately sorted fine sand lens that does not extend across the width of the core

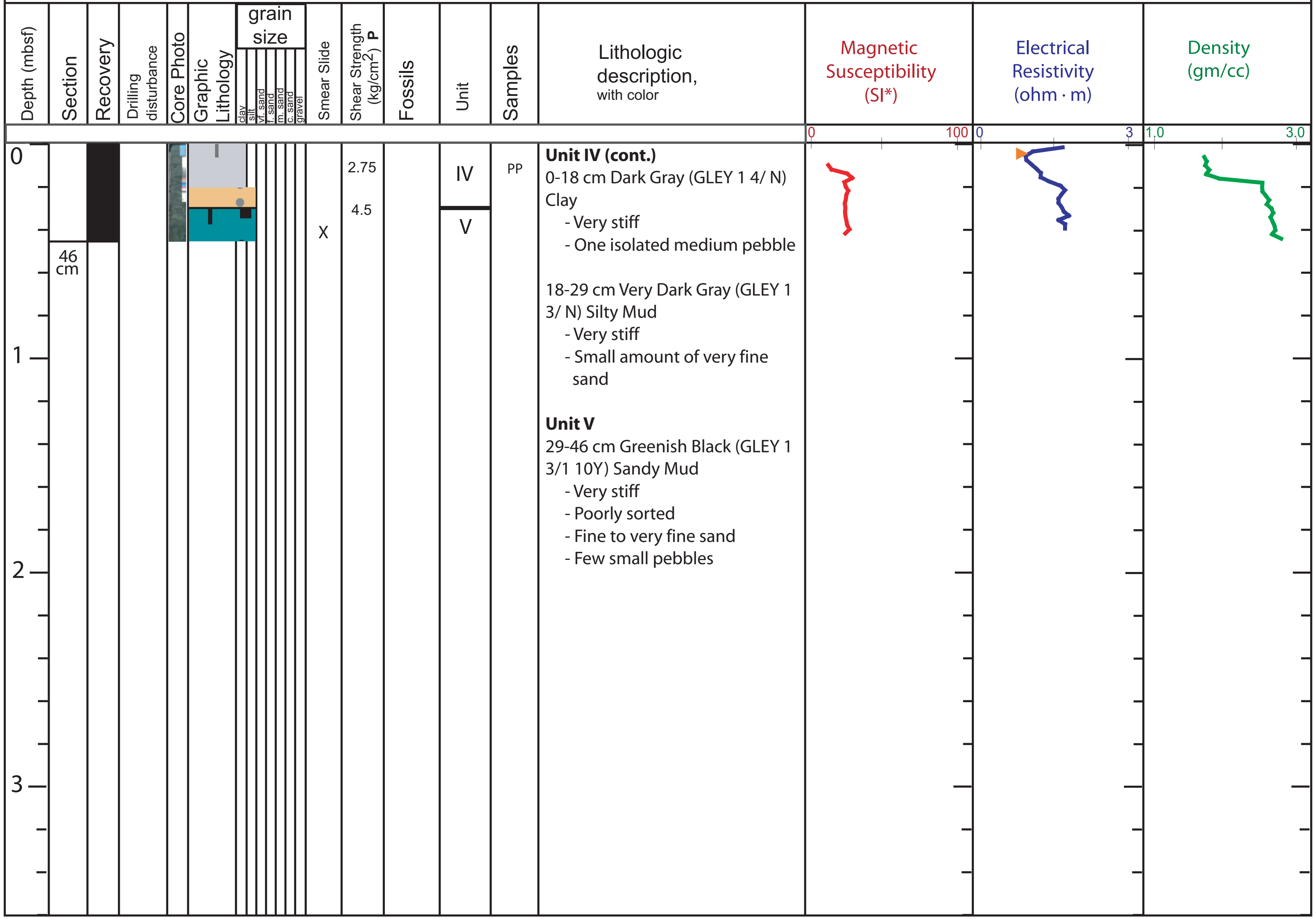
38-43 cm Dark Gray (GLEY 1 3/ N) Clay



NBP0602A Site: 5 Hole: D

Water Depth: 506m

Core Number: 9 Top 24.78 mbsf Core Type: R_a



Unit IV (cont.)

0-18 cm Dark Gray (GLEY 1 4/ N) Clay
- Very stiff
- One isolated medium pebble

18-29 cm Very Dark Gray (GLEY 1 3/ N) Silty Mud
- Very stiff
- Small amount of very fine sand

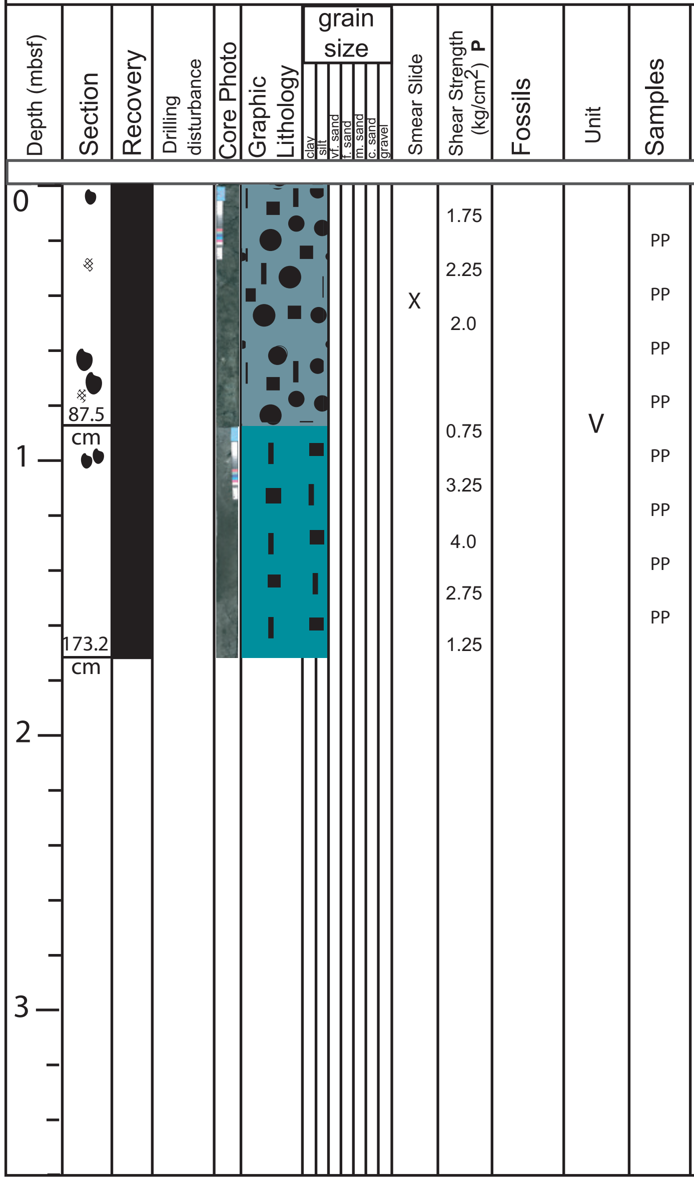
Unit V

29-46 cm Greenish Black (GLEY 1 3/1 10Y) Sandy Mud
- Very stiff
- Poorly sorted
- Fine to very fine sand
- Few small pebbles

NBP0602A Site: 5 Hole: D

Water Depth: 506m

Core Number: 10 Top 24.98 mbsf Core Type: R_a



Lithologic description, with color

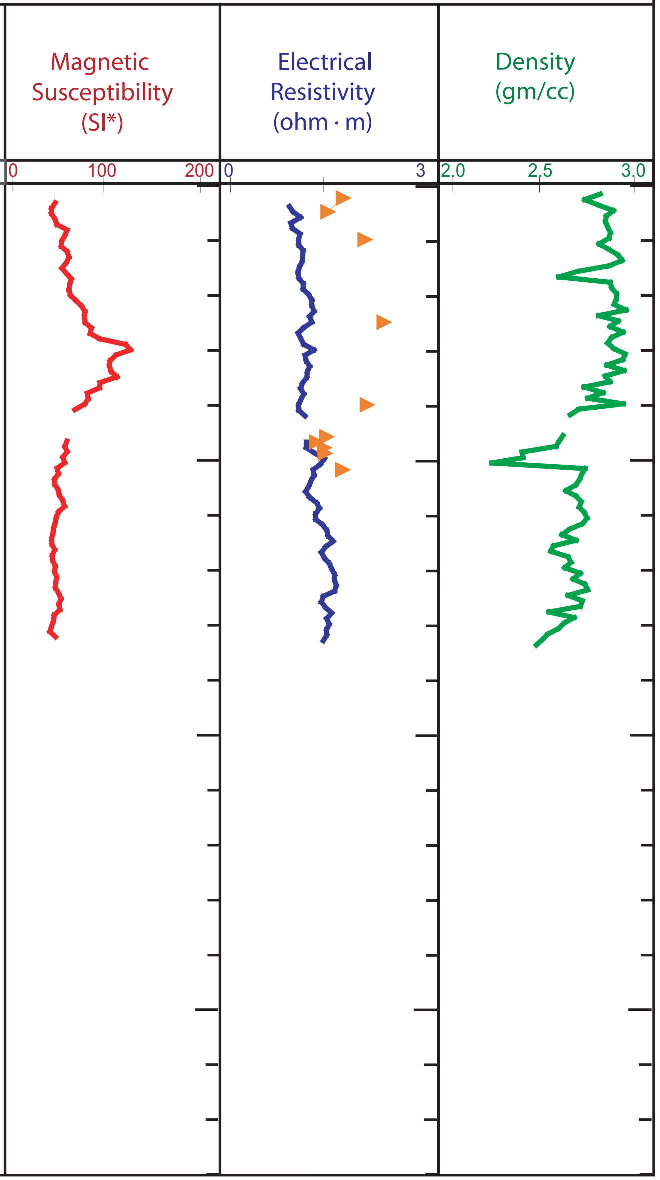
Unit V (cont.)

0-87.5 cm Greenish Black (GLEY 1 2.5/1 10Y) Sandy Mud with Pebbles

- Very firm
- Fine to very fine sand
- 31 cm - Dark Reddish Brown mottle (5YR 3/2)
- 33-34 cm Dark Gray (GLEY 1 4/ N) Silty Mud lens that does not extend laterally across core
- 75 cm - Greenish Black (GLEY 2 2.5/1 5BG) lamina

87.5-173.2 cm Greenish Black (GLEY 1 2.5/1 10Y) Sandy Mud

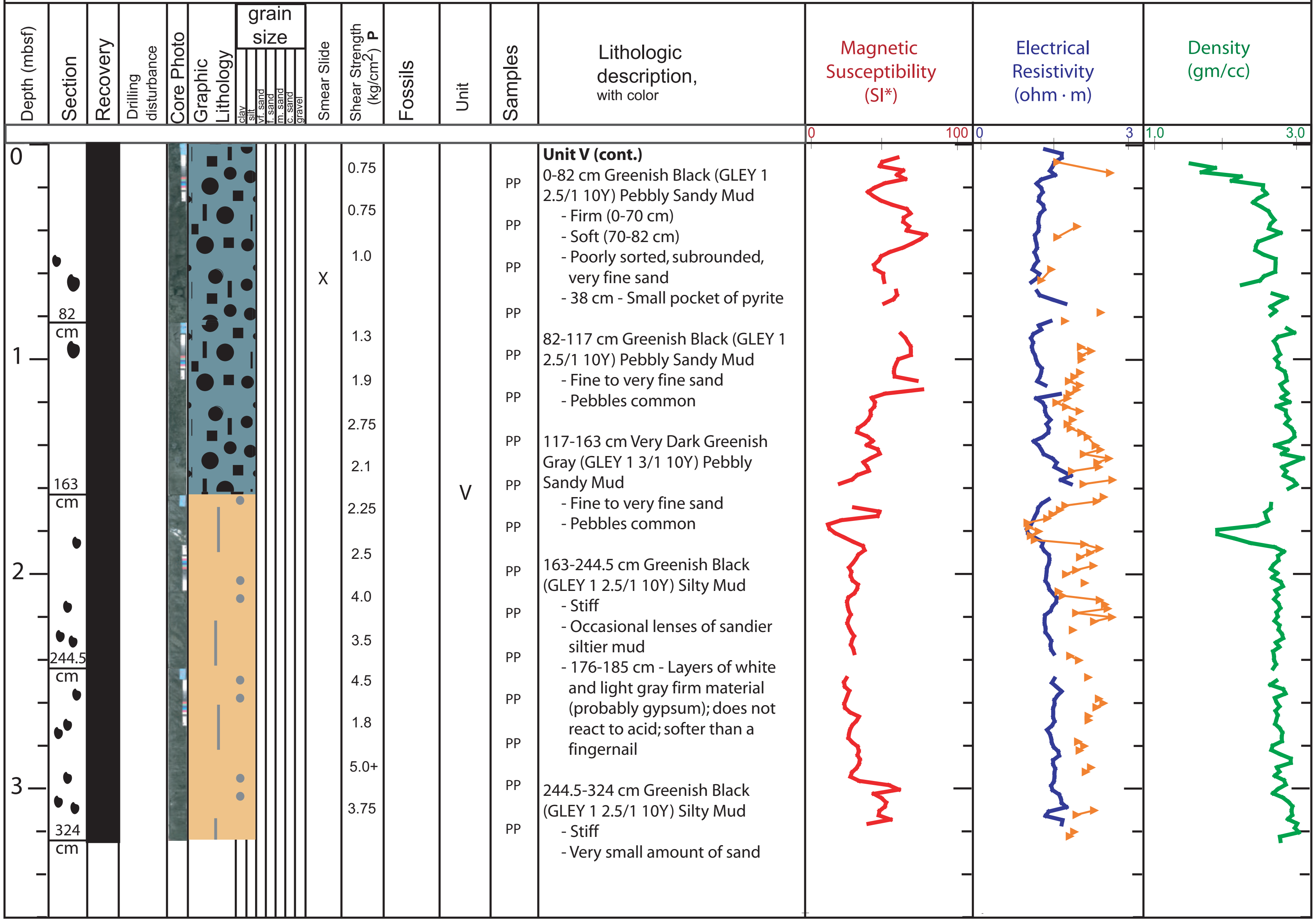
- Firm to very firm
- Sand is mostly fine to very fine with occasional coarse grains
- Very few pebbles
- 87.5-124 cm - Some dark to black mottling
- 118- 126 cm - Small (2-3 mm) pockets of greenish fine sand



NBP0602A Site: 5 Hole: D

Water Depth: 506m

Core Number: 11 Top 26.68 mbsf Core Type: R_a



Unit V (cont.)

0-82 cm Greenish Black (GLEY 1 2.5/1 10Y) Pebbly Sandy Mud
- Firm (0-70 cm)
- Soft (70-82 cm)
- Poorly sorted, subrounded, very fine sand
- 38 cm - Small pocket of pyrite

82-117 cm Greenish Black (GLEY 1 2.5/1 10Y) Pebbly Sandy Mud
- Fine to very fine sand
- Pebbles common

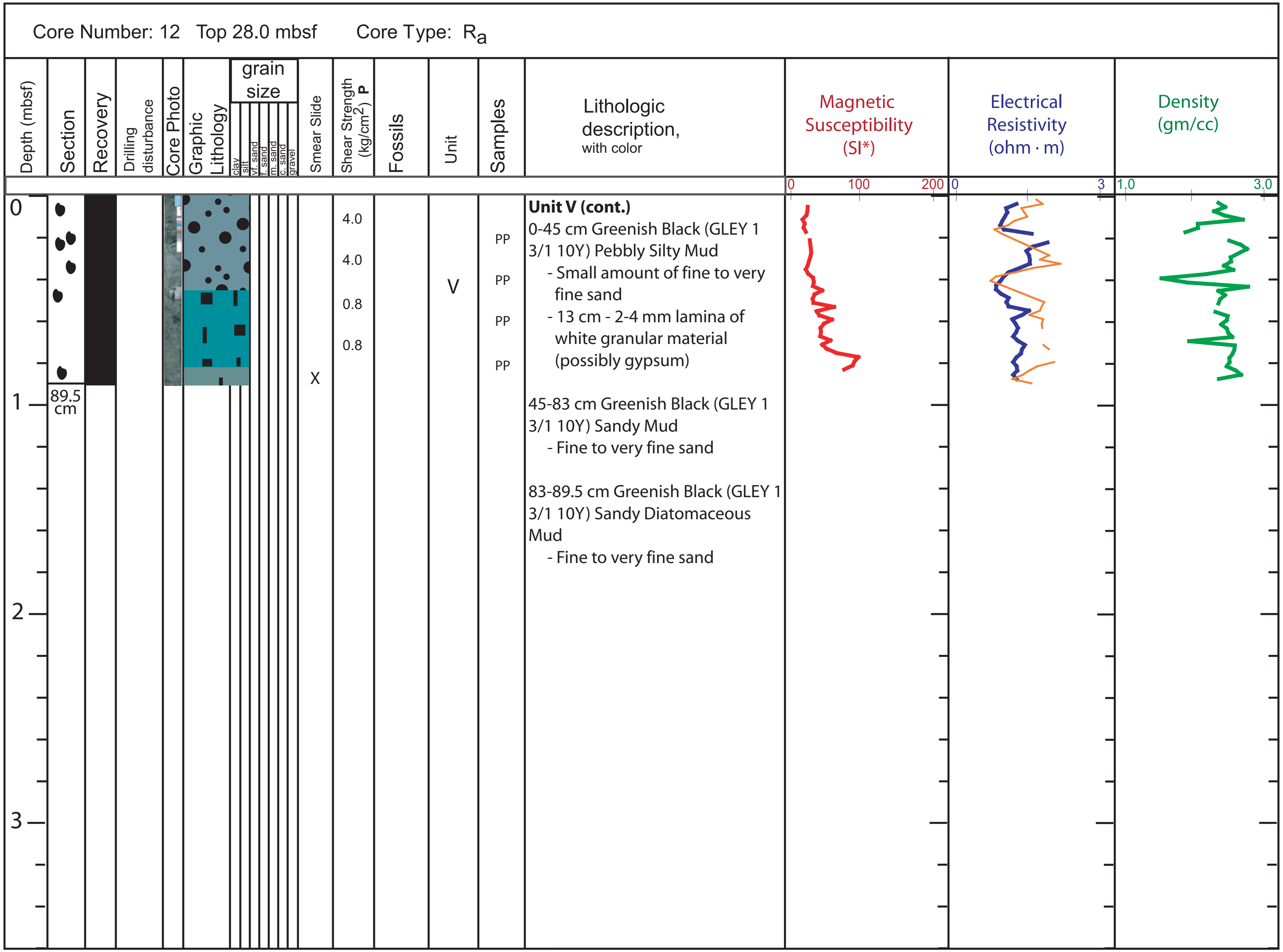
117-163 cm Very Dark Greenish Gray (GLEY 1 3/1 10Y) Pebbly Sandy Mud
- Fine to very fine sand
- Pebbles common

163-244.5 cm Greenish Black (GLEY 1 2.5/1 10Y) Silty Mud
- Stiff
- Occasional lenses of sandier siltier mud
- 176-185 cm - Layers of white and light gray firm material (probably gypsum); does not react to acid; softer than a fingernail

244.5-324 cm Greenish Black (GLEY 1 2.5/1 10Y) Silty Mud
- Stiff
- Very small amount of sand

NBP0602A Site: 5 Hole: D

Water Depth: 506m



Core Number: 12 Top 28.0 mbsf Core Type: R_a

Lithologic description, with color

Unit V (cont.)

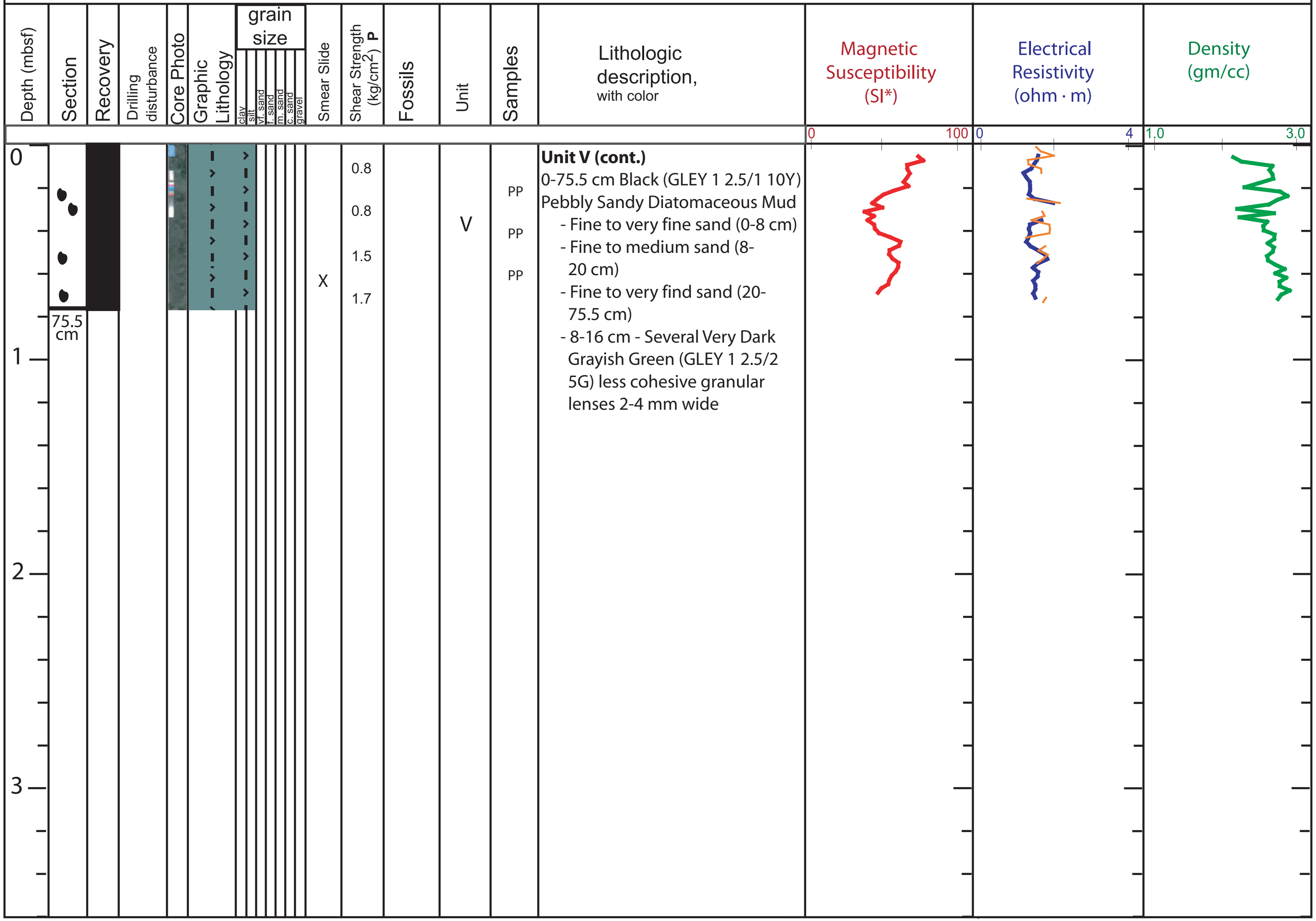
0-45 cm Greenish Black (GLEY 1 3/1 10Y) Pebbly Silty Mud
- Small amount of fine to very fine sand
- 13 cm - 2-4 mm lamina of white granular material (possibly gypsum)

45-83 cm Greenish Black (GLEY 1 3/1 10Y) Sandy Mud
- Fine to very fine sand

83-89.5 cm Greenish Black (GLEY 1 3/1 10Y) Sandy Diatomaceous Mud
- Fine to very fine sand

NBP0602A Site: 5 Hole: D Water Depth: 506m

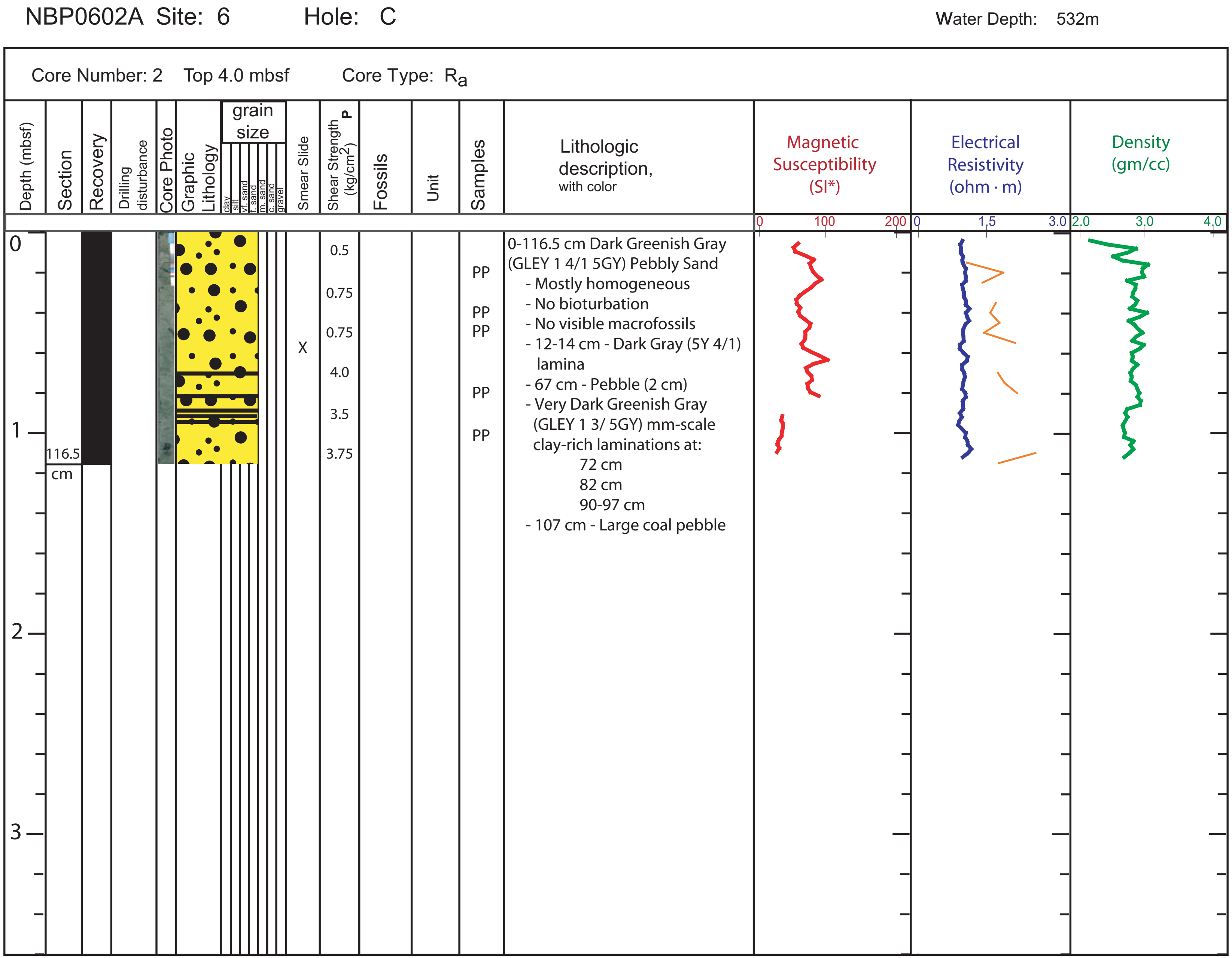
Core Number: 13 Top 29.6 mbsf Core Type: R_a



Unit V (cont.)

0-75.5 cm Black (GLEY 1 2.5/1 10Y) Pebbly Sandy Diatomaceous Mud

- Fine to very fine sand (0-8 cm)
- Fine to medium sand (8-20 cm)
- Fine to very find sand (20-75.5 cm)
- 8-16 cm - Several Very Dark Grayish Green (GLEY 1 2.5/2 5G) less cohesive granular lenses 2-4 mm wide

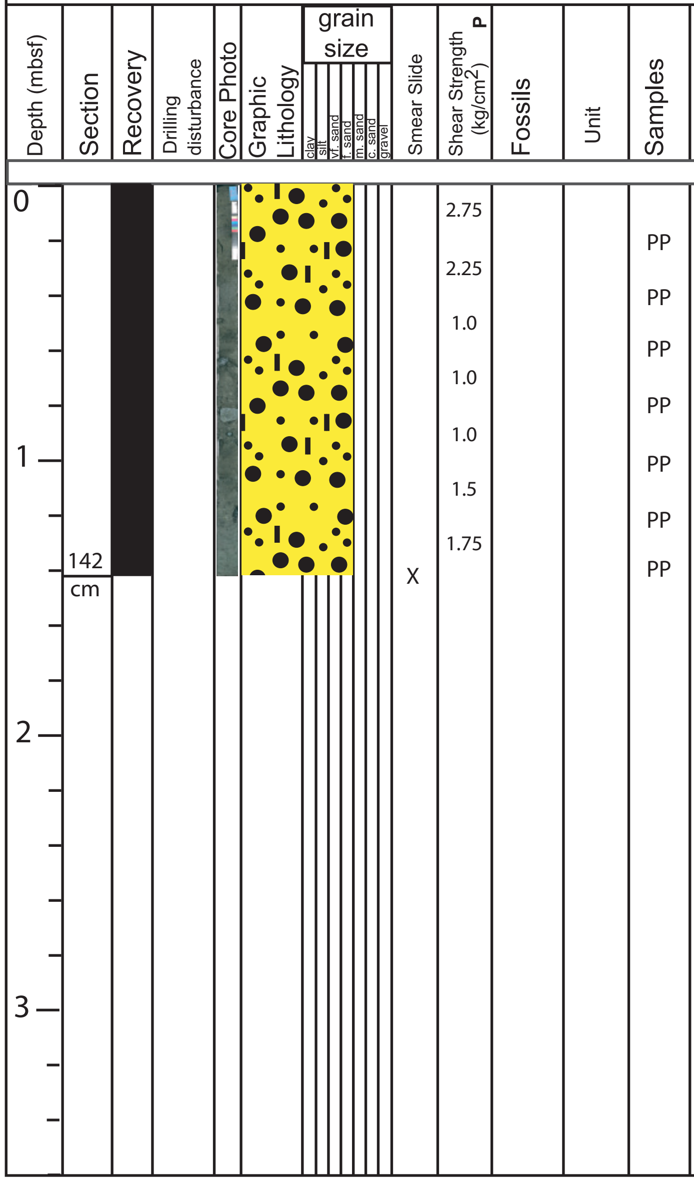


0-116.5 cm Dark Greenish Gray (GLEY 1 4/1 5GY) Pebbly Sand
- Mostly homogeneous
- No bioturbation
- No visible macrofossils
- 12-14 cm - Dark Gray (5Y 4/1) lamina
- 67 cm - Pebble (2 cm)
- Very Dark Greenish Gray (GLEY 1 3/ 5GY) mm-scale clay-rich laminations at:
  72 cm
  82 cm
  90-97 cm
- 107 cm - Large coal pebble

NBP0602A Site: 6 Hole: C

Water Depth: 532m

Core Number: 4 Top 10.0 mbsf Core Type: R_a



Lithologic description, with color

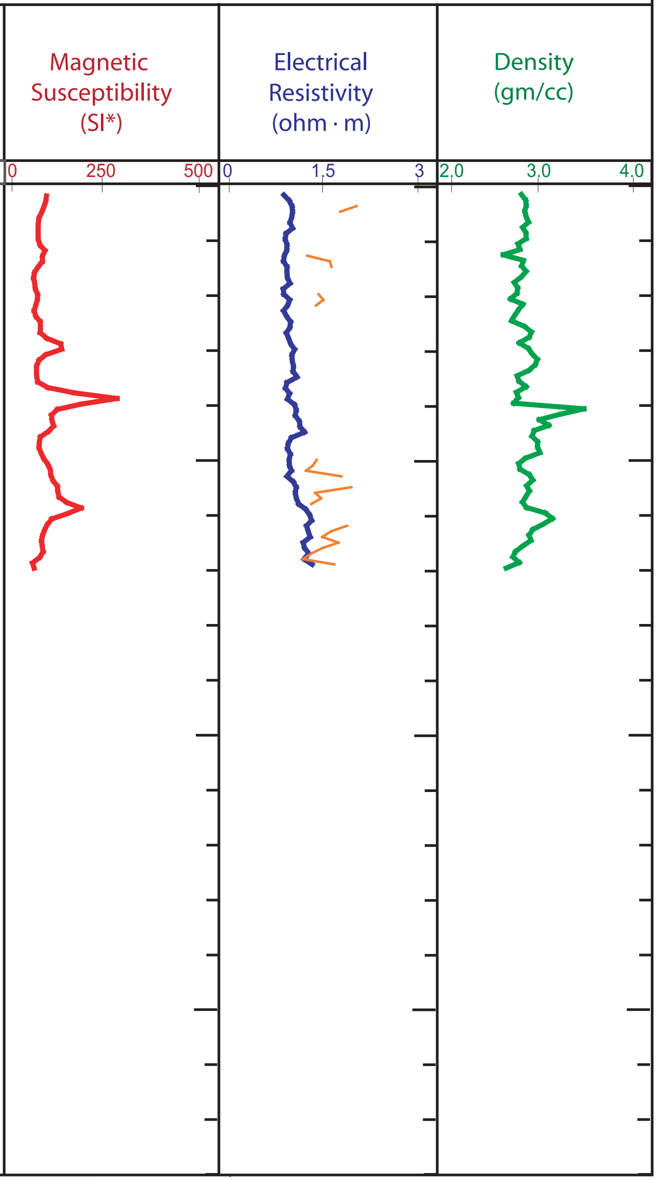
0-35 cm Dark Greenish Gray (GLEY 1 4/1 10Y) Pebbly Muddy Sand
- Firm
- Fine, well-sorted, subrounded to rounded sand
- Coarse to very coarse, angular to subrounded pebbles
- Very subtle dark thin laminae
- No bioturbation or visible macrofossils
- 12 cm - Large coal pebble

35-53 cm Dark Gray (GLEY 1 4/ N) Pebbly Muddy Sand
- As above, but with cleaner sand with green (glauconite?) grains

53-105 cm Dark Greenish Gray (GLEY 1 4/1 10Y) Pebbly Muddy Sand
- Firm
- Fine, well-sorted, subrounded to rounded sand
- Coarse to very coarse, angular to subrounded pebbles
- Very subtle dark thin laminae
- No bioturbation or visible macrofossils

105-142 cm Dark Gray (GLEY 1 4/ N) Pebbly Muddy Sand
- As above, but with cleaner sand with green (glauconite?) grains

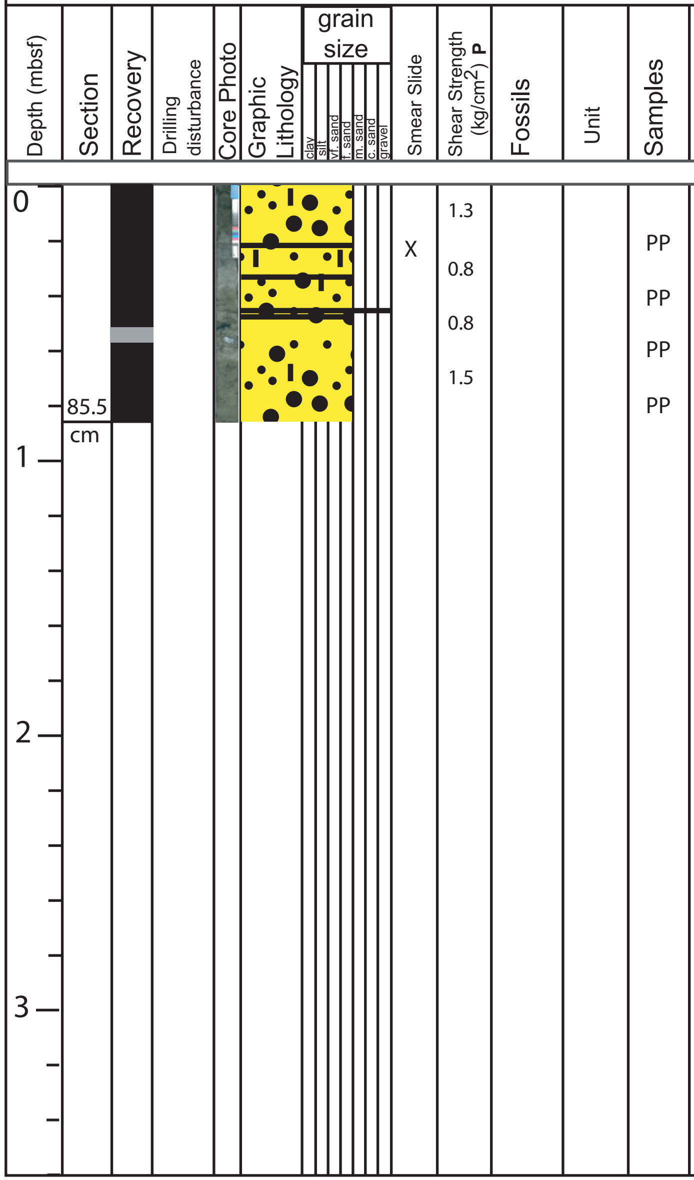
Boundaries between color changes are sharp



NBP0602A Site: 6 Hole: C

Water Depth: 532m

Core Number: 5 Top 12.0 mbsf Core Type: R_a



Lithologic description, with color

0-18 cm Greenish Black (GLEY 1 2.5/1 10Y) Pebbly Muddy Sand
- Firm
- No bioturbation or macrofossils

18-36 cm Dark Greenish Gray (GLEY 1 4/1 10Y) Pebbly Muddy Sand
- Firm
- Cleaner sand with less matrix
- No bioturbation or macrofossils
- 21-23 cm - Thin black laminae
- 26 cm - Lens (3 cm) of black material

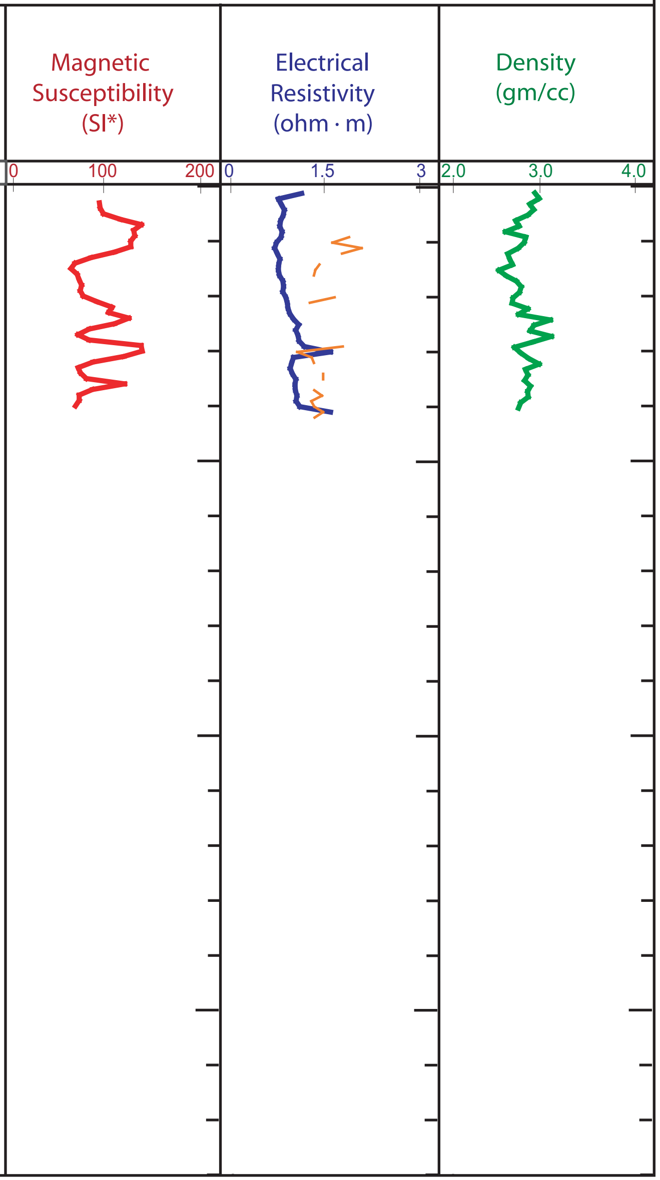
36-55 cm Greenish Black (GLEY 1 2.5/1 10Y) Pebbly Muddy Sand
- Firm
- No bioturbation or macrofossils
- 36 cm - Clay-rich lamina
- 45-46 cm - Pebble lamina
- 47 cm - Clay-rich lamina

(50-58 cm Possibly Disturbed)

55-63 cm Dark Greenish Gray (GLEY 1 4/1 10Y) Pebbly Muddy Sand
- Firm
- Cleaner sand with less matrix
- No bioturbation or macrofossils

63-85.5 cm Greenish Black (GLEY 1 2.5/1 10Y) Pebbly Muddy Sand
- Firm
- No bioturbation or macrofossils

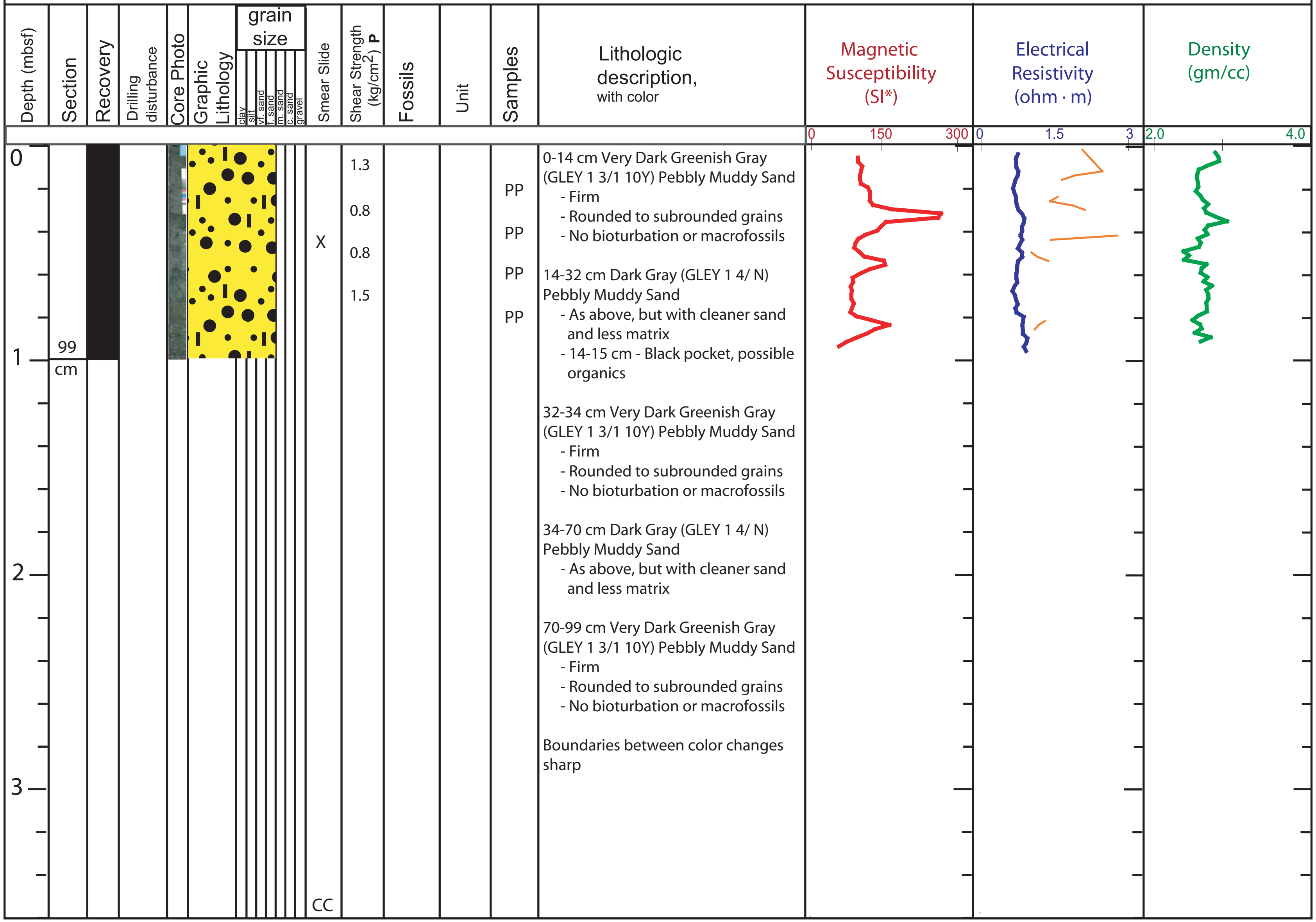
Boundaries between color changes sharp



NBP0602A Site: 6 Hole: C

Water Depth: 532m

Core Number: 6 Top 14.0 mbsf Core Type: R_a



0-14 cm Very Dark Greenish Gray (GLEY 1 3/1 10Y) Pebbly Muddy Sand
- Firm
- Rounded to subrounded grains
- No bioturbation or macrofossils

14-32 cm Dark Gray (GLEY 1 4/ N) Pebbly Muddy Sand
- As above, but with cleaner sand and less matrix
- 14-15 cm - Black pocket, possible organics

32-34 cm Very Dark Greenish Gray (GLEY 1 3/1 10Y) Pebbly Muddy Sand
- Firm
- Rounded to subrounded grains
- No bioturbation or macrofossils

34-70 cm Dark Gray (GLEY 1 4/ N) Pebbly Muddy Sand
- As above, but with cleaner sand and less matrix

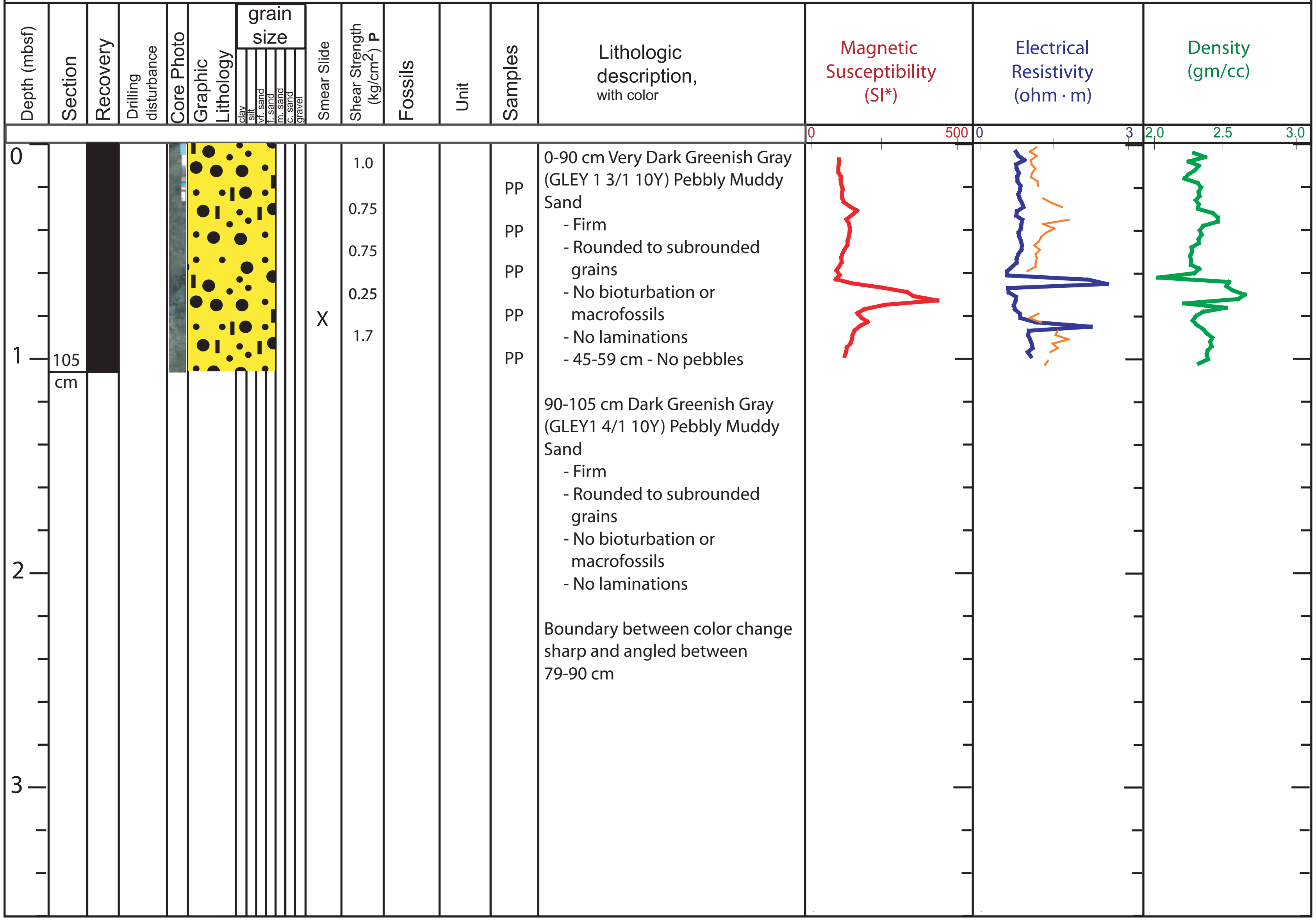
70-99 cm Very Dark Greenish Gray (GLEY 1 3/1 10Y) Pebbly Muddy Sand
- Firm
- Rounded to subrounded grains
- No bioturbation or macrofossils

Boundaries between color changes sharp

NBP0602A Site: 6 Hole: C

Water Depth: 532m

Core Number: 7 Top 16.0 mbsf Core Type: R_a



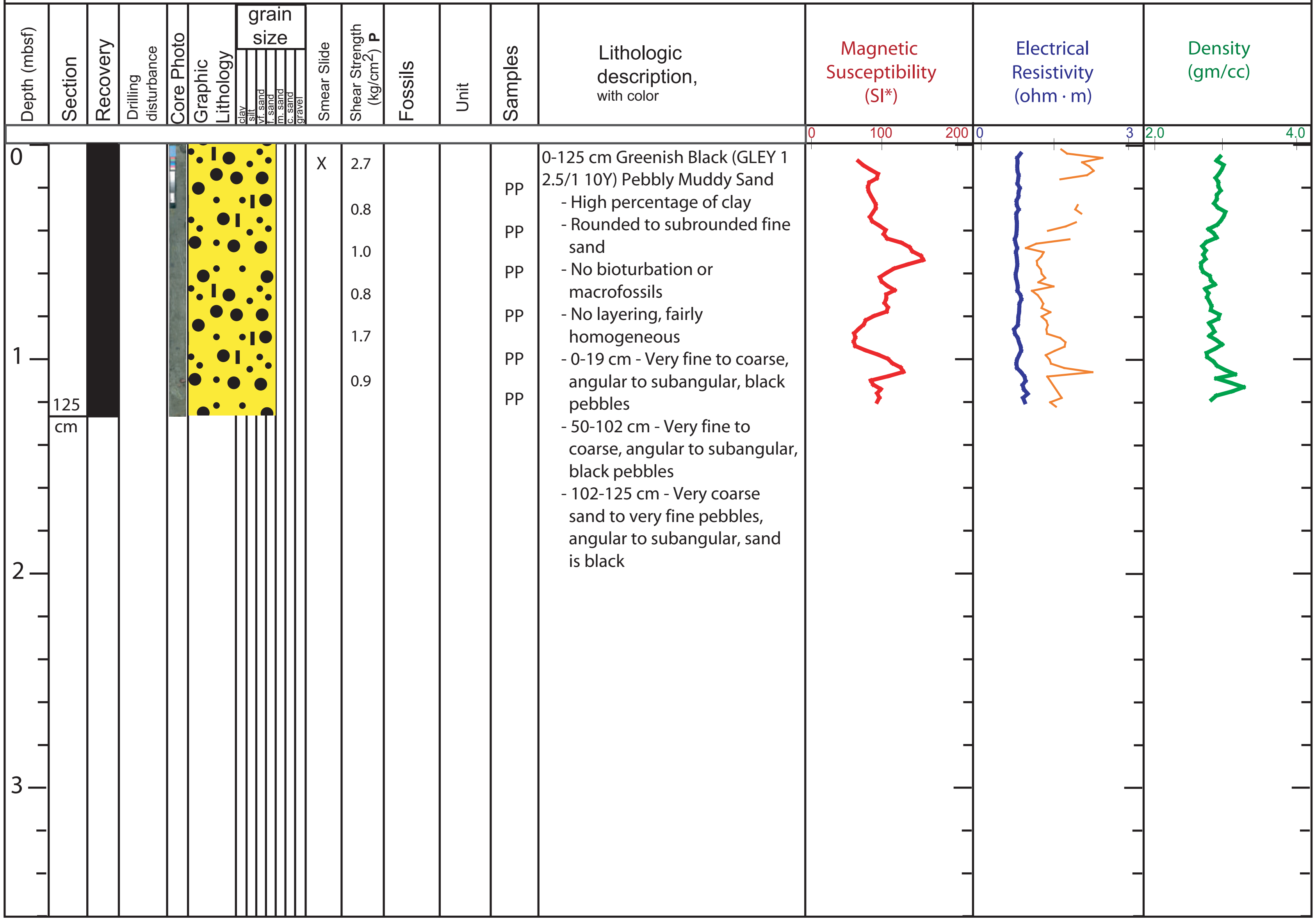
0-90 cm Very Dark Greenish Gray (GLEY 1 3/1 10Y) Pebbly Muddy Sand
- Firm
- Rounded to subrounded grains
- No bioturbation or macrofossils
- No laminations
- 45-59 cm - No pebbles

90-105 cm Dark Greenish Gray (GLEY1 4/1 10Y) Pebbly Muddy Sand
- Firm
- Rounded to subrounded grains
- No bioturbation or macrofossils
- No laminations

Boundary between color change sharp and angled between 79-90 cm

NBP0602A Site: 6 Hole: C Water Depth: 532m

Core Number: 8 Top 18.0 mbsf Core Type: R_a



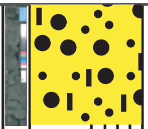
0-125 cm Greenish Black (GLEY 1 2.5/1 10Y) Pebbly Muddy Sand

- High percentage of clay
- Rounded to subrounded fine sand
- No bioturbation or macrofossils
- No layering, fairly homogeneous
- 0-19 cm - Very fine to coarse, angular to subangular, black pebbles
- 50-102 cm - Very fine to coarse, angular to subangular, black pebbles
- 102-125 cm - Very coarse sand to very fine pebbles, angular to subangular, sand is black

NBP0602A Site: 6 Hole: C

Water Depth: 532m

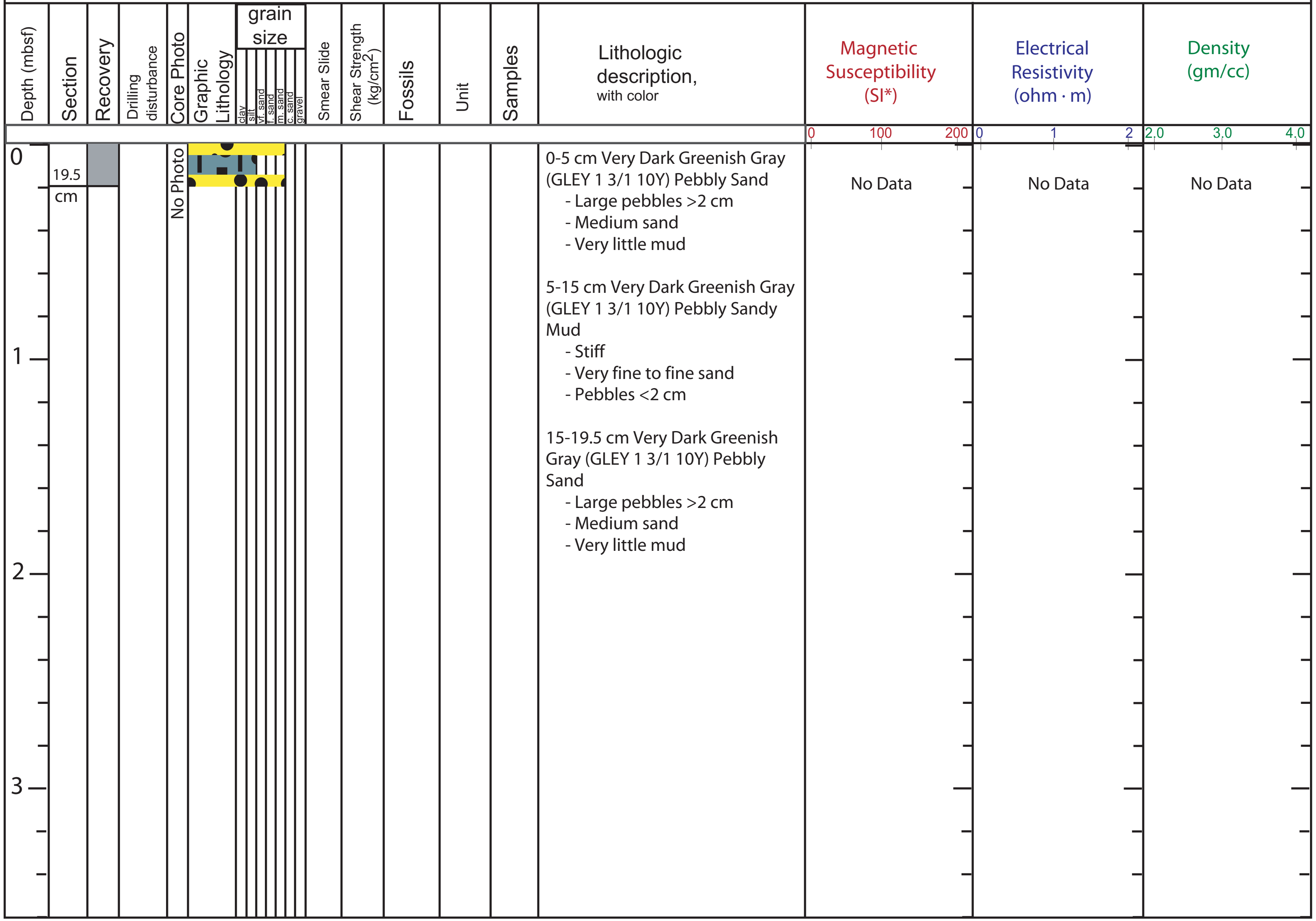
Core Number: 9 Top 20.0 mbsf Core Type: R_a

Depth (mbsf)	Section	Recovery	Drilling disturbance	Core Photo	Graphic Lithology	grain size (clay, silt, vf. sand, f. sand, m. sand, c. sand, gravel)	Smear Slide	Shear Strength (kg/cm^2) P	Fossils	Unit	Samples	Lithologic description, with color	Magnetic Susceptibility (SI*)	Electrical Resistivity (ohm · m)	Density (gm/cc)
													0 250 500	0 1 2	0.0 2.0 4.0
0	43 cm						X	0.5 0.75			PP PP	0-43 cm Very Dark Greenish Gray (GLEY 1 3/1 10Y) Pebbly Sandy Mud - Rounded to subrounded fine sand - No bioturbation or macrofossils - No layering Recovery is suspect and believed to be disturbed	No Data	No Data	No Data
1															
2															
3															

APPENDIX 5-3 LITHOLOGIC LOGS HOLE NBP0602A-6D

NBP0602A Site: 6 Hole: D Water Depth: 528m

Core Number: 1 Top 0.0 mbsf Core Type: R_a



0-5 cm Very Dark Greenish Gray (GLEY 1 3/1 10Y) Pebbly Sand
- Large pebbles >2 cm
- Medium sand
- Very little mud

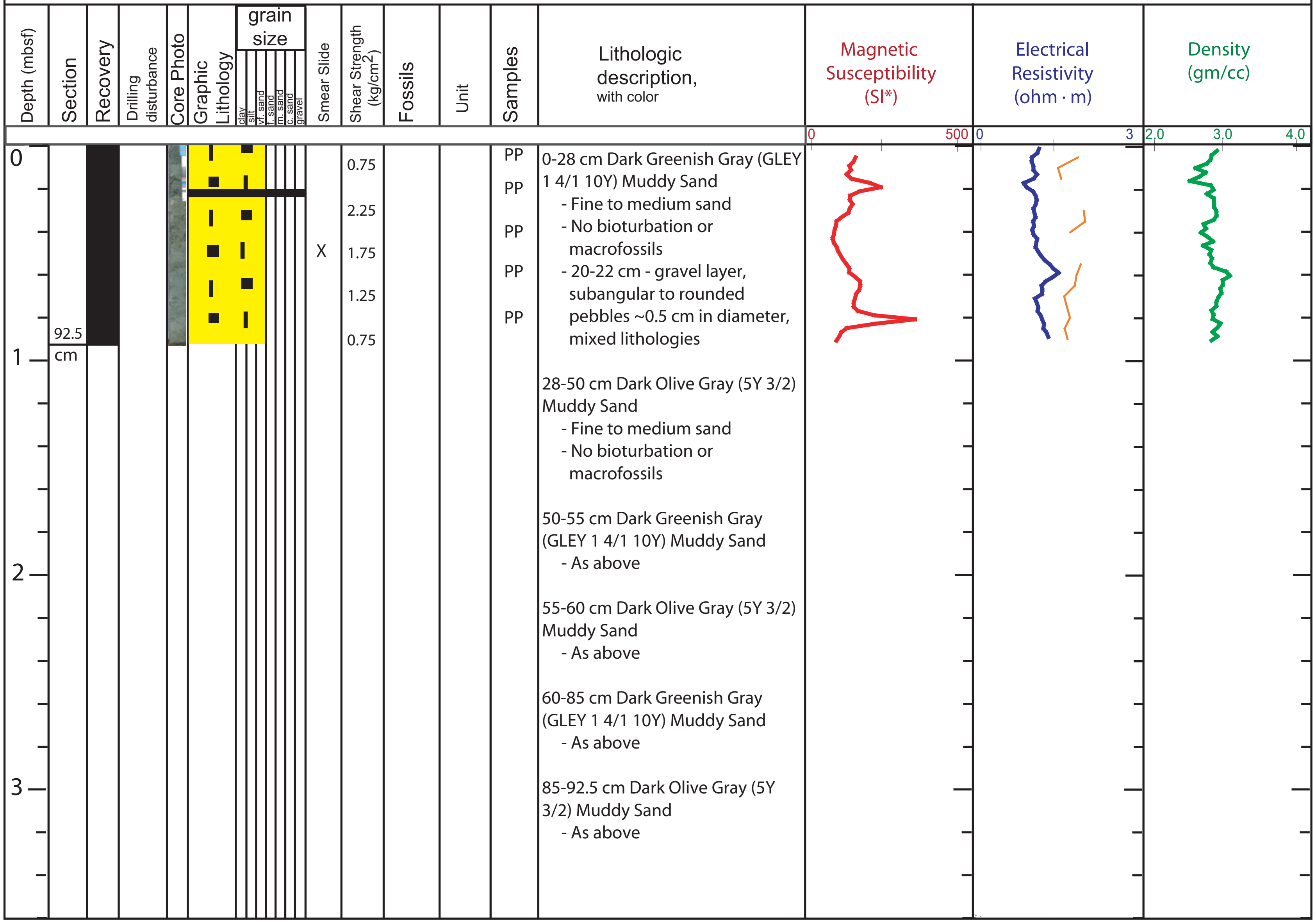
5-15 cm Very Dark Greenish Gray (GLEY 1 3/1 10Y) Pebbly Sandy Mud
- Stiff
- Very fine to fine sand
- Pebbles <2 cm

15-19.5 cm Very Dark Greenish Gray (GLEY 1 3/1 10Y) Pebbly Sand
- Large pebbles >2 cm
- Medium sand
- Very little mud

NBP0602A Site: 6 Hole: D

Water Depth: 528m

Core Number: 2 Top 5.2 mbsf Core Type: R_a



0-28 cm Dark Greenish Gray (GLEY 1 4/1 10Y) Muddy Sand
- Fine to medium sand
- No bioturbation or macrofossils
- 20-22 cm - gravel layer, subangular to rounded pebbles ~0.5 cm in diameter, mixed lithologies

28-50 cm Dark Olive Gray (5Y 3/2) Muddy Sand
- Fine to medium sand
- No bioturbation or macrofossils

50-55 cm Dark Greenish Gray (GLEY 1 4/1 10Y) Muddy Sand
- As above

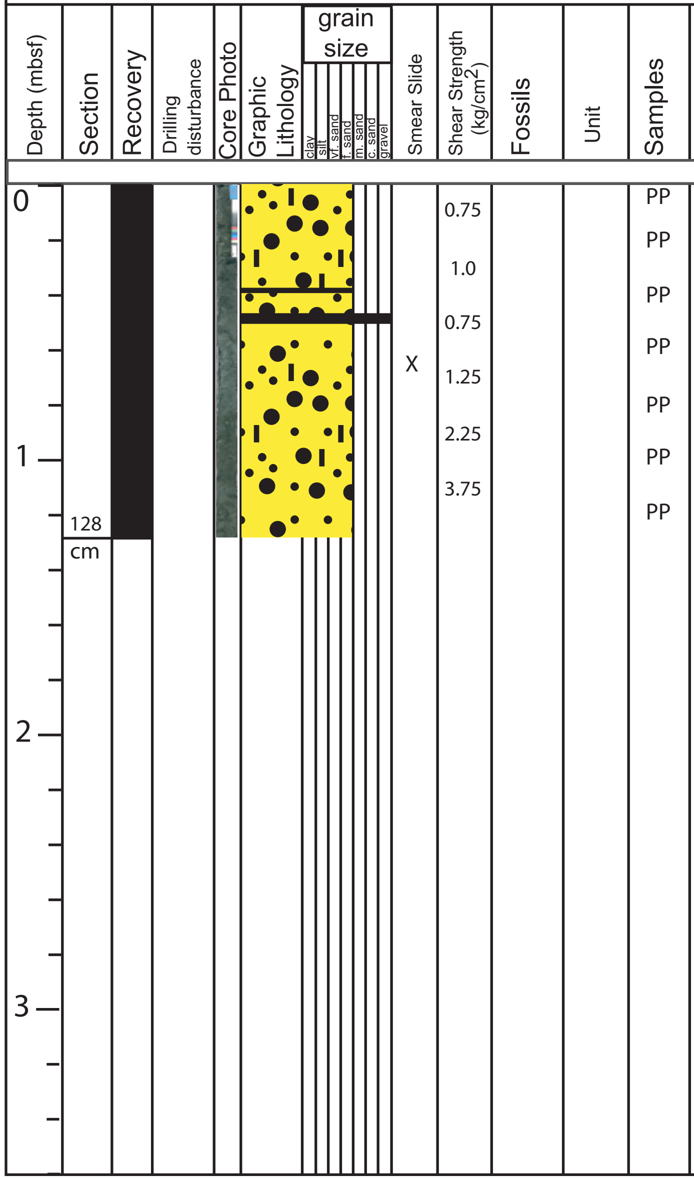
55-60 cm Dark Olive Gray (5Y 3/2) Muddy Sand
- As above

60-85 cm Dark Greenish Gray (GLEY 1 4/1 10Y) Muddy Sand
- As above

85-92.5 cm Dark Olive Gray (5Y 3/2) Muddy Sand
- As above

NBP0602A Site: 6 Hole: D Water Depth: 528m

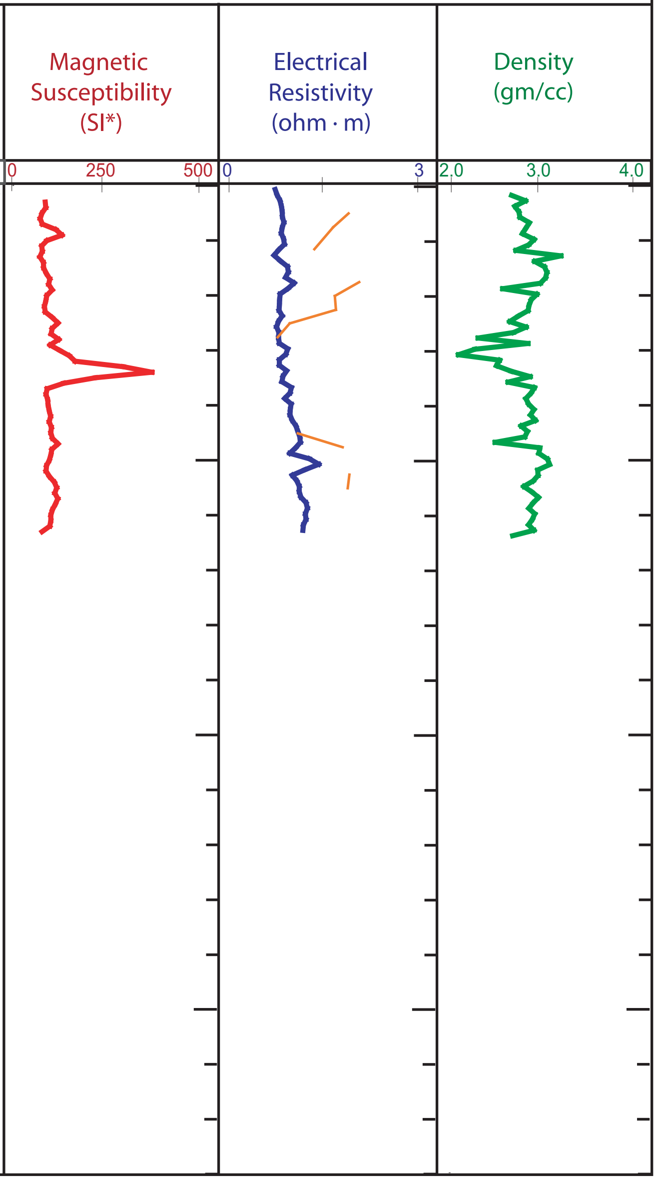
Core Number: 3 Top 8.94 mbsf Core Type: R$_a$



Lithologic description, with color

0-85 cm Dark Greenish Gray (GLEY 1 4/1 5GY) Pebbly Muddy Sand
- Fine to medium sand
- Mixed pebble lithologies
- No bioturbation or macrofossils
- 39 cm - Clay lamination ~15 mm thick
- 50-53 cm - Gravel (<0.5 cm diameter)
- 68 cm - Large pebble (3 cm)

85-128 cm Very Dark Greenish Gray (GLEY 1 3/1 10Y) Pebbly Muddy Sand
- Fine to medium sand
- Possible higher clay content
- No bioturbation or macrofossils
- 105 cm - Large pebble (3 cm)



CHAPTER 6: SITE 8
Table of Contents

HOLES NBP0602A-8A-KC, -8B

Date/time occupied (date; Julian Day; GMT): 22 March 2006; 081; 0800

Date/time departed: 24 March 2006; 083; 0445

Time on station: 44 hr, 45 min

Geographic area: Firth of Tay

Ice coverage during station: $^1/_{10}$

Kasten Core: 63° 20.572' S, 55° 53.195' W; 629 mbsl

NBP0602A-8A-KC: 3.19 m organic-rich diatomaceous mud

Drill Hole 8B: 63° 20.572' S, 55° 53.195' W

Water depth (multibeam, m): 629

Water depth (drill-pipe measurement from sea level, m): 623

Total penetration (m): 79

Number of drill runs: 32

Total length of cored section (m): 75

Total drill core recovered (m): 59.1

Drill-core recovery (%): 78.8

Total competent drill core recovered (m): 33.4

Competent drill-core recovery (%): 43.4

Oldest sediment drilled:
Depth sub-bottom (m): 79
Nature: Clay
Age: Quaternary

HOLES NBP0602A-8C, -8D-KC

Date/time occupied (date; Julian Day; GMT): 24 March 2006; 083; 0445

Date/time departed: 24 March 2006; 083; 1245

Time on station: 8 hr

Geographic area: Firth of Tay

Ice coverage during station: $^{1}/_{10}$

Kasten Core: 63° 20.574' S, 55° 53.145' W; 624 mbsl

NBP0602A-8D-KC: 3.18 m organic-rich diatomaceous mud

Drill Hole 8C: 63° 20.574' S, 55° 53.145' W

Water depth (multibeam, m): 624

Water depth (drill-pipe measurement from sea level, m): 623

Total penetration (m): 34

Number of drill runs: 3

Total length of cored section (m): 9

Total drill core recovered (m): 6.8

Drill-core recovery (%): 76

Total competent drill core recovered (m): 5.4

Competent drill-core recovery (%): 59

Oldest sediment drilled:
Depth sub-bottom (m): 34
Nature: Diatomaceous mud
Age: Holocene

Principal Results: Upon leaving Site NBP0602A-7, we sought once again to find enough open water to drill our primary targets. Unfortunately, we found in turn that our previous Sites NBP0602A-4, -3 and -2, and Proposed Sites JRB3 and JRB2, were partially or completely occluded by ice. Thus, we headed north to the Firth of Tay between Joinville and Dundee Islands to core an expanded Holocene section for paleoclimate reconstruction. A detailed multibeam and chirp survey located a promising silled minibasin in ice-free waters with at least 50 m of acoustically laminated sediment.

An initial Kasten core (NBP0602A-8A-KC) returned full (3.19 m) of dark greenish black to black, organic-rich, pungent Holocene diatomaceous mud. No pebbles were noted, but several 2-4 cm pieces of ikaite, a hydrous calcium carbonate mineral, were randomly distributed throughout. Thereafter, 32 push-core runs in Hole NBP0602A-8B reached 79 mbsf, although no usable material was recovered in the uppermost 8 m. Recovery of competent *in situ* sediment was 43%.

Sediment from Hole NBP0602A-8B is divided into three lithologic units. Lithologic Unit I (0-64.18 mbsf) consists of greenish black to black diatomaceous mud with pieces of ikaite, sponge spicules, and numerous articulated and fragmented bivalves throughout. Lithologic Unit II (64.18-76.0 mbsf) is mostly black to very dark greenish gray clay or clayey mud with numerous graded beds usually 5-10 cm thick (maximum ~60 cm). Clay is the dominant component (62-80%) with diatoms comprising only 1-10%. Lithologic Unit III (76.0-79.0 mbsf) consists of homogeneous dark gray clay with no macrofossils, laminations, or bioturbation evident. Clay is the dominant mineral component (80-81%), with only 2-3% diatoms present.

The Holocene diatom assemblages of Site NBP0602A-8 are dominated by *Chaetoceros* spp., *Thalassiosira antarctica*, *Cocconeis* spp., *Fragilariopsis curta*, *F. cylindrus*, and *F. vanheurckii*, which are taxa characteristic of a modern sea-ice flora. Several laminations are comprised entirely of *Chaetoceros* spores. Rapid sedimentation of these spores is often associated with spring blooms in stratified waters at the sea-ice edge. Although the entire section is presumed to be Holocene, diatom biostratigraphy can only constrain the age to <140 ka based on the absence of *Rouxia leventerae*.

Hole NBP0602A-8C was offset 20 m from Hole NBP0602A-8B to fill gaps between 25.0-34.0 mbsf in the original hole. Three core runs attained 59% recovery. The sediment is similar to that from Lithologic Unit I of Hole 8B, consisting mostly of diatomaceous mud. Foraminifers were also found in several intervals from Hole 8C.

Kasten Core NBP0602A-8D-KC yielded 3.18 m of diatomaceous mud while pipe was being tripped out of Hole NBP0602A-8C. This core captured the sediment/water interface and released myriads of gas bubbles that swelled the sediment. The only large gap remaining in the Holocene section from the Firth of Tay is between 3-8 mbsf, which could be filled during a later cruise using a jumbo piston core.

SEISMIC STRATIGRAPHY

Only a few seismic lines were collected in the Firth of Tay area during a 1991 *Polar Duke* cruise to the region. Data collected just south of the mouth of the bay show a relatively thick laminated unit resting above bedrock and glacial deposits (Fig. 6-1). A single line collected within the bay indicated that the laminated unit extends into the bay. During this cruise a detailed multibeam and chirp sub-bottom profiling survey was conducted during the evening and early morning of 21 and 22 March, which led to the identification of several small, isolated minibasins within the bay (Fig. 6-2). The largest and northernmost basin was selected for drilling because it contains the thickest undisturbed section and was situated in ice-free waters (Fig. 6-3). Several crossings of the basin showed sediment gravity flows along the steep flanks of the basin, but none of these extend into the central part of the northernmost basin in which the drill site is located. At Site NBP0602A-8, a minimum of 50 m of acoustically laminated deposits was imaged at the location selected for drilling.

Figure 6-1. Seismic Line PD91-38B illustrating Holocene sediment overlying bedrock at the mouth of the Firth of Tay.

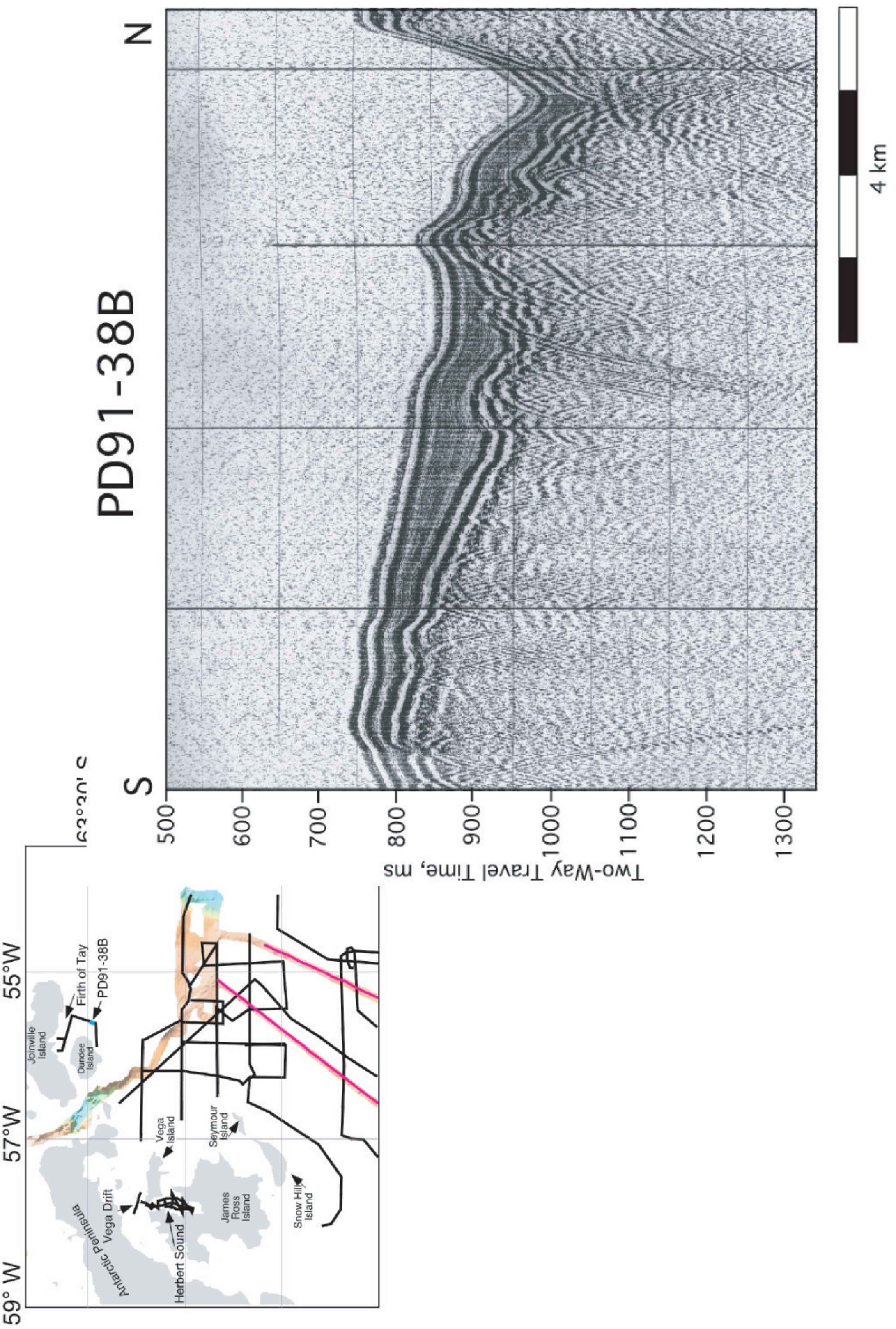


Figure 6-2. Multibeam images of Site NBP0602A-8.

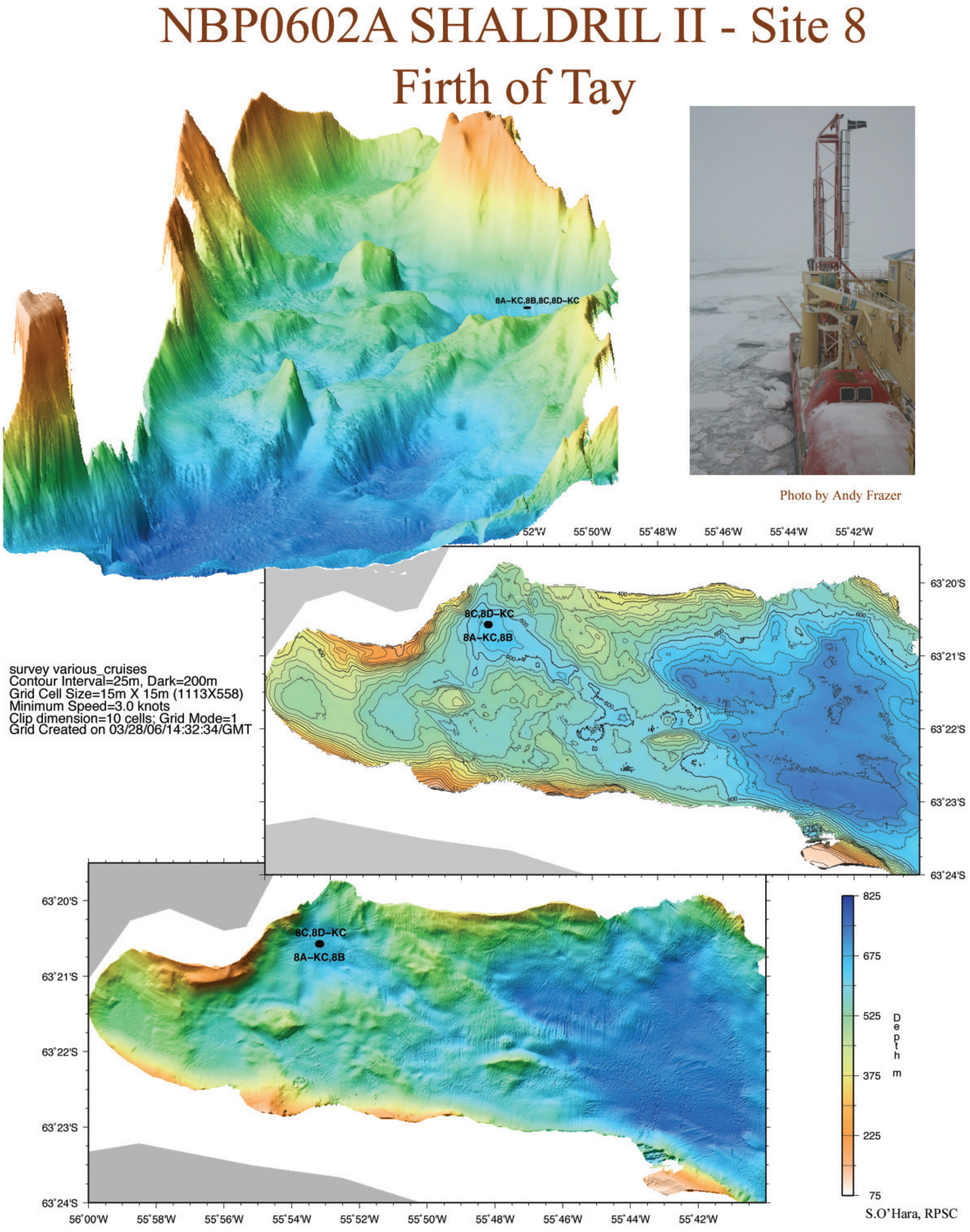
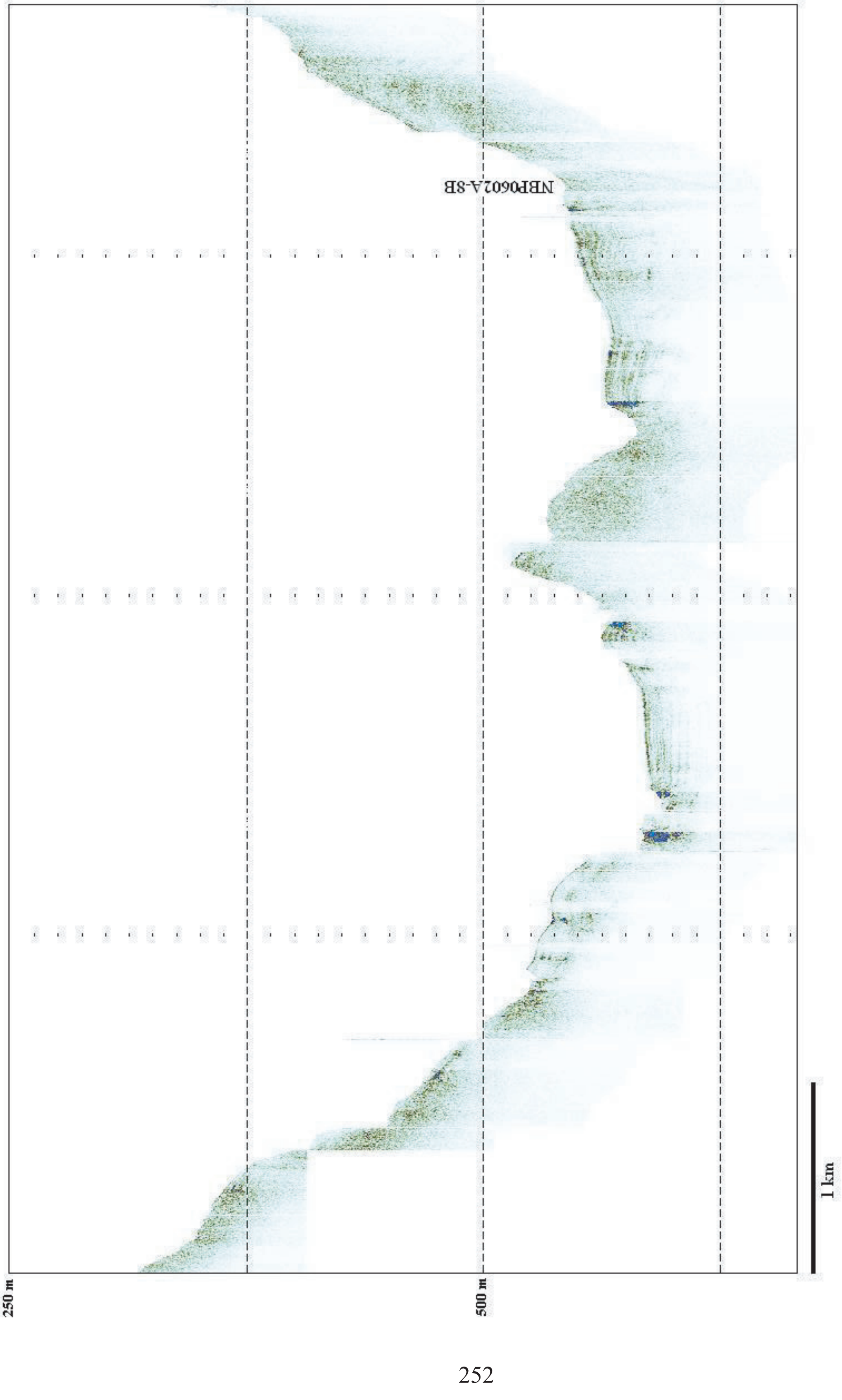


Figure 6-3. 3.5 kHz profile showing Holocene core site (NBP0602A-8B) in the Firth of Tay.



SITE 8

A. OBJECTIVES

Site NBP0602A-8 was drilled in the Firth of Tay, which is an embayment between Joinville Island to the north and Dundee Island to the south. This is one of two proposed sites intended to sample an expanded Holocene section for paleoclimatic reconstruction in the area south of the Antarctic Peninsula. The other proposed site is the Vega Drift, but ice conditions did not allow drilling at that site. Site 8 is intended to complement existing long Holocene records from the Palmer Deep (Domack et al., 2001) and a site drilled in Maxwell Bay, South Shetland Islands during SHALDRIL 1 (Site NBP0502-1; SHALDRIL Scientific Party, 2005). The combined three sites provide the aerial coverage needed to investigate oscillations in climatic and oceanographic fronts during the Holocene.

B. OPERATIONS

Site NBP0602A-8 includes four holes, two Kasten cores and two drill holes, in the Firth of Tay between Joinville and Dundee islands (Table 6-1). Holes NBP0602A-8A-KC and NBP0602A-8B are located at 63° 20.572' S, 55° 53.195' W in 629 m of water. Holes NBP0602A-8C and NBP0602A-8D-KC are located at 63° 20.574' S, 55° 53.145' W in 624 m of water.

Kasten Core NBP0602A-8A-KC was collected using all fourteen weights on the top of the core. The core barrel over-penetrated into the sediment and a good sediment/water interface was not preserved. Hole NBP0602A-8B includes 32 core runs extending from the surface to a total depth of 79 mbsf. Only core runs 25 and 32 used the spring-loaded extended-nose coring tool from the SHALDRIL suite of tools. These two intervals were somewhat stiffer than the rest of the hole, requiring the use of the spring-loaded extended-nose tool. The other 30 core runs used the standard push sampler that was also used in Maxwell Bay during SHALDRIL I. The only modification to this tool for SHALDRIL II is that it has a new crossover sub so that it fits the barrels used with the new SHALDRIL tools. No core was recovered above 8 mbsf. This gap at the top of the sedimentary section is at least partially attributable to the very soft, watery sediment near the surface. Should this section be needed, it could be recovered at a later date with a jumbo piston core. Relatively good coverage was achieved in the section below 8 mbsf. Total recovery for the hole is 79%, with 43% competent recovery.

Hole NBP0602A-8C was drilled to sample the interval from 25 to 34 mbsf to cover the portion of Hole NBP0602A-8B that had the most significant gaps. The hole was washed from the surface to 25 mbsf and no material was recovered from this interval. Three 3-m push cores were collected in the target interval. Overall, they had 76% recovery with competent, undisturbed material representing 59% of the cored interval. Kasten Core NBP0602A-8D-KC was collected using eight weights. This lighter core barrel preserved the sediment/water interface and recovered a full core.

Each of these holes penetrated through the entire targeted interval and ended intentionally. There was minimal ice in the region and overall station keeping was not difficult.

C. LITHOSTRATIGRAPHY

Site NBP0602A-8 consists of four holes, two Kasten cores and two drill holes. There was 100% recovery in the two Kasten cores. The first Kasten core over-penetrated and did not recover the sediment/water interface. Good recovery came from the two drill holes as well; however, due to the weight of the drill bit, the top of each core was almost always partially disturbed. Therefore, the second drill hole successfully cored the interval from the first with the most significant gaps at an offset distance of 20 m.

Hole NBP0602A-8A-KC extends from 0 to 3.19 mbsf (Fig. 6-4). Sediment from this hole consists of very dark greenish black (GLEY 1 3/ 10Y) to black (GLEY 1 2.5/ N) layers of soft, organic-rich, pungent diatomaceous mud. The layers vary from 10-80 cm thick. Trace amounts of very fine sand are found in the core, although no pebbles were present. Several pieces of ikaite, usually between 2-4 cm long, are randomly distributed. Ikaite is a hydrous calcium carbonate mineral known to occur in cold waters. It rapidly dehydrates into a chalky substance if its temperature increases too much, so pieces of ikaite in this core no longer exist. Sponge spicules and worm tubes were found throughout. Several articulated bivalves were also found. Mottling and bioturbation are evident. This core was filled with gas that bubbled upon release and caused the sediment to rise slightly above the sides of the container. Smear-slide analysis (Table 6-2) indicates that clay is the dominant mineral component (31-49%), quartz is second (7-22%), and feldspar is third (2-5%). Heavy minerals (1-3%) and calcite (trace amounts-2%) are also present, as are trace amounts of the following minerals: mica, glauconite, hornblende, volcanic glass, and hematite. Diatoms are very numerous, comprising 40-45% of the core, while sponge spicules comprise 1-2%.

Hole NBP0602A-8B was drilled at the same location as the first Kasten core, and extends from 0-79.0 mbsf (Fig. 6-5; Appendix 6-1). This hole has been divided into three lithologic units. Although sample recovery did not start until 8.0 mbsf, the lithology of the first sample is identical to that described from the first Kasten core; therefore, Lithologic Unit I extends from 0-64.18 mbsf. Sediment from this unit consists of greenish black (GLEY 1 2.5/ 5GY) to black (GLEY 1 2.5/ N) diatomaceous mud. Layers of siltier diatomaceous mud, varying between 1 and 3 cm, occur between 51.73 and 53.22 mbsf. Trace amounts of fine sand are found in this unit. Pebbles are rare. Often the upper part of each 3-m section of core is disturbed, owing to a small amount of cave-in during the push technique. The upper part of each core is always soft as a result, but the undisturbed portion is firm, and a sharp contact exists between them. Pieces of ikaite are found throughout the unit. Sponge spicules are ubiquitous, and numerous articulated and fragmented bivalves are found throughout. Occasionally, thin layers of bivalve hash are observed. Thin laminations are present, but are usually masked by moderate bioturbation or black mottling in the organic-rich sediment. Smear-slide analysis (Table 6-2) indicates that clay and diatom percentages vary inversely throughout, with clay ranging between 23-65% and diatoms between 10-65%. Quartz composes 3-22% of the unit. Heavy minerals comprise trace amounts to 4%, calcite trace amounts to 2%, with feldspar, hornblende, glauconite, and mica found in trace amounts. Sponge spicules also occur in trace numbers to 3%, and macroscopic plant material comprises approximately 3% of the assemblage at 43.73 mbsf.

Lithologic Unit II extends from 64.18-76.0 mbsf. Sediment from this unit is mostly dark gray (GLEY 1 4/ N) clay or clayey mud with numerous graded beds throughout. The graded beds are usually 5-10 cm thick, although the thickest is over 60 cm. All of the beds are muddy, but the subdominant grain size grades from fine pebbles at the base to silty mud before transitioning back to clay. No bioturbation, mottling, or color variations occur in the unit. Macrofossils are very rare. Thin laminations of sand do occur, but are believed to be incomplete graded bed sequences. Smear-slide analysis (Table 6-2) indicates that clay is the dominant mineral component (62-80%), quartz is second (5-24%), and both feldspar and heavy minerals are third (trace amounts to 7%). Calcite (trace amounts to 3%) is also present, as are trace amounts to 1% of mica, glauconite, hornblende, and hematite. Diatoms comprise 1-10% of the sediment, while sponge spicules constitute only trace numbers.

The details of the contact between Lithologic Unit III and the overlying Lithologic Unit II are unknown because of incomplete recovery between cores. Additionally, the final core run penetrated from 76.0-79.0 mbsf, but recovered only 0.235 m of sediment. Lithologic Unit III extends by convention from 76.0-79.0 mbsf. Sediment from this unit is dark gray (GLEY 1 4/ N), pebbly, sandy clay from 76.00-76.15 mbsf, with numerous subangular to subrounded fine pebbles and subangular medium to fine sand. Below 76.15 mbsf the unit is composed of dark gray clay. No laminations, mottling, bioturbation, or macrofossils occur. Smear-slide analysis (Table 6-2) indicates that clay is the dominant mineral component (80-81%), quartz is second (10%), and both feldspar and heavy minerals are third (3%). Calcite (1%) is also present, as are trace amounts of mica, glauconite, hornblende, and hematite. Diatoms comprise 2-3% of the sediment, while sponge spicules constitute only trace numbers.

Hole NBP0602A-8C is a drill hole located 20 m away from Hole NBP0602A-8B. This hole extends from 25.0-33.04 mbsf (Fig. 6-6; Appendix 6-2). It was collected to fill the most significant gaps and disturbed sections of the previous hole. Sediment from this hole consists of greenish black (GLEY 1 2.5/1 5GY and GLEY 1 2.5/1 10Y) to black (GLEY 1 2.5/ N) diatomaceous mud. A few foraminifers were found between 25.0-26.085 mbsf. Black mottling is evident. Sponge spicules are found throughout this hole, as are worm tubes and bivalve shell fragments. The sediments are moderately bioturbated. A piece of ikaite was noted at 31.38-31.39 mbsf. Two intervals distinctly different from the diatomaceous mud that characterizes the rest of the recovered core are found in Core NBP0602A-8C-2E. The first, which extends from 29.64-29.75 mbsf, is dark gray (GLEY 1 4/ N), pebbly, sandy mud. No diatoms were found during smear-slide analysis of this interval. The second is an interval of very dark greenish gray clayey mud (GLEY 1 3/1 10Y) that occurs from 30.09-30.22 mbsf. This unit shows slight mottling and bioturbation. Diatoms compose 13% of the sediment in this interval. Smear-slide analysis of the diatomaceous mud (Table 6-2) indicates that clay is the dominant mineral component, typically comprising 36-55%, with lesser amounts of quartz (7-17%), feldspar (3-7%), heavy minerals (1-5%), calcite (trace amounts to 1%), and glauconite (trace amounts to 1%). Hematite and hornblende are found in trace amounts. Diatoms comprise 19-45%, and sponge spicules trace amounts to 2%.

Kasten Core NBP0602A-8D-KC was taken on location while pulling pipe from Hole NBP0602A-8C. Sediment from this core extends from 0.0-3.18 mbsf and is identical to that seen in the first Kasten core (Fig. 6-7). The sediment consists of layers of dark greenish gray (GLEY 1 4/1 10Y), greenish black (GLEY 1 2.5/1 10Y), and black (GLEY 1 2.5/ N), soft, organic-rich, pungent diatomaceous mud. The layers vary from 20-100 cm thick. No pebbles are present. Several pieces of ikaite, usually between 2-4 cm long, are randomly distributed. Sponge spicules and worm tubes are found throughout, as are shell fragments of bivalves. One large articulated bivalve was found at 1.09 mbsf. Mottling and bioturbation are evident. Because the core was filled with gas, after the core was opened, the release of the overburden pressure allowed gas bubbles to form and the core began to swell, making a barely audible popping sound. Smear-slide analysis (Table 6-2) indicates that the sediment is composed of clay (26-33%), quartz (15-20%), heavy minerals (2-7%), feldspar (3-5%), and mica (1%). Calcite is found in trace amounts to 1%, and glauconite, hematite, and hornblende are all found in trace amounts. Diatoms comprise 30-40% and sponge spicules occur in trace amounts to 1%. An interval of muddy diatomaceous ooze occurs at 0.64 mbsf. Diatoms comprise 70% of the sediment at this depth, most of which are *Chaetoceros* spp. resting spores.

D. BIOSTRATIGRAPHY

Site NBP0602A-8 was drilled in the Firth of Tay on the south side of Joinville Island. Two Kasten cores (NBP0602A-8A-KC and -8D-KC) were taken at the site, and two longer cores were drilled with the Seacore drill rig (Holes NBP0602A-8B and -8C). These combined cores represent a thick composite section of presumed Holocene age sediment. The lowermost part of the section was recovered in Hole 8B, and the hole was terminated upon reaching basement at ~79 mbsf (in Core NBP0602A-8B-32E_s). Initial shipboard paleontological work for Site NBP0602A-8 was focused on diatom analysis of smear slides. A listing of observed diatom taxa is presented in Table 6-3.

In the composite section recovered at Site NBP0602A-8, the organic-rich diatomaceous muds from 0 to ~62 mbsf (Cores NBP0602A-8A-KC through -8B-26E) contain common to abundant diatoms that are moderately to well preserved. Below this level from ~62 to 79 mbsf (Cores NBP0602A-8B-27E to -8B-32E$_s$), diatoms are poorly preserved and rare to few in abundance. The abrupt drop in diatom abundance and preservation in the lower part of the section corresponds to a transition to "blue" glacial mud lithologies at the bottom of the core.

In preliminary smear-slide analysis, a relatively uniform diatom assemblage was observed throughout the Site NBP0602A-8 section (Table 6-3). The assemblages are dominated by small *Chaetoceros* resting spores, *Fragilariopsis curta*, *F. vanheurckii*, *Thalassiosira antarctica* group, and *Cocconeis* spp. Common diatom taxa of secondary abundance include *Actinocyclus actinochilus, Fragilariopsis cylindrus, F. obliquecostata, F. ritscheri, F. sublinearis, Porosira* spp., *Synedropsis* spp., *Thalassiosira gracilis* group, small *Navicula* spp., and *Pseudogomphonema* spp. With the exception of very rare reworked *Denticulopsis* specimens, all diatom taxa observed in Site 8 samples are extant species that are characteristic of modern diatom flora associated with the sea-ice environment (Armand et al., 2005). The entire section is presumed to be Holocene in age, although diatom biostratigraphy only constrains the age to ~140 ka or younger based on the absence of *Rouxia leventerae* (Zielinski et al., 2002).

Chaetoceros spp. are particularly abundant in most samples from Site NBP0602A-8. Rapid sedimentation of *Chaetoceros* spores is often associated with spring blooms in stratified waters at the sea-ice edge (Leventer et al., 2002), suggesting seasonal development of stratification in the Firth of Tay after sea-ice breakout. "Toothpick" sampling of several intervals also identified laminations comprised entirely of *Chaetoceros* spores; however, these laminations were relatively rare. This may be due to disturbance of primary sedimentary structures by core degassing after recovery, particularly in the upper part of the section.

Aside from a major decrease in diatom abundance below ~62 mbsf, downcore changes in Site NBP0602A-8 diatom assemblages are relatively subtle. From initial qualitative observations, the most distinctive change noted in the assemblages is the occurrence of *Eucampia antarctica* var. *antarctica* in the lower part of the section (~52 to 79 mbsf; Cores NBP0602A-23E to -32E$_s$) (Table 6-3). This interval may correlate to the early to mid-Holocene interval (~11,000 to 6,000 cal. yr. BP) of ODP Site 1098 (Palmer Deep), in which this taxon is relatively common (Taylor and Sjunneskog, 2002). Additionally, increased abundance of both *E. antarctica* var. *antarctica* and *Fragilariopsis kerguelensis* may hint at relatively warm conditions in the interval between ~53 and 62 mbsf (Cores NBP0602A-8B-23E to -26E) (Table 6-3). This interval may correspond to an interval within the mid-Holocene climatic optimum identified at Site 1098 (~9,000 to 4,000 cal. yr. BP) (Taylor and Sjunneskog, 2002; Sjunneskog and Taylor, 2002). Further determination of Holocene paleoenvironmental changes recorded at Site 8 will require detailed quantitative diatom analysis, and radiocarbon age constraints will help assess possible correlations to other Holocene drill cores in the Antarctic Peninsula region.

E. PHYSICAL PROPERTIES

At Site NBP0602A-8, two Kasten cores (NBP0602A-8A-KC and NBP0602A-8D-KC) were taken and two holes (NBP0602A-8B and NBP0602A-8C) were drilled. Cores from both drill holes were run through the multisensor core logger (MSCL) obtaining measurements every 2 cm; the Middlebury College electrical resistivity (MCER) probe obtained electrical resistivity (ER) measurements every 5 cm, and discrete samples were taken every 10 cm and stored for future analyses. For the Kasten cores the MCER probe obtained ER data every 2 cm and discrete samples were taken at the same interval. Magnetic susceptibility (MS) was obtained on the split archive core for Hole NBP0602A-8A-KC.

All sites have nearly the same lithology throughout, primarily consisting of an organic-rich diatomaceous mud varying in color from black to greenish gray. This sediment was highly gaseous and caused core disturbance with the formation of gas cracks. Much of the MSCL data is thus suspect as all sensors of the MSCL are biased when cracks occur; however, many sections are intact so care should be taken when examining the physical properties data.

Core NBP0602A-8B drilled to 79 mbsf, and the lower 28 m contain silty or fine pebbly mud layers. As observed at previous sites, the occurrence of pebbles correlates to higher MS and ER values and lower density values (e.g., Lithology Log NBP0602A-8B-28E and NBP0602A-8B-30E).

In general for all holes, the organic-rich diatomaceous mud has a range of ER values between 0.29-0.77 ohm-m for the MCER probe. NBP0602A-8A-KC, which just sampled the top of the organic-rich diatomaceous mud, has an average value of 0.39 ohm-m. NBP0602A-8B and NBP0602A-8C have average ER values of 0.61 and 0.58 ohm-m respectively. These higher average ER values include the silty layers of the lower sections and also show the effect of compaction. MS measurements have a background value around 60 SI units. Large peaks often reach values of 500 SI. Only those high values in undisturbed sections are of significance and are generally related to the presence of pebbles or silty laminations. Density averaged 1.56 g/cm^3 for Hole 8B, and is slightly higher in Hole 8C (1.7 g/cm^3). Since Hole 8B is averaged over 79 m, this explains the lower averaged density values. Hole 8B shows a downcore increase in all physical properties due to compaction.

F. SITE SUMMARY

Site NBP0602A-8 was drilled in the Firth of Tay between Joinville and Dundee Islands, seeking an expanded Holocene section for paleoclimate reconstruction to complement existing sites in the Palmer Deep (ODP Leg 178) and in Maxwell Bay, South Shetland Islands (SHALDRIL I). A detailed multibeam and chirp survey located a promising silled minibasin in ice-free waters with at least 50 m of acoustically laminated sediment.

Initial Kasten Core NBP0602A-8A-KC returned full after some over-penetration, yielding dark greenish black to black layers of soft, organic-rich, pungent Holocene diatomaceous mud. The core contained several 2-4 cm pieces of ikaite, a hydrous calcium carbonate mineral, randomly distributed throughout. Thereafter, 32 push-core runs in Hole NBP0602A-8B from the surface reached 79 mbsf, although no usable material was recovered in the first 8 m. Discounting cavings (a common byproduct of the push-core technique in soft, watery sediments), recovery of competent *in situ* sediment was 43%. The sediment from this hole is divided into three lithologic units.

Lithologic Unit I (0-64.18 mbsf) consists primarily of greenish black to very dark greenish gray organic-rich diatomaceous mud with black mottling and laminations. Macrofossils are rare to abundant and include sponge spicules and bivalves.

Lithologic Unit II (64.18-76.0 mbsf) consists of dark gray clay to clayey mud, with intervals of pebbly mud to pebbly, sandy mud. Black silt and sand laminations and graded beds are abundant. Macrofossils are very rare.

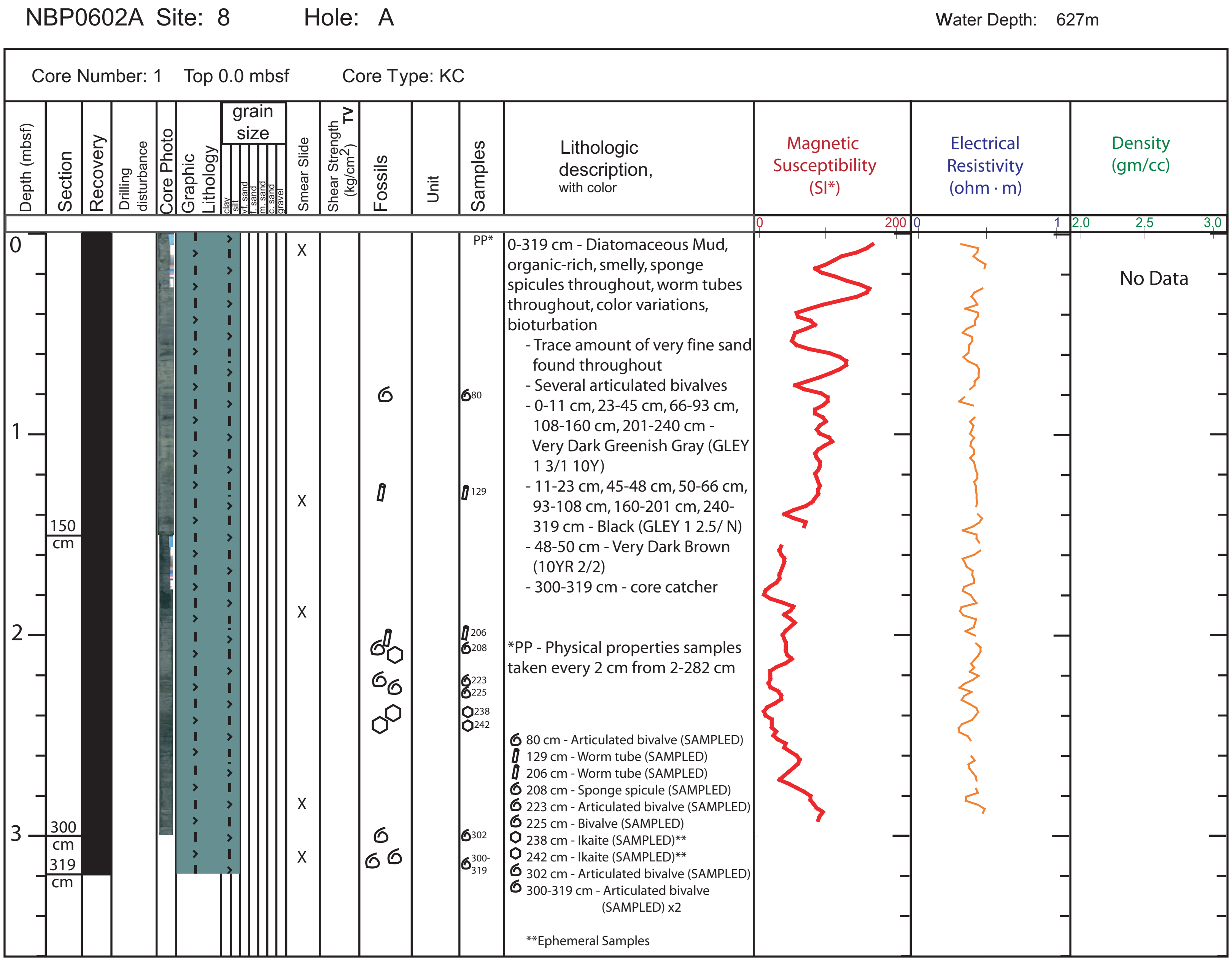
Lithologic Unit III (76.0-79.0) mbsf is dark gray clay with abundant pebbles and sand in the upper 15 cm. No laminations, bioturbation, or macrofossils are evident.

The diatom assemblages of Hole NBP0602A-8B are dominated by *Chaetoceros* spp, *T. antarctica*, *Cocconeis* spp., *F. curta*, *F. cylindrus*, and *F. vanheurckii*. These taxa are characteristic of modern diatom sea-ice flora. Several laminations are comprised entirely of *Chaetoceros* spores. Rapid sedimentation of these spores is often associated with spring blooms in stratified waters at the sea-ice edge. Although the entire section is presumed to be Holocene in age, diatom biostratigraphy can only constrain the age to <140 ka based on the absence of *R. leventerae*.

Much of the sediment is highly gaseous, resulting in core disturbance and cracks in the core liner, thus making much of the MSCL data suspect. The lower sections of the core, where the data is more reliable, show consistent trends of down-core compaction. As with previous holes, large peaks in the MS and ER data and lower density values correlate to pebbles within the cores.

Hole NBP0602A-8C was offset 20 m from Hole NBP0602A-8B to fill gaps between 25.0-34.0 mbsf in the first hole. Three cores attained 59% recovery. Sediment consists of diatomaceous mud with numerous macrofossils and ikaite. Foraminifers occur in several intervals. Kasten Core NBP0602A-8D-KC recovered a full (3.18 m) core while pipe was being tripped out at Hole NBP0602A-8C. It captured the sediment/water interface that was not recovered in the first Kasten core.

The only large gap remaining in the Firth of Tay Holocene section is between 3 and 8 mbsf, where push cores were ineffective in recovering the soft, watery sediment. This gap can be filled during a later cruise with a jumbo piston core.



0-319 cm - Diatomaceous Mud, organic-rich, smelly, sponge spicules throughout, worm tubes throughout, color variations, bioturbation
- Trace amount of very fine sand found throughout
- Several articulated bivalves
- 0-11 cm, 23-45 cm, 66-93 cm, 108-160 cm, 201-240 cm - Very Dark Greenish Gray (GLEY 1 3/1 10Y)
- 11-23 cm, 45-48 cm, 50-66 cm, 93-108 cm, 160-201 cm, 240-319 cm - Black (GLEY 1 2.5/ N)
- 48-50 cm - Very Dark Brown (10YR 2/2)
- 300-319 cm - core catcher

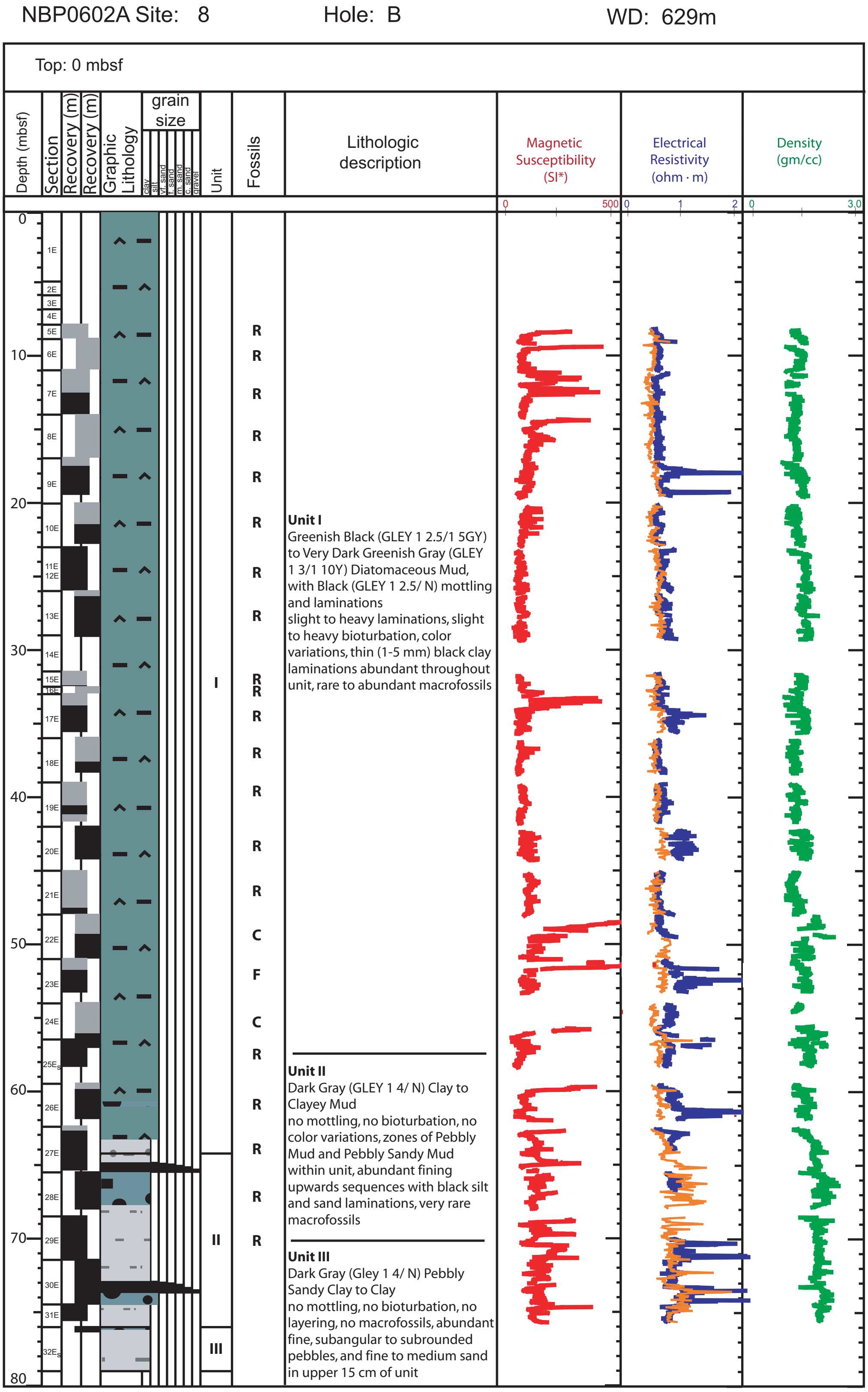
*PP - Physical properties samples taken every 2 cm from 2-282 cm

80 cm - Articulated bivalve (SAMPLED)
129 cm - Worm tube (SAMPLED)
206 cm - Worm tube (SAMPLED)
208 cm - Sponge spicule (SAMPLED)
223 cm - Articulated bivalve (SAMPLED)
225 cm - Bivalve (SAMPLED)
238 cm - Ikaite (SAMPLED)**
242 cm - Ikaite (SAMPLED)**
302 cm - Articulated bivalve (SAMPLED)
300-319 cm - Articulated bivalve (SAMPLED) x2

**Ephemeral Samples

Figure 6-4. Lithologic log for Kasten Core NBP0602A-8A-KC.

Figure 6-5. Summary lithologic log of Hole NBP0602A-8B.

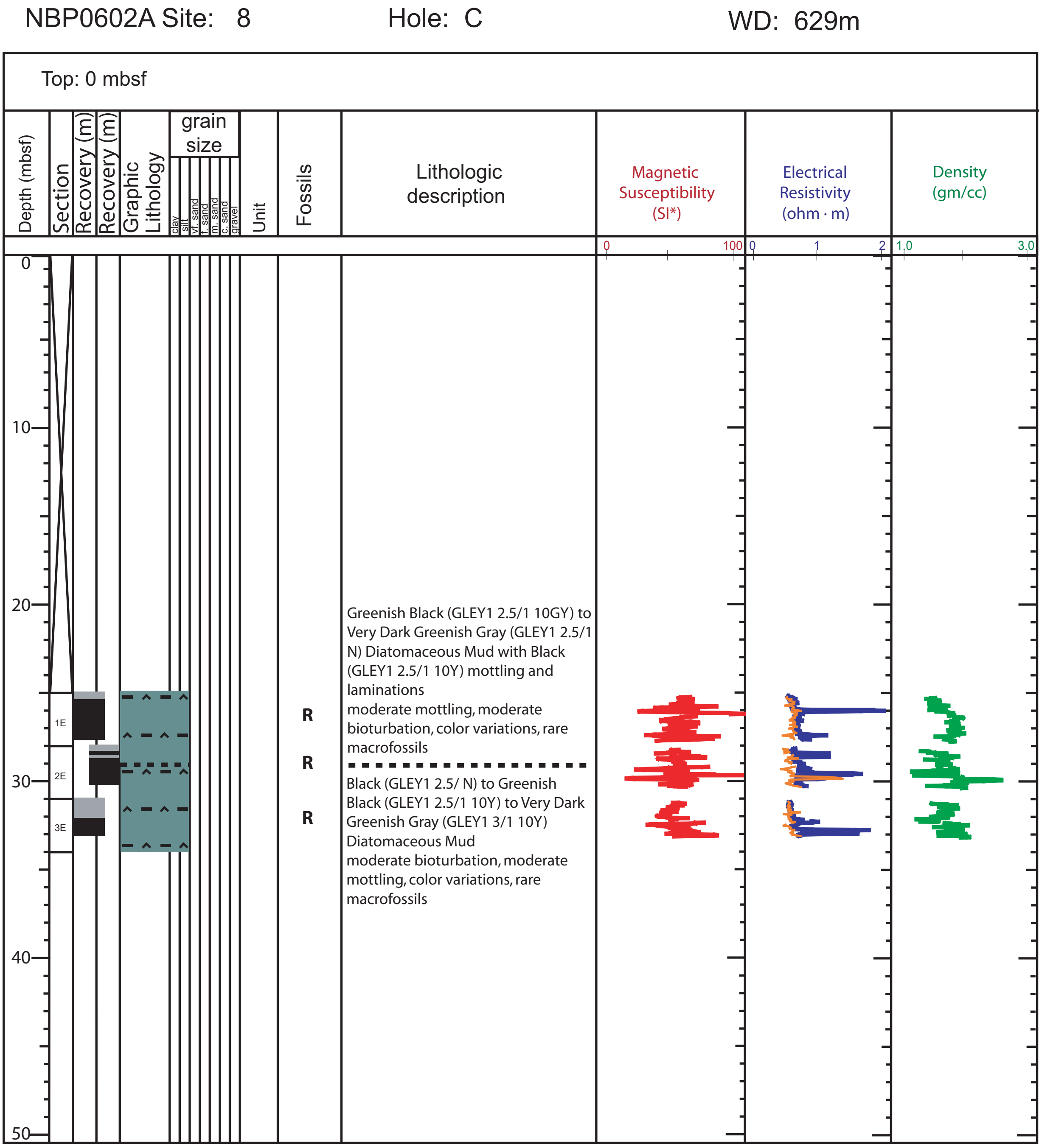


Unit I
Greenish Black (GLEY 1 2.5/1 5GY) to Very Dark Greenish Gray (GLEY 1 3/1 10Y) Diatomaceous Mud, with Black (GLEY 1 2.5/ N) mottling and laminations
slight to heavy laminations, slight to heavy bioturbation, color variations, thin (1-5 mm) black clay laminations abundant throughout unit, rare to abundant macrofossils

Unit II
Dark Gray (GLEY 1 4/ N) Clay to Clayey Mud
no mottling, no bioturbation, no color variations, zones of Pebbly Mud and Pebbly Sandy Mud within unit, abundant fining upwards sequences with black silt and sand laminations, very rare macrofossils

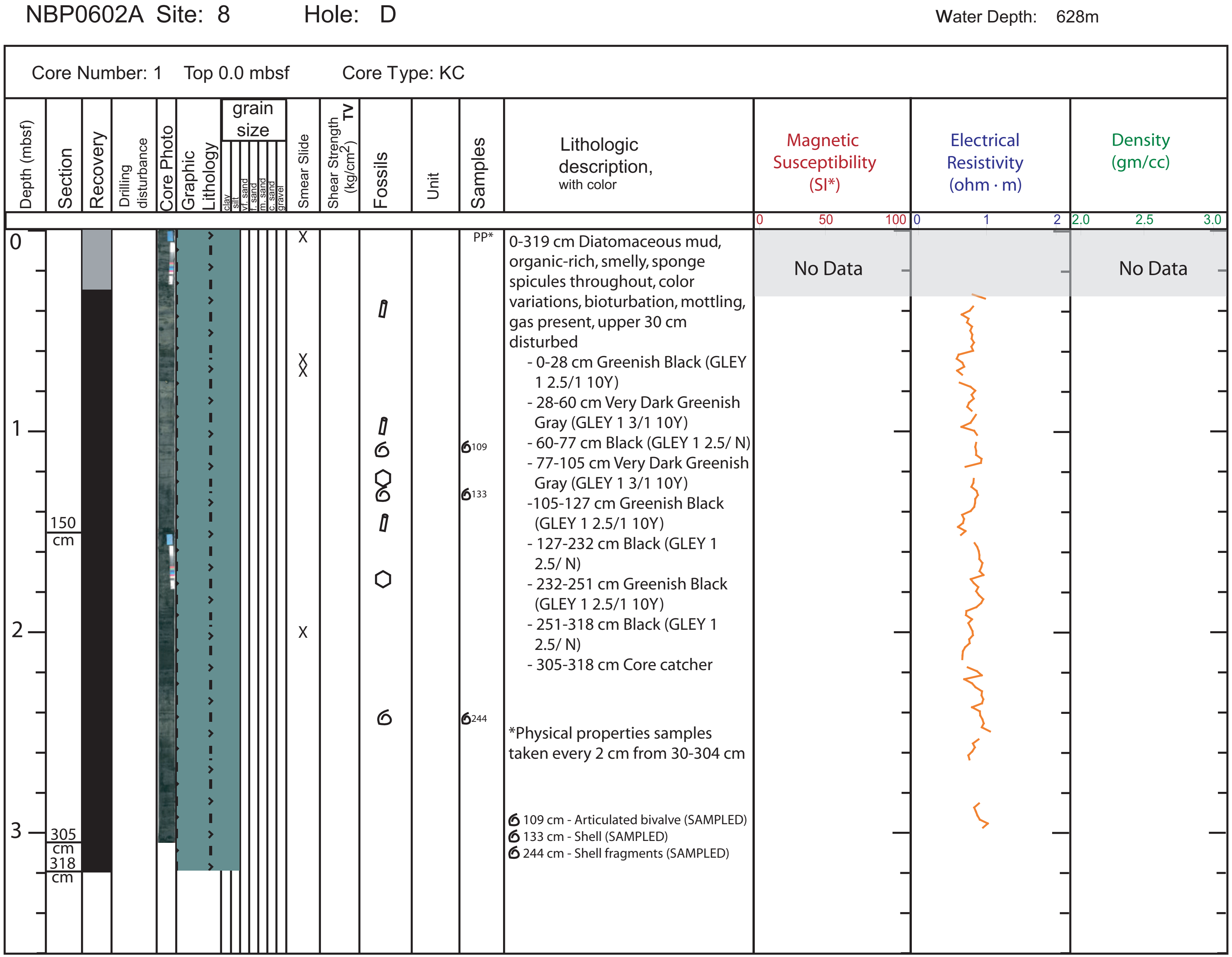
Unit III
Dark Gray (Gley 1 4/ N) Pebbly Sandy Clay to Clay
no mottling, no bioturbation, no layering, no macrofossils, abundant fine, subangular to subrounded pebbles, and fine to medium sand in upper 15 cm of unit

Figure 6-6. Summary lithologic log of Hole NBP0602A-8C.



Greenish Black (GLEY1 2.5/1 10GY) to Very Dark Greenish Gray (GLEY1 2.5/1 N) Diatomaceous Mud with Black (GLEY1 2.5/1 10Y) mottling and laminations
moderate mottling, moderate bioturbation, color variations, rare macrofossils

Black (GLEY1 2.5/ N) to Greenish Black (GLEY1 2.5/1 10Y) to Very Dark Greenish Gray (GLEY1 3/1 10Y) Diatomaceous Mud
moderate bioturbation, moderate mottling, color variations, rare macrofossils



0-319 cm Diatomaceous mud, organic-rich, smelly, sponge spicules throughout, color variations, bioturbation, mottling, gas present, upper 30 cm disturbed

- 0-28 cm Greenish Black (GLEY 1 2.5/1 10Y)
- 28-60 cm Very Dark Greenish Gray (GLEY 1 3/1 10Y)
- 60-77 cm Black (GLEY 1 2.5/ N)
- 77-105 cm Very Dark Greenish Gray (GLEY 1 3/1 10Y)
- 105-127 cm Greenish Black (GLEY 1 2.5/1 10Y)
- 127-232 cm Black (GLEY 1 2.5/ N)
- 232-251 cm Greenish Black (GLEY 1 2.5/1 10Y)
- 251-318 cm Black (GLEY 1 2.5/ N)
- 305-318 cm Core catcher

*Physical properties samples taken every 2 cm from 30-304 cm

6 109 cm - Articulated bivalve (SAMPLED)
6 133 cm - Shell (SAMPLED)
6 244 cm - Shell fragments (SAMPLED)

Figure 6-7. Lithologic log for Kasten Core NBP0602A-8D-KC.

Table 6-1. Drilling and coring recovery log for Holes NBP0602A-8A-KC, -8B, -8C, and -8D-KC.

NBP0602A SHALDRIL II Site 8 (Firth of Tay)
Multibeam Water Depth: 629 m @ A, B; 624 @ C, D

Station Number/Hole	Core Number	Core Type	Top (mbsf)	Bottom (mbsf)	Interval Cored (m)	"Push Distance" (m)	Recovery: total (m)	Recovery: competent (m)	Recovery: disturbed (m)	Gaps (m)	Recovery Corrected (m)	Total Recovery (%)	Recovery Corrected (%)	Section Number	Section Lengths (cm)	Date (JD)	Time on Deck (GMT)	Initials	Comments
8A	1	KC	0.0	3.19	0-3.19	3.19	3.19	3.19	0	0	3.19	100.0%	100.0%	1	?	81	1230	JSW	Overpenetrated, but appears to have preserved close to top; Stinky organics
8B	1	E	0	5	4-5	1	0	0	0	0	0	0.0%	0.0%	0	0	81	1845	CD	Bagged - watery sample
8B	2	E	5	6	5-6	1	0	0	0	0	0	0.0%	0.0%	0	0	81	1900	CD	No recovery
8B	3	E	6	7	6-7	1	0	0	0	0	0	0.0%	0.0%	0	0	81	2015	CD	Three bags - water with small sediment sample
8B	4	E	7	8	7-8	1	0	0	0	0	0	0.0%	0.0%	0	0	81	2136	CD	Bagged - semi-solid
8B	5	E	8	9	8-9	1	0.93	0	0.93	0	0	93.0%	0.0%	1	93	81	2213	CD	
8B	6	E	9	11	9-11	2	1.94	0	1.94	0	0	97.0%	0.0%	1	96	81	2256	CD	
8B	6	E												2	98	81	2256	CD	
8B	7	E	11	14	11-14	3	2.98	1.48	1.5	0	1.48	99.3%	49.3%	1	150	82	0008	CD	
8B	7	E												2	148	82	0008	CD	
8B	8	E	14	17	14-17	3	2.92	0	2.92	0	0	97.3%	0.0%	1	150	82	0106	CD	
8B	8	E												2	142	82	0106	CD	
8B	9	E	17	20	17-20	3	2.44	1.94	0.50	0	1.94	81.3%	64.7%	1	122.5	82	0152	CD	
8B	9	E												2	121.5	82	0152	CD	
8B	10	E	20	23	20-23	3	2.76	1.26	1.50	0	1.26	92.0%	42.0%	1	150	82	0255	CD	
8B	10	E												2	125.7	82	0255	CD	
8B	11	E	23	26	23-26	0	0	0	0	0	0	0.0%	0.0%	1	0.0	82	-	-	Probably no latch and tool never actually pushed. (Core barrel came up empty and was sent down w/o being recorded)
8B	12	E	23	26	23-26	3	2.91	0	2.91	0	0	97.0%	0.0%	1	60	82	0525	CAC	Core liner shattered top 30 cm
8B	12	E												2	89.5	82	0525	CAC	
8B	12	E					.							3	147.5	82	0525	CAC	
8B	13	E	26	29	26-29	3	3.085	2.835	0.25	0.12	2.715	102.8%	90.5%	1	11.0	82	0620	JC	14.0 cm found in core barrel from top added as first section
8B	13	E												2	150.0	82	0620	JC	
8B	13	E												3	147.5	82	0620	JC	
8B	14	E	29	31.5	29-31.5	2.5	0	0	0	0	0	0.0%	0.0%	0	0.0	82	0746	JM	No recovery - Cobble jammed bit?
8B	15	E	31.5	32.5	31.5-32.5	1.0	1.01	0.11	0.90	0	0.11	101.0%	11.0%	1	101	82	0900	JSW	Didn't latch? Disturbed core

Table 6-1 (continued).

NBP0602A SHALDRIL II Site 8 (Firth of Tay)
Multibeam Water Depth: 629 m @ A, B; 624 @ C, D

Station Number/Hole	Core Number	Core Type	Top (mbsf)	Bottom (mbsf)	Interval Cored (m)	"Push Distance" (m)	Recovery: total (m)	Recovery: competent (m)	Recovery: disturbed (m)	Gaps (m)	Recovery Corrected (m)	Total Recovery (%)	Recovery Corrected (%)	Section Number	Section Lengths (cm)	Date (JD)	Time on Deck (GMT)	Initials	Comments
8B	16	E	32.5	32.965	32.5-32.965	0.465	0.48	0	0.48	0	0	103.2%	0.0%	1	48.0	82	1000	JM	Didn't latch? Disturbed core; switch barrels for next one
8B	17	E	33	36	33-36	3.0	2.545	1.795	0.75	0	1.795	84.8%	59.8%	1	149.5	82	1120	JM	Latch still questionable, had to hammer with overshot a bit
8B	17	E												2	105.0	82	1120	JM	
8B	18	E	36	39	36-39	3.0	2.305	0.805	1.50	0	0.805	76.8%	26.8%	1	150	82	1235	JM/ JSW	
8B	18	E												2	80.5	82	1235	JM/ CAC	
8B	19	E	39	42	39-42	3.0	2.635	0.595	2.04	0	0.595	87.8%	19.8%	1	150.5	82	1315	JM/ CAC	
8B	19	E												2	113.5	82	1315	JM/ CAC	
8B	20	E	42	45	42-45	3.0	2.16	2.16	0	0.03	2.13	72.0%	71.0%	1	11.5	82	1415	JSW	Gassy!
8B	20	E												2	70.0	82	1415	JSW	
8B	20	E												3	134.5	82	1415	JSW	
8B	21	E	45	48	45-48	3.0	2.95	0	2.50	0	0	98.3%	0.0%	1	151.0	82	1443	JM/ CAC	
8B	21	E												2	144.0	82	1443	JM/ CAC	
8B	22	E	48	51	48-51	3.0	2.98	1.73	1.25	0.40	1.33	99.3%	44.3%	1	149	82	1650	CD	
8B	22	E												2	149	82	1650	CD	
8B	23	E	51	54	51-54	3.0	2.22	1.64	0.58	0	1.64	74.0%	54.7%	1	73.0	82	1803	CD	
8B	23	E												2	149	82	1803	CD	
8B	24	E	54	56.5	54-56.5	2.5	2.985	0.985	2.00	0.26	0.725	119.4%	29.0%	1	151.5	82	1905	JSW	Encountered hard bottom at 56.5; Switch from push sampler to extended nose push
8B	24	E												2	147.0	82	1905	JSW	
8B	25	Es	56.5	59.5	56.5-59.5	3.0	1.78	1.78	0	0	1.78	59.3%	59.3%	1	89	82	2018	CD	Harder from 56.5-58.5 then soft again - go back to push core
8B	25	Es												2	89	82	2018	CD	
8B	26	E	59.5	62.5	59.5-62.5	3.0	2.38	2.06	0.32	0	2.06	79.3%	68.7%	1	119	82	2150	CD	
8B	26	E												2	119.0	82	2150	CD	
8B	27	E	62.5	65.5	62.5-65.5	3.0	2.86	2.70	0.16	0.03	2.67	95.3%	89.0%	1	142.0	82	2235	CD	
8B	27	E												2	144	82	2235	CD	
8B	28	E	65.5	68.5	65.5-68.5	3.0	2.43	2.43	0	0.03	2.40	81.0%	80.0%	1	121.5	82	2324	CD	
8B	28	E												2	121.5	82	2324	CD	

Table 6-1 (continued).

NBP0602A SHALDRIL II Site 8 (Firth of Tay)

Multibeam Water Depth: 629 m @ A, B; 624 @ C, D

Station Number/Hole	Core Number	Core Type	Top (mbsf)	Bottom (mbsf)	Interval Cored (m)	"Push Distance" (m)	Recovery: total (m)	Recovery: competent (m)	Recovery: disturbed (m)	Gaps (m)	Recovery Corrected (m)	Total Recovery (%)	Recovery Corrected (%)	Section Number	Section Lengths (cm)	Date (JD)	Time on Deck (GMT)	Initials	Comments
8B	29	E	68.5	71.5	68.5-71.5	3.0	2.995	2.995	0	0	2.995	99.8%	99.8%	1	148.0	83	0025	CD	
8B	29	E												2	151.5	83	0025	CD	
8B	30	E	71.5	74.5	71.5-74.5	3.0	2.975	2.975	0	0	2.975	99.2%	99.2%	1	149.5	83	0106	CD	
8B	30	E												2	148.0	83	0106	CD	Top 5 cm of second section extruded from liner - no MSCL
8B	31	E	74.5	76	74.5-76	1.5	1.18	1.02	0.16	0	1.02	78.7%	68.0%	1	118	83	0202	CD	
8B	32	Es	76	79	76-79	3.0	0.235	0.085	0.15	0	0.085	7.8%	2.8%	1	23.5	83	0322	JM	
Totals						**10.5**	**7.4**	**7.1**	**0.3**	**0.0**	**7.1**	**70.3%**	**67.4%**						
8C	1	E	25	28	25-28	3.0	2.58	2.47	0.11	0.01	2.46	86.0%	82.0%	1	108.5	83	0627	CAC	
8C	1	E												2	149.5	83	0627	CAC	
8C	2	E	28	31	28-31	3.0	2.22	1.87	0.35	0.08	1.79	74.0%	59.7%	1	94.5	83	0720	JM	
8C	2	E												2	128.5	83	0720	JM	
8C	3	E	31	34	31-34	3.0	2.04	1.06	1.10	0	1.06	68.0%	35.3%	1	110	83	0828	JM	
8C	3	E												2	90	83	0828	JM	
Totals						**9.0**	**6.8**	**5.4**	**1.6**	**0.1**	**5.3**	**76.0%**	**59.0%**						
8D	1	KC	0	3.18	0-3.18	3.2	3.18	3.18	0	0	3.18	100.0%	100.0%	1	318	83	1150	JSW	

Table 6-2. Smear-slide data for Holes NBP0602A-8A-KC, -8B, -8C, and -8D-KC.

		Components																	Grain Size						
		Minerals											Biogenic					Rock							
Sample	Approximate Depth (mbsf)	Calcite	Clay	Dolomite	Feldspar	Glauconite	Heavy Minerals	Hematite	Hornblende	Mica	Quartz	Volcanic Glass	Diatoms	Radiolarians	Silicoflagellates	Sponge Spicules	Macroscopic Plant Debris	Fragments	Sand	Silt	Clay	Sorting	Roundness	Lithology	Comments
Hole 8A-KC																									
NBP0602A-8A-KC, 8 cm	0.08	1	36		3	tr	3	tr	tr	tr	15	tr	40			2			5	33	62	M	a-sr	Diatomaceous Mud	~15% diatom spores
NBP0602A-8A-KC, 135 cm	1.35	tr	32		3	1	2				16		45			1			3	38	59	M	sa-r	Diatomaceous Mud	~22 diatom spores
NBP0602A-8A-KC, 189 cm	1.89	tr	51		2		1				5		40			1			1	13	86	M	sa-r	Diatomaceous Mud	~25% diatom spores
NBP0602A-8A-KC, 285 cm	2.85	1	31		3	1	2			tr	15		45			2			5	37	58	M	a-sr	Diatomaceous Mud	~25% diatom spores
NBP0602A-8A-KC, CC	3.19	1	32		5	tr	2	tr			18		40			2			5	40	55	M	a-sr	Diatomaceous Mud	~20% diatom spores
Hole 8B																									
NBP0602A-8B-5E, 15 cm	8.15	1	34		2	tr	tr		tr		17		45			1			3	34	63	M	sa-sr	Diatomaceous mud	~15% diatom spores
NBP0602A-8B-5E, 77 cm	8.77	1	27		3	tr	1				21		45			2			5	44	51	M	sa-r	Diatomaceous mud	~25% diatom spores
NBP0602A-8B-6E, 69 cm	9.69	tr	36		4	tr	tr			tr	21		38			1			5	36	59	M	sa-sr	Diatomaceous mud	~13% diatom spores
NBP0602A-8B-6E, 185 cm	7.85	tr	39		3		tr				12		45			1			3	25	72	M	sa-r	Diatomaceous mud	~25% diatom spores
NBP0602A-8B-7E, 87 cm	11.87	tr	47		4	tr	2			tr	16		30			1			7	25	68	M	a-r	Diatomaceous mud	~15% diatom spores
NBP0602A-8B-7E, 212 cm	13.12		53		2	tr	1			tr	17		25			2			5	21	74	M	a-sr	Diatomaceous mud	~10% diatom spores
NBP0602A-8B-8E, 141.5 cm	15.415	tr	31		3	tr	1			tr	17		47			1			5	35	60	M	a-sr	Diatomaceous mud	~25% diatom spores
NBP0602A-8B-8E, 255 cm	16.55	tr	25		3	tr	2				22		47			1			5	47	48	M	a-r	Diatomaceous mud	~22% diatom spores
NBP0602A-8B-9E, 92 cm	17.92	tr	46		4	1	2			tr	21		25			2			3	35	62	M	a-r	Diatomaceous mud	~10% diatom spores
NBP0602A-8B-9E, 216 cm	19.16	tr	65		1	1	1			tr	9		22			1			1	13	86	M	a-sr	Diatomaceous mud	~7% diatom spores
NBP0602A-8B-10E, 139.5 cm	21.395	tr	44		5	1	1			tr	22		22			2			3	35	62	M	a-sr	Diatomaceous mud	~7% diatom spores
NBP0602A-8B-10E, 246 cm	22.46	tr	42		3	tr	4				22		27			2			4	37	59	M	a-sr	Diatomaceous mud	~12% diatom spores
NBP0602A-8B-12E, 15 cm	23.15	tr	28		3		3			tr	20		45			1			1	47	52	M	a-sr	Diatomaceous mud	~25% diatom spores
NBP0602A-8B-12E, 134.5 cm	24.35	tr	44		5	tr	3		tr	tr	20		27			1			7	32	61	M	a-sr	Diatomaceous mud	~12% diatom spores
NBP0602A-8B-12E, 269 cm	25.69	1	36		7	tr	2			2	20	tr	30			1			15	30	55	P	sr-r	Sandy Diatomaceous mud	~5% diatom spores
NBP0602A-8B-13E, 94.5 cm	26.95	tr	40		5	tr	2	tr			3		50			tr			3	17	80	M	sr	Diatomaceous mud	~25% diatom spores
NBP0602A-8B-13E, 247 cm	28.47	tr	32		1	tr	tr	tr			2		65		tr	tr			3	7	90	M-W	sr	Diatomaceous mud	~50% diatom spores
NBP0602A-8B-15E, 6 cm	31.56	1	39		3		2	1		tr	4		50			tr			3	17	80	M	sa-sr	Diatomaceous mud	~25% diatom spores
NBP0602A-8B-15E, 97 cm	32.47	1	51		3	tr	2	1		tr	7		35			tr			5	15	80	M	sa-sr	Diatomaceous mud	~7% diatom spores; some hematite stained grains
NBP0602A-8B-16E, 32 cm	32.82	tr	52		3	tr	2	tr		1	7		35			tr			2	18	80	M	sa	Diatomaceous mud	~7% diatom spores; framboidal pyrite

Notes: Sample: E = cored with the push sampler; E_s = cored with spring-loaded, non-rotating, extended-nose core barrel; Components/Grain Size: Numbers represent percentages, tr = trace; Sorting: W = well; M = moderate, P = poor; Roundness: a = angular, sa = subangular, sr = subrounded, r = rounded.

Table 6-2 (continued).

		Components																	Grain Size						
		Minerals										Biogenic					Rock							
Sample	Approximate Depth (mbsf)	Calcite	Clay	Dolomite	Feldspar	Glauconite	Heavy Minerals	Hematite	Hornblende	Mica	Quartz	Volcanic Glass	Diatoms	Radiolarians	Silicoflagellates	Sponge Spicules	Macroscopic Plant Debris	Fragments	Sand	Silt	Clay	Sorting	Roundness	Lithology	Comments
NBP0602A-8B-16E, 42.5 cm	32.925	tr	39		5	tr	3	1			7		45			tr			5	23	72	M	sr	Diatomaceous mud	~14% diatom spores
NBP0602A-8B-17E, 93 cm	33.93	tr	43		2		2	tr			3		50			tr			1	13	86	M-W	sr	Diatomaceous mud	~25% diatom spores
NBP0602A-8B-17E, 173.2 cm	34.732	tr	48		5	tr	3	1		tr	7		35			1			5	19	76	M	sa-sr	Diatomaceous mud	~3% diatom spores
NBP0602A-8B-18E, 83 cm	36.83	1	57		3		3	1		tr	5		30			tr			2	14	84	M	sa	Diatomaceous mud	~1-2% diatom spores
NBP0602A-8B-18E, 203 cm	38.03	1	56		3		2	1		tr	7		30			tr			2	17	81	M	sr	Diatomaceous mud	~3% diatom spores
NBP0602A-8B-19E, 108 cm	40.08	tr	59		3		3	tr		tr	5		30			tr			1	15	84	M	sr	Diatomaceous mud	~6% diatom spores
NBP0602A-8B-19E, 207 cm	41.07	1	55		7	1	2	1		1	7		25			tr			3	23	74	M	sa	Diatomaceous mud	~1% diatom spores
NBP0602A-8B-20E, 67.5 cm	42.675	1	61		3		2	1		tr	7		25			tr			1	17	82	M	sr	Diatomaceous mud	~3% diatom spores
NBP0602A-8B-20E, 102.5 cm	43.025	tr	61		3	tr	2	tr		tr	4		30			tr			tr	13	87	M-W	sr	Diatomaceous mud	~5% diatom spores
NBP0602A-8B-20E, 173 cm	43.73	2	23		5		1			tr	10		45			1	3		5	30	65	P	sr-r	Diatomaceous mud	~20% diatom spores
NBP0602A-8B-21E, 97.5 cm	45.975	1	54		5		2	1		tr	7		30			tr			2	20	78	M	sa-sr	Diatomaceous mud	~2% diatom spores
NBP0602A-8B-21E, 178 cm	46.78	tr	57		3		2	1		tr	6		30			1			1	15	84	M	sr	Diatomaceous mud	~3% diatom spores
NBP0602A-8B-22E, 136 cm	49.36	tr	60		4	tr	2			tr	10		22			2			3	18	79	M	a-sr	Diatomaceous mud	~7% diatom spores
NBP0602A-8B-22E, 289.5 cm	50.895	1	53		5	1	2			tr	18		18			3			3	31	66	M	a-sr	Diatomaceous mud	~3% diatom spores
NBP0602A-8B-23E, 66 cm	51.66	tr	54		6	tr	1			tr	11		27			1			3	22	75	M	a-sr	Diatomaceous mud	~7% diatom spores
NBP0602A-8B-23E, 174 cm	52.74	1	49		2	tr	1				7		40			tr			3	15	82	M	a-sr	Diatomaceous mud	~25% diatom spores
NBP0602A-8B-24E, 144.5 cm	55.445	1	39		5	1	3	1		tr	10		40			tr			5	29	66	P	sr	Diatomaceous mud	~8% diatom spores
NBP0602A-8B-24E, 196 cm	55.96	1	57		3		2	tr		tr	7		30			tr			3	16	81	M	sr	Diatomaceous mud	~3% diatom spores
NBP0602A-8B-25Es, 56 cm	57.06		64		3	tr	1	tr	tr		7		25			tr			3	12	85	M	sr	Diatomaceous mud	~1% diatom spores
NBP0602A-8B-25Es, 129 cm	57.79	tr	51		3	tr	3			tr	17		25			1			1	30	69	M	a-sr	Diatomaceous mud	~10% diatom spores
NBP0602A-8B-26E, 76 cm	60.26		80		1		tr				6		13			tr			tr	8	92	W	a-sr	Diatomaceous mud	~10% diatom spores
NBP0602A-8B-26E, 212 cm	61.62		59		2	tr	1				13		25						1	20	79	M	a-sr	Diatomaceous mud	~15% diatom spores
NBP0602A-8B-27E, 85.5 cm	63.355	tr	61		5	tr	3				20		10			1			3	28	69	M	a-sr	Diatomaceous mud	~3% diatom spores
NBP0602A-8B-27E, 155 cm	64.05	1	64		12	tr	5	tr			17		1			tr			5	35	60	P	a-sr	Mud	
NBP0602A-8B-27E, 164.5 cm	64.145	1	53		12	tr	3				29		1			1			10	38	52	P	a-sr	Mud	One white sperical object present as well with no birefrengence
NBP0602A-8B-27E, 249 cm	64.99	tr	62		6		7				24		1			tr			15	22	63	P	a-sr	Mud	Sand grains coated, hard to tell lighology
NBP0602A-8B-27E, 273.5 cm	65.235	tr	70		7		7				11		5			tr			3	29	68	P	a-sr	Silty clay	

Notes: Sample: E = cored with the push sampler; E_s = cored with spring-loaded, non-rotating, extended-nose core barrel; Components/Grain Size: Numbers represent percentages, tr = trace; Sorting: W = well; M = moderate, P = poor; Roundness: a = angular, sa = subangular, sr = subrounded, r = rounded.

Table 6-2 (continued).

Sample	Approximate Depth (mbsf)	Components																	Grain Size						
		Minerals											Biogenic					Rock							
		Calcite	Clay	Dolomite	Feldspar	Glauconite	Heavy Minerals	Hematite	Hornblende	Mica	Quartz	Volcanic Glass	Diatoms	Radiolarians	Silicoflagellates	Sponge Spicules	Macroscopic Plant Debris	Fragments	Sand	Silt	Clay	Sorting	Roundness	Lithology	Comments
NBP0602A-8B-28E, 31cm	65.81	1	77		3		2	tr	tr		10		7			tr			2	15	83	M	r	Silty clay	Diatoms fragmented
NBP0602A-8B-28E, 234.5 cm	67.845	2	85		3		tr		tr	tr	7		3			tr			tr	12	88	M-W	sr	Clay	Diatoms fragmented
NBP0602A-8B-29E, 85 cm	69.35	1	80		3		7	tr		1	5		3			tr			tr	18	82	M	sr	Silty clay	Diatoms fragmented
NBP0602A-8B-29E, 216 cm	70.66	2	86		2		2	tr	1	tr	5		2	tr		tr			2	10	88	M-W	r	Clay	Diatoms fragmented
NBP0602A-8B-30E, 93 cm	72.43	3	76		5	tr	2	tr	tr	tr	7		7			tr			7	12	81	M	r	Clay	Diatoms mostly fragmented
NBP0602A-8B-30E, 184 cm	73.34	1	76		3	tr	2	1			7		10			tr			tr	15	85	M	sr	Silty clay	Diatoms mostly fragmented
NBP0602A-8B-31E, 44 cm	74.94	2	84		3		2	1	tr	tr	5		3			tr			3	10	87	M-W	sr	Clay	Diatoms mostly fragmented
NBP0602A-8B-31E, 55.5 cm	75.055	2	79		3		3	2		tr	10		3			tr			-	19	81	M	r	Silty clay	Diatoms fragmented
NBP0602A-8B-32E$_s$, 11 cm	76.11	1	81		3		3	tr		tr	10		2			tr			3	15	82	M	sr	Silty clay	Diatoms mostly fragmented
NBP0602A-8B-32E$_s$, 17.5 cm	76.175	1	80		3	tr	3		tr	tr	10		3			tr			-	18	82	M	r	Silty clay	Diatoms fragmented
Hole 8C																									
NBP0602A-8C-1E, 52 cm	25.52	1	40		7	1	4				17		22			2			7	32	61	M	a-sr	Diatomaceous mud	~15% diatom spores
NBP0602A-8C-1E, 148 cm	26.48	tr	46		3	tr	3				12		35			1			3	25	72	M	a-sr	Diatomaceous mud	~25% diatom spores
NBP0602A-8C-2E, 26 cm	28.26	1	46		5		3				13		31			1		1	7	26	67	P	a-sr	Diatomaceous mud	~20% diatom spores; diatoms covered with clay
NBP0602A-8C-2E, 52 cm	28.52	tr	55		5	tr	2				10		27			1			5	19	76	M	a-sr	Diatomaceous mud	~20% diatom spores
NBP0602A-8C-2E, 160 cm	29.60	2	50		10	tr	5				25					tr			10	40	50	P	a-sr	Mud	
NBP0602A-8C-2E, 205 cm	30.05		43		3	1	1		tr		7		45			tr			3	19	70	M	a-sr	Diatomaceous mud	~35% diatom spores; thick clay coating
NBP0602A-8C-2E, 212 cm	30.12		70		4	1	3				9		13			tr			1	19	80	M	a-sr	Silty clay	
NBP0602A-8C-3E, 55.5 cm	31.555	tr	36		6	1	3				13		40			1			5	34	61	M	a-sr	Diatomaceous mud	~25% diatom spores
NBP0602A-8C-3E, 127 cm	32.27	tr	55		5	tr	5	tr			15		19			1			3	28	69	M	a-sr	Diatomaceous mud	~9% diatom spores
NBP0602A-8C-3E, 144 cm	32.44	tr	43		3	tr					12		42			tr			1	25	74	M	a-sr	Diatomaceous mud	~35% diatom spores; many grains with clay coating
Hole 8D-KC																									
NBP0602A-8D-KC, 0 cm	surface	tr	26		3	tr	2	tr	tr	1	20		30			tr			5	45	50	P	sa	Diatomaceous mud	~10% diatom spores
NBP0602A-8D-KC, 64 cm	0.64	1	19		1	tr	1	tr			8		70			tr			3	34	63	M	sa	Muddy diatomaceous ooze	~55% diatom spores
NBP0602A-8D-KC, 70 cm	0.70	tr	33		3	tr	7	tr		1	15		40			1			5	39	56	P-M	sr	Diatomaceous mud	~20% diatom spores
NBP0602A-8D-KC, 200 cm	2.00	1	33		5	tr	5	tr	tr	1	20		35			tr			10	39	51	P	sr	Diatomaceous Mud	~10% diatom spores

Notes: Sample: E = cored with the push sampler; E$_s$ = cored with spring-loaded, non-rotating, extended-nose core barrel; Components/Grain Size: Numbers represent percentages, tr = trace; Sorting: W = well; M = moderate, P = poor; Roundness: a = angular, sa = subangular, sr = subrounded, r = rounded.

Table 6-3. Stratigraphic occurrence and relative abundance of diatom taxa in Holes NBP0602A-8A-KC, -8B, and -8C.

						Diatoms - Planktonic, Extant																			
Cruise/Hole/Core/Interval	**Depth (mbsf)**	**Slide Preparation**	**Diatom Abundance**	**Preservation**	**Fragmentation**	*Actinocyclus actinochilus*	*Chaetoceros bulbosum*	*Chaetoceros* spp. (small veg. cells & resting spores)	*Corethron criophilum* (valves & spines)	*Coscinodiscus* spp.	*Eucampia antarctica* var. *antarctica*	*Eucampia antarctica* var. *recta*	*Fragilariopsis curta*	*Fragilariopsis cylindrus*	*Fragilariopsis kerguelensis*	*Fragilariopsis obliquecostata*	*Fragilariopsis pseudonana*	*Fragilariopsis rhombica*	*Fragilariopsis ritscheri*	*Fragilariopsis sublinearis*	*Fragilariopsis vanheurckii*	*Odontella weissflogii*	*Porosira* spp.	*Proboscia alata*	*Proboscia* spp.
Hole 8A-KC																									
NBP0602A-8A-KC, 8 cm	0.08	smear	A	G	L-M	F		A		fr(X)		X	C	R		R			R	F	F		F	X	
NBP0602A-8A-KC, 135 cm	1.35	smear	A	G	L-M	F		A	X				F	F	X(vr)	R			R	R	C		R		
NBP0602A-8A-KC-CC	3.19	smear	A	G	L-M	X		A	X				C	X		R			R	F	F		R		
Hole 8B																									
NBP0602A-8B-5E-CC	8.93	smear	C	G	L-M	R		A	X	X		X	C	F		R		X	R	R	F		R		
NBP0602A-8B-6E, 96 cm	9.96	smear	A	G	L-M	F		A				X	C	F	X	F			R		R	X	X		
NBP0602A-8B-7E, 148 cm	13.98	smear	A	M	L-M	R-F		A	X			X	F-C	R	X	X		X	R	R	F	X	R	X	
NBP0602A-8B-8E, 142 cm	16.92	smear	A	M	L-M	R		A	X	X			C	F	X	R			X	R	F	X	R		
NBP0602A-8B-9E, 237 cm	19.37	smear	A	M	L-M	R-F		A	X				F-C	F		R			X	F	R-F	X	X	X	
NBP0602A-8B-10E, 125 cm	22.75	smear	A	M	M	F		A				R	F-C	R	X	R		X	X	R	F	R	X	X-R	
NBP0602A-8B-12E, 147 cm	25.87	smear	A	M-G	L-M	X		A				X	C	X	X	R-F		X	R	F	R-F	R	R		
NBP0602A-8B-13E, 147 cm	28.97	smear	C-A	M	M	R		A	X	fr(X)		R	C	R		R		X	R	R	F	R	R		
NBP0602A-8B-15E-CC	32.50	smear	A	M-G	L-M	F		A		fr(X)		X	C	R	X	R			X		F-C	X	R	X	X
NBP0602A-8B-16E-CC	32.98	smear	A	M-G	L-M	X		A				R	C	R	R	R		X	R	F	F	X	R	X	
NBP0602A-8B-17E, 105 cm	35.54	smear	A	M	L-M	F		A		X		R	C	R-F	X	R		X	R	F	F	X	R	X	
NBP0602A-8B-18E, 81 cm	38.31	smear	A	M-G	M	R		VA	X				R	F		R			X		F		X		
NBP0602A-8B-19E, 113 cm	41.64	smear	A	M	M	X		C		X			C	F		X			F	F	X		X	X	
NBP0602A-8B-20E, 134 cm	44.16	smear	A	M	L-M	F		C-A	X	fr(X)		X	C	F	X	R-F		X	F	F	F	X	X		
NBP0602A-8B-21E, 144 cm	47.95	smear	A	M-G	L-M	F		VA					C	R-F	X	X			R	F	F		X		
NBP0602A-8B-22E, 149 cm	50.95	smear	C	M	M	R		VA		X			F	R		X	X	X	F	R	F	X	X		
NBP0602A-8B-23E, 149 cm	53.22	smear	A	M	M	F		C-A			R-F	X	C	R-F	X	R		X	R	R	F	X	X	X	
NBP0602A-8B-24E, 147 cm	56.50	smear	A	M	M	R		A		R	R		R	R	R	R		X	F		F	X	X		
NBP0602A-8B-25Es, 89 cm	58.28	smear	A	M	M	R	X	A		X	R	X	R	F	R	F		R	F	F	F-C	X			
NBP0602A-8B-26E-CC	61.88	smear	A	G	L-M	R	X	A	X		F	X	C	R	F	X			F	F	F				
NBP0602A-8B-27E-CC	64.36	smear	F	M	H	R		F			X	X	F	X	X	R		X	R	F	F		X		
NBP0602A-8B-28E-CC	66.93	smear	R	P	H	F		F					F		R	X				R	R				
NBP0602A-8B-29E, 151 cm	71.49	smear	F	P	H	R		F		fr(X)	R	X	F	R	X(vr)	X		X	R	R-F	R	X			
NBP0602A-8B-30E, 148 cm	74.47	smear	R-F	P	H	X		X			R	X	F	X		R			R	F	X	X			
NBP0602A-8B-31E-CC	75.68	smear	R	P	H	X		R				X	R						X		X		X	X	
NBP0602A-8B-32Es, 24 cm	76.24	smear	R	P	H	X		R	X		X	X	R		X	R			X					X	
Hole 8C																									
NBP0602A-8C-1E-CC	27.58	smear	A	M-G	M	R		A		X		X	C	R	R	R			R	R-F	F-C	R			
NBP0602A-8C-2E, 128 cm	30.23	smear	C	M-P	M-H	R		C		fr(X)		X	F	F		X		X	X	X	F		X		
NBP0602A-8C-3E, 90 cm	33.00	smear	A	M-G	L-M	R	X	A	X	fr(X)			F-C	R	X	X			X	R	F	R	R		

Notes: Abundance: A = abundant, C = common, F = few, R = rare, X = present, fr = fragments; Preservation: G = good, M = moderate, P = poor; Fragmentation: L = low, M = moderate, H = high.

Table 6-3 (continued).

						Diatoms - Planktonic, Extant												Diatoms - Benthic/Sea-Ice Benthic, Extant									
Cruise/Hole/Core/Interval	**Depth (mbsf)**	**Slide Preparation**	**Diatom Abundance**	**Preservation**	**Fragmentation**	*Radialiplicata clavigera*	*Rhizosolenia* spp.	*Stellarima microtrias*	*Synedropsis* spp.	*Thalassionema nitzschioides*	*Thalassiosira antarctica* var. *antarctica*	*Thal. gracilis* var. *gracilis / expecta*	*Thalassiosira lentiginosa*	*Thalassiosira ritscheri*	*Thlassiosira tumida*	*Thalassiosira* spp. (small)	*Thalassiothrix/Trichotoxon* spp.	*Achnanthes* spp.	*Amphora* spp.	*Cocconeis* spp. (several taxa)	*Delphineis* spp.	*Entomoneis kjellmanii*	*Grammatophora* spp.	*Navicula directa*	*Navicula imperfecta*	*Navicula* spp. (small)	*Nitzschia* spp.
Hole 8A-KC																											
NBP0602A-8A-KC, 8 cm	0.08	smear	A	G	L-M	X			R		C			X		X			X	C						R	X
NBP0602A-8A-KC, 135 cm	1.35	smear	A	G	L-M		X	X	X		C	X			X	X			R	R						X	
NBP0602A-8A-KC-CC	3.19	smear	A	G	L-M			X	R		C								R	C	X	X		X	X	R	F
Hole 8B																											
NBP0602A-8B-5E-CC	8.93	smear	C	G	L-M	fr(X)		X			F-C	X		X		X			X	F						R	R
NBP0602A-8B-6E, 96 cm	9.96	smear	A	G	L-M				X		F	X			fr(X)	X			R	X	X			X		R	X
NBP0602A-8B-7E, 148 cm	13.98	smear	A	M	L-M			X	R		C	X			X		fr(X)			F		X				X	
NBP0602A-8B-8E, 142 cm	16.92	smear	A	M	L-M		X		R		F	R			X		X			F-C	X			X	X	R	
NBP0602A-8B-9E, 237 cm	19.37	smear	A	M	L-M				R		C	R			X	X				F							
NBP0602A-8B-10E, 125 cm	22.75	smear	A	M	M	fr(X)	R	X	R		C	X								F				X			X
NBP0602A-8B-12E, 147 cm	25.87	smear	A	M-G	L-M				R		F	R			X		fr(X)		X		R			X		X	
NBP0602A-8B-13E, 147 cm	28.97	smear	C-A	M	M	fr(X)	X		R-F		C	R					fr(X)		R	F	X			R		X	X
NBP0602A-8B-15E-CC	32.50	smear	A	M-G	L-M	fr(X)	R	X	F	X	F-C						fr(X)		R	F	X				X	R	X
NBP0602A-8B-16E-CC	32.98	smear	A	M-G	L-M	fr(X)	X	X	R		C	R							X	F			X			X	X
NBP0602A-8B-17E, 105 cm	35.54	smear	A	M	L-M	fr(X)		X	R		C	X			X		R		R	F				X		R	X
NBP0602A-8B-18E, 81 cm	38.31	smear	A	M-G	M			X	R-F		C	X	X						X	R-F	X			X		R	
NBP0602A-8B-19E, 113 cm	41.64	smear	A	M	M	fr(X)	X	X	X		C	X							R	F	X					X	
NBP0602A-8B-20E, 134 cm	44.16	smear	A	M	L-M			X	R		C	X				X	fr(X)	X		F	X					X	
NBP0602A-8B-21E, 144 cm	47.95	smear	A	M-G	L-M	fr(X)	X		R-F		C	X								F	X	fr(X)				R	X
NBP0602A-8B-22E, 149 cm	50.95	smear	C	M	M	fr(X)		X	R	fr(X)	C	X				X			X	F	X	X				R	X
NBP0602A-8B-23E, 149 cm	53.22	smear	A	M	M		X		R		C	X							X	F	X					R-F	
NBP0602A-8B-24E, 147 cm	56.50	smear	A	M	M		X		R		C	X			X				X	F	X						
NBP0602A-8B-25Es, 89 cm	58.28	smear	A	M	M		X		X		C	X			X				R					X		X	R
NBP0602A-8B-26E-CC	61.88	smear	A	G	L-M				X		F	R					fr(X)			R		R					
NBP0602A-8B-27E-CC	64.36	smear	F	M	H			X	X		F	R			X		fr(X)			R					X	X	
NBP0602A-8B-28E-CC	66.93	smear	R	P	H			fr(X)			R	R								R							
NBP0602A-8B-29E, 151 cm	71.49	smear	F	P	H			X			F	X	X		X	X				X	X						
NBP0602A-8B-30E, 148 cm	74.47	smear	R-F	P	H						F	F			X					R							
NBP0602A-8B-31E-CC	75.68	smear	R	P	H		X	fr(X)			R	X					fr(X)			X						X	
NBP0602A-8B-32Es, 24 cm	76.24	smear	R	P	H			fr(X)			R	X					fr(X)			X						X	
Hole 8C																											
NBP0602A-8C-1E-CC	27.58	smear	A	M-G	M		F		R		C				R		fr(X)		X	R-F	X			X			R
NBP0602A-8C-2E, 128 cm	30.23	smear	C	M-P	M-H			X	X		F	X			X		fr(X)		X	R-F	X					R	
NBP0602A-8C-3E, 90 cm	33.00	smear	A	M-G	L-M		X		R		F-C	X								F	X					X	

Notes: Abundance: A = abundant, C = common, F = few, R = rare, X = present, fr = fragments; Preservation: G = good, M = moderate, P = poor; Fragmentation: L = low, M = moderate, H = high.

Table 6-3 (continued).

						Diatoms - Benthic/Sea-Ice Benthic, Extant						Diatoms - Extinct, Miocene-Pliocene	Silico-flagellates, Ebridians, etc.
Cruise/Hole/Core/Interval	**Depth (mbsf)**	**Slide Preparation**	**Diatom Abundance**	**Preservation**	**Fragmentation**	*Pleurosigma* spp.	*Pinnularia quadratarea*	*Pinnularia* spp.	*Pseudogomphonema* spp.	*Rhabdonema* spp.	*Trachyneis* spp.	*Denticulopsis simonsenii / vulgaris*	*Distephanus speculum speculum*
Hole 8A-KC													
NBP0602A-8A-KC, 8 cm	0.08	smear	A	G	L-M				F		X		
NBP0602A-8A-KC, 135 cm	1.35	smear	A	G	L-M	X	X		R		X		
NBP0602A-8A-KC-CC	3.19	smear	A	G	L-M	X	X		F				
Hole 8B													
NBP0602A-8B-5E-CC	8.93	smear	C	G	L-M				F		X		
NBP0602A-8B-6E, 96 cm	9.96	smear	A	G	L-M		X		F		X		
NBP0602A-8B-7E, 148 cm	13.98	smear	A	M	L-M				R		X		
NBP0602A-8B-8E, 142 cm	16.92	smear	A	M	L-M				X		X		X
NBP0602A-8B-9E, 237 cm	19.37	smear	A	M	L-M				R				X
NBP0602A-8B-10E, 125 cm	22.75	smear	A	M	M	X	X		X				X
NBP0602A-8B-12E, 147 cm	25.87	smear	A	M-G	L-M				R	X			
NBP0602A-8B-13E, 147 cm	28.97	smear	C-A	M	M				R				
NBP0602A-8B-15E-CC	32.50	smear	A	M-G	L-M		X					*r* (X)	
NBP0602A-8B-16E-CC	32.98	smear	A	M-G	L-M				R			*r* (X)	
NBP0602A-8B-17E, 105 cm	35.54	smear	A	M	L-M				X				X
NBP0602A-8B-18E, 81 cm	38.31	smear	A	M-G	M	X	X						
NBP0602A-8B-19E, 113 cm	41.64	smear	A	M	M				X				X
NBP0602A-8B-20E, 134 cm	44.16	smear	A	M	L-M								
NBP0602A-8B-21E, 144 cm	47.95	smear	A	M-G	L-M		X						
NBP0602A-8B-22E, 149 cm	50.95	smear	C	M	M				X				
NBP0602A-8B-23E, 149 cm	53.22	smear	A	M	M				R				
NBP0602A-8B-24E, 147 cm	56.50	smear	A	M	M								
NBP0602A-8B-25Es, 89 cm	58.28	smear	A	M	M				X				
NBP0602A-8B-26E-CC	61.88	smear	A	G	L-M						X		
NBP0602A-8B-27E-CC	64.36	smear	F	M	H								X
NBP0602A-8B-28E-CC	66.93	smear	R	P	H								
NBP0602A-8B-29E, 151 cm	71.49	smear	F	P	H								
NBP0602A-8B-30E, 148 cm	74.47	smear	R-F	P	H						R		
NBP0602A-8B-31E-CC	75.68	smear	R	P	H							*r* (X)	
NBP0602A-8B-32Es, 24 cm	76.24	smear	R	P	H								
Hole 8C													
NBP0602A-8C-1E-CC	27.58	smear	A	M-G	M		X		R				
NBP0602A-8C-2E, 128 cm	30.23	smear	C	M-P	M-H		X		X				
NBP0602A-8C-3E, 90 cm	33.00	smear	A	M-G	L-M								X

Notes: Abundance: A = abundant, C = common, F = few, R = rare, X = present, fr = fragments; Preservation: G = good, M = moderate, P = poor; Fragmentation: L = low, M = moderate, H = high.

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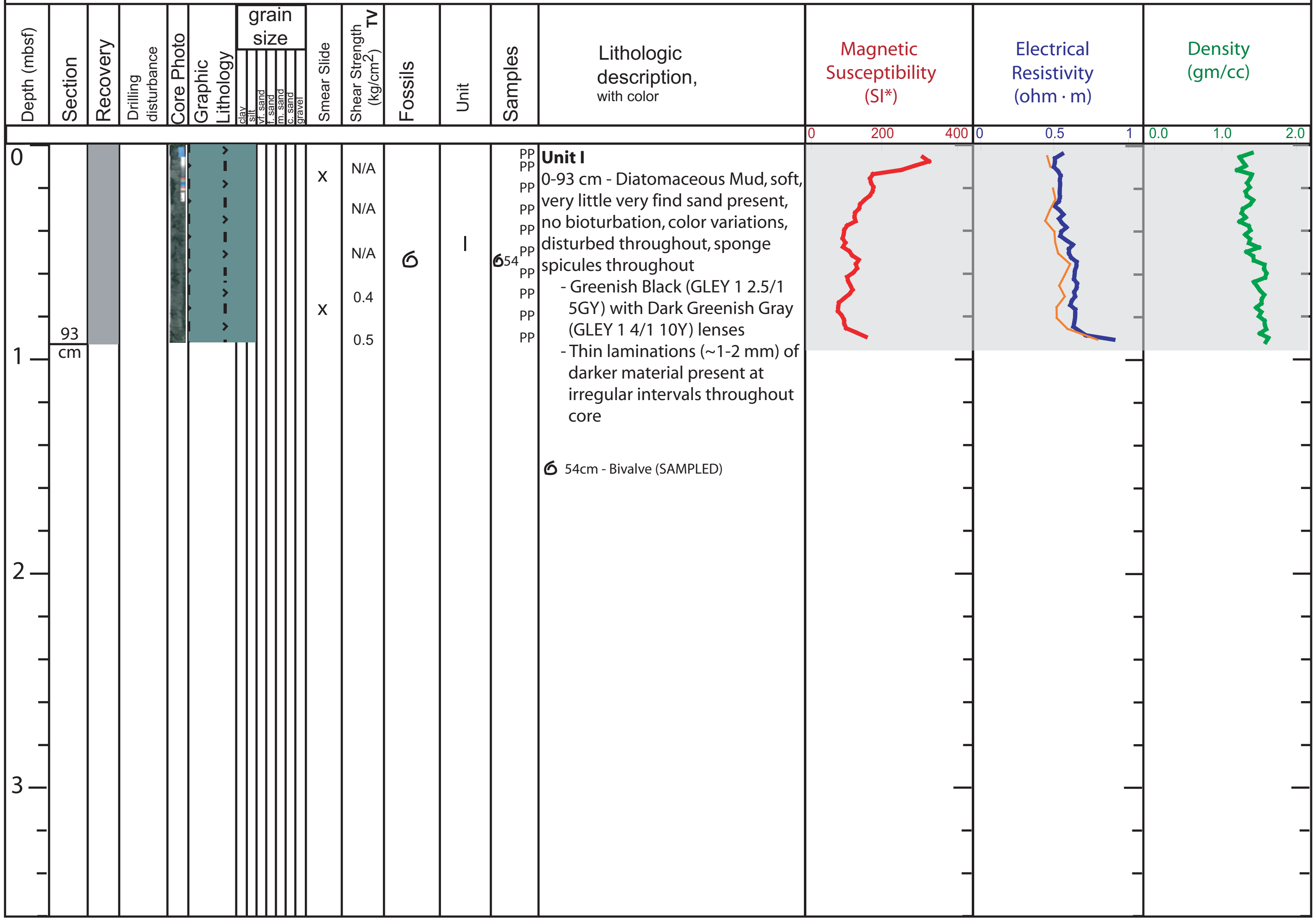
NBP0602A Site: 8 Hole: B

Water Depth: 629m

Core Number: 5 Top 8.0 mbsf Core Type: E



Unit I

0-93 cm - Diatomaceous Mud, soft, very little very find sand present, no bioturbation, color variations, disturbed throughout, sponge spicules throughout

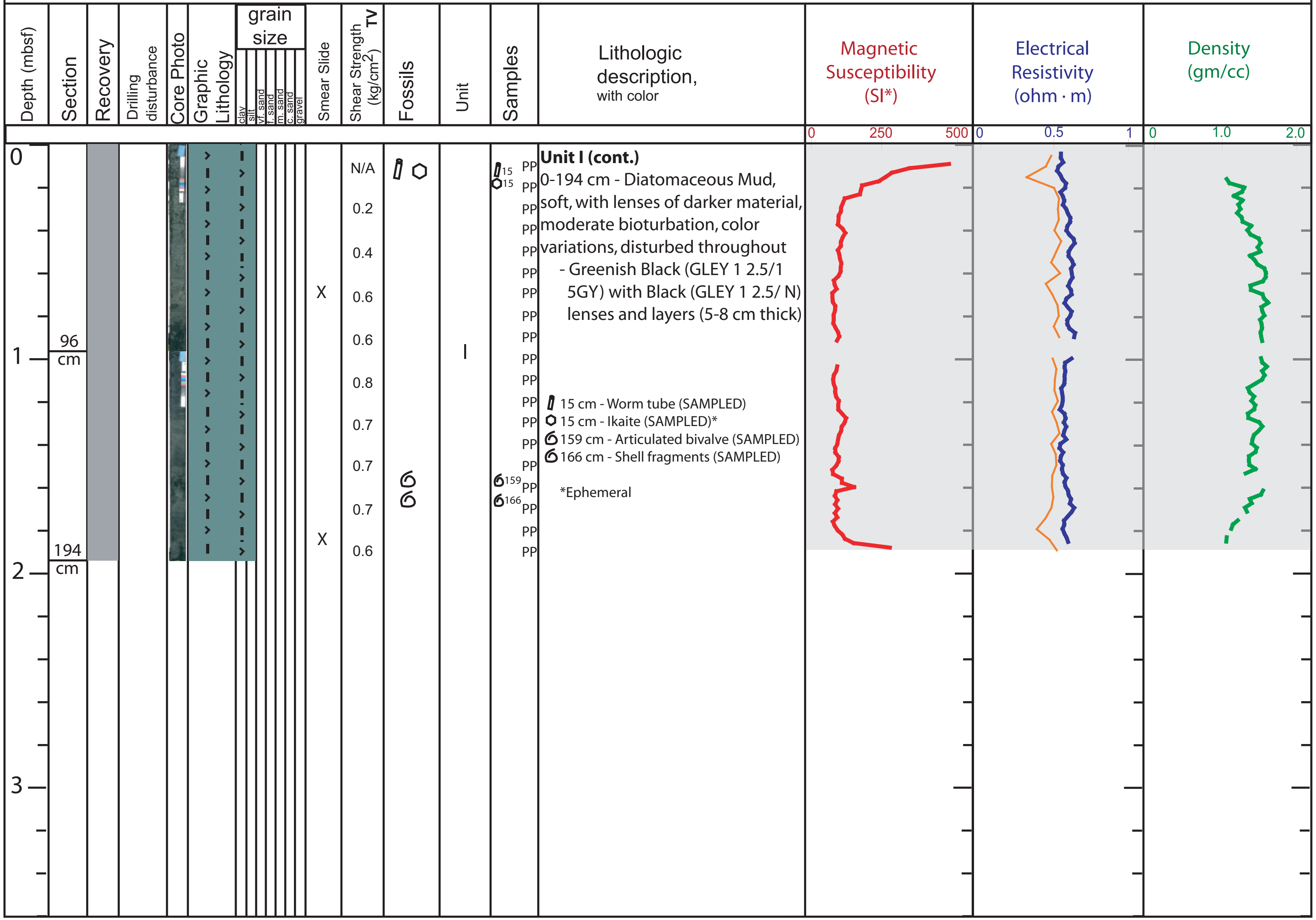
- Greenish Black (GLEY 1 2.5/1 5GY) with Dark Greenish Gray (GLEY 1 4/1 10Y) lenses
- Thin laminations (~1-2 mm) of darker material present at irregular intervals throughout core

6 54cm - Bivalve (SAMPLED)

NBP0602A Site: 8 Hole: B

Water Depth: 629m

Core Number: 6 Top 9.0 mbsf Core Type: E



Unit I (cont.)

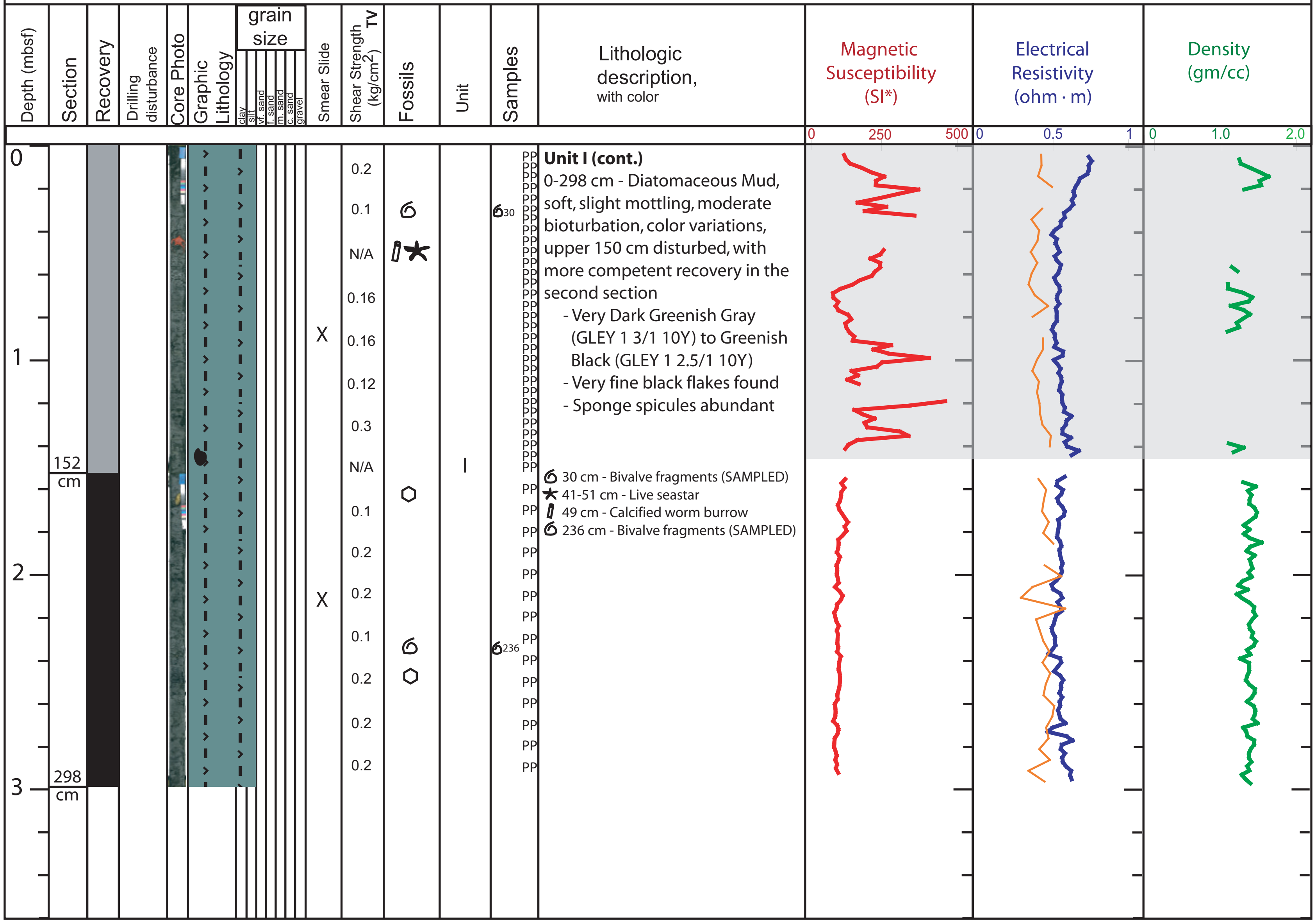
0-194 cm - Diatomaceous Mud, soft, with lenses of darker material, moderate bioturbation, color variations, disturbed throughout
- Greenish Black (GLEY 1 2.5/1 5GY) with Black (GLEY 1 2.5/ N) lenses and layers (5-8 cm thick)

15 cm - Worm tube (SAMPLED)
15 cm - Ikaite (SAMPLED)*
159 cm - Articulated bivalve (SAMPLED)
166 cm - Shell fragments (SAMPLED)

*Ephemeral

NBP0602A Site: 8 Hole: B Water Depth: 629m

Core Number: 7 Top 11.0 mbsf Core Type: E



Unit I (cont.)

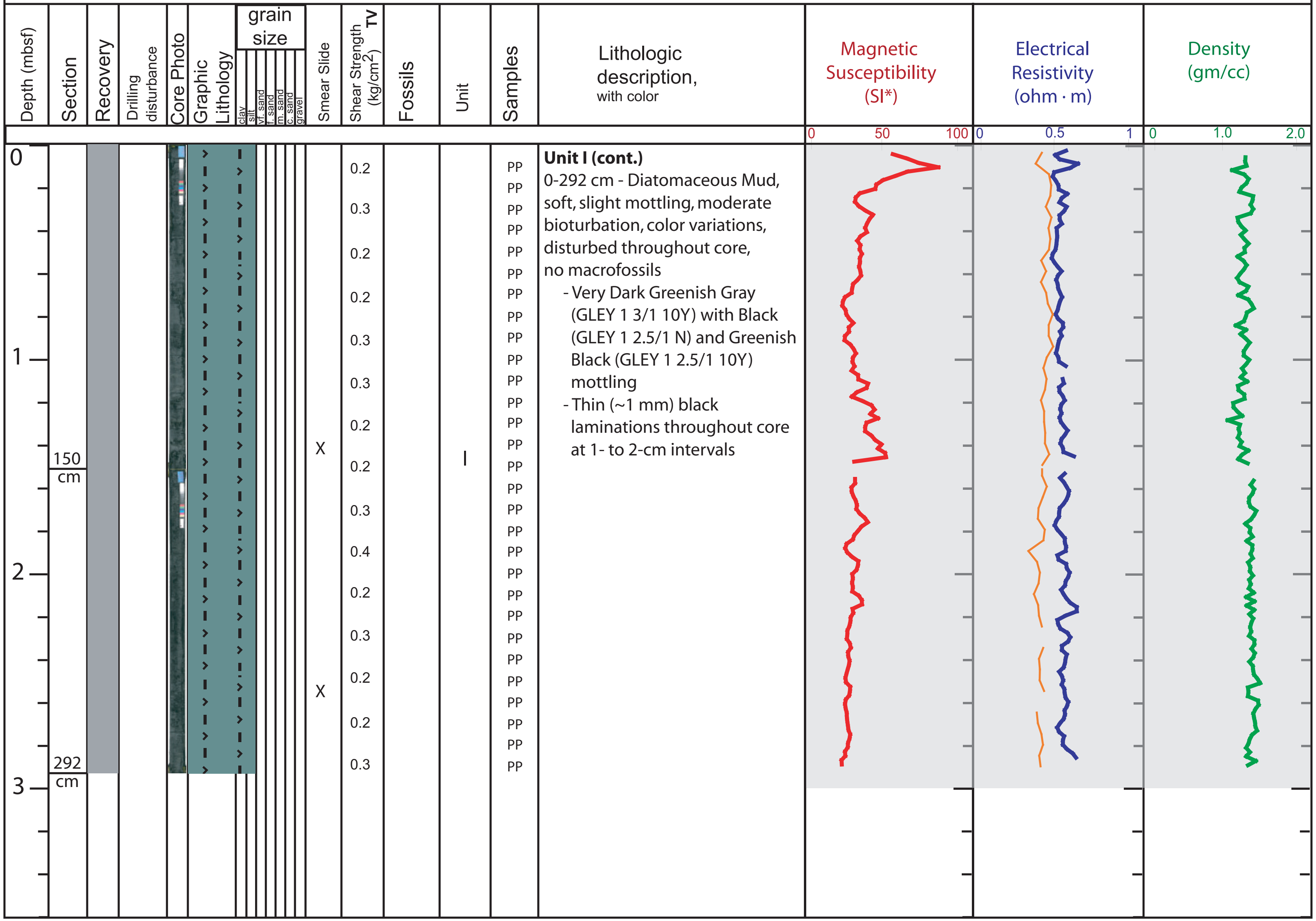
0-298 cm - Diatomaceous Mud, soft, slight mottling, moderate bioturbation, color variations, upper 150 cm disturbed, with more competent recovery in the second section

- Very Dark Greenish Gray (GLEY 1 3/1 10Y) to Greenish Black (GLEY 1 2.5/1 10Y)
- Very fine black flakes found
- Sponge spicules abundant

30 cm - Bivalve fragments (SAMPLED)
★ 41-51 cm - Live seastar
49 cm - Calcified worm burrow
236 cm - Bivalve fragments (SAMPLED)

NBP0602A Site: 8 Hole: B Water Depth: 629m

Core Number: 8 Top 14.0 mbsf Core Type: E



Unit I (cont.)

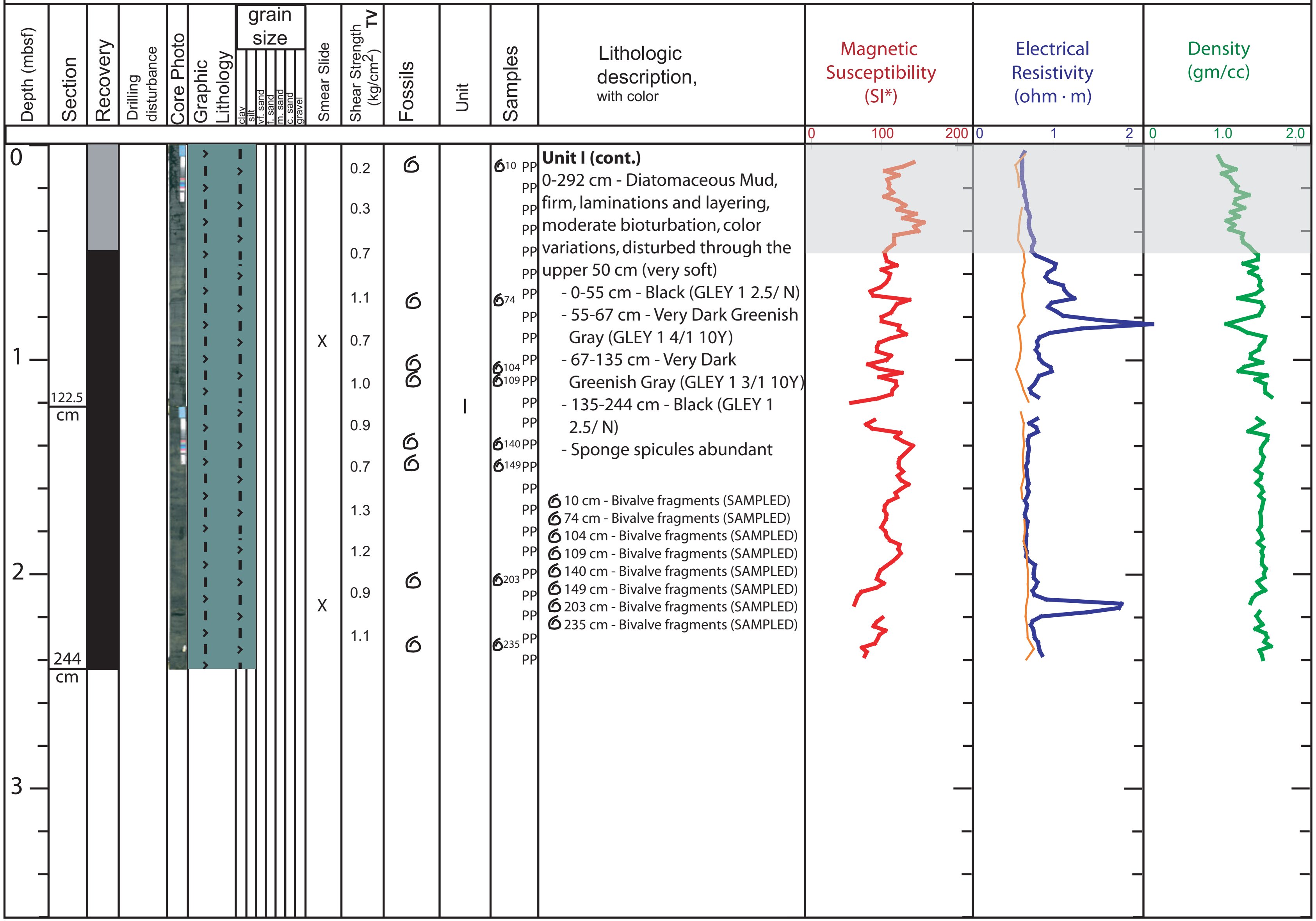
0-292 cm - Diatomaceous Mud, soft, slight mottling, moderate bioturbation, color variations, disturbed throughout core, no macrofossils

- Very Dark Greenish Gray (GLEY 1 3/1 10Y) with Black (GLEY 1 2.5/1 N) and Greenish Black (GLEY 1 2.5/1 10Y) mottling
- Thin (~1 mm) black laminations throughout core at 1- to 2-cm intervals

NBP0602A Site: 8 Hole: B

Water Depth: 629m

Core Number: 9 Top 17.0 mbsf Core Type: E



Unit I (cont.)

0-292 cm - Diatomaceous Mud, firm, laminations and layering, moderate bioturbation, color variations, disturbed through the upper 50 cm (very soft)

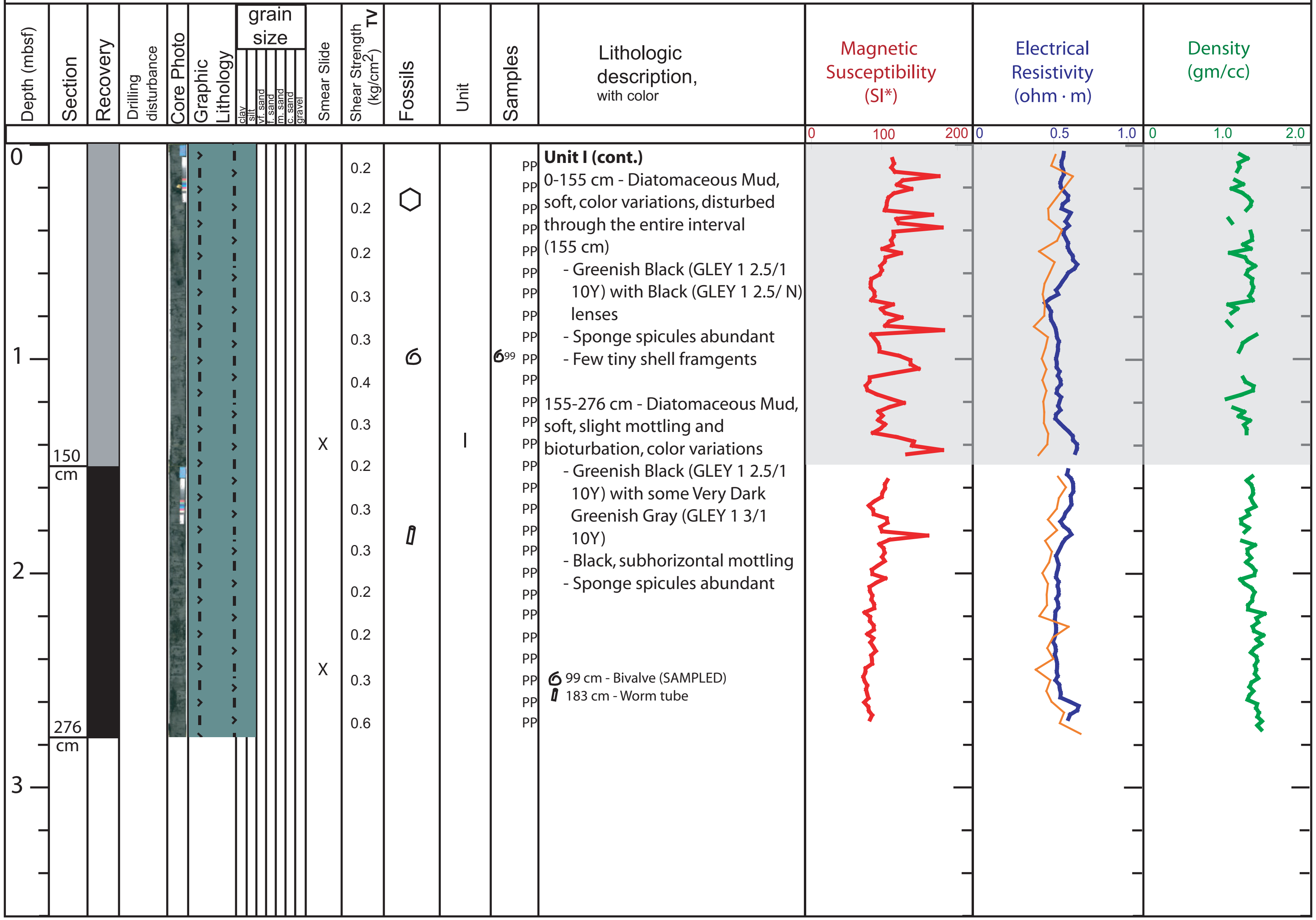
- 0-55 cm - Black (GLEY 1 2.5/ N)
- 55-67 cm - Very Dark Greenish Gray (GLEY 1 4/1 10Y)
- 67-135 cm - Very Dark Greenish Gray (GLEY 1 3/1 10Y)
- 135-244 cm - Black (GLEY 1 2.5/ N)
- Sponge spicules abundant

6 10 cm - Bivalve fragments (SAMPLED)
6 74 cm - Bivalve fragments (SAMPLED)
6 104 cm - Bivalve fragments (SAMPLED)
6 109 cm - Bivalve fragments (SAMPLED)
6 140 cm - Bivalve fragments (SAMPLED)
6 149 cm - Bivalve fragments (SAMPLED)
6 203 cm - Bivalve fragments (SAMPLED)
6 235 cm - Bivalve fragments (SAMPLED)

NBP0602A Site: 8 Hole: B

Water Depth: 629m

Core Number: 10 Top 20.0 mbsf Core Type: E



Unit I (cont.)

0-155 cm - Diatomaceous Mud, soft, color variations, disturbed through the entire interval (155 cm)

- Greenish Black (GLEY 1 2.5/1 10Y) with Black (GLEY 1 2.5/ N) lenses
- Sponge spicules abundant
- Few tiny shell framgents

155-276 cm - Diatomaceous Mud, soft, slight mottling and bioturbation, color variations

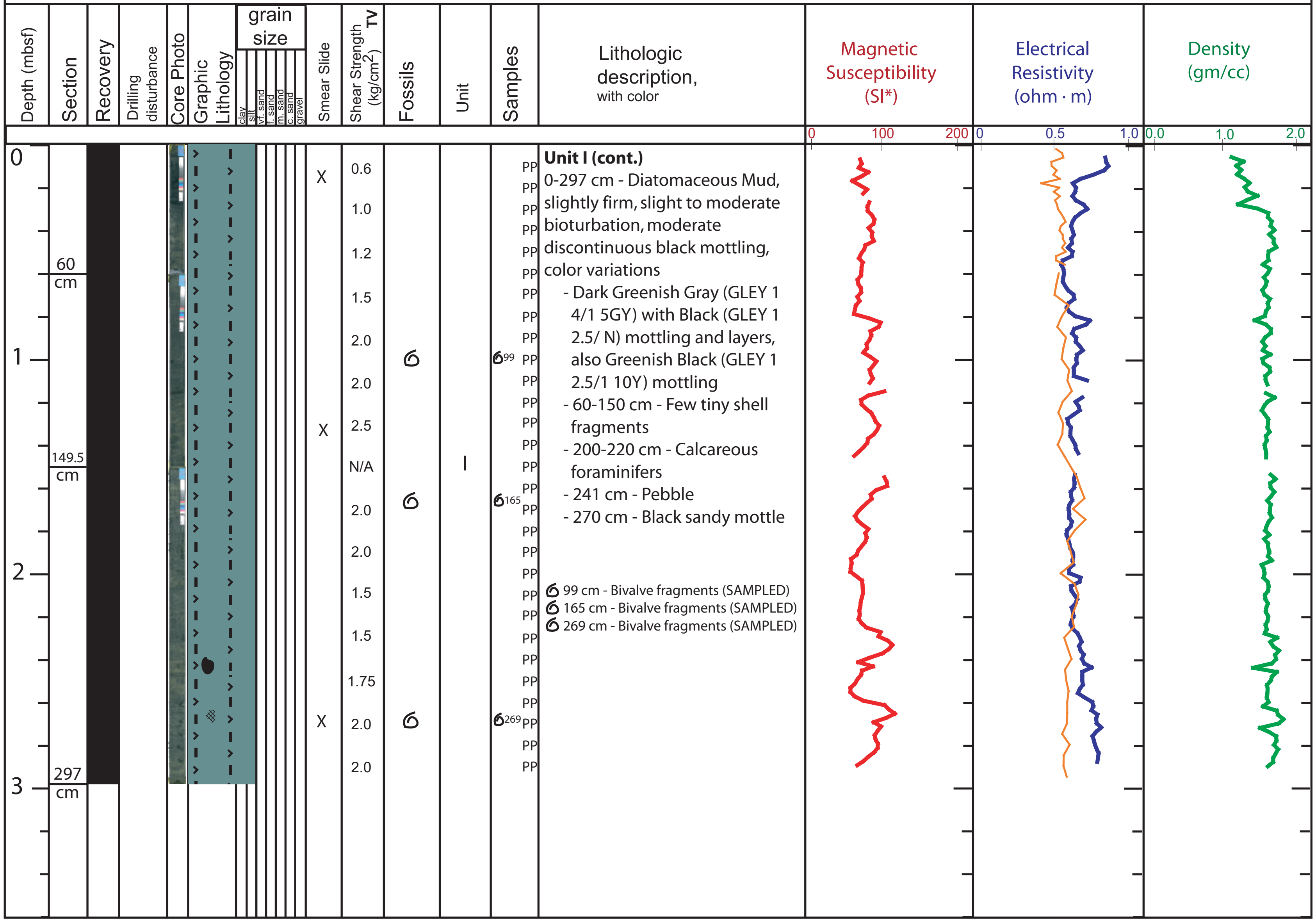
- Greenish Black (GLEY 1 2.5/1 10Y) with some Very Dark Greenish Gray (GLEY 1 3/1 10Y)
- Black, subhorizontal mottling
- Sponge spicules abundant

6 99 cm - Bivalve (SAMPLED)
183 cm - Worm tube

NBP0602A Site: 8 Hole: B

Water Depth: 629m

Core Number: 12 Top 23.0 mbsf Core Type: E



Unit I (cont.)

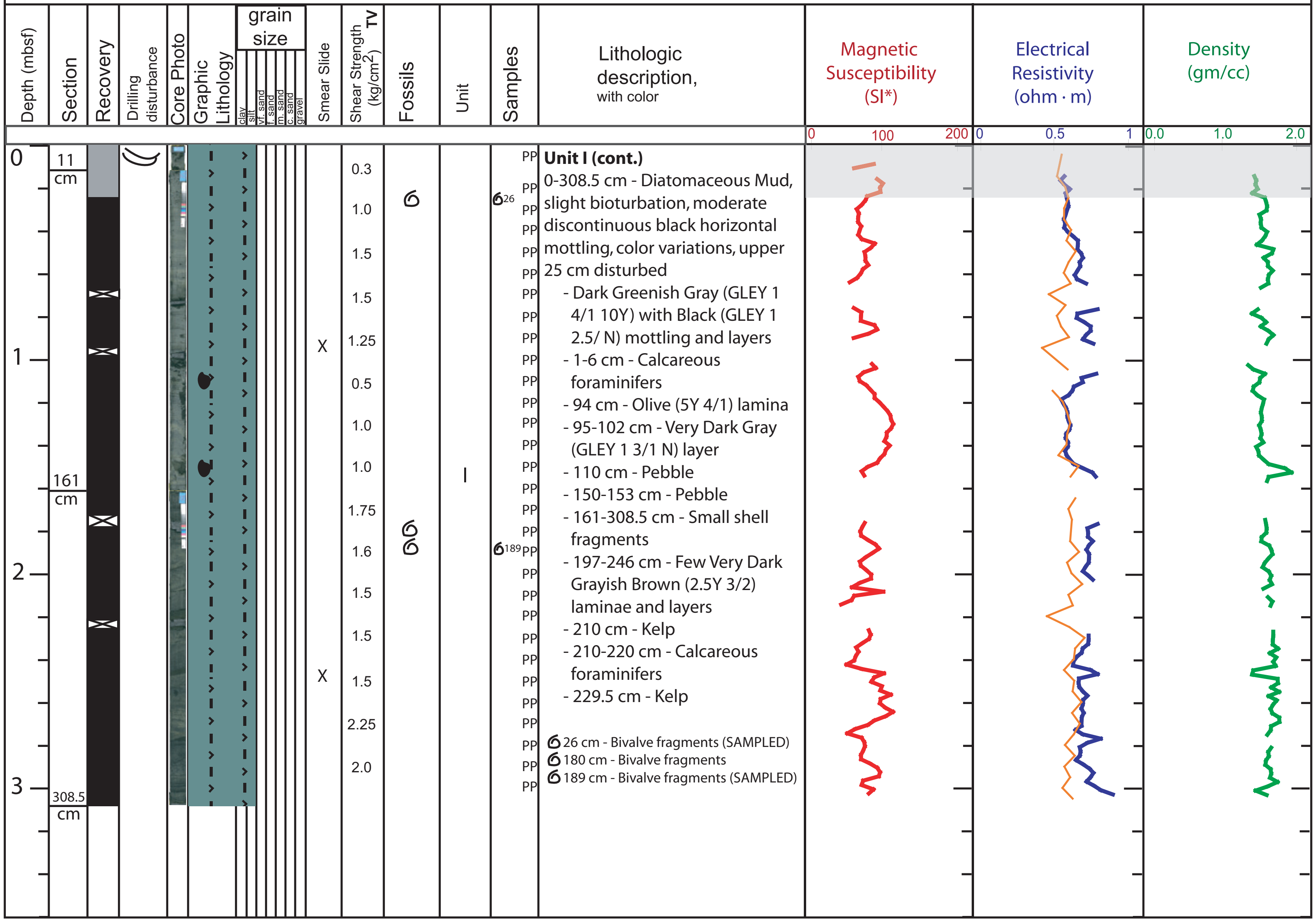
0-297 cm - Diatomaceous Mud, slightly firm, slight to moderate bioturbation, moderate discontinuous black mottling, color variations

- Dark Greenish Gray (GLEY 1 4/1 5GY) with Black (GLEY 1 2.5/ N) mottling and layers, also Greenish Black (GLEY 1 2.5/1 10Y) mottling
- 60-150 cm - Few tiny shell fragments
- 200-220 cm - Calcareous foraminifers
- 241 cm - Pebble
- 270 cm - Black sandy mottle

6 99 cm - Bivalve fragments (SAMPLED)
6 165 cm - Bivalve fragments (SAMPLED)
6 269 cm - Bivalve fragments (SAMPLED)

NBP0602A Site: 8 Hole: B Water Depth: 629m

Core Number: 13 Top 26.0 mbsf Core Type: E



Unit I (cont.)

0-308.5 cm - Diatomaceous Mud, slight bioturbation, moderate discontinuous black horizontal mottling, color variations, upper 25 cm disturbed

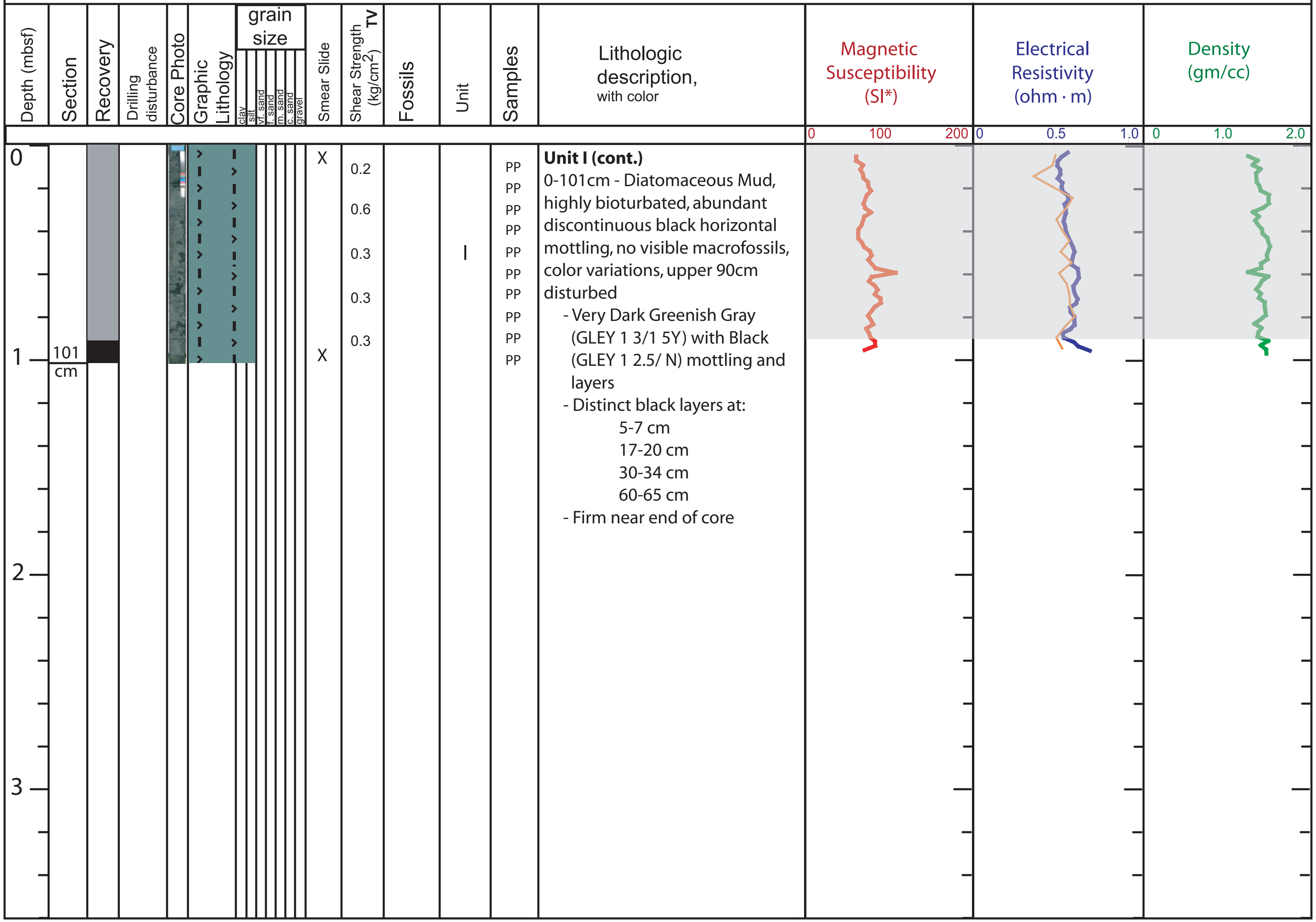
- Dark Greenish Gray (GLEY 1 4/1 10Y) with Black (GLEY 1 2.5/ N) mottling and layers
- 1-6 cm - Calcareous foraminifers
- 94 cm - Olive (5Y 4/1) lamina
- 95-102 cm - Very Dark Gray (GLEY 1 3/1 N) layer
- 110 cm - Pebble
- 150-153 cm - Pebble
- 161-308.5 cm - Small shell fragments
- 197-246 cm - Few Very Dark Grayish Brown (2.5Y 3/2) laminae and layers
- 210 cm - Kelp
- 210-220 cm - Calcareous foraminifers
- 229.5 cm - Kelp

6 26 cm - Bivalve fragments (SAMPLED)
6 180 cm - Bivalve fragments
6 189 cm - Bivalve fragments (SAMPLED)

NBP0602A Site: 8 Hole: B

Water Depth: 629m

Core Number: 15 Top 31.5 mbsf Core Type: E



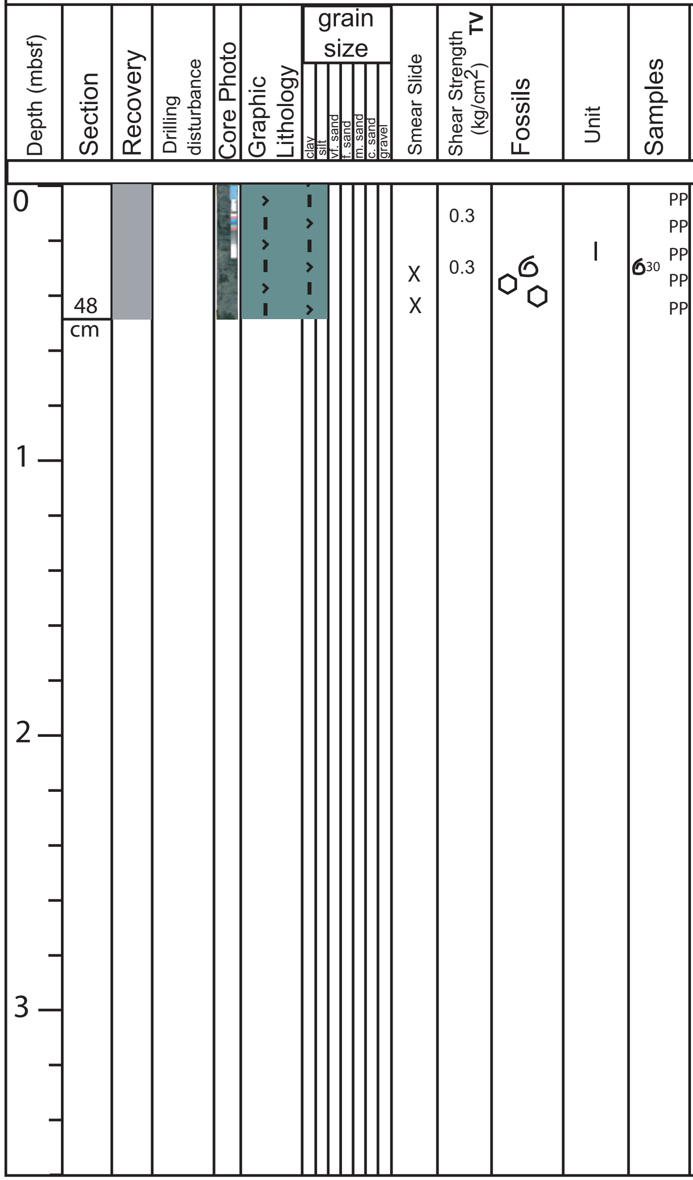
Unit I (cont.)

0-101cm - Diatomaceous Mud, highly bioturbated, abundant discontinuous black horizontal mottling, no visible macrofossils, color variations, upper 90cm disturbed

- Very Dark Greenish Gray (GLEY 1 3/1 5Y) with Black (GLEY 1 2.5/ N) mottling and layers
- Distinct black layers at:
  - 5-7 cm
  - 17-20 cm
  - 30-34 cm
  - 60-65 cm
- Firm near end of core

NBP0602A Site: 8 Hole: B Water Depth: 629m

Core Number: 16 Top 32.5 mbsf Core Type: E



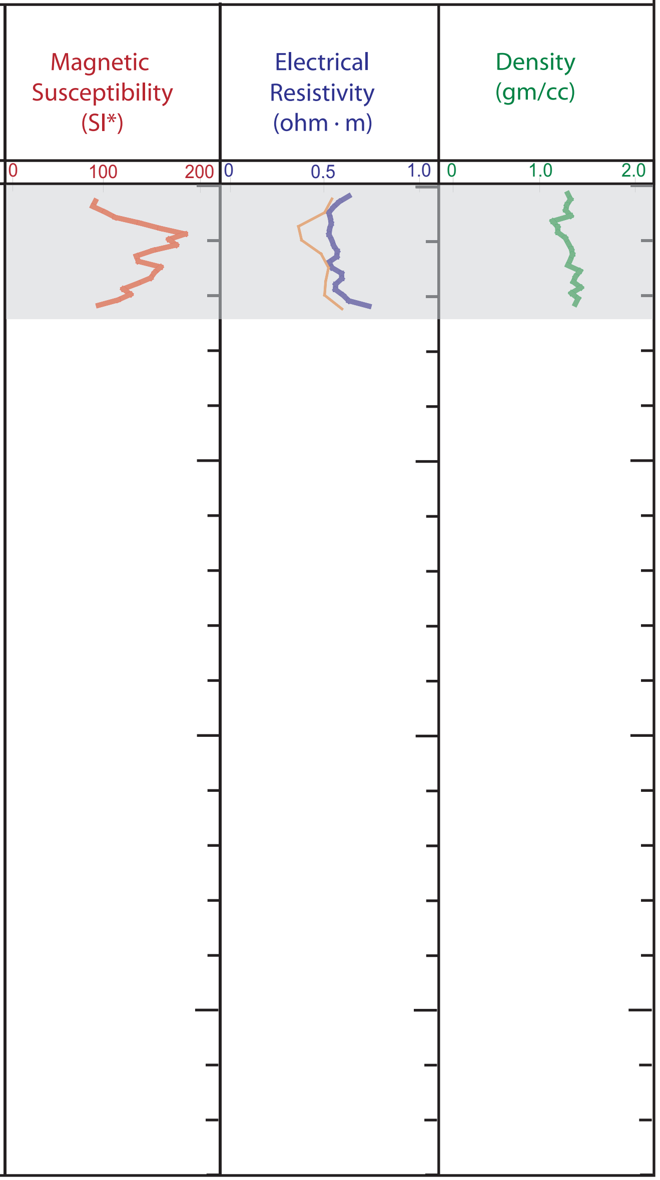
Lithologic description, with color

Unit I (cont.)

0-48 cm - Diatomaceous Mud, severely bioturbated, heavy black mottling, color variations, whole core believed to be disturbed

- Very Dark Greenish Gray (GLEY 1 3/1 10Y) with Black (GLEY 1 2.5/ N) mottling
- 14 cm - Black lamina
- Cottage cheese texture

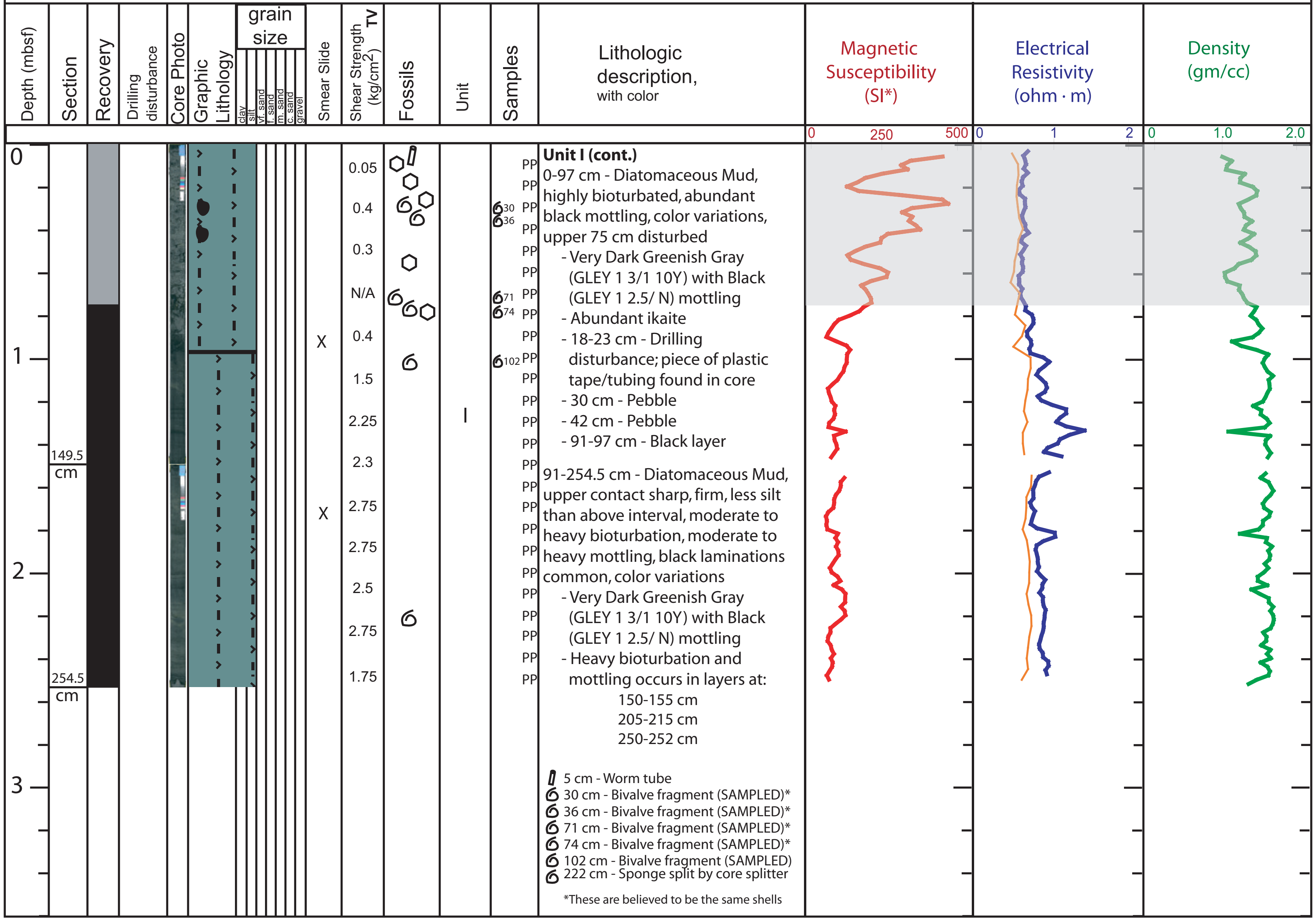
30 cm - Intact gastropod (SAMPLED)



NBP0602A Site: 8 Hole: B

Water Depth: 629m

Core Number: 17 Top 33.0 mbsf Core Type: E



Unit I (cont.)

0-97 cm - Diatomaceous Mud, highly bioturbated, abundant black mottling, color variations, upper 75 cm disturbed

- Very Dark Greenish Gray (GLEY 1 3/1 10Y) with Black (GLEY 1 2.5/ N) mottling
- Abundant ikaite
- 18-23 cm - Drilling disturbance; piece of plastic tape/tubing found in core
- 30 cm - Pebble
- 42 cm - Pebble
- 91-97 cm - Black layer

91-254.5 cm - Diatomaceous Mud, upper contact sharp, firm, less silt than above interval, moderate to heavy bioturbation, moderate to heavy mottling, black laminations common, color variations

- Very Dark Greenish Gray (GLEY 1 3/1 10Y) with Black (GLEY 1 2.5/ N) mottling
- Heavy bioturbation and mottling occurs in layers at:
  150-155 cm
  205-215 cm
  250-252 cm

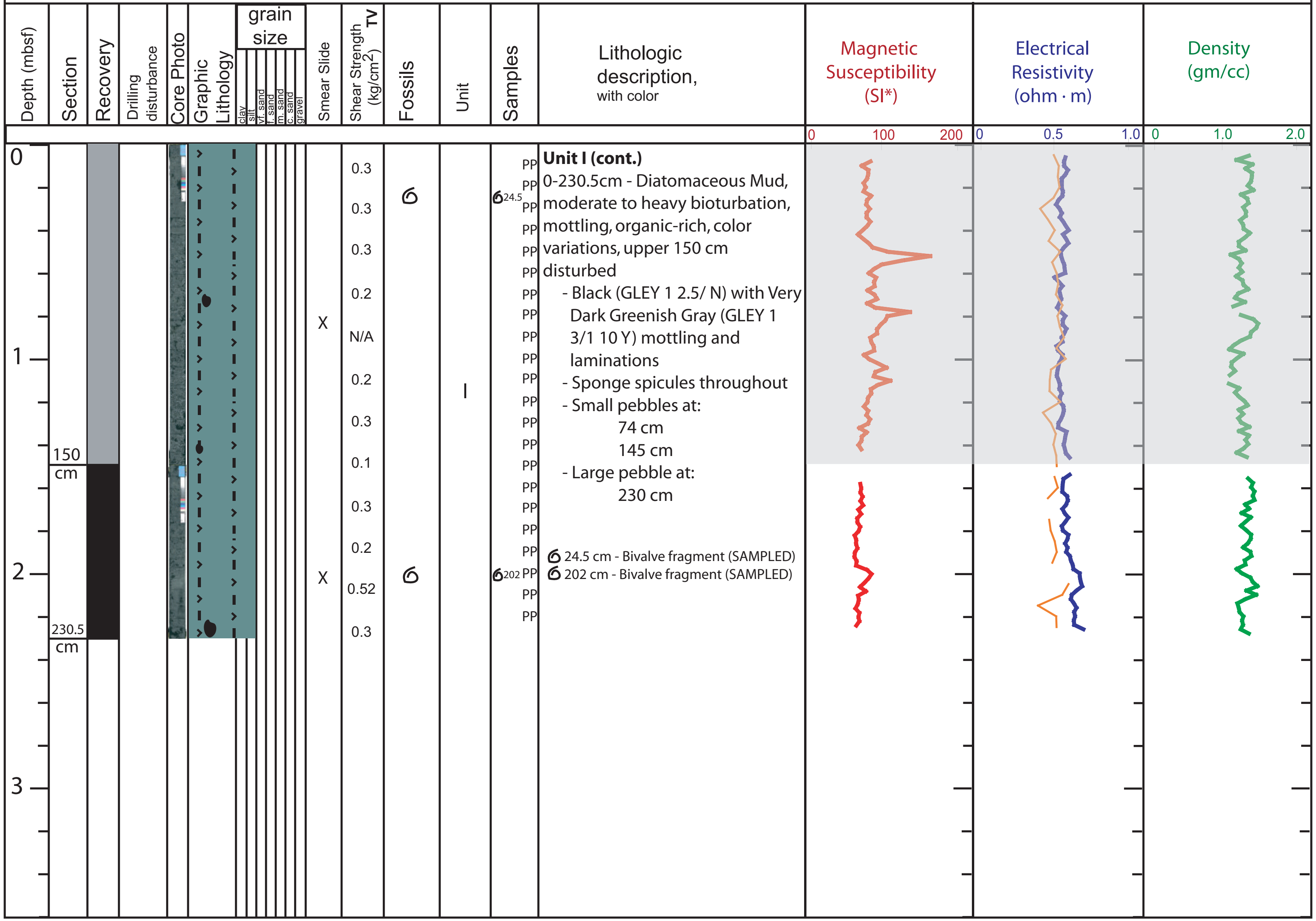
5 cm - Worm tube
30 cm - Bivalve fragment (SAMPLED)*
36 cm - Bivalve fragment (SAMPLED)*
71 cm - Bivalve fragment (SAMPLED)*
74 cm - Bivalve fragment (SAMPLED)*
102 cm - Bivalve fragment (SAMPLED)
222 cm - Sponge split by core splitter

*These are believed to be the same shells

NBP0602A Site: 8 Hole: B

Water Depth: 629m

Core Number: 18 Top 36.0 mbsf Core Type: E



Unit I (cont.)

0-230.5cm - Diatomaceous Mud, moderate to heavy bioturbation, mottling, organic-rich, color variations, upper 150 cm disturbed

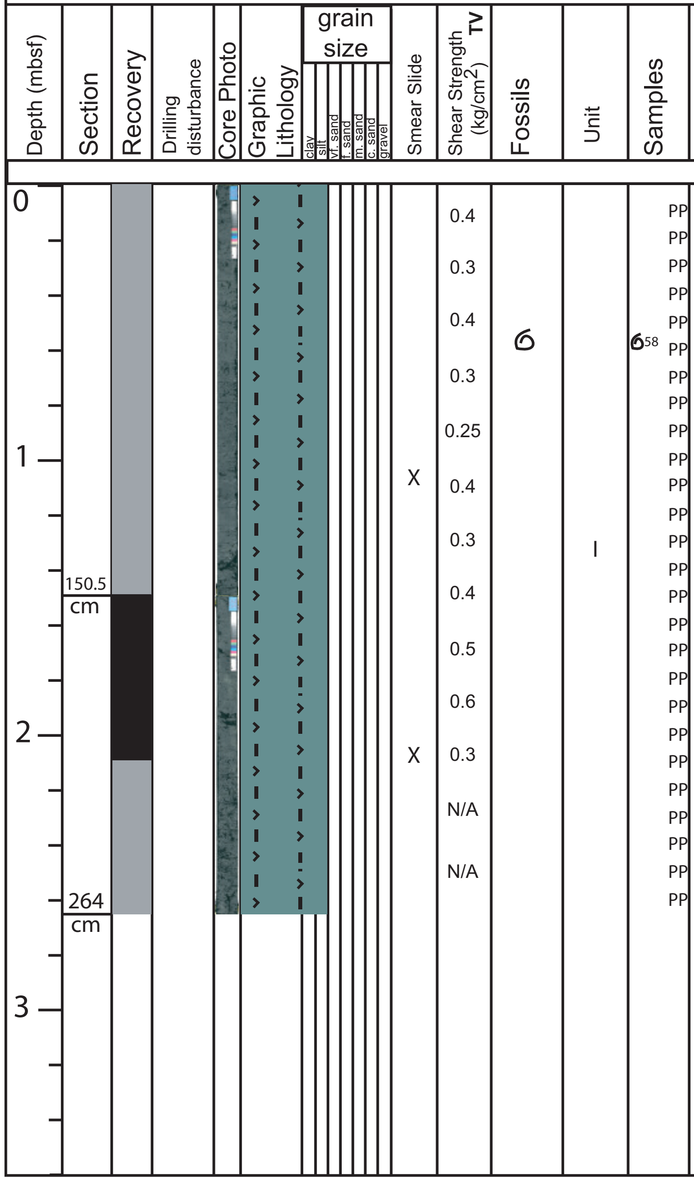
- Black (GLEY 1 2.5/ N) with Very Dark Greenish Gray (GLEY 1 3/1 10 Y) mottling and laminations
- Sponge spicules throughout
- Small pebbles at:
  74 cm
  145 cm
- Large pebble at:
  230 cm

24.5 cm - Bivalve fragment (SAMPLED)
202 cm - Bivalve fragment (SAMPLED)

NBP0602A Site: 8 Hole: B

Water Depth: 629m

Core Number: 19 Top 39.0 mbsf Core Type: E



Lithologic description, with color

Unit I (cont.)

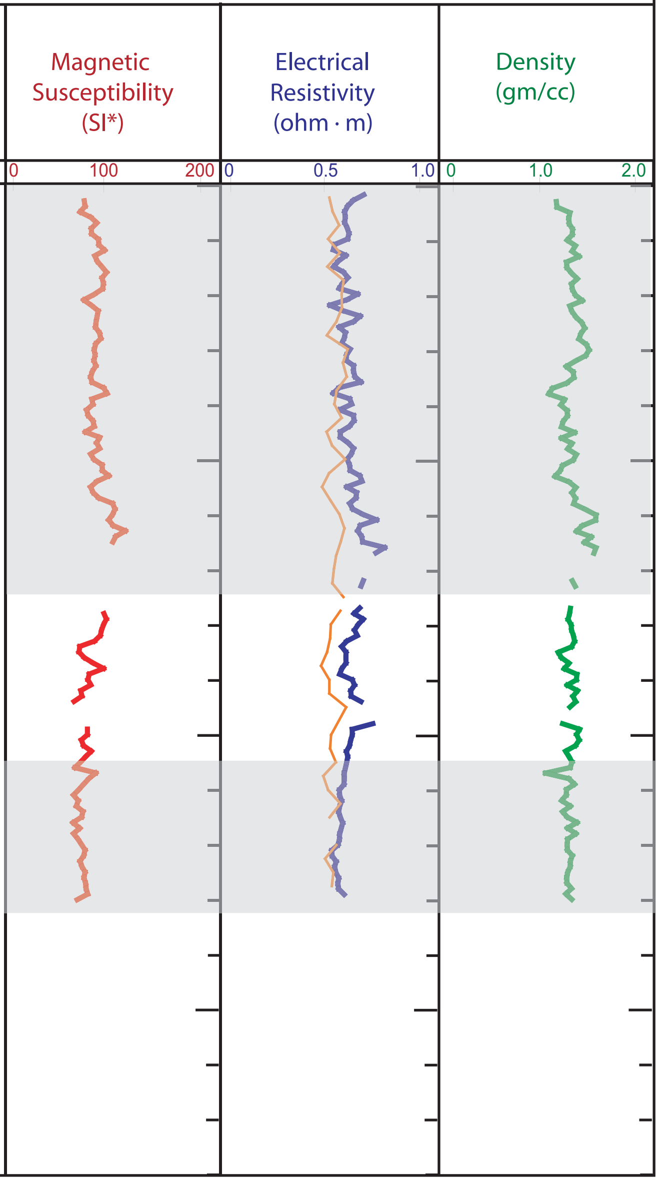
0-210 cm - Diatomaceous Mud, moderate to heavy bioturbation, slight light-colored mottling, organic-rich, color variations, upper 150 cm disturbed

- Black (GLEY 1 2.5/ N) with Very Dark Greenish Gray (GLEY 1 3/1 10Y) mottling and laminations

210-264cm - Diatomaceous Mud, gradational contact, less silt than previous interval, heavily bioturbated, no mottling, 210-264 cm disturbed and very soft

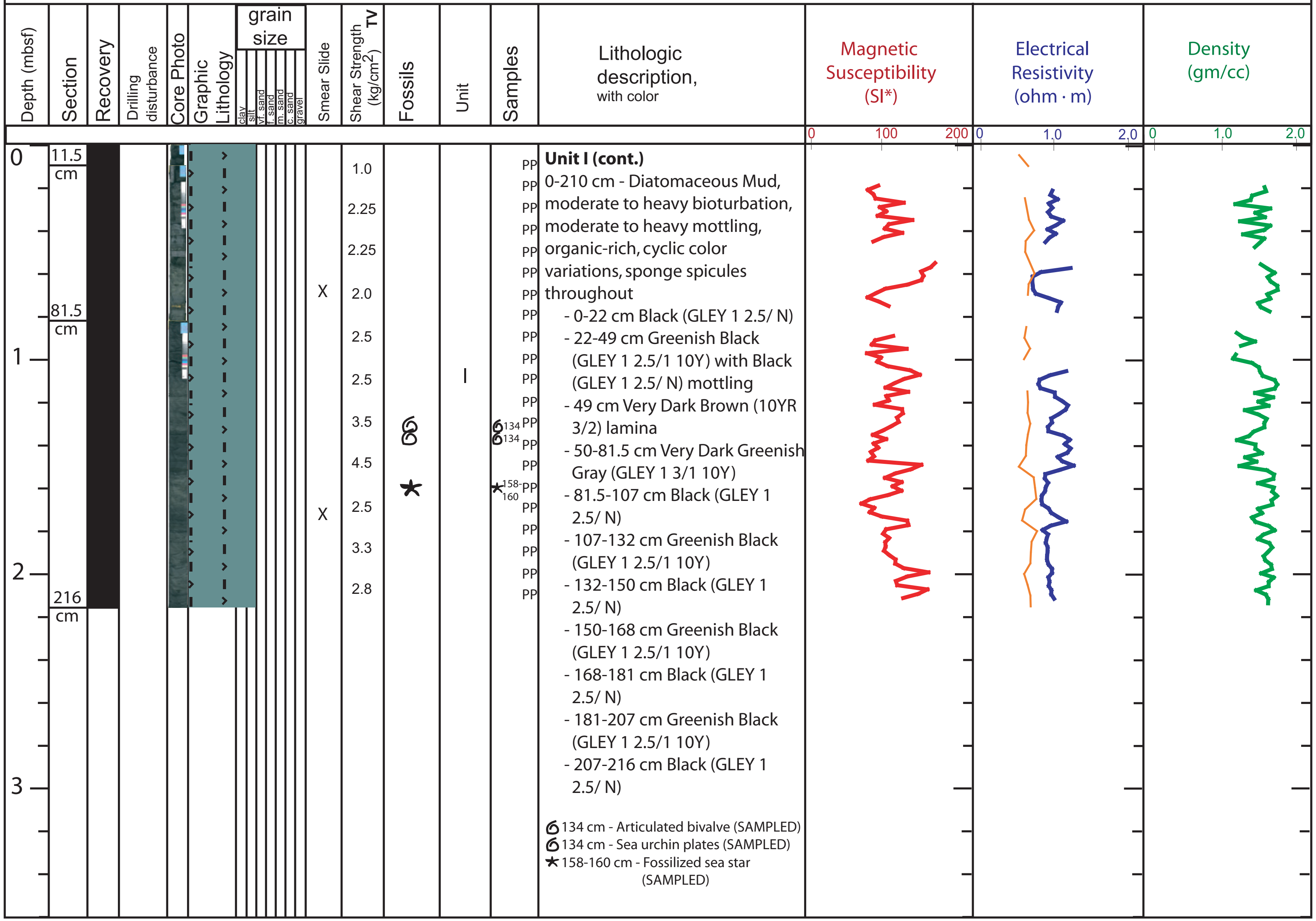
- Black (GLEY 1 2.5/ N)

6 58 cm - Bivalve fragment (SAMPLED)



NBP0602A Site: 8 Hole: B Water Depth: 629m

Core Number: 20 Top 42.0 mbsf Core Type: E



Unit I (cont.)

0-210 cm - Diatomaceous Mud, moderate to heavy bioturbation, moderate to heavy mottling, organic-rich, cyclic color variations, sponge spicules throughout

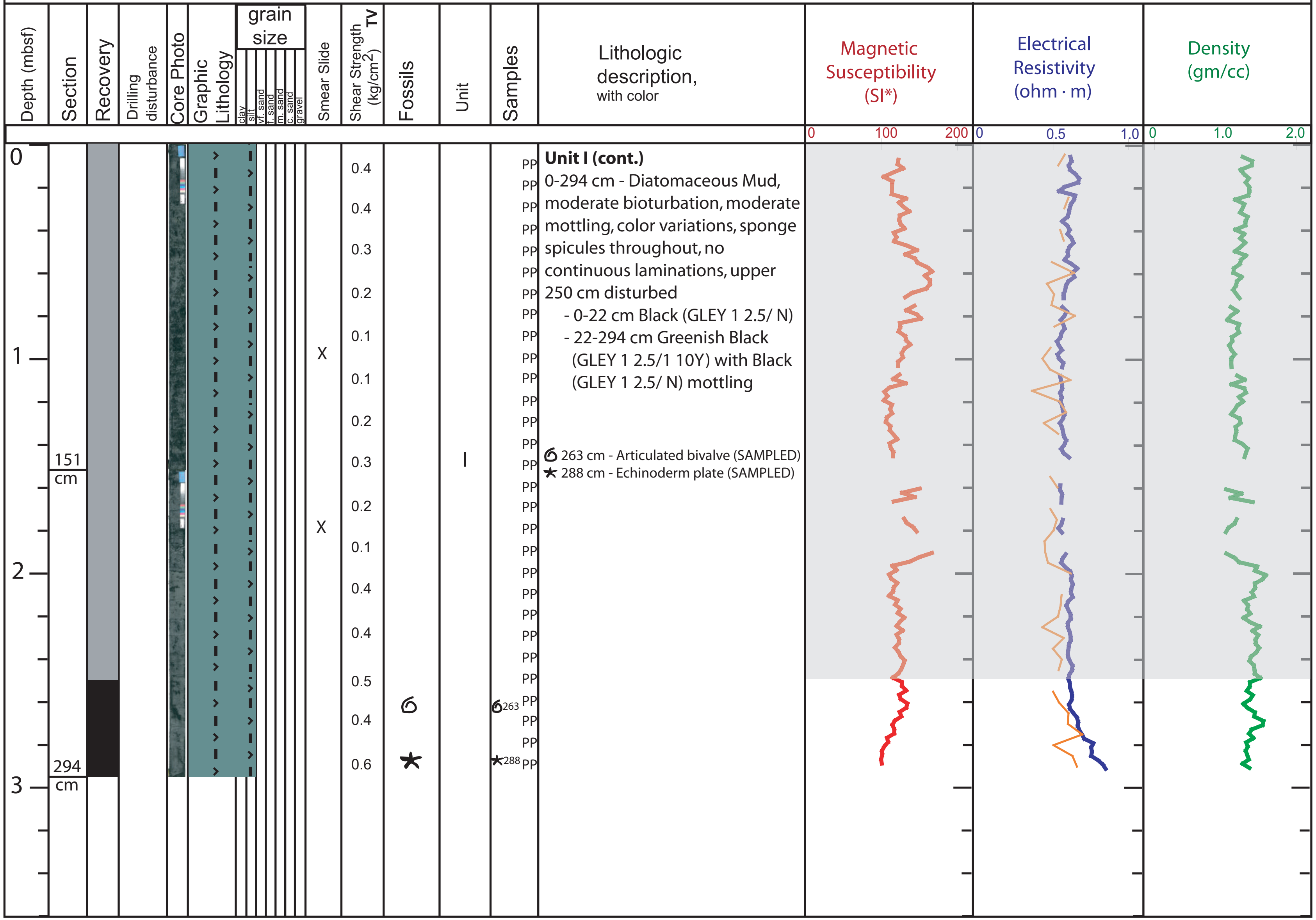
- 0-22 cm Black (GLEY 1 2.5/ N)
- 22-49 cm Greenish Black (GLEY 1 2.5/1 10Y) with Black (GLEY 1 2.5/ N) mottling
- 49 cm Very Dark Brown (10YR 3/2) lamina
- 50-81.5 cm Very Dark Greenish Gray (GLEY 1 3/1 10Y)
- 81.5-107 cm Black (GLEY 1 2.5/ N)
- 107-132 cm Greenish Black (GLEY 1 2.5/1 10Y)
- 132-150 cm Black (GLEY 1 2.5/ N)
- 150-168 cm Greenish Black (GLEY 1 2.5/1 10Y)
- 168-181 cm Black (GLEY 1 2.5/ N)
- 181-207 cm Greenish Black (GLEY 1 2.5/1 10Y)
- 207-216 cm Black (GLEY 1 2.5/ N)

6 134 cm - Articulated bivalve (SAMPLED)
6 134 cm - Sea urchin plates (SAMPLED)
★ 158-160 cm - Fossilized sea star (SAMPLED)

NBP0602A Site: 8 Hole: B

Water Depth: 629m

Core Number: 21 Top 45.0 mbsf Core Type: E



Unit I (cont.)

0-294 cm - Diatomaceous Mud, moderate bioturbation, moderate mottling, color variations, sponge spicules throughout, no continuous laminations, upper 250 cm disturbed

- 0-22 cm Black (GLEY 1 2.5/ N)
- 22-294 cm Greenish Black (GLEY 1 2.5/1 10Y) with Black (GLEY 1 2.5/ N) mottling

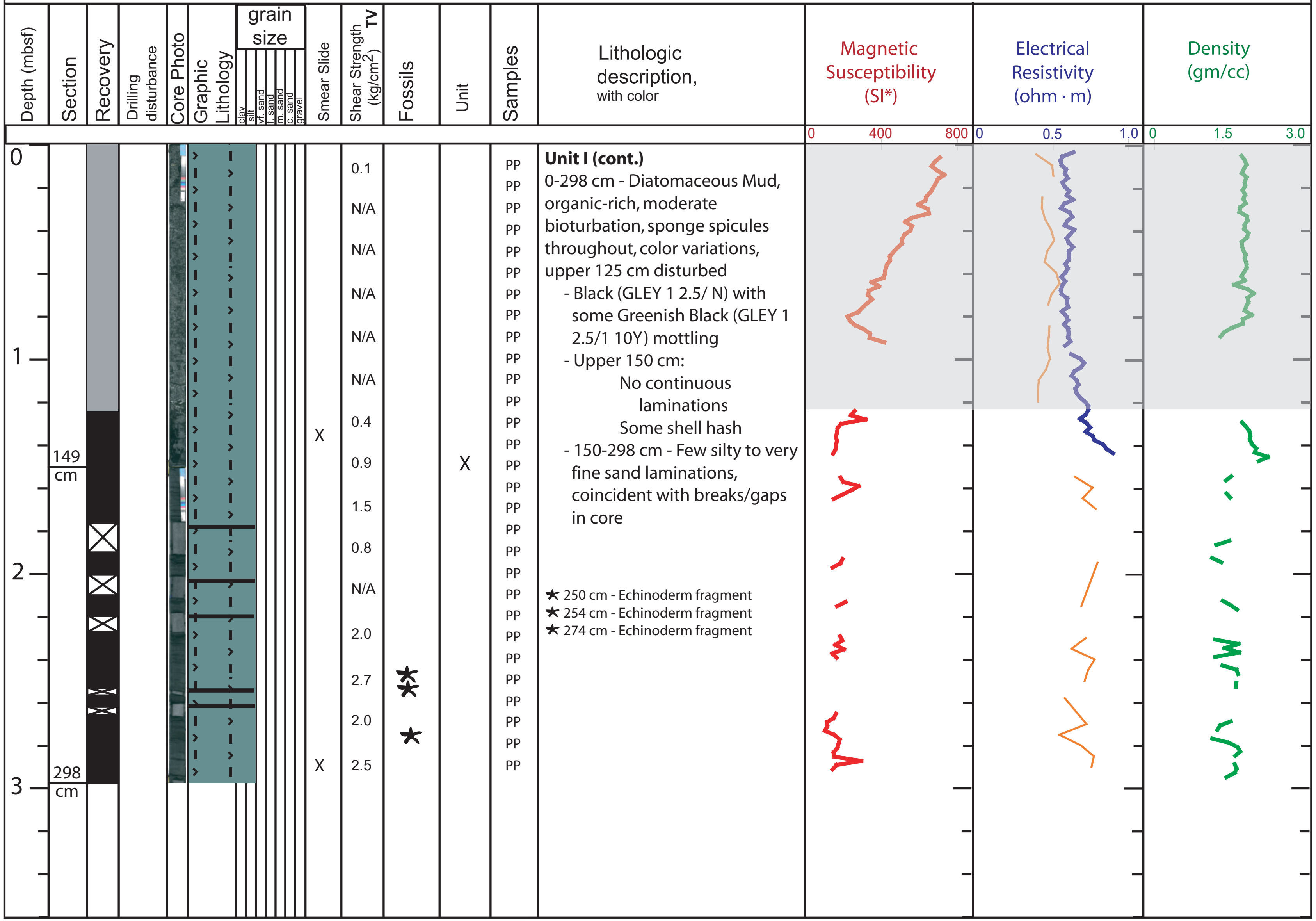
6 263 cm - Articulated bivalve (SAMPLED)

★ 288 cm - Echinoderm plate (SAMPLED)

NBP0602A Site: 8 Hole: B

Water Depth: 629m

Core Number: 22 Top 48.0 mbsf Core Type: E



Unit I (cont.)

0-298 cm - Diatomaceous Mud, organic-rich, moderate bioturbation, sponge spicules throughout, color variations, upper 125 cm disturbed

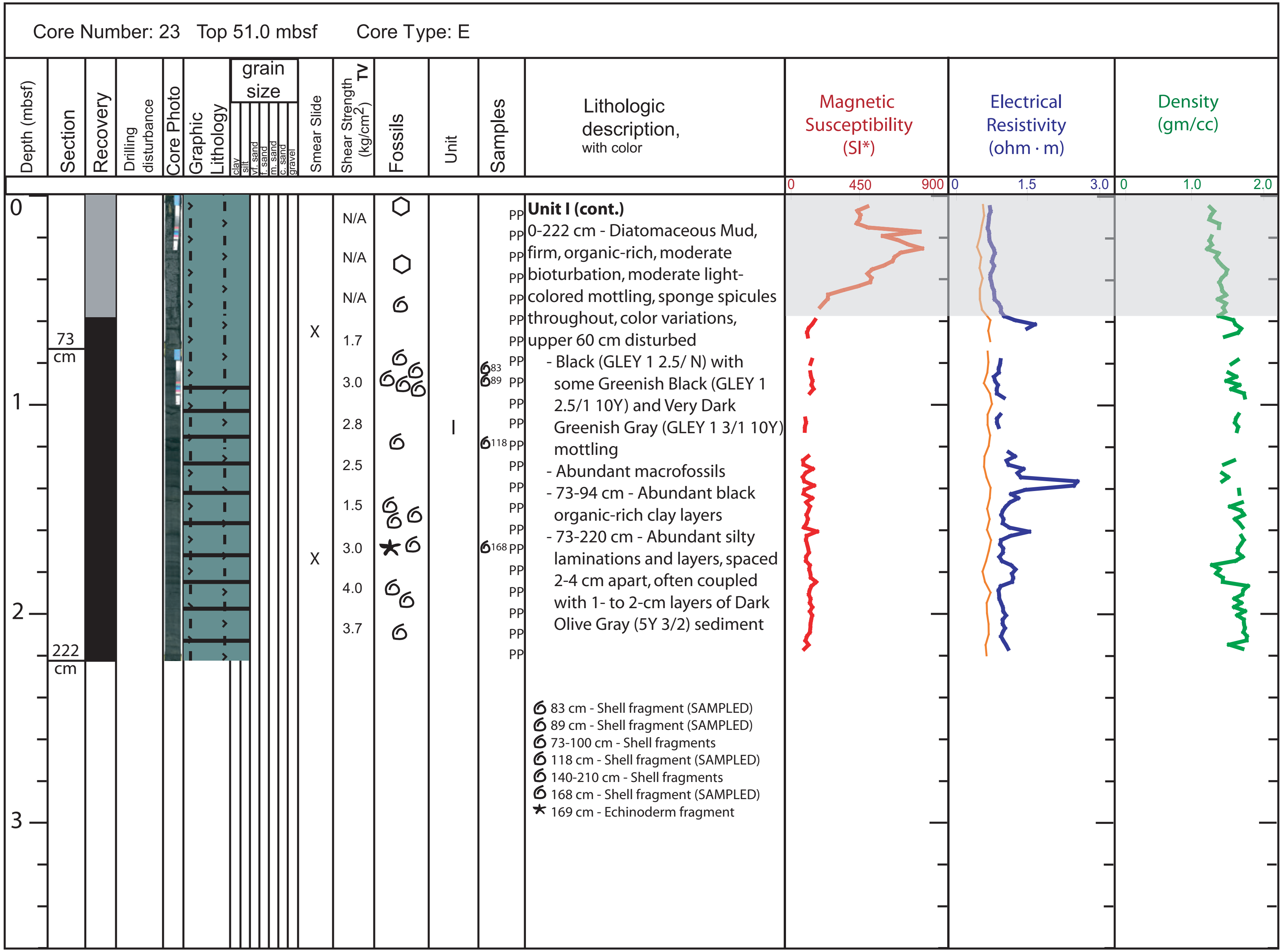
- Black (GLEY 1 2.5/ N) with some Greenish Black (GLEY 1 2.5/1 10Y) mottling
- Upper 150 cm:
  No continuous laminations
  Some shell hash
- 150-298 cm - Few silty to very fine sand laminations, coincident with breaks/gaps in core

★ 250 cm - Echinoderm fragment
★ 254 cm - Echinoderm fragment
★ 274 cm - Echinoderm fragment

NBP0602A Site: 8 Hole: B

Water Depth: 629m

Core Number: 23 Top 51.0 mbsf Core Type: E



Unit I (cont.)

0-222 cm - Diatomaceous Mud, firm, organic-rich, moderate bioturbation, moderate light-colored mottling, sponge spicules throughout, color variations, upper 60 cm disturbed

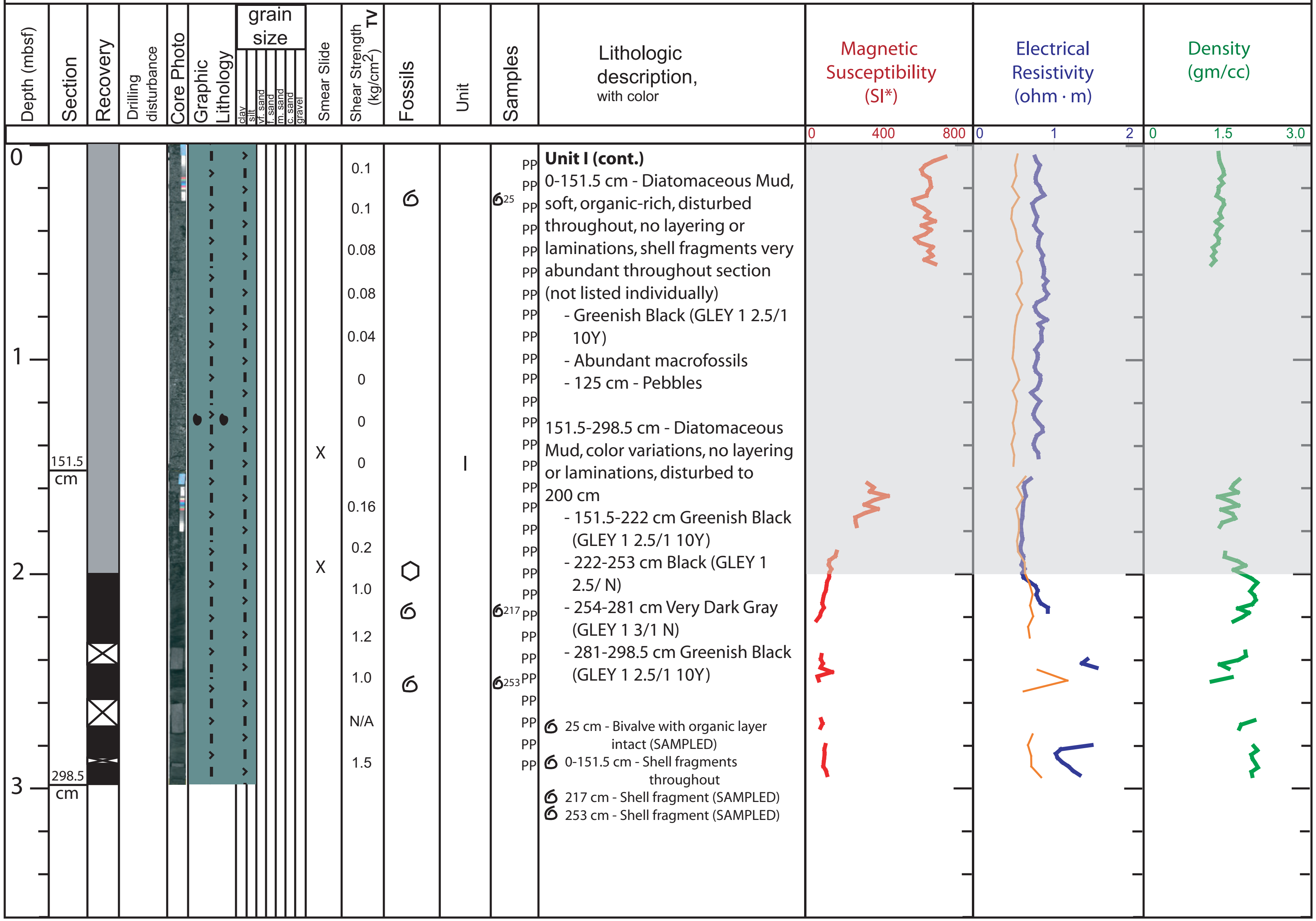
- Black (GLEY 1 2.5/ N) with some Greenish Black (GLEY 1 2.5/1 10Y) and Very Dark Greenish Gray (GLEY 1 3/1 10Y) mottling
- Abundant macrofossils
- 73-94 cm - Abundant black organic-rich clay layers
- 73-220 cm - Abundant silty laminations and layers, spaced 2-4 cm apart, often coupled with 1- to 2-cm layers of Dark Olive Gray (5Y 3/2) sediment

6 83 cm - Shell fragment (SAMPLED)
6 89 cm - Shell fragment (SAMPLED)
6 73-100 cm - Shell fragments
6 118 cm - Shell fragment (SAMPLED)
6 140-210 cm - Shell fragments
6 168 cm - Shell fragment (SAMPLED)
★ 169 cm - Echinoderm fragment

NBP0602A Site: 8 Hole: B

Water Depth: 629m

Core Number: 24 Top 54.0 mbsf Core Type: E



Unit I (cont.)

0-151.5 cm - Diatomaceous Mud, soft, organic-rich, disturbed throughout, no layering or laminations, shell fragments very abundant throughout section (not listed individually)

- Greenish Black (GLEY 1 2.5/1 10Y)
- Abundant macrofossils
- 125 cm - Pebbles

151.5-298.5 cm - Diatomaceous Mud, color variations, no layering or laminations, disturbed to 200 cm

- 151.5-222 cm Greenish Black (GLEY 1 2.5/1 10Y)
- 222-253 cm Black (GLEY 1 2.5/ N)
- 254-281 cm Very Dark Gray (GLEY 1 3/1 N)
- 281-298.5 cm Greenish Black (GLEY 1 2.5/1 10Y)

25 cm - Bivalve with organic layer intact (SAMPLED)

0-151.5 cm - Shell fragments throughout

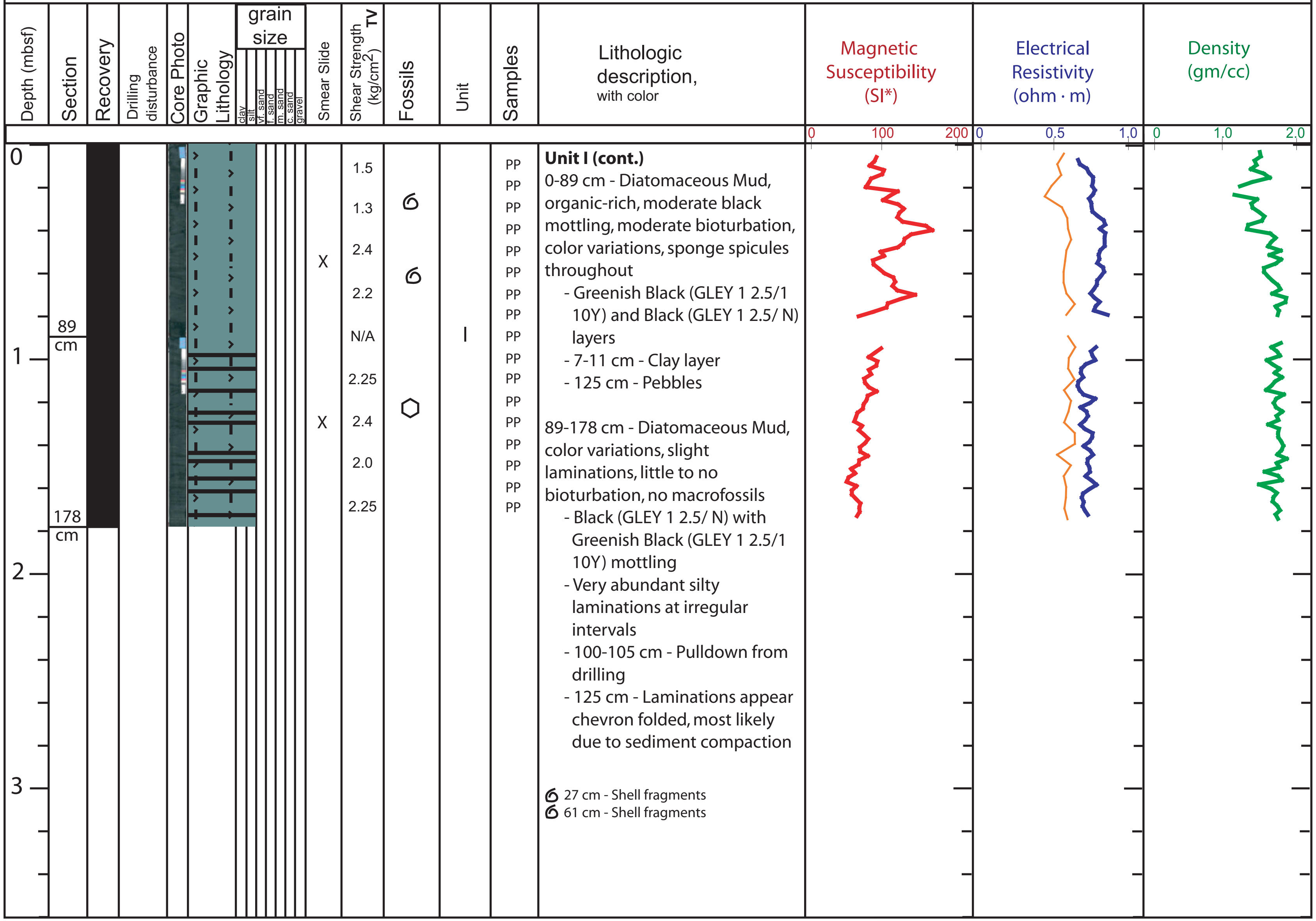
217 cm - Shell fragment (SAMPLED)

253 cm - Shell fragment (SAMPLED)

NBP0602A Site: 8 Hole: B

Water Depth: 629m

Core Number: 25 Top 56.5 mbsf Core Type: E_S



Lithologic description, with color

Unit I (cont.)

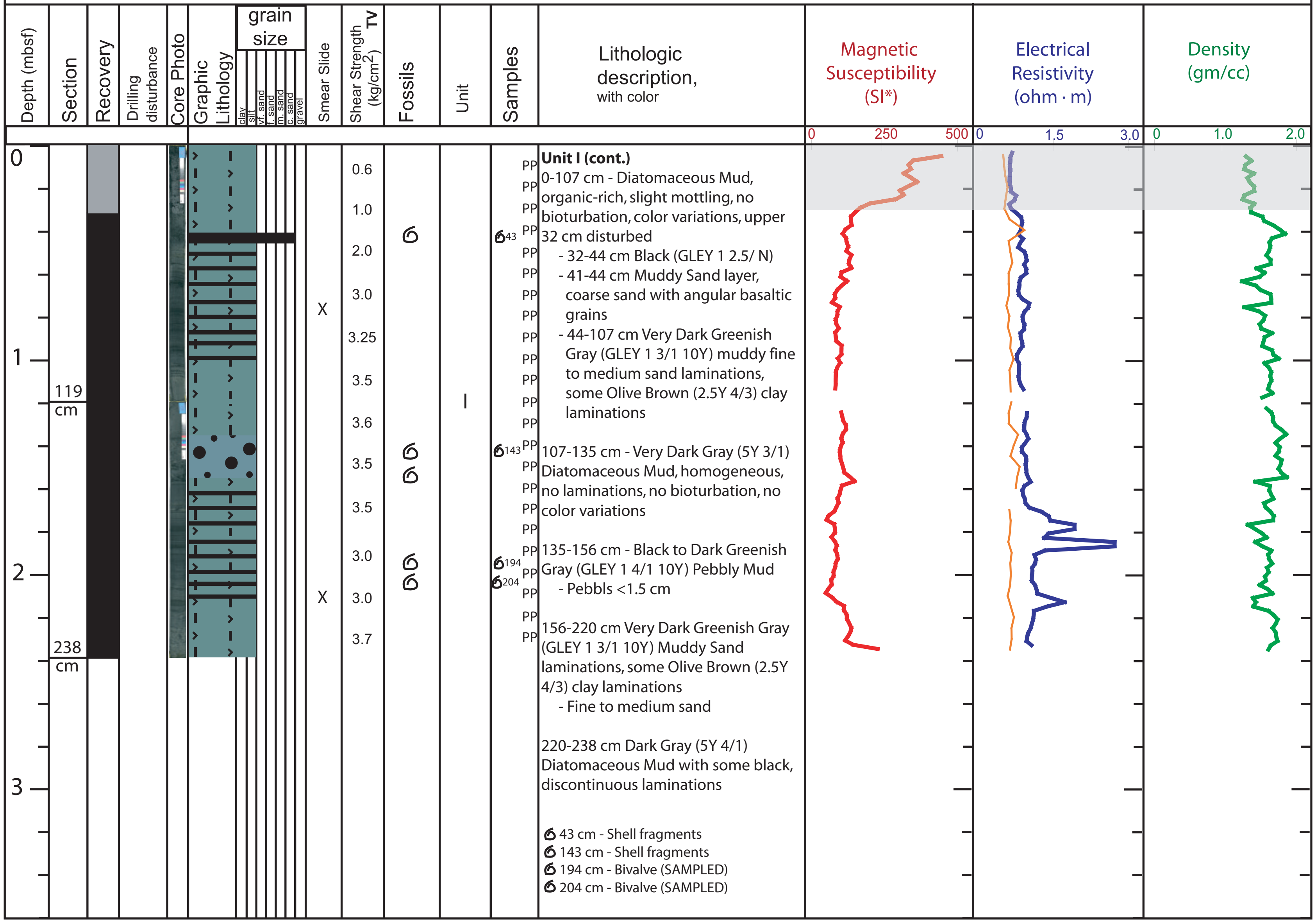
0-89 cm - Diatomaceous Mud, organic-rich, moderate black mottling, moderate bioturbation, color variations, sponge spicules throughout
- Greenish Black (GLEY 1 2.5/1 10Y) and Black (GLEY 1 2.5/ N) layers
- 7-11 cm - Clay layer
- 125 cm - Pebbles

89-178 cm - Diatomaceous Mud, color variations, slight laminations, little to no bioturbation, no macrofossils
- Black (GLEY 1 2.5/ N) with Greenish Black (GLEY 1 2.5/1 10Y) mottling
- Very abundant silty laminations at irregular intervals
- 100-105 cm - Pulldown from drilling
- 125 cm - Laminations appear chevron folded, most likely due to sediment compaction

6 27 cm - Shell fragments
6 61 cm - Shell fragments

NBP0602A Site: 8 Hole: B Water Depth: 629m

Core Number: 26 Top 59.5 mbsf Core Type: E



Unit I (cont.)

0-107 cm - Diatomaceous Mud, organic-rich, slight mottling, no bioturbation, color variations, upper 32 cm disturbed
- 32-44 cm Black (GLEY 1 2.5/ N)
- 41-44 cm Muddy Sand layer, coarse sand with angular basaltic grains
- 44-107 cm Very Dark Greenish Gray (GLEY 1 3/1 10Y) muddy fine to medium sand laminations, some Olive Brown (2.5Y 4/3) clay laminations

107-135 cm - Very Dark Gray (5Y 3/1) Diatomaceous Mud, homogeneous, no laminations, no bioturbation, no color variations

135-156 cm - Black to Dark Greenish Gray (GLEY 1 4/1 10Y) Pebbly Mud
- Pebbls <1.5 cm

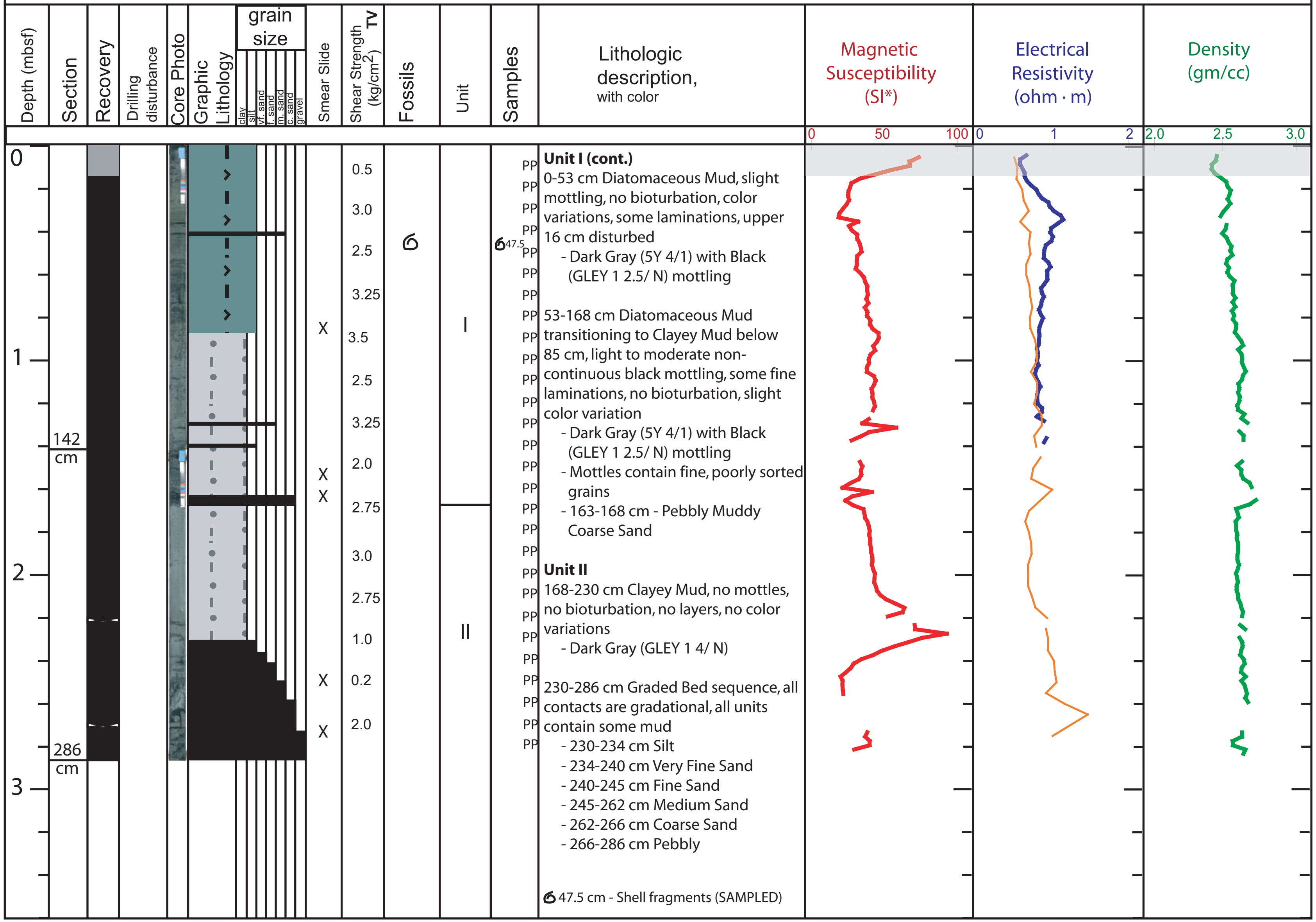
156-220 cm Very Dark Greenish Gray (GLEY 1 3/1 10Y) Muddy Sand laminations, some Olive Brown (2.5Y 4/3) clay laminations
- Fine to medium sand

220-238 cm Dark Gray (5Y 4/1) Diatomaceous Mud with some black, discontinuous laminations

6 43 cm - Shell fragments
6 143 cm - Shell fragments
6 194 cm - Bivalve (SAMPLED)
6 204 cm - Bivalve (SAMPLED)

NBP0602A Site: 8 Hole: B Water Depth: 629m

Core Number: 27 Top 62.5 mbsf Core Type: E



Unit I (cont.)

0-53 cm Diatomaceous Mud, slight mottling, no bioturbation, color variations, some laminations, upper 16 cm disturbed

- Dark Gray (5Y 4/1) with Black (GLEY 1 2.5/ N) mottling

53-168 cm Diatomaceous Mud transitioning to Clayey Mud below 85 cm, light to moderate non-continuous black mottling, some fine laminations, no bioturbation, slight color variation

- Dark Gray (5Y 4/1) with Black (GLEY 1 2.5/ N) mottling
- Mottles contain fine, poorly sorted grains
- 163-168 cm - Pebbly Muddy Coarse Sand

Unit II

168-230 cm Clayey Mud, no mottles, no bioturbation, no layers, no color variations

- Dark Gray (GLEY 1 4/ N)

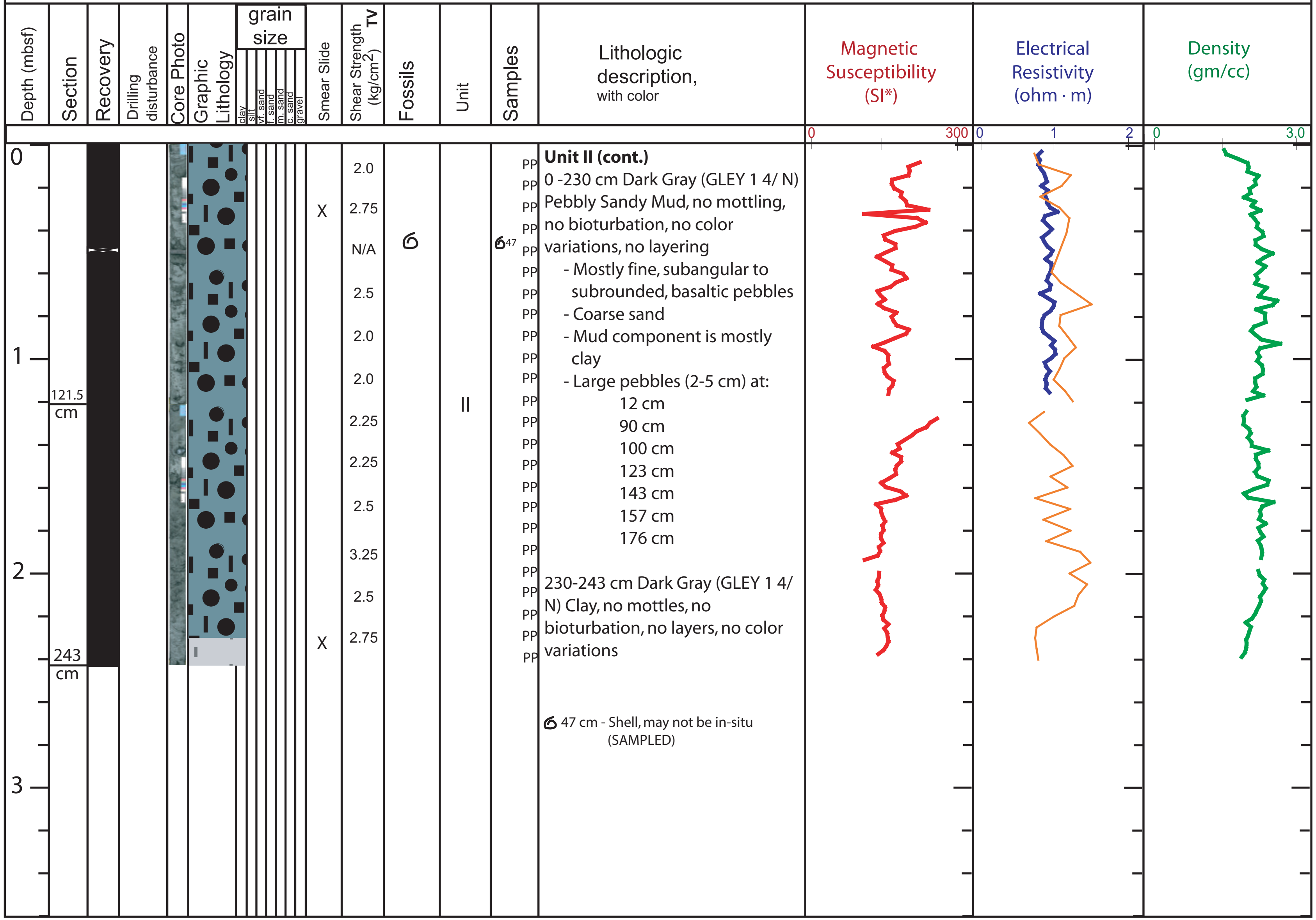
230-286 cm Graded Bed sequence, all contacts are gradational, all units contain some mud

- 230-234 cm Silt
- 234-240 cm Very Fine Sand
- 240-245 cm Fine Sand
- 245-262 cm Medium Sand
- 262-266 cm Coarse Sand
- 266-286 cm Pebbly

47.5 cm - Shell fragments (SAMPLED)

NBP0602A Site: 8 Hole: B Water Depth: 629m

Core Number: 28 Top 65.5 mbsf Core Type: E



Unit II (cont.)

0 -230 cm Dark Gray (GLEY 1 4/ N) Pebbly Sandy Mud, no mottling, no bioturbation, no color variations, no layering

- Mostly fine, subangular to subrounded, basaltic pebbles
- Coarse sand
- Mud component is mostly clay
- Large pebbles (2-5 cm) at:
    - 12 cm
    - 90 cm
    - 100 cm
    - 123 cm
    - 143 cm
    - 157 cm
    - 176 cm

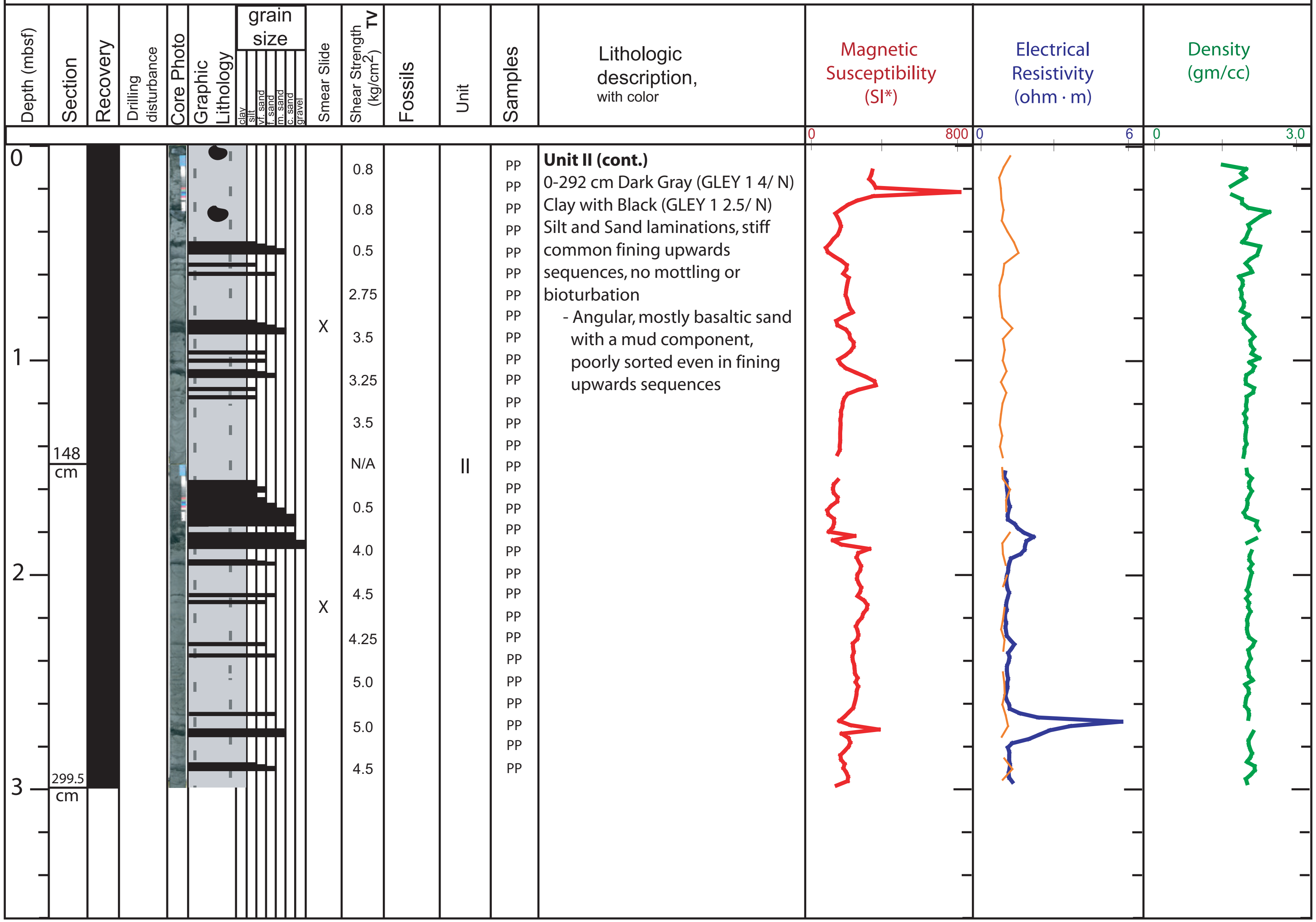
230-243 cm Dark Gray (GLEY 1 4/ N) Clay, no mottles, no bioturbation, no layers, no color variations

47 cm - Shell, may not be in-situ (SAMPLED)

NBP0602A Site: 8 Hole: B

Water Depth: 629m

Core Number: 29 Top 68.5 mbsf Core Type: E



Unit II (cont.)

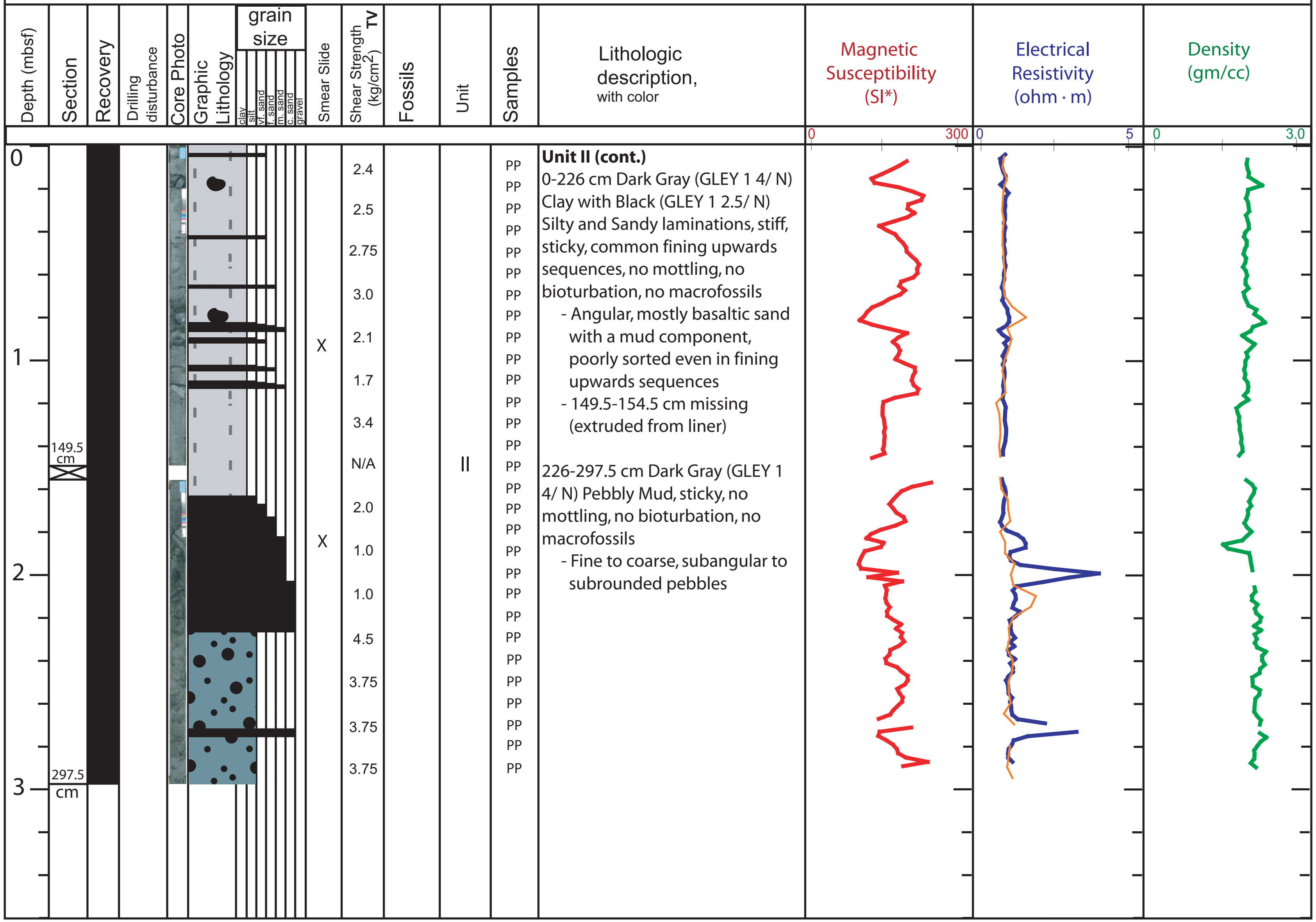
0-292 cm Dark Gray (GLEY 1 4/ N) Clay with Black (GLEY 1 2.5/ N) Silt and Sand laminations, stiff common fining upwards sequences, no mottling or bioturbation

- Angular, mostly basaltic sand with a mud component, poorly sorted even in fining upwards sequences

NBP0602A Site: 8 Hole: B

Water Depth: 629m

Core Number: 30 Top 71.5 mbsf Core Type: E



Unit II (cont.)

0-226 cm Dark Gray (GLEY 1 4/ N) Clay with Black (GLEY 1 2.5/ N) Silty and Sandy laminations, stiff, sticky, common fining upwards sequences, no mottling, no bioturbation, no macrofossils

- Angular, mostly basaltic sand with a mud component, poorly sorted even in fining upwards sequences
- 149.5-154.5 cm missing (extruded from liner)

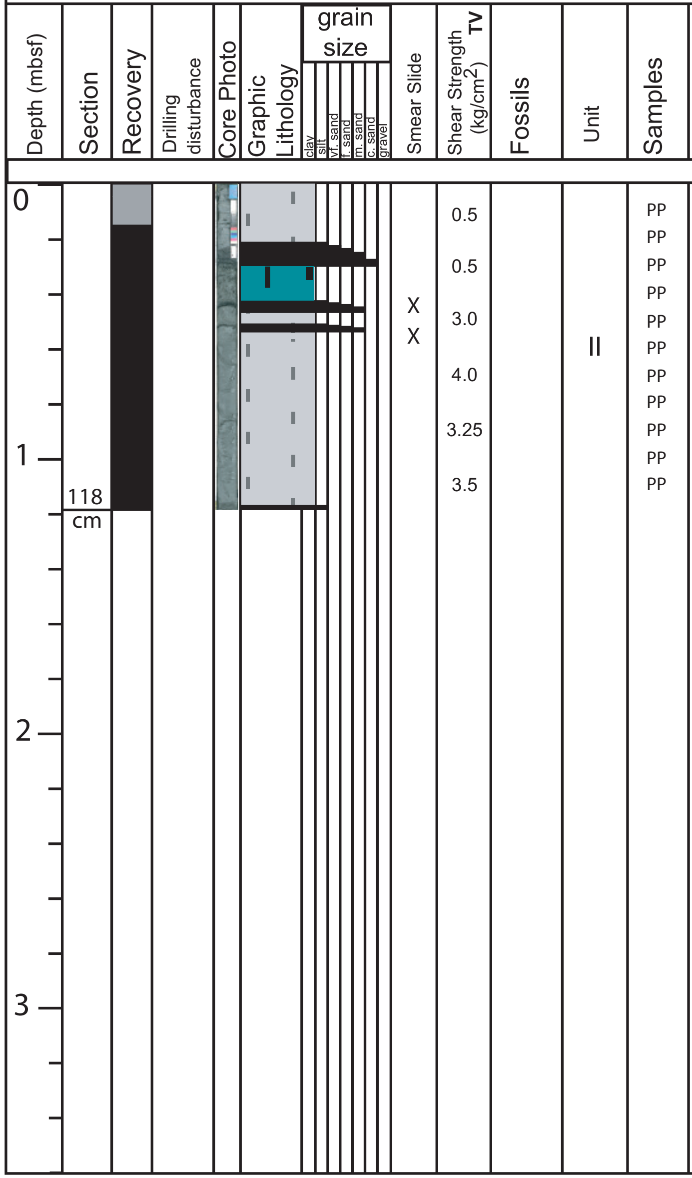
226-297.5 cm Dark Gray (GLEY 1 4/ N) Pebbly Mud, sticky, no mottling, no bioturbation, no macrofossils

- Fine to coarse, subangular to subrounded pebbles

NBP0602A Site: 8 Hole: B

Water Depth: 629m

Core Number: 31 Top 74.5 mbsf Core Type: E



Lithologic description, with color

Unit II (cont.)

0-31 cm Dark Gray (GLEY 1 4/ N) Clay with some Black (GLEY 1 2.5/ N) Sand layers, some fining upwards sequences, no mottling, no bioturbation, no macrofossils

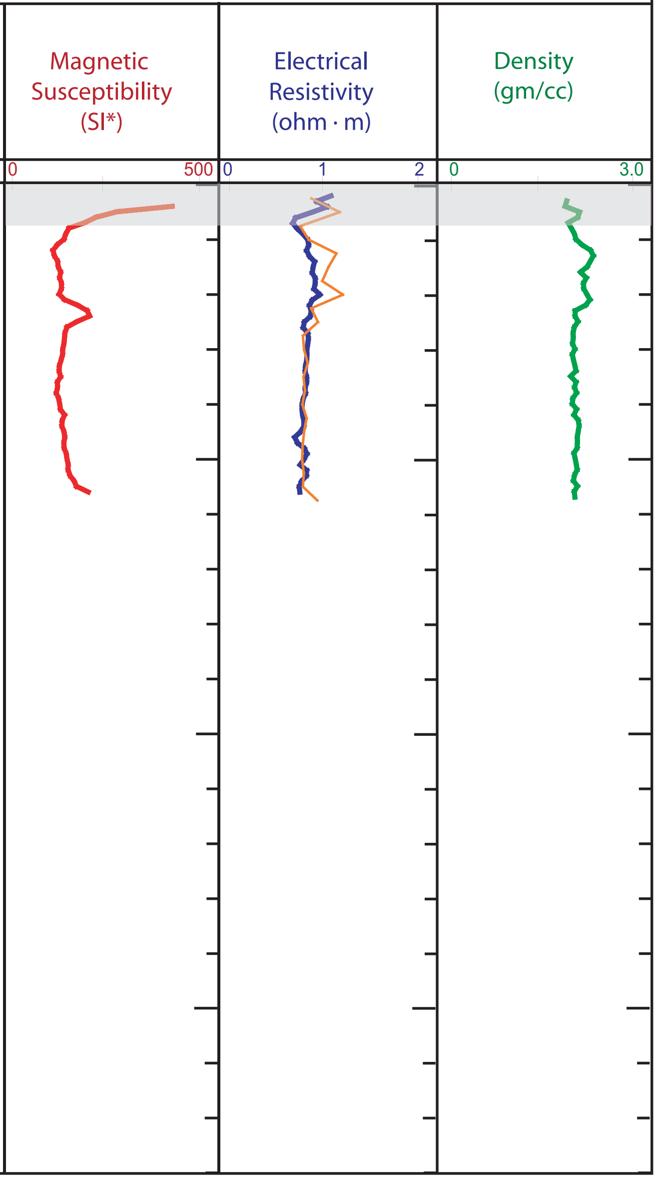
- Angular sand with a mud component

31-42 cm - Dark Gray (GLEY 1 4/ N) Sandy Mud, no mottling, no bioturbation, no macrofossils

- Coarse sand; most likely the bottom of a fining upwards sequence with a high percentage of clay

42-118 cm Dark Gray (GLEY 1 4/ N) Clay with some Black (GLEY 1 2.5/ N) Silt and Sand layers, some fining upwards sequences, no mottling, no bioturbation, no macrofossils

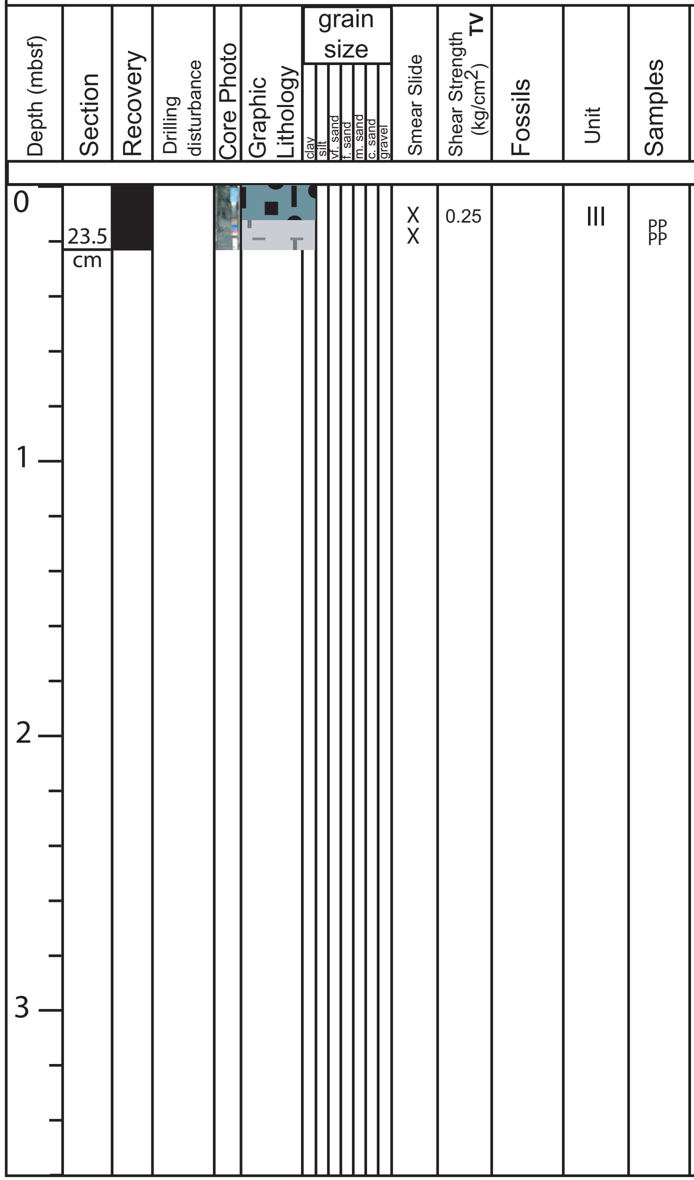
- Angular sand with a mud component



NBP0602A Site: 8 Hole: B

Water Depth: 629m

Core Number: 32 Top 76.0 mbsf Core Type: E_S



Lithologic description, with color

Unit III

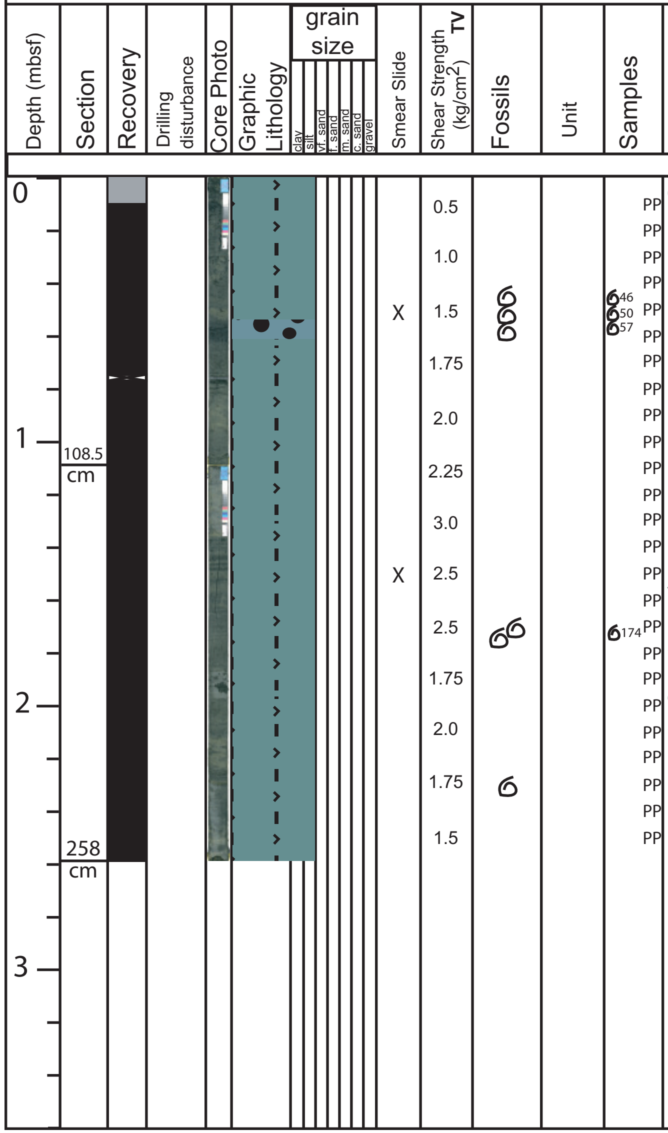
0-15 cm Dark Gray (GLEY 1 4/ N) Pebbly Sandy Clay, no mottling, no bioturbation, no layering, no macrofossils
- Abundant fine, subangular to subrounded pebbles
- Fine to medium, subangular sand

15-23.5 cm Dark Gray (GLEY 1 4/ N) Clay, no mottling, no layering, no bioturbation, no macrofossils

Magnetic Susceptibility (SI*) 0 50 100	Electrical Resistivity (ohm · m) 0 1 2	Density (gm/cc) 2,0 2,5 3,0
No Data	No Data	No Data

NBP0602A Site: 8 Hole: C Water Depth: 629m

Core Number: 1 Top 25.0 mbsf Core Type: E



Lithologic description, with color

0-54 cm - Diatomaceous Mud, moderate bioturbation, moderate mottling, color variations, upper 11 cm disturbed

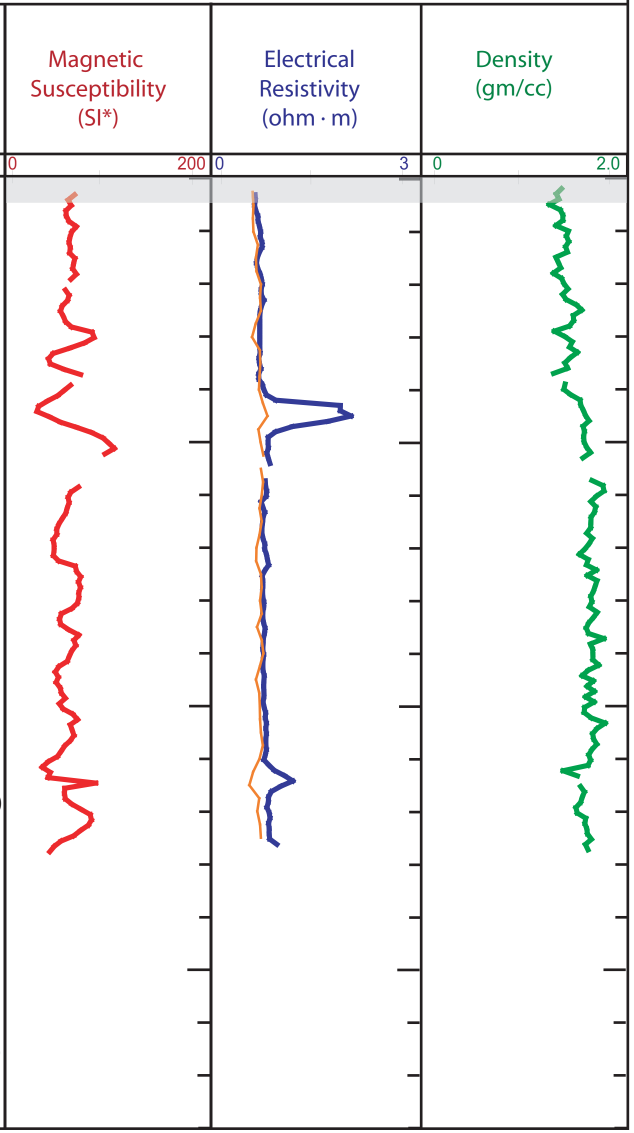
- Dark Greenish Gray (GLEY 1 4/ 5GY) to Very Dark Greenish Gray (GLEY 1 3/1 10Y) with Black (GLEY 1 2.5/ N) mottling and layers
- Mottling discontinuous and subhorizontal
- Calcareous foraminifers

54-61 cm Black (GLEY 1 2.5/ N) Pebbly Mud, organic-rich, no color variation, no mottling, highly bioturbated, abundant sponge spicules

61-258 cm Diatomaceous Mud, slight mottling, slight bioturbation, color variations

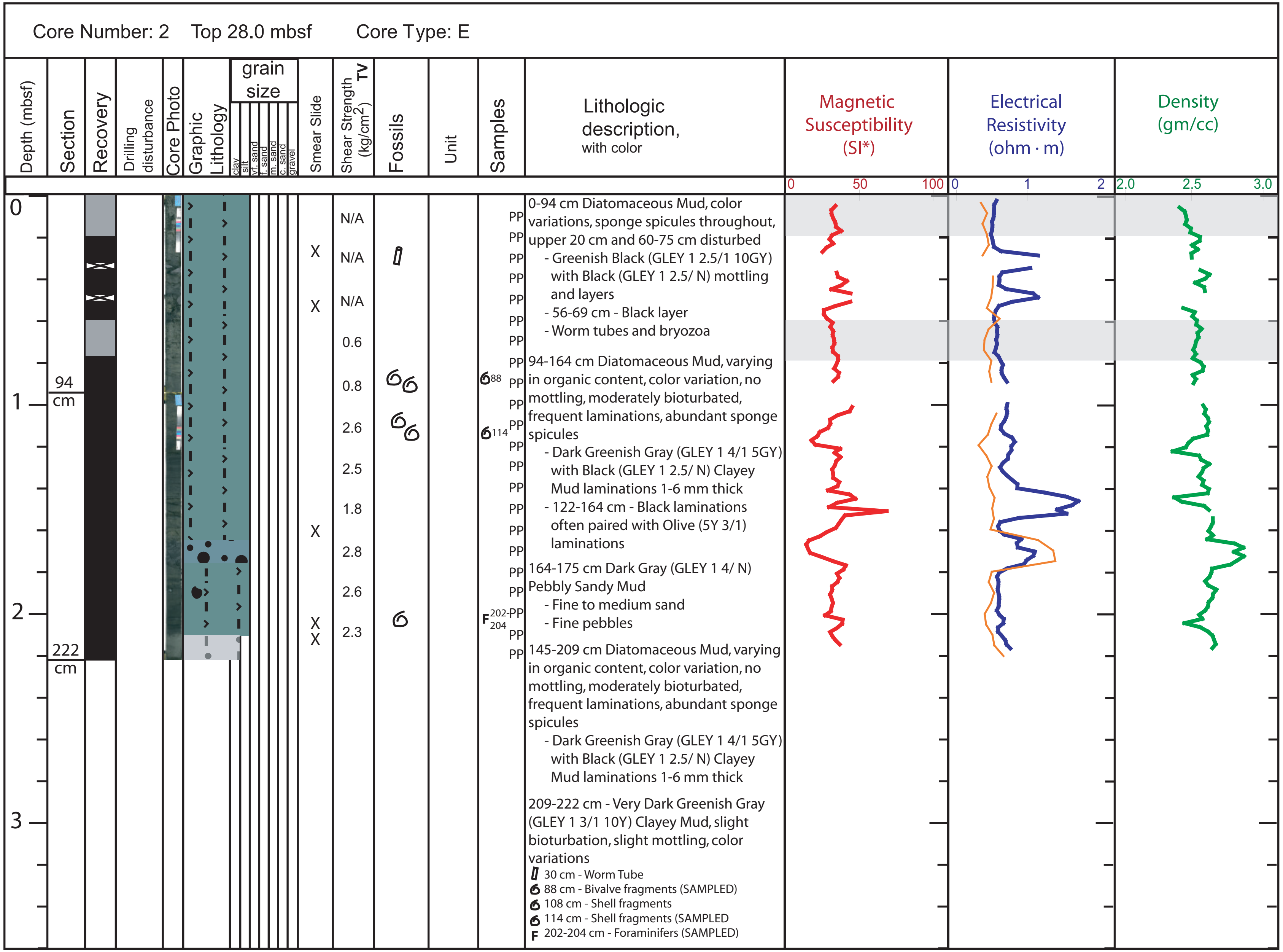
- Dark Greenish Gray (GLEY 1 4/ 5GY) with Black (GLEY 1 2.5/ N) mottling
- 230 cm - Olive (5Y 4/3) layer with irregular surface; possible soft sediment deformation

6 46 cm - Shell fragments (SAMPLED)
6 50 cm - Algal material (SAMPLED)
6 57 cm -Sea urchin frags (SAMPLED)
6 174 cm - Articulated bivalve (SAMPLED)
6 176 cm - Very samll vertibrae
6 231 cm - Shell fragments



NBP0602A Site: 8 Hole: C Water Depth: 629m

Core Number: 2 Top 28.0 mbsf Core Type: E



0-94 cm Diatomaceous Mud, color variations, sponge spicules throughout, upper 20 cm and 60-75 cm disturbed
- Greenish Black (GLEY 1 2.5/1 10GY) with Black (GLEY 1 2.5/ N) mottling and layers
- 56-69 cm - Black layer
- Worm tubes and bryozoa

94-164 cm Diatomaceous Mud, varying in organic content, color variation, no mottling, moderately bioturbated, frequent laminations, abundant sponge spicules
- Dark Greenish Gray (GLEY 1 4/1 5GY) with Black (GLEY 1 2.5/ N) Clayey Mud laminations 1-6 mm thick
- 122-164 cm - Black laminations often paired with Olive (5Y 3/1) laminations

164-175 cm Dark Gray (GLEY 1 4/ N) Pebbly Sandy Mud
- Fine to medium sand
- Fine pebbles

145-209 cm Diatomaceous Mud, varying in organic content, color variation, no mottling, moderately bioturbated, frequent laminations, abundant sponge spicules
- Dark Greenish Gray (GLEY 1 4/1 5GY) with Black (GLEY 1 2.5/ N) Clayey Mud laminations 1-6 mm thick

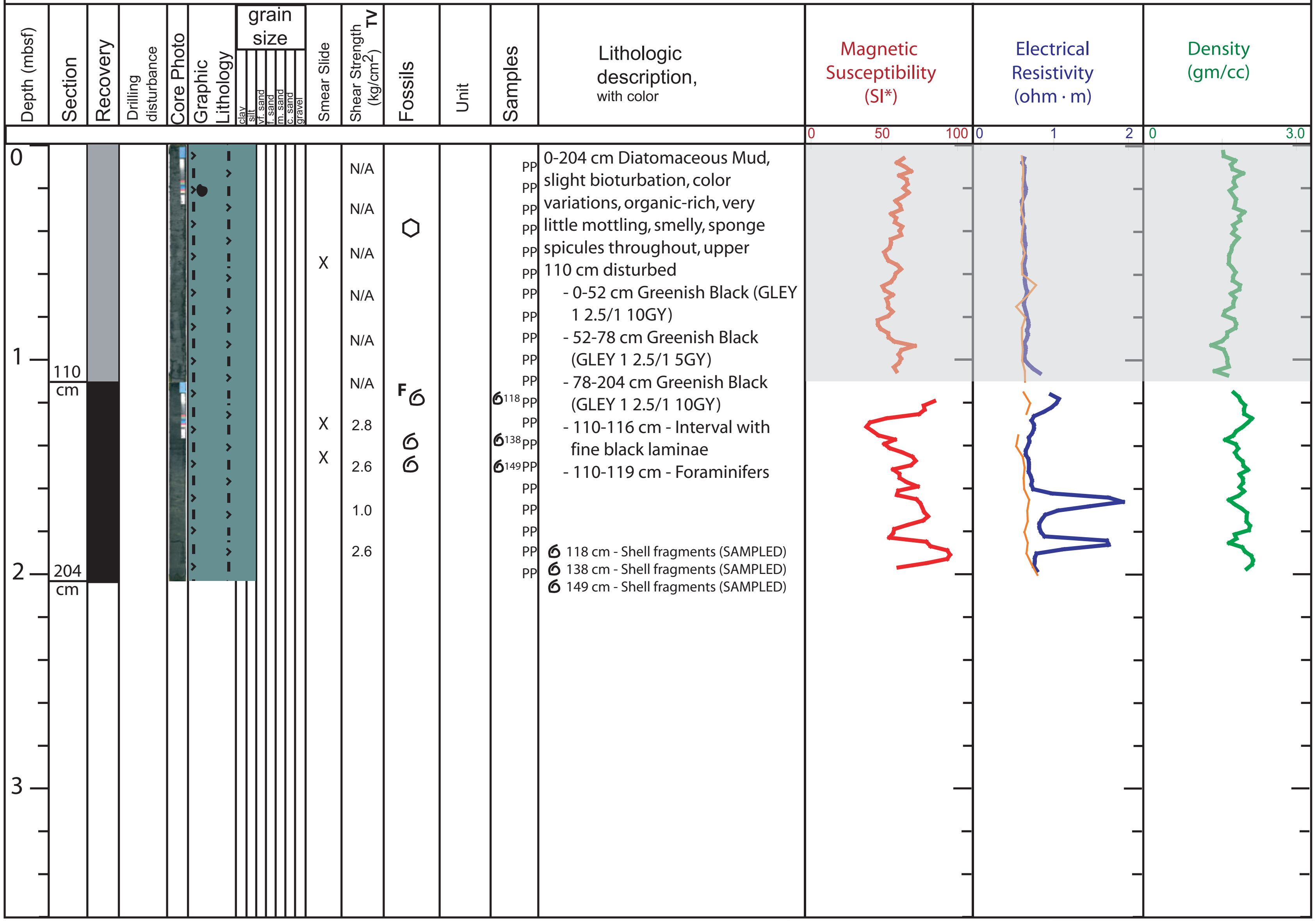
209-222 cm - Very Dark Greenish Gray (GLEY 1 3/1 10Y) Clayey Mud, slight bioturbation, slight mottling, color variations

30 cm - Worm Tube
88 cm - Bivalve fragments (SAMPLED)
108 cm - Shell fragments
114 cm - Shell fragments (SAMPLED
F 202-204 cm - Foraminifers (SAMPLED)

NBP0602A Site: 8 Hole: C

Water Depth: 629m

Core Number: 3 Top 31.0 mbsf Core Type: E



0-204 cm Diatomaceous Mud, slight bioturbation, color variations, organic-rich, very little mottling, smelly, sponge spicules throughout, upper 110 cm disturbed

- 0-52 cm Greenish Black (GLEY 1 2.5/1 10GY)
- 52-78 cm Greenish Black (GLEY 1 2.5/1 5GY)
- 78-204 cm Greenish Black (GLEY 1 2.5/1 10GY)
- 110-116 cm - Interval with fine black laminae
- 110-119 cm - Foraminifers

118 cm - Shell fragments (SAMPLED)
138 cm - Shell fragments (SAMPLED)
149 cm - Shell fragments (SAMPLED)

CHAPTER 7: SITES 9 and 10
Table of Contents

HOLE NBP0602A-9A

Date/time occupied (date; Julian Day; GMT): 26 March 2006; 085; 1100

Date/time departed: 26 March 2006; 085; 1430

Time on station: 3 hrs, 30 min

Geographic area: Northern James Ross Basin

Ice coverage during station: $^{5}/_{10}$ to $^{6}/_{10}$

Position: 64° 10.313' S, 55° 56.425' W

Water depth (multibeam, m): 396

Water depth (drill-pipe measurement from sea level, m): 396

Total penetration (m): 4.23

Number of drill runs: 1

Total length of cored section (m): 4.23 (washed)

Total drill core recovered (m): 1.96

Drill-core recovery (%): 46.3

Oldest sediment drilled:
 Depth sub-bottom (m): 4.23 (washed)
 Nature: Sandy mud
 Age: Late Pleistocene

HOLE NBP0602A-9B

Date/time occupied (date; Julian Day; GMT): 26 March 2006; 085; 1430

Date/time departed: 26 March 2006; 085; 2200

Time on station: 7 hrs, 30 min

Geographic area: Northern James Ross Basin

Ice coverage during station: $^{4}/_{10}$ to $^{8}/_{10}$

Position: 64° 10.437' S, 55° 56.565' W

Water depth (multibeam, m): 391

Water depth (drill-pipe measurement from sea level, m): 395

Total penetration (m): 10

Number of drill runs: 3

Total length of cored section (m): 5.5

Total drill core recovered (m): 3.75

Drill-core recovery (%): 68

Oldest sediment drilled:
Depth sub-bottom (m): 10
Nature: Mud
Age: Late Pleistocene

Principal Results: After voluntarily leaving Site NBP0602A-8, we sought once again to drill our primary objectives associated with the Seymour Island transect. Site NBP0602A-4 was covered by ice, and an attempt to run pipe in the vicinity of Proposed Site JRB3 was terminated by an iceberg. Proposed Site JRB2 was also occluded by ice, but between Proposed Sites JRB1 and JRB2 an enticingly wide opening was found just east of a large (5-mile long) tabular iceberg, where Hole NBP0602A-9A was spudded in hopes of reaching lower Oligocene strata. The alien bit washed to 4.23 mbsf within an hour, a drilling rate twice that achieved through similar compacted till at nearby SHALDRIL I Site NBP0502-3 the previous April. A large floe of multiyear sea ice that forced the ship to offset about $^1/_6$ of a nautical mile ended the hole.

Hole NBP0602A-9B was then drilled to 10 mbsf, resulting in 45% and 96% recovery during the last two of the three total core runs through upper Pleistocene glaciomarine mud. Unfortunately before drilling could progress further the ice started moving rapidly with the currents, forcing abandonment of the hole. Hole 9B is divided into two lithologic units. Lithologic Unit I extends from 0-7.5 mbsf and consists of pebbly, sandy mud. Lithologic Unit II extends from 7.5 mbsf to the bottom of the hole (10.0 mbsf) and consists of pebbly, silty mud. Both units are poorly sorted and contain abundant pebbles of mixed lithologies. Rare, poorly preserved diatoms consist of extant species that range back to the Pliocene; however, the absence of *Rouxia spp.* suggests the sediments are late Pleistocene in age.

Sedimentary rip-up clasts are common within the tills of both holes, and some yielded common, moderately to well-preserved calcareous nannofossils of latest

Cretaceous (Maastrichtian) age. Containing up to a dozen taxa, the assemblages are the most diverse and richest of this age known to date from similar lithologies along the northern Antarctic Peninsula.

HOLE NBP0602A-10A

Date/time occupied (date; Julian Day; GMT): 27 March 2006; 086; 2200

Date/time departed: 28 March 2006; 087; 1800

Time on station: 8 hr

Geographic area: Northern James Ross Basin

Ice coverage during station: $^{1}/_{10}$ to $^{4}/_{10}$

Position: 64° 05.190' S, 55° 58.830' W

Water depth (multibeam, m): 373

Water depth (drill-pipe measurement from sea level, m): 376

Total penetration (m): 3

Number of drill runs: 1

Total length of cored section (m): 3 (washed)

Total drill core recovered (m): 0

Drill-core recovery (%): 0

Oldest sediment drilled: N/A

Principal Results: After abandoning Site NBP0602A-9 due to ice, we began a circumnavigation of the large tabular iceberg nearby, searching for “keel water” that might provide a respite for drilling, whereby the large iceberg would “run interference” for us against pack ice and smaller icebergs. Accordingly, Hole NBP0602A-10A was spudded in relatively open water to the east of the tabular iceberg, but the hole was aborted by thick brash ice moving with the wind after the non-coring bit had penetrated to only 3 mbsf. We then tried to run pipe at the south end of the tabular iceberg, but that effort ended when the iceberg began to move rapidly to the north, leaving the ship exposed to thick brash ice moving with the wind from the north, as well as to more ice moving perpendicular to the wind from the west, creating an untenable situation. As a similar rapid movement of the ice in various directions had occurred in this area at about the same time the day before, currents under the influence of changing tides may have been responsible. Thus, it appears that the drilling process takes too much time to benefit from the "keel waters" of non-grounded icebergs in areas of shifting tides. We also found that the non-coring bit drilled no faster in tills than the alien bit, while the latter can also recover core even when washing down.

SEISMIC STRATIGRAPHY

(See "**Seismic Stratigraphy**" Ch. 3, Sites 1 and 2, p. 93)

SITE 9

A. OBJECTIVES

Site NBP0602A-9 (Fig. 7-1) intended to sample lower Oligocene strata situated above the uppermost Eocene to lower Oligocene strata sampled at Site NBP0602A-3. The site targeted an acoustically laminated interval located between Proposed Sites JRB1 and JRB2. Neither hole reached the targeted interval.

B. OPERATIONS

Site NBP0602A-9 includes two drill holes. NBP0602A-9A is located at 64° 10.313' S, 55° 56.425' W in 396 m of water, and NBP0602A-9B is located at 64° 10.437' S, 55° 56.565' W in 391 m of water.

Hole NBP0602A-9A was drilled to a total depth of 4.23 mbsf using the alien bit (Table 7-1). The section was drilled as an open hole since the target interval was at about 20 mbsf. Despite this, nearly 2 m of core was obtained in the single core run completed. The hole was terminated after the first core run due to ice. Penetration through the overburden at this site averaged around 4 m/hour.

Hole NBP0602A-9B reached a total depth of 10.0 mbsf in three runs using the alien bit (Table 7-1). The first core run did not attempt to sample but still returned nearly 2 m of the overburden. The next two core runs accomplished 45% and 96% recovery. The hole was terminated due to ice at 10 mbsf after the third core run. The time to reach 10 mbsf was about 5.5 hours, although the speed in the upper portion of the hole was greater than the speed in the lower portion.

This site was the first test during 2006 of drilling through the stiff overburden that was problematic during 2005. Overall, a penetration rate of about 2 m/hour was achieved, about twice that of 2005. In this sense, the site is considered a success since it demonstrated the superiority of the SHALDRIL coring tools used this year.

C. LITHOSTRATIGRAPHY

Site NBP0602A-9 consists of two drill holes. Hole NBP0602A-9A was abandoned because of ice after drilling from 0-4.23 mbsf, retrieving one washed core (Fig. 7-2). The core consists of very dark gray (5Y 3/1) pebbly, sandy mud. The mud matrix is very clay rich. Both Torvane measurements and physical inspection show the core to be very stiff; shear strength measurements are between 10-17.5 kg/cm^2. The sand and pebbles are very poorly sorted, angular to subangular, and consist of basalts, quartzites, and sedimentary clasts (siltstones and sandstones). The sedimentary clasts are poorly indurated. Smear-slide analysis of the <250 µm fraction (Table 7-2) shows the sediment consists of mud and sandy mud. Clay comprises ~50% of the sediment, quartz 18-20%, and feldspar 10-12%. Calcite and heavy minerals occur in minor amounts (5%), as does mica (2-3%). Trace amounts of glauconite, hornblende, hematite, and volcanic glass also occur. Biogenic components include 3-5% diatoms and trace numbers of sponge spicules. Many of the larger quartz and feldspar grains are coated with clay.

Hole NBP0602A-9B is offset from the first hole by about 200 m. The hole reached a total depth of 10.0 mbsf. This hole was divided into two lithologic units (Fig. 7-3; Appendix 7-1). Lithologic Unit I (0-7.5 mbsf) consists of very dark gray (5Y 3/1) pebbly sandy mud, the same lithology recovered in Hole NBP0602A-9A. The sediment is clay rich and poorly sorted, with very fine to very coarse pebbles abundant. Smear-slide analysis of the <250 µm fraction (Table 7-2) is similar to that from Hole 9A. The sediment is mud and sandy mud, consisting primarily of clay (51-65%), quartz (15%), and feldpsar (10-12%), with lesser amounts of calcite (2-5%), heavy minerals (3-7%), and diatoms (3-5%). Analysis of a sedimentary clast from this unit yielded a similar lithology (sandy mud), no diatoms, and trace numbers of reworked Cretaceous calcareous nannofossils.

Lithologic Unit II (7.5-10.0 mbsf) is very dark greenish gray (GLEY 1 3/1 10Y) pebbly silty mud. The sediment is very stiff and poorly sorted, with an abundance of pebbles (similar to Unit I). Pebbles consist mostly of volcanic rocks, quartzites, and poorly indurated sedimentary clasts (siltstones and sandstones). Sedimentary clasts occur in the upper portion of Unit II (7.5-8.7 mbsf), but are not present in the lower portion of the core from 8.7-10.0 mbsf. Smear-slide analysis of the <250 µm fraction (Table 7-2) shows Unit II consists of mud. The mineral compositions are similar to Unit I, with clay the predominant mineral (62%), and lesser amounts of quartz (16%), feldspar (10-12%), and heavy minerals (7-10%). Calcite (1%) and diatoms (1%) are less abundant than in Unit I, while glauconite, hematite, hornblende, and sponge spicules mostly occur sporadically in trace amounts.

D. BIOSTRATIGRAPHY

Initial shipboard paleontological work for Site NBP0602A-9 included smear-slide examination of diatom and calcareous nannofossil assemblages. Observed diatom and calcareous nannofossil taxa are listed in Tables 7-3 and 7-4.

Seven samples from Holes NBP0602A-9A and -9B were examined for diatoms. All samples contain rare to few, poorly preserved diatoms. Most observed taxa are extant species that range back to the late Pliocene, but the absence of *Rouxia* spp. suggests that the drilled sections are late Pleistocene in age. Very rare specimens of reworked taxa were also observed; these taxa, such as *Actinocyclus ingens* and *Denticulopsis vulgari*s, are common in Miocene to middle Pleistocene sediments of the Southern Ocean and are often observed as reworked specimens in younger strata.

Numerous sedimentary clasts, interpreted as rip-up clasts, were identified in the glaciomarine muds of Holes NBP0602A-9A and -9B. Several of these clasts were examined for diatoms, but all samples were either barren or contained very rare fragments. The identifiable fragments were all upper Pliocene-Pleistocene taxa, such as *Thalassiosira antarctica*, and are most likely present in the samples due to contamination from the surrounding mud matrix.

Two clasts from Core NBP0602A-9A-1R_a were examined for calcareous nannofossils (Table 7-4). Both samples contain common (1 specimen/2-10 fields of view), moderately to well-preserved calcareous nannofossils, although many are fragmented. The assemblage consists of typical Late Cretaceous species, including *Biscutum constans*, *Eiffellithus turriseiffelii*, *Cyclagelosphaera margerelii*, *Prediscosphaera* spp., *Cribrosphaerella* spp., and *Arkhangelskiella* spp. Several species typical of Maastrichtian high-latitude deposits also occur, including *Biscutum coronum*, *Kamptnerius magnificus*, *Nephrolithus frequens*, and *N. corystus*. The presence of *N. frequens* places the age of the material in the clasts as latest Cretaceous (Maastrichtian).

E. PHYSICAL PROPERTIES

Site NBP0602A-9 consists of two holes. Cores from Holes NBP0602A-9A and -9B had little recovery. All cores were run on the multisensor core logger (MSCL) with readings every 2 cm; the Middlebury College electrical resistivity (MCER) probe was done every 5 cm, with discrete samples taken every 10 to 20 cm.

The 1.96 m recovered in Hole NBP0602A-9A consists of a pebbly sandy mud that is most likely a lodgement till. Large peaks in magnetic susceptibility (MS) correspond to local isolated rocks or several pebbles (e.g., Lithology Log NBP0602A-9A, 20 cm and 137-157 cm). Along with the MS peaks, electrical resistivity (ER) rises and density decreases. Due to the uneven nature of the split core, MCER-ER measurements were not consistent throughout the core and those with high variance were removed; however, those remaining values match well with the MSCL-ER values.

Hole NBP0602A-9B recovered material down to 10 mbsf. Consisting of pebbly sandy to silty mud, the sediment shows large variability in MSCL measurements. Lithologic Log NBP0602A-9B-1R_a (30-60 cm) shows variability in MS, ER, and density when pebbles are present. A large basaltic pebble located at 143 cm correlates to the large MS peak in the same lithology log. Similarly, when a non-magnetic rock occurs, such as those in Lithology Log NBP0602A-9B-3R_a (50 and 90 cm), the MS values are near zero.

F. SITE SUMMARY

After an attempt to run pipe in the area of Proposed Site JRB3 was terminated by ice, an opening between Proposed Sites JRB1 and JRB2 was selected for Site

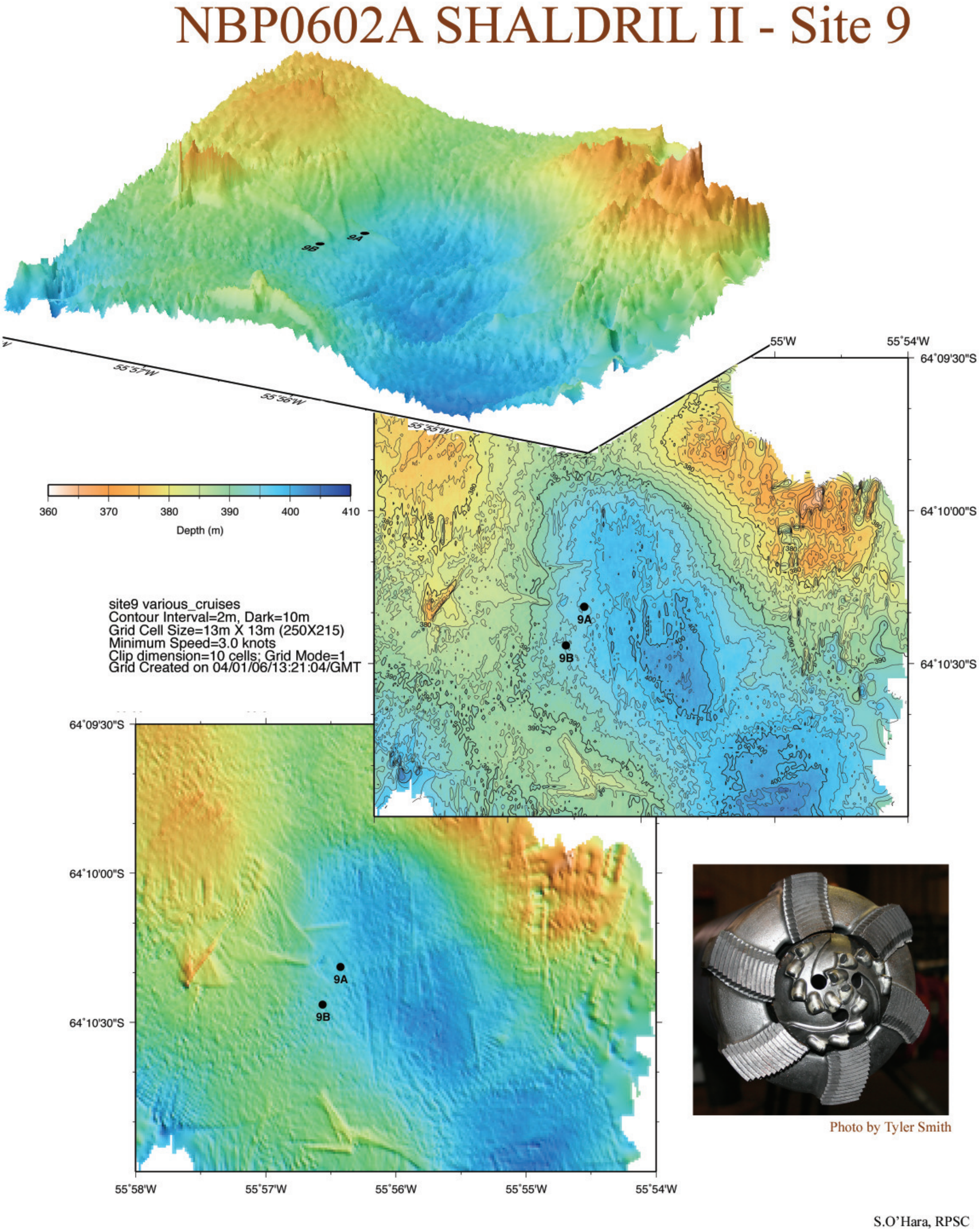
NBP0602A-9. The objective of this site was to sample lower Oligocene strata. The alien bit washed to 4.23 mbsf within an hour, a drilling rate twice that achieved through similar compacted till at nearby SHALDRIL I Site NBP0502-3 the previous April. The hole recovered 2 m of upper-Pleistocene, glaciomarine sandy mud. The attempt was ended by a large floe of multiyear sea ice that forced the ship to offset $^1/_6$ of a nautical mile with the pipe suspended about 20 m above the bottom.

Hole NBP0602A-9B was then drilled to 10 mbsf in three core runs, with the alien bit providing 45% and 96% recovery in the last two cores through upper Pleistocene, glaciomarine mud. After the third core run the ice started moving rapidly against the 15-kn wind with thick pack ice moving up from the south, forcing abandonment of the hole. Sediment from this hole is divided into two lithologic units:

Lithologic Unit I (0-7.5 mbsf) consists of pebbly, sandy mud that is poorly sorted and clay rich, and it contains abundant pebbles and sedimentary clasts.
Lithologic Unit II (7.5-10 mbsf) is pebbly, silty mud that is otherwise similar to Unit I.

Both Holes NBP0602A-9A and -9B yielded rare to few, poorly preserved diatoms. Discounting reworked Miocene to middle Pleistocene taxa, the age assigned is late Pleistocene. Sedimentary rip-up clasts are common within the till. One gritty gray clast contained little quartz or calcite but rather near-isotropic grains considered to be zeolite, which would indicate a volcanic parent material. Two brownish clasts yielded common, moderately to well-preserved calcareous nannofossils of latest Cretaceous (Maastrichtian) age, including the austral high-latitude index taxa *Nephrolithus frequens, N. corystus,* and *Biscutum coronum*. The clasts are believed to have been derived from fossiliferous Mesozoic strata from nearby localities along the northern Antarctic Peninsula as represented by those described on Seymour and James Ross Islands. Containing up to a dozen taxa, however, the clasts examined represent the most diverse and richest Maastrichatian nannoflora known to date from similar lithologies in this region.

Figure 7-1. Multibeam images of Site NBP0602A-9.



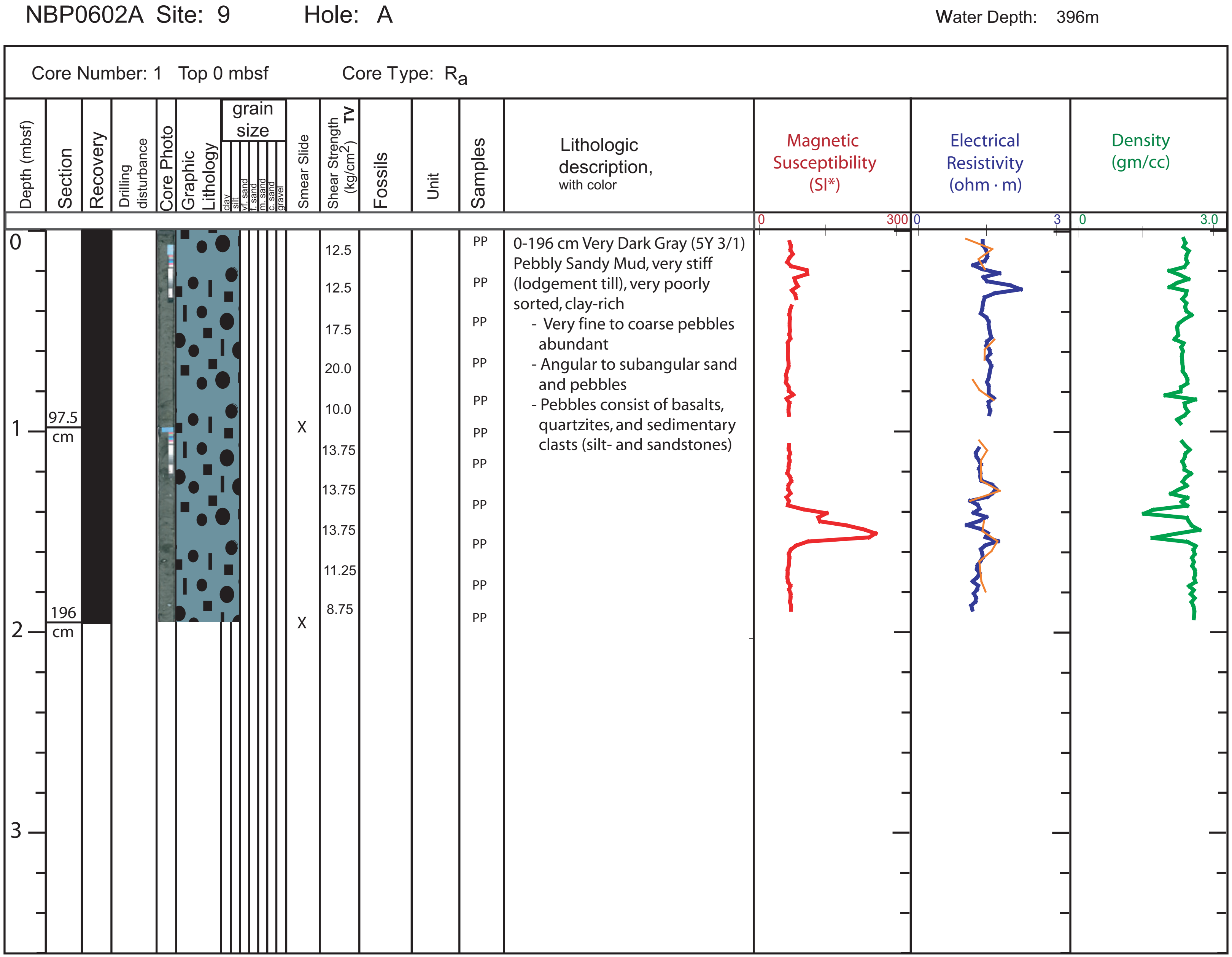
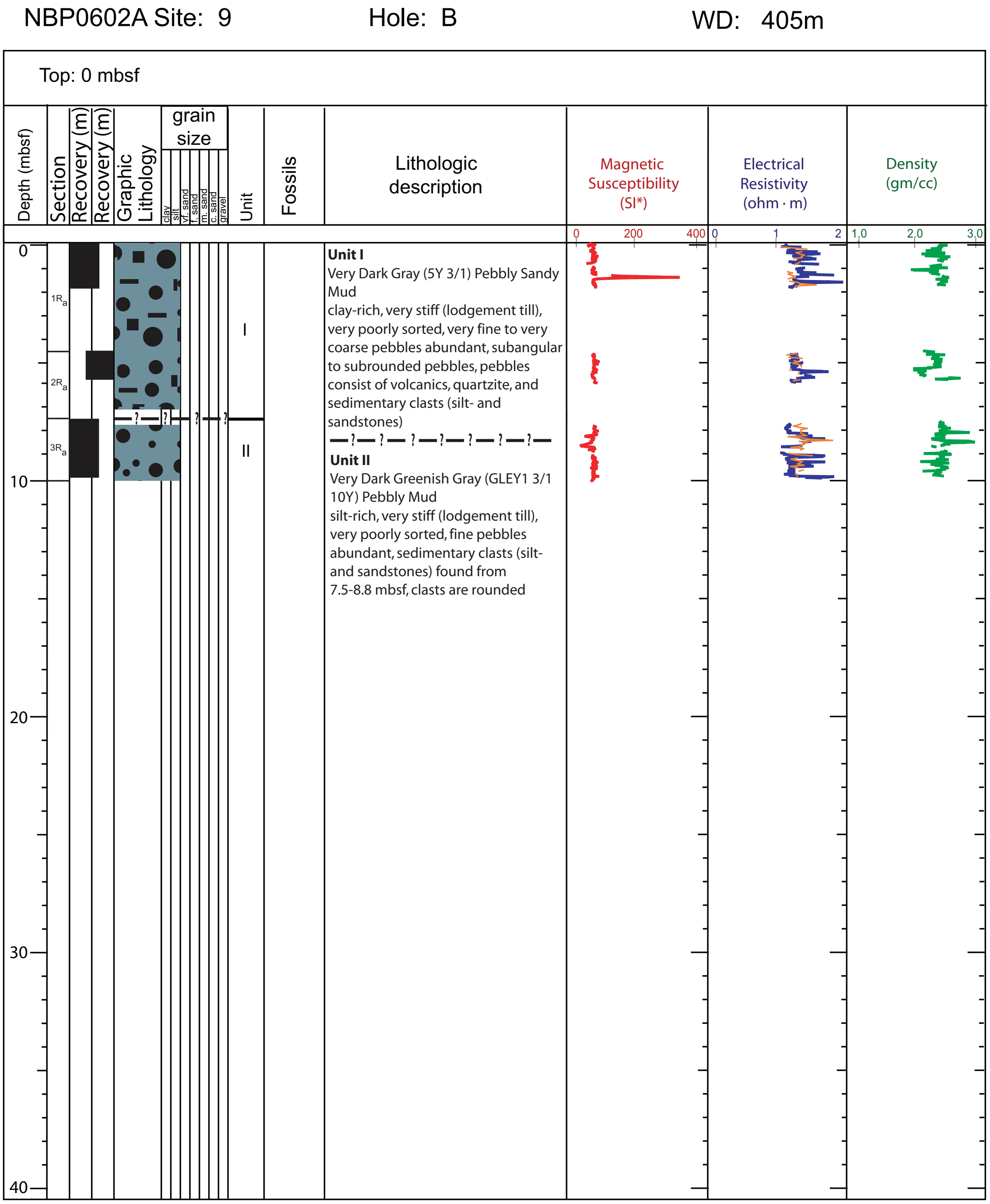


Figure 7-2. Lithologic log for Hole NBP0602A-9A.

Figure 7-3. Summary lithologic log of Hole NBP0602A-9B.



Unit I
Very Dark Gray (5Y 3/1) Pebbly Sandy Mud
clay-rich, very stiff (lodgement till), very poorly sorted, very fine to very coarse pebbles abundant, subangular to subrounded pebbles, pebbles consist of volcanics, quartzite, and sedimentary clasts (silt- and sandstones)

—?—?—?—?—?—?—

Unit II
Very Dark Greenish Gray (GLEY1 3/1 10Y) Pebbly Mud
silt-rich, very stiff (lodgement till), very poorly sorted, fine pebbles abundant, sedimentary clasts (silt- and sandstones) found from 7.5-8.8 mbsf, clasts are rounded

Table 7-1. Drilling and coring recovery log for Holes NBP0602A-9A and -9B.

NBP06-02A SHALDRIL II Site 9 (Seymour Island)

Multibeam Water Depth: 396 at A; 391 at B

Station Number/Hole	Core Number	Core Type	Top (mbsf)	Bottom (mbsf)	Interval Cored (m)	"Push Distance" (m)	Recovery: total (m)	Recovery: competent (m)	Recovery: disturbed (m)	Gaps (m)	Recovery Corrected (m)	Total Recovery (%)	Recovery Corrected (%)	Section Number	Section Lengths (cm)	Date (JD)	Time on Deck (GMT)	Initials	Comments
9A	1	Ra-w	0.0	4.23	0-4.23	4.23	1.96	1.96	0	0	1.96	46.3%	46.3%	1	97.5	85	1500	CD	
9A	1	Ra-w												2	98.5	85	1500	CD	Leaving hole due to ice; Will offset by 20 m
9B	1	Ra-w	0.0	4.5	0-4.5	3.0	1.86	1.86	0	0	1.86	62.0%	62.0%	1	91.0	85	1753	CD	
9B	1	Ra-w												2	95.0	85	1753	CD	
9B	2	Ra	4.5	7.5	4.5-7.5	3.0	1.35	1.35	0	0	1.35	45.0%	45.0%	1	135	85	1941	CD	Rock in core catcher
9B	3	Ra	7.5	10.0	7.5-10.0	2.5	2.40	2.40	0	0	2.40	96.0%	96.0%	1	120	85	2239	CD	
9B	3	Ra												2	120	85	2239	CD	EOH--hole terminated due to ice

Table 7-2. Smear-slide data for Holes NBP0602A-9A and -9B.

		Components														Grain Size						
		Minerals										Biogenic			Rock							
Sample	**Approximate Depth (mbsf)**	Calcite	Clay	Feldspar	Glauconite	Heavy Minerals	Hematite	Hornblende	Mica	Quartz	Volcanic Glass	Calcareous Nannofossils	Diatoms	Sponge Spicules	Fragments	Sand	Silt	Clay	Sorting	Roundness	**Lithology**	**Comments**
Hole 9A																						
NBP0602A-9A-1R$_{a\text{-}w}$, 97.5 cm	(.975-4.23)	5	55	12	tr	5	tr	tr	2	18	tr		3	tr		10	33	57	P	sa-sr	Mud	Coated grains; diatoms fragmented
NBP0602A-9A-1R$_{a\text{-}w}$, 196 cm	(1.96-4.23)	5	52	10	tr	5	tr	tr	3	20			5	tr		15	30	55	P	sa-sr	Sandy mud	Coated grains; diatoms fragmented
Hole 9B																						
NBP0602A-9B-1R$_{a\text{-}w}$, 91 cm	(0.91-4.5)	2	65	10	tr	3	tr	tr	2	15			3	tr		7	25	68	P	sr	Mud	Diatoms fragmented
NBP0602A-9B-2R$_a$, 10 cm	4.6	5	51	15	tr	7	tr	tr	2	15		tr	5	tr		15	31	54	P	a-sr	Sandy mud	Diatoms fragmented
NBP06-02A-9B-2R$_a$, 107 cm	5.57	1	65	13	1	3	tr			17		tr				15	20	65	P	a-sr	Sandy mud	Rip-up clast
NBP06-02A-9B-3R$_a$, 10 cm	7.6	1	62	10	tr	10				16			1	tr		12	25	63	P	a-sr	Mud	
NBP06-02A-9B-3R$_a$, 130 cm	8.8	1	62	12	1	7	tr	tr		16			1	tr		7	30	63	P	a-sr	Mud	

Notes: Sample: R$_a$ = cored using alien coring bit; R$_{a\text{-}w}$ = wash cored using alien coring bit; Components/Grain Size: Numbers represent percentages, tr = trace; Sorting: P = poor; Roundness: a = angular, sa = subangular, sr = subrounded.

Table 7-3. Stratigraphic occurrence and relative abundance of diatom taxa in Holes NBP0602A-9A and -9B.

Cruise/Hole/Core/Interval	Depth (mbsf)	Slide Preparation	Diatom Abundance	Preservation	Fragmentation	Diatoms																						
						Actinocyclus actinochilus	*Actinocyclus ingens*	*Chaetoceros* spp. (small veg. cells & resting spores)	*Cocconeis* spp. (several taxa)	*Coscinodiscus* spp.	*Dactyliosolen antarcticus* (girdle bands)	*Denticulopsis simonsenii / vulgaris*	*Eucampia antarctica* var. *antarctica*	*Eucampia antarctica* var. *recta*	*Fragilariopsis curta*	*Fragilariopsis kerguelensis*	*Fragilariopsis obliquecostata*	*Nitzschia* spp.	*Porosira* spp.	*Radialiplicata clavigera*	*Rhizosolenia* spp.	*Stellarima microtrias*	*Thalassionema nitzschioides*	*Thalassiosira antarctica* var. *antarctica*	*Thal. gracilis* var. *gracilis / expecta*	*Thalassiosira oliverana*	*Thalassiothrix/Trichotoxon* spp.	*Trinacria excavata* group
Hole 9A																												
NBP0602A-9A-1R$_{a-w}$, 98 cm	0.98	smear	R	P	H	fr(X)		R	X	fr(X)			X	X								fr(X)		R				
NBP0602A-9A-1R$_{a-w}$, 194 cm	1.94	smear	F	P	H	fr(R)		F	X	fr(X)	X		X	R			fr(X)							F		X	fr(X)	fr(X)
NBP0602A-9A-1R$_{a-w}$-CC	1.96	smear	F	P	H	fr(R)		F	R	fr(X)				R		X	fr(X)				X	R		F			fr(X)	
Hole 9B																												
NBP0602A-9B-1R$_{a-w}$, 91 cm	0.91	smear	R-F	P	H	fr(X)	fr(X)	F	R	fr(X)			X	X	X			fr(X)			X			F			fr(X)	
NBP0602A-9B-1R$_{a-w}$-CC	1.86	smear	R-F	P	H	fr(X)		F	X	fr(X)		fr(X)		fr(X)			fr(X)						fr(X)	fr(F)			fr(X)	
NBP0602A-9B-2R$_{a}$-CC	5.85	smear	R	P	H	fr(R)		F	X	fr(X)		fr(X)		X					fr(X)	fr(X)			fr(X)	F	X		fr(X)	
NBP0602A-9B-3R$_{a}$-CC	9.40	smear	R	P	H	fr(R)		F	X	fr(X)				R	X	X	fr(X)				X	X		F			R	

Notes: Abundance: F = few, R = rare, X = present, fr = fragment; Preservation: P = poor; Fragmentation: H = high.

Table 7-4. Occurrence and relative abundance of calcareous nannofossil taxa in sedimentary clasts from Hole NBP0602A-9A.

			Reworked Cretaceous Calcareous Nannofossils													
Cruise/Hole/Core/Interval	**Abundance**	**Preservation**	*Arkhangelskiella* spp.	*Biscutum constans*	*Biscutum coronum*	*Braarudosphaera* spp.	*Cribrosphaerella daniae* (?)	*Cribrosphaerella ehrenbergii*	*Cyclagelosphaera margerelii*	*Eiffellithus turriseiffelii*	*Kamptnerius magnificus*	*Loxolithus* spp.	*Nephrolithus corystus*	*Nephrolithus frequens*	*Prediscosphaera* spp.	*Thoracosphaera* spp.
Hole 9A																
NBP0602A-9A-1R$_{a\text{-}w}$, 2nd clast	C	P-M		F	?		F		X	C	F			F	X	F
NBP0602A-9A-1R$_{a\text{-}w}$, 3rd clast	C	M-G	F	F		X		F		F	F	X	R		F	X

Notes: Abundance: C = common, F = few, R = rare, X = present, ? = questionable; Preservation: G = good, M = moderate, P = poor.

SITE 10

A. OBJECTIVES

Site NBP0602A-10 (Fig. 7-4) was slightly offset from Site NBP0602A-9 but targeted the same stratigraphic interval. This hole did not reach the target strata.

B. OPERATIONS

Site NBP0602A-10A was drilled at 64° 05.190' S, 55° 58.830' W in 373 m of water. Its location is close to that of Site NBP0602A-9, and it encountered similar stiff overburden. In order to try to achieve a faster penetration rate, the hole was begun using the non-coring bit. A total depth of 3.0 mbsf was reached in 46 minutes of drilling before the hole was abandoned due to ice (Table 7-5). While the non-coring bit did penetrate the stiff overburden successfully, the speed at which it made the hole was at best equal, if not slower, than the speed at which the alien bit drilled. Thus, it was decided that if given the opportunity to drill this material again, the alien bit will continue to be the preferred method since it is at least as fast and returns some material.

F. SITE SUMMARY

After abandoning Site NBP0602A-9, we began a circumnavigation of a large tabular iceberg, searching for “keel water” that might provide a respite for drilling, wherein the large iceberg would run interference for us against the pack ice and smaller icebergs. With the tabular iceberg moving slowly northwards against the wind, we began to run pipe in relatively open water to the east, but thick brash ice moving with the wind aborted Hole NBP0602A-10A after the non-coring bit had penetrated to only 3 mbsf.

With the pipe still suspended above the mudline, we then sought to move into the lee of the large tabular iceberg on its south end, but finally had to pull the pipe onboard to do so since our forward progress of about 1 kn through the water was too slow to outpace sea ice moving down from the north. Once repositioned off the south end of the iceberg, whose position appeared to be stable, pipe was run toward the mudline. The tabular iceberg then began to move rapidly to the north, leaving the ship exposed to thick brash ice moving with the wind from the north, as well as to more ice moving perpendicular to the wind from the west. Thus ended our attempt to use keel water from a non-grounded iceberg to facilitate drilling. Although this technique has been highly successful for shorter-term operations elsewhere such as taking CTD casts, drilling operations require too much time for this to be practical in most circumstances. We also found that the non-coring bit took longer to drill ahead in tills than the alien bit, which can also recover core even when washing down.

Figure 7-4. Multibeam images of Site NBP0602A-10.

NBP0602A SHALDRIL II - Site 10

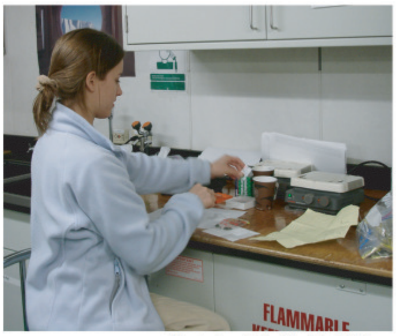
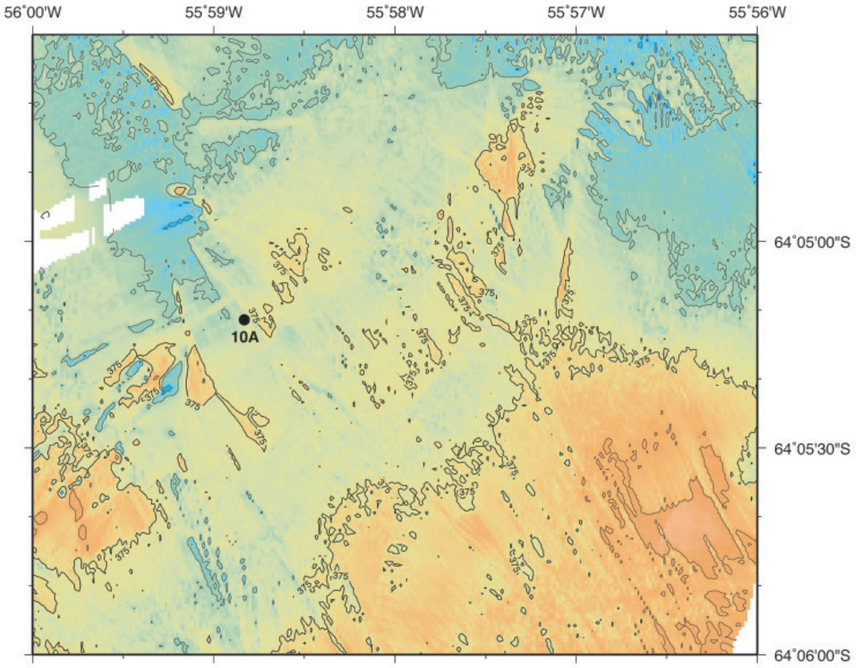
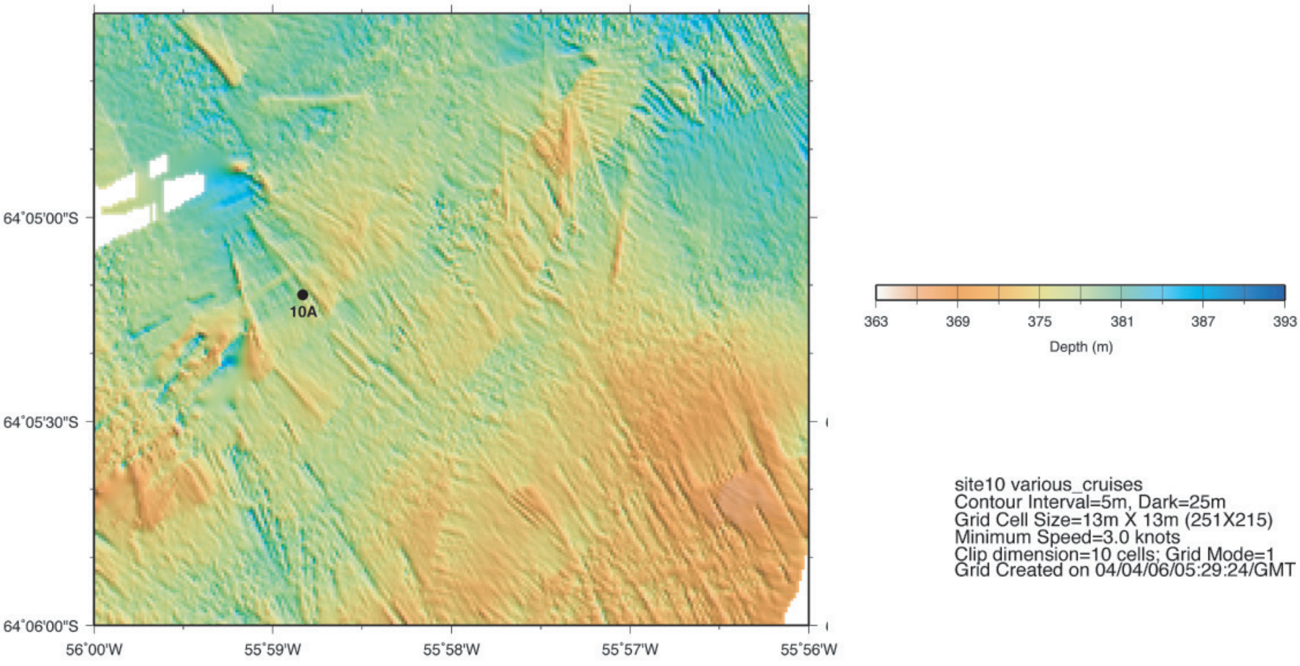


Photo by Julia Smith Wellner





site10 various_cruises
Contour Interval=5m, Dark=25m
Grid Cell Size=13m X 13m (251X215)
Minimum Speed=3.0 knots
Clip dimension=10 cells; Grid Mode=1
Grid Created on 04/04/06/05:29:24/GMT

S.O'Hara, RPSC

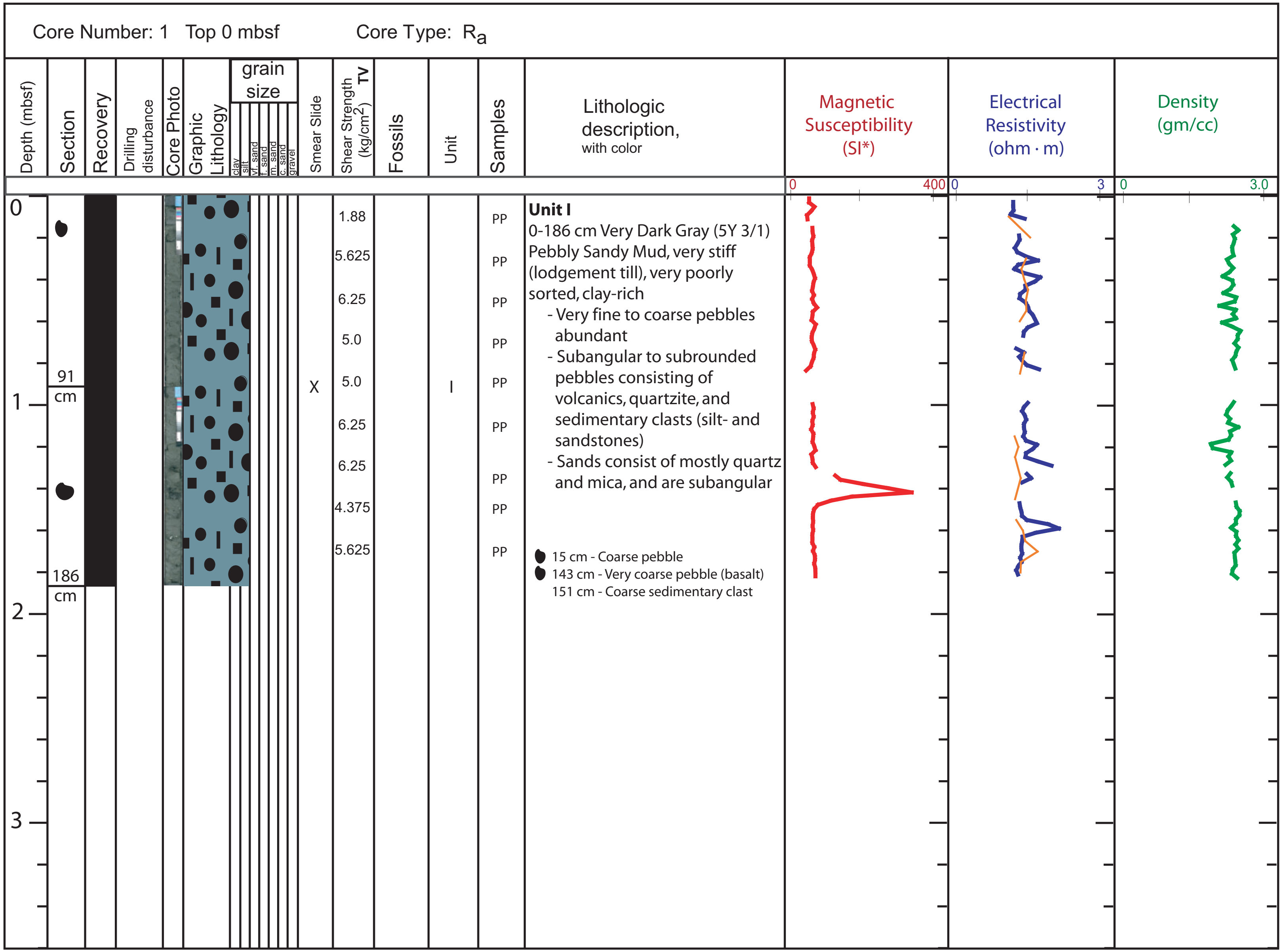
Table 7-5. Drilling and coring recovery log for Site NBP0602A-10.

NBP0602A SHALDRIL II Site 10 (Seymour Island)
Multibeam Water Depth: 373 m

Station Number/Hole	Core Number	Core Type	Top (mbsf)	Bottom (mbsf)	Interval Cored (m)	"Push Distance" (m)	Recovery: total (m)	Recovery: competent (m)	Recovery: disturbed (m)	Gaps (m)	Recovery Corrected (m)	Total Recovery (%)	Recovery Corrected (%)	Section Number	Section Lengths (cm)	Date (JD)	Time on Deck (GMT)	Initials	Comments
10A		Rn	0.0	3.00															hole terminated due to ice; no recovery

NBP0602A Site: 9 Hole: B Water Depth: 391m

Core Number: 1 Top 0 mbsf Core Type: R_a



Unit I

0-186 cm Very Dark Gray (5Y 3/1) Pebbly Sandy Mud, very stiff (lodgement till), very poorly sorted, clay-rich

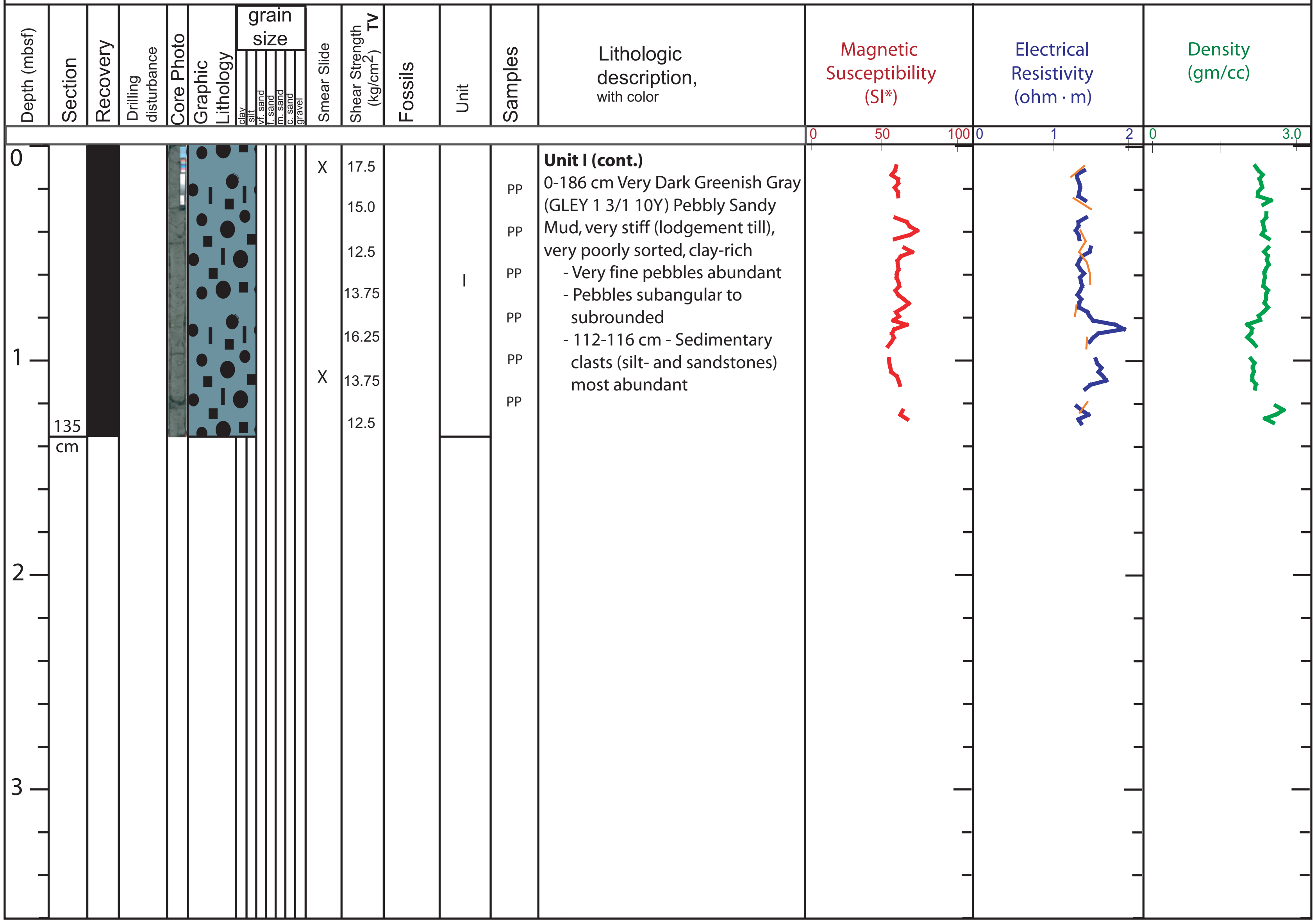
- Very fine to coarse pebbles abundant
- Subangular to subrounded pebbles consisting of volcanics, quartzite, and sedimentary clasts (silt- and sandstones)
- Sands consist of mostly quartz and mica, and are subangular

● 15 cm - Coarse pebble
● 143 cm - Very coarse pebble (basalt)
151 cm - Coarse sedimentary clast

NBP0602A Site: 9 Hole: B

Water Depth: 391m

Core Number: 2 Top: 4.5 mbsf Core Type: R_a



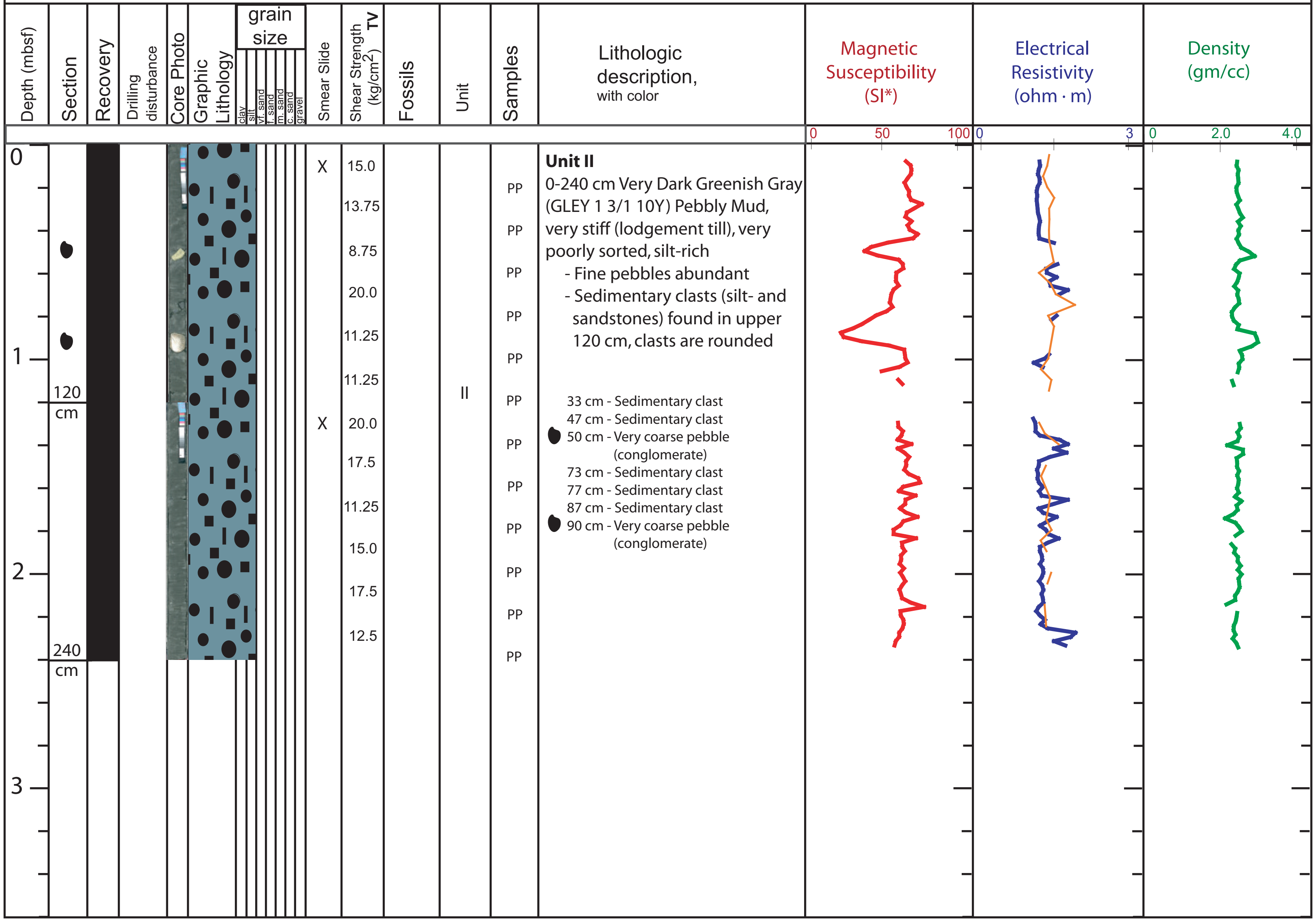
Unit I (cont.)

0-186 cm Very Dark Greenish Gray (GLEY 1 3/1 10Y) Pebbly Sandy Mud, very stiff (lodgement till), very poorly sorted, clay-rich

- Very fine pebbles abundant
- Pebbles subangular to subrounded
- 112-116 cm - Sedimentary clasts (silt- and sandstones) most abundant

NBP0602A Site: 9 Hole: B Water Depth: 391m

Core Number: 3 Top: 7.5 mbsf Core Type: R_a



Unit II

0-240 cm Very Dark Greenish Gray (GLEY 1 3/1 10Y) Pebbly Mud, very stiff (lodgement till), very poorly sorted, silt-rich

- Fine pebbles abundant
- Sedimentary clasts (silt- and sandstones) found in upper 120 cm, clasts are rounded

33 cm - Sedimentary clast
47 cm - Sedimentary clast
● 50 cm - Very coarse pebble (conglomerate)
73 cm - Sedimentary clast
77 cm - Sedimentary clast
87 cm - Sedimentary clast
● 90 cm - Very coarse pebble (conglomerate)

CHAPTER 8: SITE 11
Table of Contents

HOLE NBP0602A-11A

Date/time occupied (date; Julian Day; GMT): 29 March 2006; 088; 1800

Date/time departed: 30 March 2006; 089; 2000

Time on station: 26 hrs

Geographic area: Admiralty Sound off James Ross Island

Ice coverage during station: $^{1}/_{10}$ to $^{4}/_{10}$

Position: 64° 08.976' S, 57° 00.860' W

Water depth (multibeam, m): 280

Water depth (drill-pipe measurement from sea level, m): 280

Total penetration (m): 13.64

Number of drill runs: 14

Total length of cored section (m): 6.64

Total drill core recovered (m): 4.13

Drill-core recovery (%): 62

Oldest sediment drilled:
Depth sub-bottom (m): 13.64 (not corrected for tidal change)
Nature: Silty mudstone
Age: Pleistocene(?)

Principal Results: After Site NBP0602A-10 was abandoned due to ice before retrieving any sediment, we opted to seek an area where the drilling capabilities of the new SHALDRIL suite of tools could be tested without interference from drifting sea ice. The objective was to stabilize the ship in fast ice while drilling a hole through sedimentary rock to test penetration rates and coring efficiency. Site NBP0602A-11A is located in Admiralty Sound, between Seymour and James Ross Islands. Although no fast ice was present in this area, we elected to drill in a relatively ice-free location near James Ross Island.

Hole NBP0602A-11A includes 14 core runs reaching approximately 14.5 mbsf. During the 12th core run it became apparent that tidal change was affecting the area (i.e., the 12th core run began at 14.64 mbsf based on drill pipe measurement, but ended at

13.34 mbsf). Changes in multibeam water depth indicate a tidal change of ~3 m during drilling; however, these changes do not correlate clearly with changes in drill pipe measurements. Therefore, we have not corrected drill depths for tidal change. Nevertheless, drilling rates within the mudstone encountered in this hole were approximately 1 m/hour, with ~50% recovery.

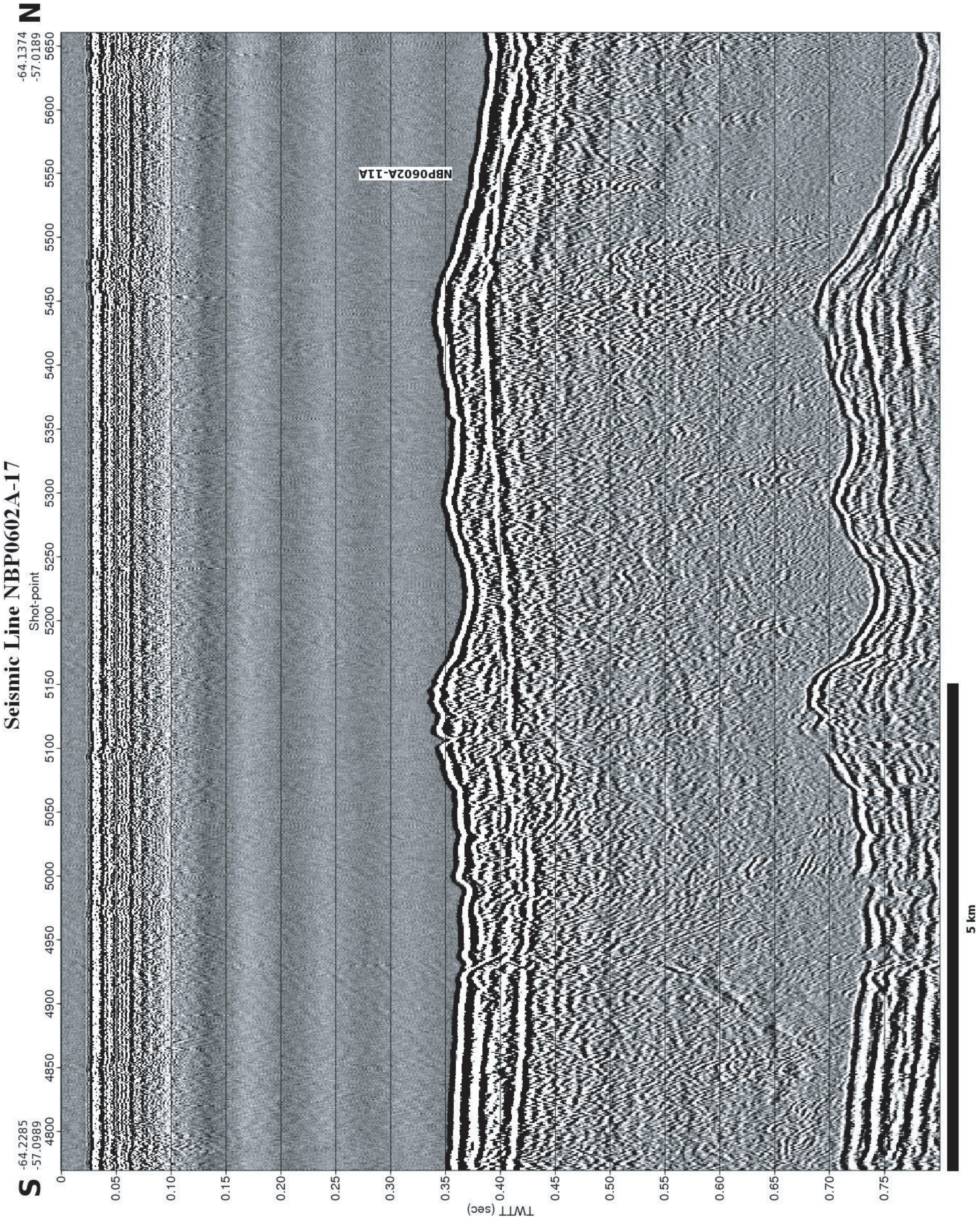
Two types of sediment were recovered in Hole NBP0602A-11A. Above 10 mbsf, the sediment consists of very dark greenish gray clayey mud with pebbles throughout. Extant diatoms from a modern, sea-ice influenced environment are present in these muds, indicating an age <140 ka. In addition, these modern muds contain rare, poorly preserved Cretaceous calcareous nannofossils that have been reworked into the section. Very dark gray clayey to silty mudstone that is broken into pieces occurs below 10 mbsf. The mudstone is barren of microfossils, but presumed to be Cretaceous. Pebbles, typically volcanic in nature, are found throughout the hole, although they are never embedded within the mudstone.

We have interpreted the sediments recovered in Hole NBP0602A-11A as Pleistocene-Recent muds containing reworked boulders of Cretaceous material. An alternate interpretation would be that sediments above 10 mbsf are modern muds <140 ka, whereas the mudstone below 10 mbsf is *in situ* Cretaceous rock, and the mud and pebbles found within this section are downhole contamination.

SEISMIC STRATIGRAPHY

A single channel seismic line was acquired using two 50 in^3 GI guns north of Seymour Island and south into the sound. The objective was to select a site with minimal glacial overburden. The seismic profile shows a relatively thick glacial unit within the central part of the sound resting directly on acoustic basement (Fig. 8-1), presumed to be Cretaceous bedrock based on along-site correlation to strata exposed on James Ross Island. The glacial cover was found to be thinner on the western side of the sound, adjacent to James Ross Island; however, the steep slope adjacent to the island was not suitable for drilling. We settled for a site near the northeastern corner of the island where glacial overburden was thin and the seafloor relatively flat.

Figure 8-1. Seismic Line NBP0602A-17 showing the location of Hole NBP0602A-11A.



SITE 11

A. OBJECTIVES

Site NBP0602A-11 is located in Admiralty Sound, between Seymour Island and James Ross Island. This was the only engineering site of SHALDRIL II. The objective of this site was to drill in sedimentary rock while stabilizing the ship in fast ice. This was our only opportunity to assess drilling rates and coring efficiency in well-lithified rock without serious threat of moving sea ice and icebergs. Unfortunately, we were not able to locate fast ice between the islands, so the site was selected in a relatively ice-free area.

B. OPERATIONS

Site NBP0602A-11 includes one drill hole located in Admiralty Sound adjacent to James Ross Island at 64° 08.976' S, 57° 00.860' W in 280 m of water (Fig. 8-2). This site was selected as an engineering test to prove both our capabilities of drilling in fast ice and to determine the speed at which we could core lithified sedimentary materials. Unfortunately, we were unable to locate any fast ice. The drill site was selected in an area of relatively open water where we thought we could core lithified materials based on the seismic survey of the area.

Tidal change in Antarctica is not well known. Drillers working in other parts of the world often make corrections to their depth measurements either during or after drilling, and operations continue through tidal change without difficulty. Based on the multibeam depth readings, there was a depth change at this location of about 3 m during the drilling operations (Fig. 8-3). Unfortunately, this change does not correlate clearly with the changes in the drill pipe measurements. It is possible that changes in water temperature and salinity accompanied the tidal change, and that these changes affected the sound velocity through the water and subsequent depth readings. Since the tidal change cannot be constrained at this time, the drill depths are reported as they were made by the drillers without any corrections. While this makes for some unusual numbers for interval cored, it seems better than applying inaccurate corrections.

Hole NBP0602A-11A reached a total depth of 14.64 mbsf in the first 11 core runs, or a total depth of 13.64 mbsf by the final (14th) core run (Table 8-1). The second and third cores used the extended-nose push sampler in order to recover softer materials in that interval. Moderately good recovery (66%) was achieved in the first push sample run but there was no recovery in the next. The remainder of the runs (1, 4-14) used the alien bit. The lithology in this hole is interpreted to include large boulders of lithified older material in a matrix of modern mud. Any type of coring tool would have difficulty recovering both of these lithologies. It is hard to calculate recovery for this hole without knowing the exact interval drilled; however, recovery seems to be about 50%. Drilling in this hole was accomplished at about 1 m/hour, or about the time estimated prior to the cruise.

C. LITHOSTRATIGRAPHY

Site NBP0602A-11 consists of one drill hole near James Ross Island. The exact depth of each core section from this hole is currently unknown since there appears to have been a large tidal change for which corrections have not been made.

Hole NBP0602A-11A extends from 0 to ~14.5 mbsf (Fig. 8-4; Appendix 8-1). Two distinct lithologies were recovered from Hole NBP0602A-11A. Above 10 mbsf, sediment consists of very dark greenish gray (GLEY 1 3/1 10Y), soft clayey mud with pebbles throughout. The pebbles and cobbles are mostly basaltic volcanic rock, but one coarse pebble is composed of sandstone. Based on biostratigraphic analysis, this soft, unconsolidated mud is Pleistocene-Recent in age. Below 10 mbsf the sediment consists of very dark gray (GLEY 1 3/ N), homogeneous, silty mudstone with dark mottles indicative of moderate bioturbation. Samples are often brecciated as a result of the coring process. No shell fragments occur. Pebbles and cobbles, ranging from 2-12 cm, are found within the core, but never encapsulated within the silty mudstone; they are either at the top of the core or surrounded by silty mud. The compacted mudstone is presumed to be of Cretaceous age, although no definitive biogenics were found during shipboard biostratigraphic analysis to confirm this age. Smear-slide analysis of the <250 µm fraction (Table 8-2) indicates the sediment consists of mud, silty clay, and clay. Clay is the dominant mineral component (44-79%), with lesser amounts of quartz (7-30%), feldspar (5-20%), and heavy minerals (1-5%). Calcite occurs in trace amounts to 3%, although it is more abundant in the upper 10 m of the hole. Mica occurs in trace amounts to 3%, primarily in the Pleistocene sediments, and one sample from Core NBP0602A-11A-3E-CC contains 2% volcanic glass. Glauconite, hornblende, and hematite also occur sporadically throughout the hole. Diatoms are present in trace amounts to 2% within the Pleistocene muds, as are traces of sponge spicules and reworked Cretaceous calcareous nannofossils.

D. BIOSTRATIGRAPHY

Initial shipboard paleontological work for Site NBP0602A-11 included smea-slide examination of diatom and calcareous nannofossil assemblages. Observed diatom and calcareous nannofossil taxa are listed in Tables 8-3 and 8-4.

The uppermost samples from Hole NBP0602A-11A (Cores NBP0602A-11A-2E to -3E; 8.1 to 9.8 mbsf) contain rare to common, moderately preserved diatoms (Table 8-3). The assemblages are comprised entirely of extant diatom taxa that are characteristic of the modern sea-ice environment. The absence of *Rouxia leventerae* indicates an age of <140 ka for this section.

Below the uppermost section of Hole NBP0602A-11A (Cores NBP0602A-11A-4R$_a$ to -14R$_a$; 9.9 mbsf to the bottom of the hole), all samples are barren of diatoms with the exception of samples from Cores NBP0602A-11A-11R$_a$ and -12R$_a$ (Table 8-3). The samples from these two cores contain very rare and poorly preserved diatoms. Although highly fragmented, the identified taxa represent an assemblage that is similar to that encountered in the uppermost section of the hole, indicating these occurrences could be due to downhole contamination of surficial muds by the drilling process.

Several smear slides were made from cleaned surfaces of the hard, dark gray, silty mudstones recovered in the lower part of Hole NBP0602A-11A. All of these preparations were barren of diatoms.

Samples from Cores NBP0602A-11A-2E to -4R$_a$ contain rare to few poorly preserved calcareous nannofossils (Table 8-4). The assemblages consist of Cretaceous species reworked into the Pleistocene-Holocene sediments. Most specimens are too poorly preserved to be identified to species level; however, the presence of *Eiffellithus eximius* constrains the age of the reworked material to Turonian-Campanian (~93.5-70.6 Ma) based on the Southern Ocean zonation of Watkins et al. (1996). Other identifiable taxa include *Biscutum constans*, *Watznaueria barnesae*, *Prediscosphaera* spp., *Tranolithus* spp., *Zeugrhabdotus* spp., and *Thoracosphaera* spp.

Samples below Core NBP0602A-11A-4R$_a$ are either barren or contain questionable traces of calcareous nannofossils (Table 8-4). Of the three samples that may contain nannofossils, Sample NBP0602A-11A-6R$_a$-CC is the only to contain fragments identified as questionable Cretaceous species (*Micula* spp. and *W. barnesae*). Other traces from this interval include possible *Thoracosphaera* spp, which can range to the present. The questionable and poorly preserved nature of specimens from Cores NBP0602A-11A-5R$_a$ to -12R$_a$ makes it impossible to constrain the age of the lower sections of this hole based on calcareous nannofossils.

E. PHYSICAL PROPERTIES

Site NBP0602A-11 consists of one hole reaching ~14.5 mbsf with little recovery. All cores were run on the multisensor core logger (MSCL) (2-cm readings); the Middlebury College electrical resistivity (MCER) probe was done every 5 cm, with discrete samples taken every 10 to 20 cm only for Core NBP0602A-11A-2E.

Hole NBP0602A-11A primarily consists of clayey mud to silty mudstone. Section recoveries were small and often broken into pieces. Large gaps, recovered sediment broken into pieces, and recovery of short cores make most of the MSCL data unreliable. Only physical property measurements obtained from Core NBP0602A-11A-2E appear to be accurate. Due to the limited recovery, broken nature of the sediment, and gaps, little can be gleaned from the analyses of the physical properties for this site.

F. SITE SUMMARY

The objective of Site NBP0602A-11 was to measure the rate of penetration and core recovery in hard sedimentary rock. The original plan called for using fast ice to stabilize the ship, but no fast ice was found, so we elected to drill in open water at a site near the northwestern side of James Ross Island (64° 08.976'S, 57° 00.860 W, in 280 m of water). The push sampler was used for the unconsolidated upper portions of the hole, whereas the alien bit was used for lithified sediment beginning with the 4th core run. The rate of penetration was about 1 m/hour (total penetration of 14.5 mbsf) with approximately 50% recovery for the 14 core runs completed. The exact depth of the cores is uncertain because tides caused the drill stem to rise up and down in the hole during the time we were on site.

Two distinct lithologies were recovered from Hole NBP0602A-11A. Above 10 mbsf, sediment consists of very dark greenish gray, soft clayey mud, with pebbles throughout. Pebbles are typically volcanic in nature. Diatoms from this interval are extant species indicative of a modern sea-ice influenced environment, and suggest an age of <140 ka for the section. In addition to diatoms, rare, poorly preserved Cretaceous (Turonian-Campanian) calcareous nannofossils also occur in this section.

Below 10 mbsf, sediment consists of very dark gray clayey to silty mudstone that is broken into pieces. The mudstones are intermittently bioturbated and presumed to be Cretaceous in age. Pebbles also occur in this section, but never within the mudstone; they either occur at the top of the core or are surrounded by mud. Samples from this interval are essentially barren of microfossils. Extant diatoms similar to those found in the upper sections of the hole occur in samples from Cores NBP0602A-11A-11Ra and -12Ra; however, samples made from mudstone scrapings were completely barren. Very questionable traces of poorly preserved calcareous nannofossils occur in several samples from this interval, although they are not age diagnostic.

There are two ways to interpret the sediments encountered in Hole NBP0602A-11A. The preferred interpretation is that the section is entirely Pleistocene-Recent, and the mudstones represent boulders of Cretaceous material incorporated into the modern matrix. An alternate interpretation is that the sediment above 10 mbsf consists of modern (<140 ka) muds, whereas the mudstone encountered below 10 mbsf is *in situ* Cretaceous material, and modern mud found within these cores is downhole contamination resulting from the coring process.

Figure 8-2. Multibeam images of Site NBP0602A-11.

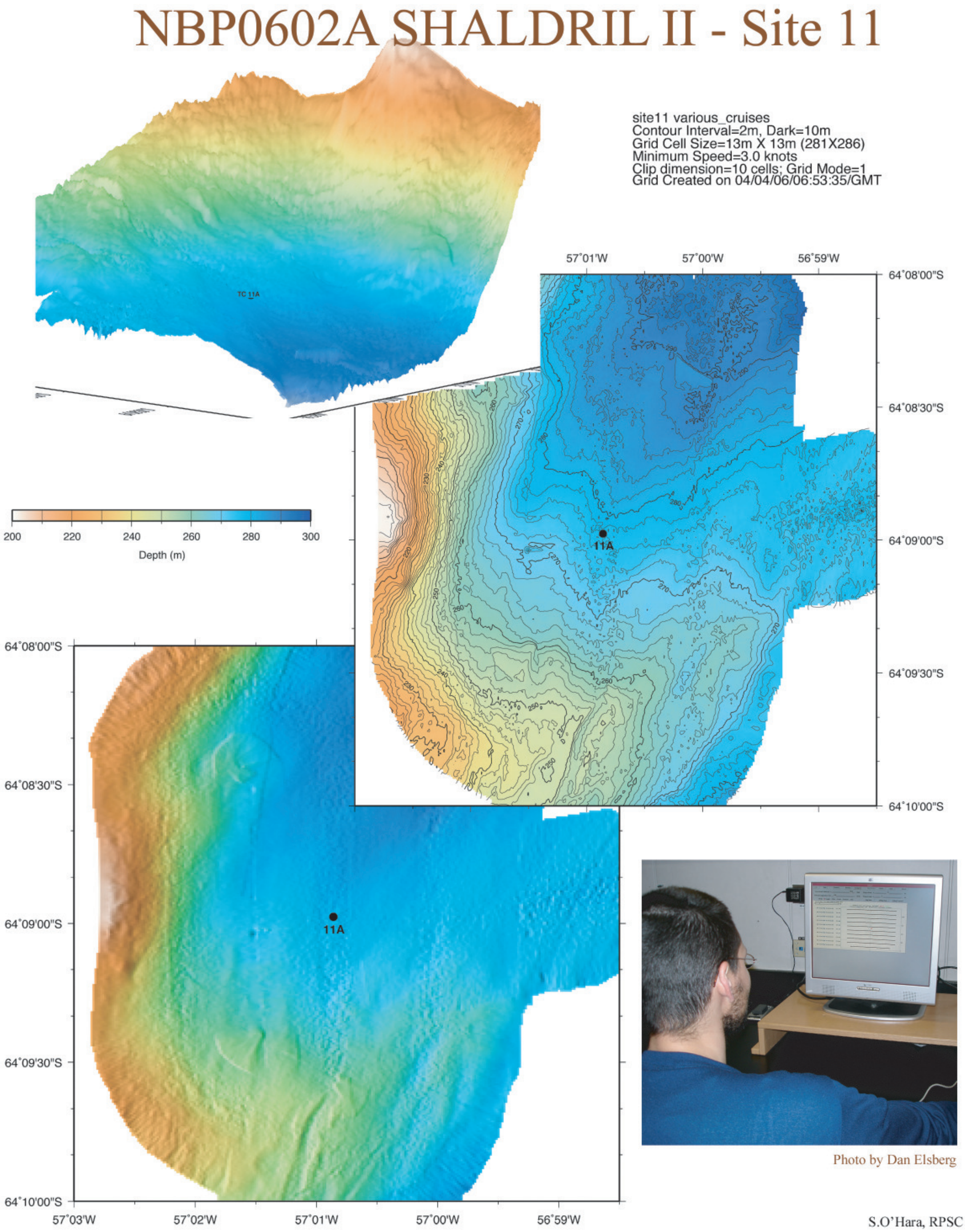


Photo by Dan Elsberg

S.O'Hara, RPSC

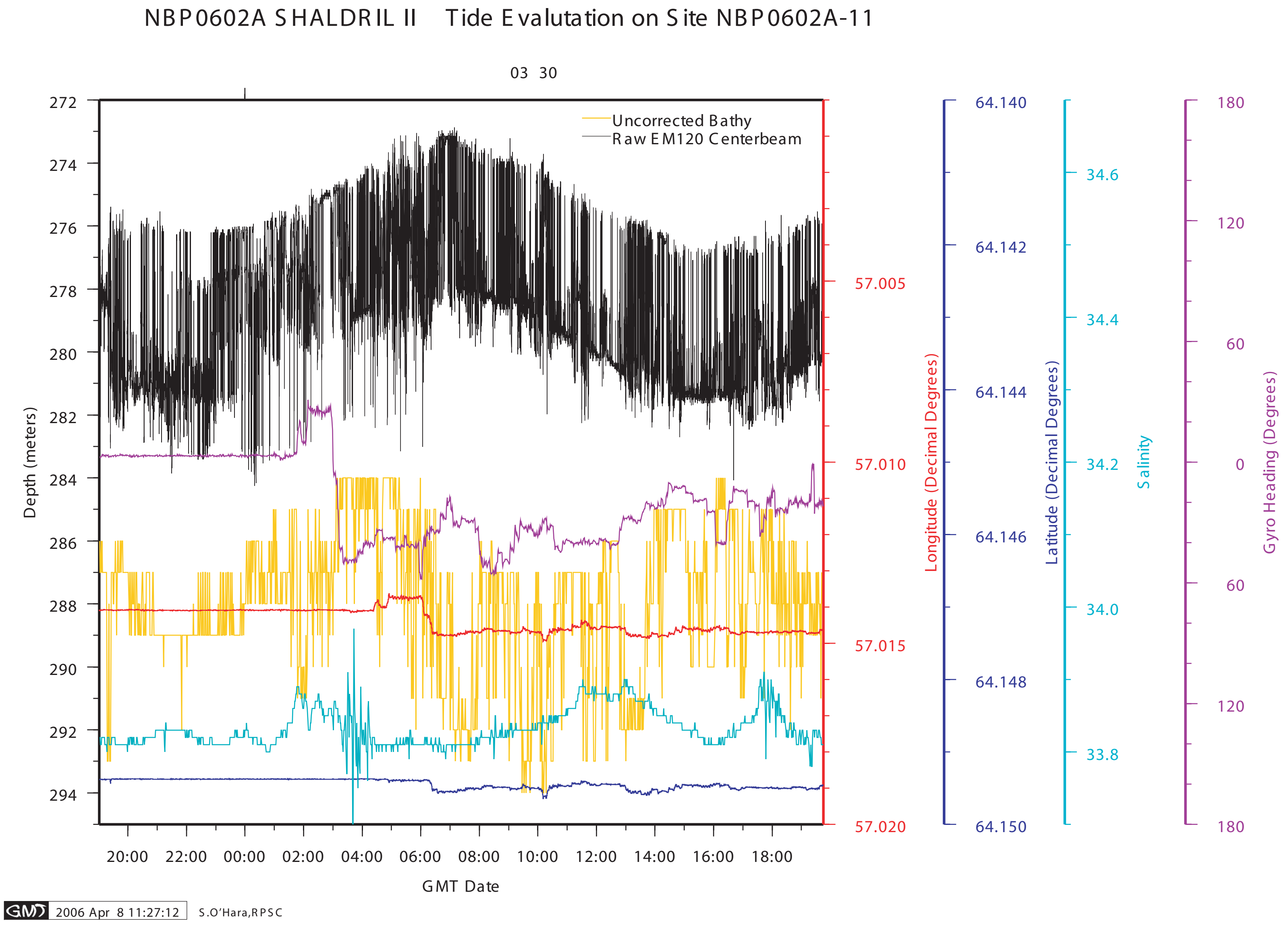


Figure 8-3. Evaluation of tidal change at Site NBP0602A-11 based on water depth measurements from multibeam.

Figure 8-4. Summary lithologic log of Hole NBP0602A-11A.

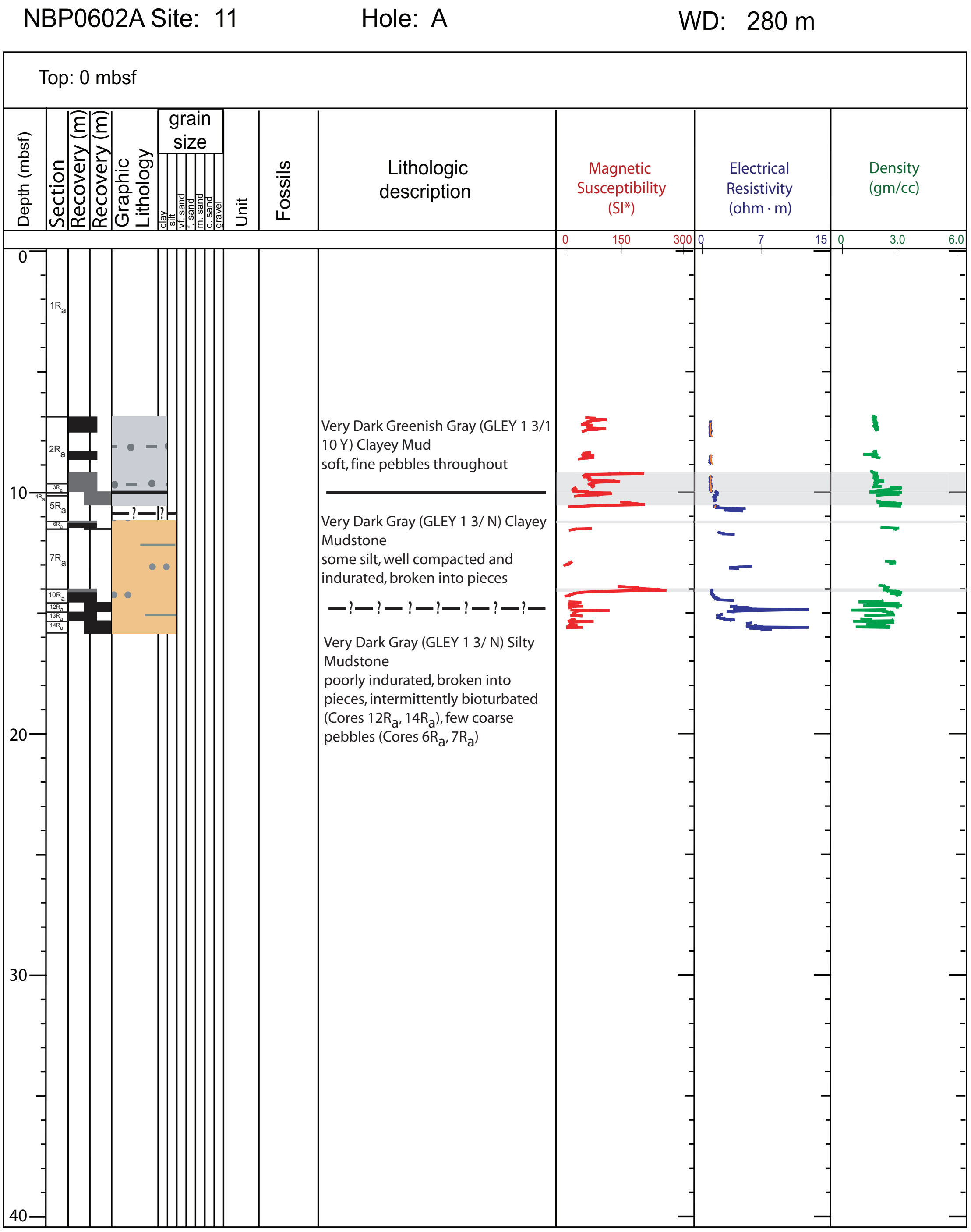


Table 8-1. Drilling and coring recovery log for Hole NBP0602A-11A.

NBP0602A SHALDRIL II Site 11 (James Ross Island)

Multibeam Water Depth: 280 m (pipe at 280.4)

Station Number/Hole	Core Number	Core Type	Top (mbsf)	Bottom (mbsf)	Interval Cored (m)	"Push Distance" (m)	Recovery: total (m)	Recovery: competent (m)	Recovery: disturbed (m)	Gaps (m)	Recovery Corrected (m)	Total Recovery (%)	Recovery Corrected (%)	Section Number	Section Lengths (cm)	Date (JD)	Time on Deck (GMT)	Initials	Comments
11A	1	Ra	0	7.0	0-7	7.00	0	0	0	0	0	0.0%	0.0%	1	0.0	88	2311	CD	No recovery - soft mud. Changing to push core
11A	2	E	7.0	9.7	7-9.7	2.7	2.991	1.78	0	1.201	0.579	65.9%	21.4%	1	67.9	89	0002	CD	Gaps at 67.9-143 cm and 182.5-227.5 cm
11A	2	E												2	39.5	89	0002	CD	
11A	2	E												3	71.3	89	0002	CD	
11A	3	E	9.7	10.0	9.7-10	0.3	0	0	0	0	0	0.0%	0.0%	1	0.0	89	0050	KN	Core catcher recovery only
11A	4	Ra	10.0	10.5	10-10.5	0.5	0	0	0	0	0	0.0%	0.0%	1	0.0	89	0250	CD	Bagged rock sample at core end and core catcher; Friable siltstone; Falling tide
11A	5	Ra	9.9	10.5	9.9-10.5	0.6	0.47	0.47	0.47	0	0.47	78.3%	78.3%	1	47.0	89	0510	JM	Friable siltstone
11A	6	Ra	10.5	11.6	10.5-11.6	1.1	0.30	0.30	0	0	0.30	27.3%	27.3%	1	27.0	89	0610	JSW	Friable mudstone; Rising tide
11A	7	Ra	11.6	12.3	11.6-12.3	0.7	0.165	0.165	0	0	0.165	23.6%	23.6%	1	11.0	89	0705	JSW	Pieces of same unit loose at top - falling in - "gravel" is same lithology
11A	8	Ra	12.3	13.0	12.3-13.0	0.7	0	0	0	0	0	0.0%	0.0%	1	1.0	89	0745	JSW	No recovery
11A	9	Ra	13.0	14.0	13.0-14.0	1.0	0.19	0.19	0	0	0.19	19.0%	19.0%	1	15.0	89	0845	JSW	Whole section is ? cc but kept in liner
11A	10	Ra	14.0	14.54	14.0-14.54	0.54	0.505	0.505	0	0	0.505	93.5%	93.5%	1	48.0	89	1000	JSW	Core catcher has 6 cm competent recovery (=100% recovery); Bottom of core is clay
11A	11	Ra	14.54	14.64	14.54-14.64	0.1	0	0	0	0	0	0.0%	0.0%	1	10.0	89	1105	JM	All in core catcher - bag. Pleistocene!
11A	12	Ra	14.64	13.34	?	?	0.345	0.345	0	0	0.345	?	?	1	34.5	89	1215	JM	No push. Falling tide.
11A	13	Ra	13.34	12.64	?	?	0.342	0.342	0	0	0.342	?	?	1	34.2	89	1440	JM	
11A	14	Ra	12.64	13.64	12.64-13.64	1.0	0.502	0.502	0	0	0.502	50.2%	50.2%	1	50.2	89	1721	CD	
							5.81												

Table 8-2. Smear-slide data for Hole NBP0602A-11A

		Components														Grain Size						
		Minerals										Biogenics			Rock							
Sample	Approximate Depth (mbsf)	Calcite	Clay	Feldspar	Glauconite	Heavy Minerals	Hematite	Hornblende	Mica	Quartz	Volcanic Glass	Calcareous Nannofossils	Diatoms	Sponge Spicules	Fragments	Sand	Silt	Clay	Sorting	Roundness	Lithology	Comments
Hole 11A																						
NBP0602A-11A-2E, 107.4 cm	8.074	2	77	5	tr	5		1	1	7			2	tr		7	15	78	M	sr	Silty clay	Biogenics fragmented
NBP0602A-11A-3E-CC	(9.7-10.0)	3	65	7	1	4	tr	tr	3	15	2	tr	tr			7	28	65	P	sr	Clayey mud	Some coated grains
NBP0602A-11A-4R_a, base	(10.0-10.5)	2	75	5		4	1		1	12						5	20	75	M	sa-sr	Silty clay	
NBP0602A-11A-5R_a, 47 cm	10.37	2	74	7		5	1	tr	1	10						10	15	75	M	sr	Silty clay	
NBP0602A-11A-6R_a, 30 cm	10.80	3	69	7	tr	5	2		tr	12					2	10	20	70	M	a-sr	Clayey mud/Silty clay	
NBP0602A-11A-7R_a, 16.5 cm	11.765	1	77	5	tr	5	2		tr	8					2	7	20	73	M	sr	Silty clay	
NBP0602A-11A-9R_a-CC	13.19	2	79	5	tr	3	1		tr	10						5	15	80	M	sa-sr	Silty clay	
NBP0602A-11A-10R_a, 33 cm	14.33	tr	45	20	tr	5	tr			30						7	43	50	P	a-sr	Mud	Grains coated with clay
NBP0602A-11A-11R_a-CC	(14.54-14.64)	1	44	20		5				30				tr		10	40	50	P	a-sr	Mud	Grains coated with clay
NBP0602A-11A-12R_a, 34.5 cm	?	tr	52	20	tr	5	tr			23						3	40	57	P	a-sr	Mud	
NBP0602A-11A-13R_a, 10.5 cm	?	tr	74	8		3		tr		15						3	20	77	P	a-sr	Clay	From a rock
NBP0602A-11A-14R_a, 30 cm	?		78	7	tr	1				14						1	20	79	P	a-sr	Clay	From a rock

Notes: Sample: E = cored using push sampler, R_a = cored using alien coring bit; Components/Grain Size: Numbers represent percentages, tr = trace; Sorting: P = poor; Roundness: a = angular, sa = subangular, sr = subrounded.

Table 8-3. Stratigraphic occurrence and relative abundance of diatom taxa in Hole NBP0602A-11A.

						Diatoms																								
Cruise/Hole/Core/Interval	**Depth (mbsf)**	**Slide Preparation**	**Diatom Abundance**	**Preservation**	**Fragmentation**	*Actinocyclus actinochilus*	*Actinocyclus ingens*	*Chaetoceros* spp. (small veg. cells & resting spores)	*Chaetoceros* spp. (large spores, ornamented)	*Cocconeis* spp. (several taxa)	*Coscinodiscus* spp.	*Denticulopsis simonsenii / vulgaris*	*Eucampia antarctica* var. *antarctica*	*Eucampia antarctica* var. *recta*	*Fragilariopsis curta*	*Fragilariopsis cylindrus*	*Fragilariopsis obliquecostata*	*Fragilariopsis ritscheri*	*Fragilariopsis sublinearis*	*Fragilariopsis vanheurckii*	*Odontella weissflogii*	*Pinnularia quadratarea*	*Radialiplicata clavigera*	*Rhizosolenia* spp.	*Stellarima microtrias*	*Synedropsis* spp.	*Thalassiosira antarctica* var. *antarctica*	*Thal. gracilis* var. *gracilis / expecta*	*Thlassiosira tumida*	*Thalassiothrix/Trichotoxon* spp.	*Trinacria excavata* group
Hole 11A																														
NBP0602A-11A-2E, 108 cm	8.08	smear	C	M	M-H	R		F	X	X			R-F	X	F	X	fr(R)	R	R	R		X	fr(X)	X	fr(X)	R	F-C	R		fr(R)	fr(X)
NBP0602A-11A-2E-CC	9.70	smear	X-R	P	H	X		R			fr(R)			X	X	X			fr(X)								R	X		R	
NBP0602A-11A-3E-CC	9.80	smear	R	X	P	fr(X)		F			fr(X)	X		X	X				X	R							R	R	fr(X)	fr(R)	
NBP0602A-11A-4R$_a$-CC	9.90	smear	B	-	-																										
NBP0602A-11A-5R$_a$, 10 cm	10.00	smear	B	-	-																										
NBP0602A-11A-5R$_a$-CC	10.37	smear	B	-	-																										
NBP0602A-11A-6R$_a$, 8 cm	10.58	smear	B	-	-																										
NBP0602A-11A-6R$_a$-CC	10.80	smear	B	-	-																										
NBP0602A-11A-7R$_a$, 6 cm	11.66	smear	B	-	-																										
NBP0602A-11A-7R$_a$-CC	11.77	smear	B	-	-																										
NBP0602A-11A-9R$_a$-CC	13.19	smear	B	-	-																										
NBP0602A-11A-10R$_a$-CC	14.51	smear	B	-	-																										
NBP0602A-11A-11R$_a$-CC	14.54	smear	X	P	H	fr(X)	fr(X)	R							X												X	X			
NBP0602A-11A-12R$_a$, 34cm	?	smear	X	P	H	fr(X)		R						X	X		fr(X)				X			X	X		R	X		fr(X)	
NBP0602A-11A-13R$_a$-CC	?	smear	B	-	-																										
NBP0602A-11A-14R$_a$-CC	?	smear	B	-	-																										

Notes: Abundance: C = common, F = few, R = rare, X = present, B = barren, fr = fragment; Preservation: M = moderate, P = poor; Fragmentation: M = moderate, H = high.

Table 8-4. Stratigraphic occurrence and relative abundance of calcareous nannofossils in Hole NBP0602A-11A.

			Cretaceous Calcareous Nannofossils													
Cruise/Hole/Core/Interval	**Abundance**	**Preservation**	*Arkhangelskiella* spp.	*Biscutum constans*	*Eiffellithus eximius*	*Eiffellithus* spp.	*Lucianorhabdus* spp.	*Micula* spp.	*Prediscosphaera spinosa*	*Prediscosphaera* spp.	*Thoracosphaera* spp.	*Tranolithus* spp.	*Vekshinella* spp.	*Watznaueria barnesae*	*Watznaueria* spp.	*Zeugrhabdotus* spp.
Hole 11A																
NBP0602A-11A-2E, 7.5 cm	R	P									R					
NBP0602A-11A-2E, 35 cm	R	P									R				?	
NBP0602A-11A-2E, 177 cm	R	P									?					
NBP0602A-11A-2E, ~270 cm	F	P									F					
NBP0602A-11A-2E-CC	R	P-M					?			R	R	?		R		
NBP0602A-11A-3E-CC	F	P	?	F	R	?					F		?	F		R
NBP0602A-11A-4$R_{a,}$ base	R	P									?					
NBP0602A-11A-4R_a-CC	F	P-M		F		?			?		F	R		R		R
NBP0602A-11A-5R_a, 47 cm	B															
NBP0602A-11A-5R_a-CC	B															
NBP0602A-11A-6R_a, 30 cm	B															
NBP0602A-11A-6R_a-CC	R?	P						?			?			?		
NBP0602A-11A-7R_a, 16.5 cm	B															
NBP0602A-11A-7R_a-CC	B															
NBP0602A-11A-9R_a-CC	tr?	P									?					
NBP0602A-11A-10$R_{a,\ 50.5\ cm}$	B															
NBP0602A-11A-10R_a-CC	B															
NBP0602A-11A-11R_a-CC	B															
NBP0602A-11A-12R_a, 34.5 cm	tr?	P														

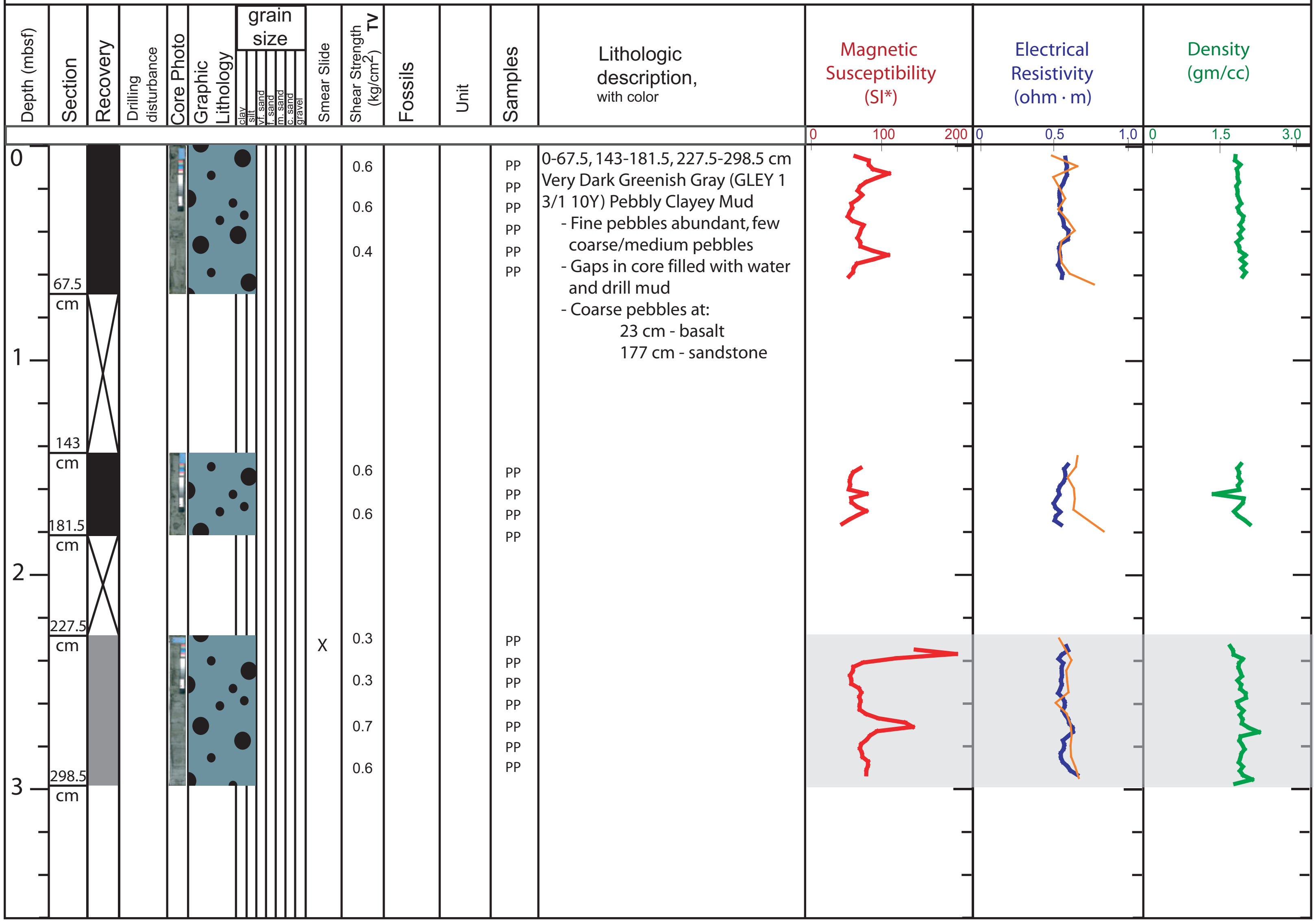
Notes: Abundance: F = few, R = rare, B = barren, tr = trace, ? = questionable; Preservation: M = moderate, P = poor.

REFERENCES

Watkins, D.K., Wise, S.W., Jr., Pospichal, J.J., and Crux, J., 1996. Upper Cretaceous calcareous nannofossil biostratigraphy and paleoceanography of the Southern Ocean. *In* Moguilevsky, A., and Whatley, R. (Eds.), *Microfossils and Oceanic Environments*, University of Wales, Aberystwyth Press, p. 355-381.

NBP0602A Site: 11 Hole: A Water Depth: 280 m

Core Number: 2 Top: 7.0 mbsf Core Type: E

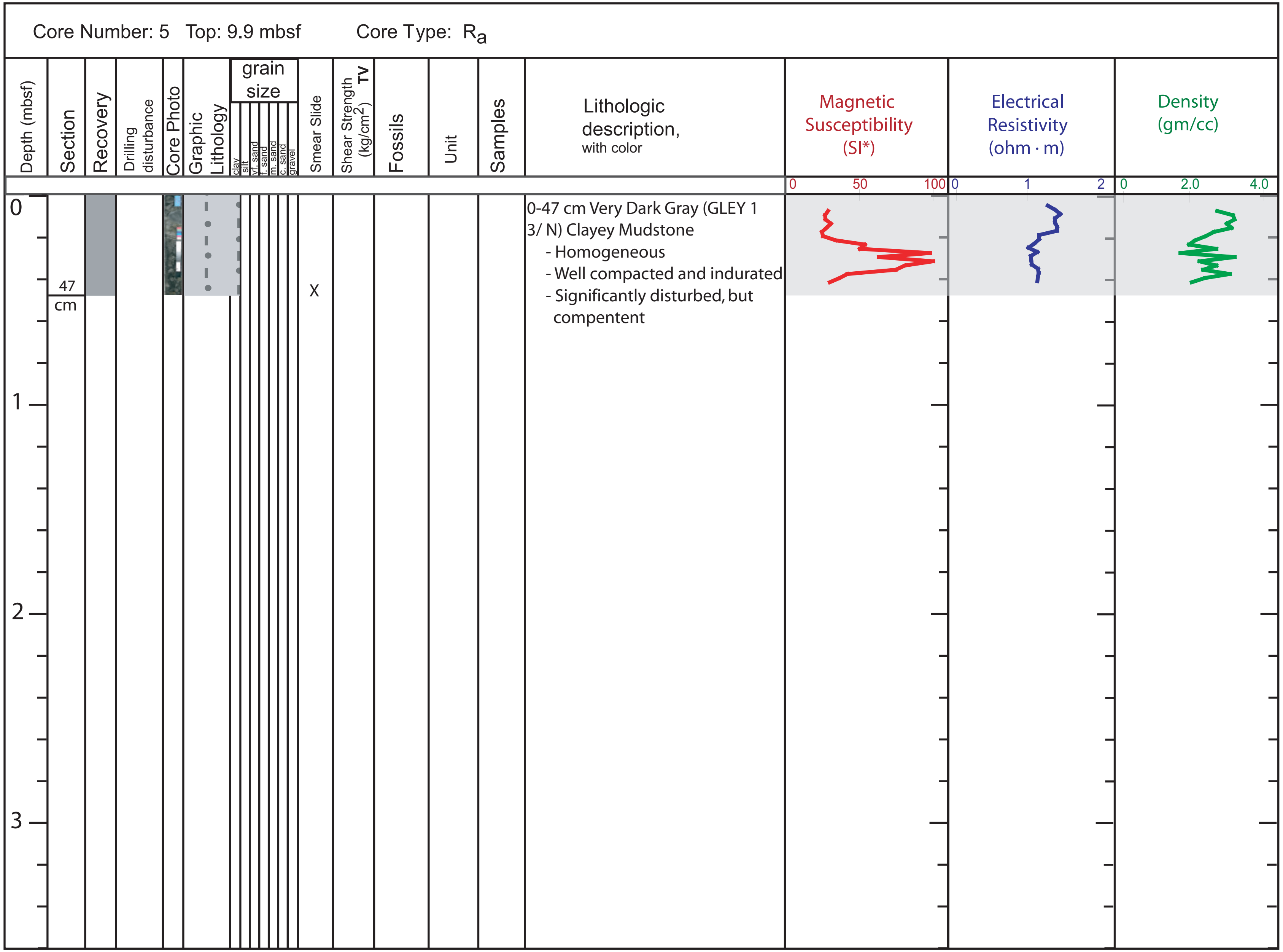


0-67.5, 143-181.5, 227.5-298.5 cm
Very Dark Greenish Gray (GLEY 1 3/1 10Y) Pebbly Clayey Mud
- Fine pebbles abundant, few coarse/medium pebbles
- Gaps in core filled with water and drill mud
- Coarse pebbles at:
  - 23 cm - basalt
  - 177 cm - sandstone

NBP0602A Site: 11 Hole: A

Water Depth: 280 m

Core Number: 5 Top: 9.9 mbsf Core Type: R_a

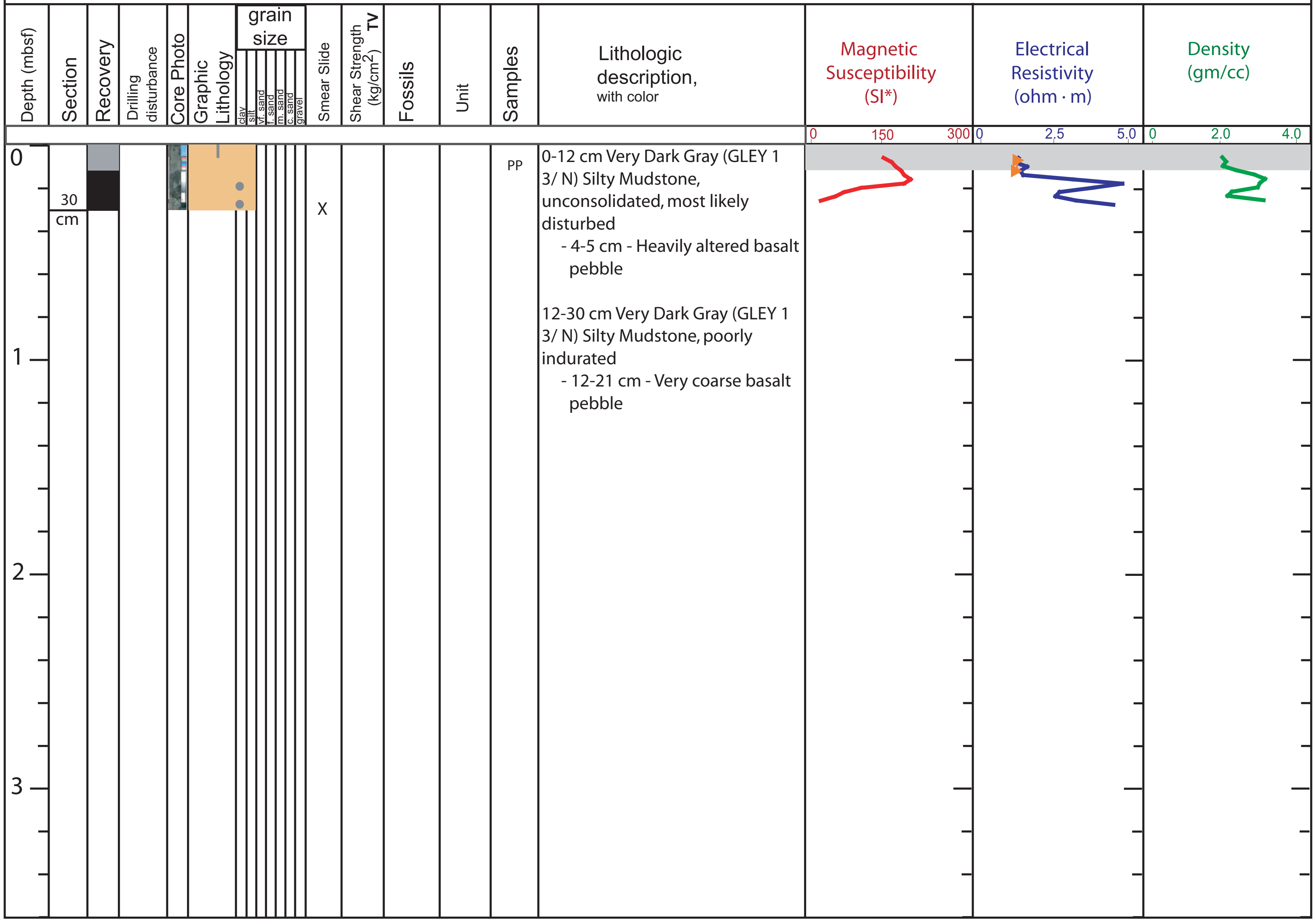


0-47 cm Very Dark Gray (GLEY 1 3/ N) Clayey Mudstone
- Homogeneous
- Well compacted and indurated
- Significantly disturbed, but compentent

NBP0602A Site: 11 Hole: A

Water Depth: 280 m

Core Number: 6 Top: 10.5 mbsf Core Type: R_a



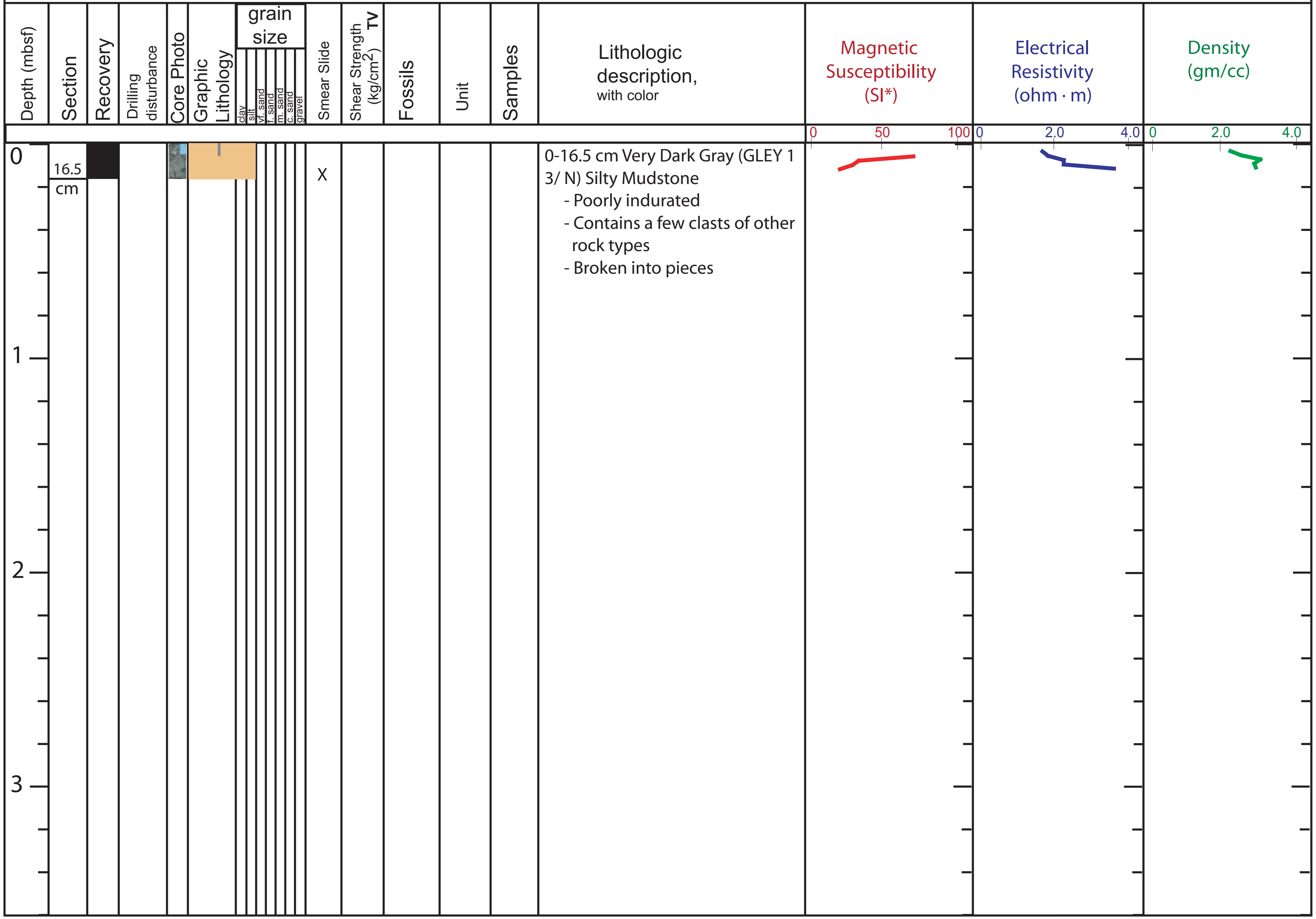
0-12 cm Very Dark Gray (GLEY 1 3/ N) Silty Mudstone, unconsolidated, most likely disturbed
- 4-5 cm - Heavily altered basalt pebble

12-30 cm Very Dark Gray (GLEY 1 3/ N) Silty Mudstone, poorly indurated
- 12-21 cm - Very coarse basalt pebble

NBP0602A Site: 11 Hole: A

Water Depth: 280 m

Core Number: 7 Top: 11.6 mbsf Core Type: R_a

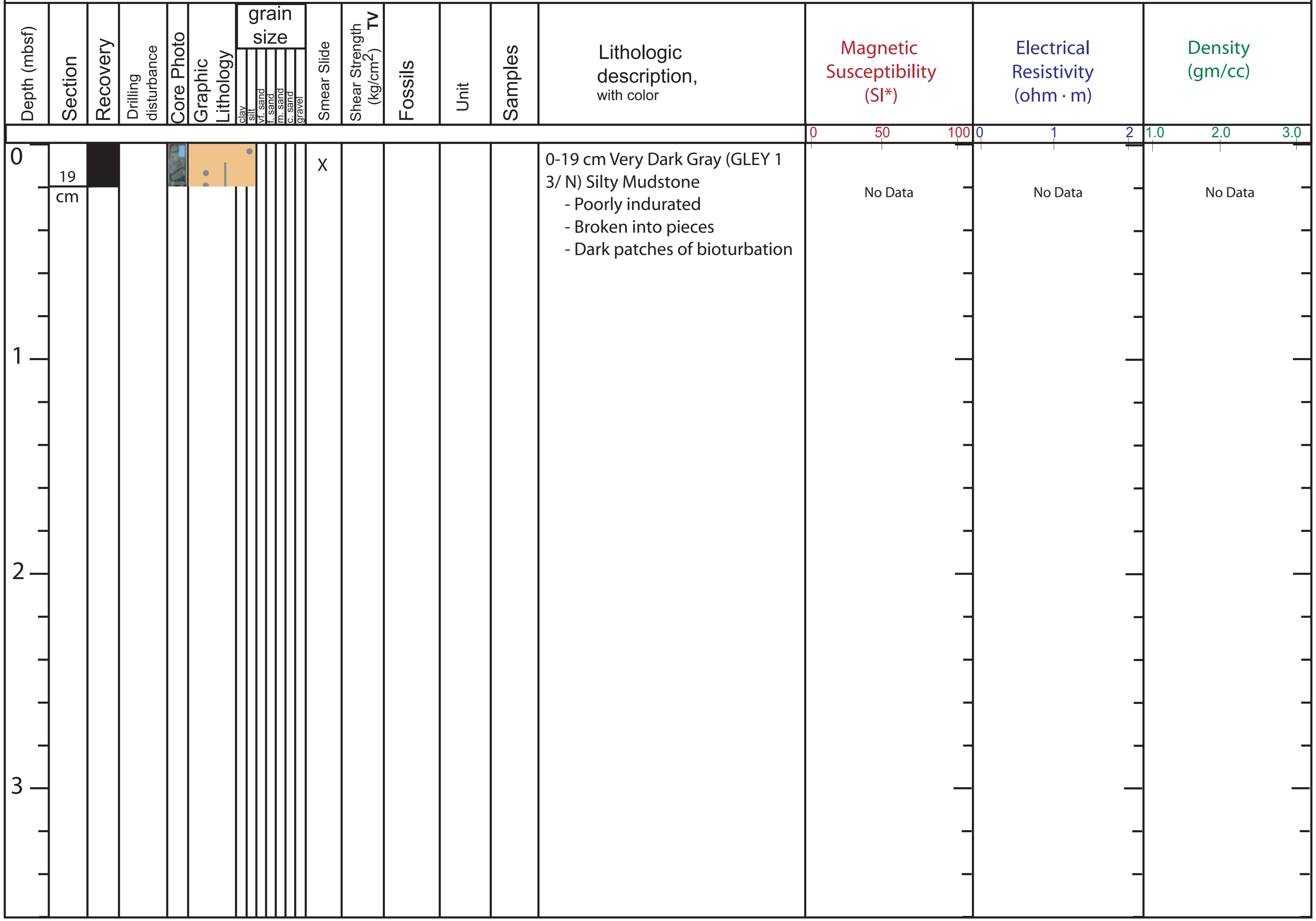


0-16.5 cm Very Dark Gray (GLEY 1 3/ N) Silty Mudstone
- Poorly indurated
- Contains a few clasts of other rock types
- Broken into pieces

NBP0602A Site: 11 Hole: A

Water Depth: 280 m

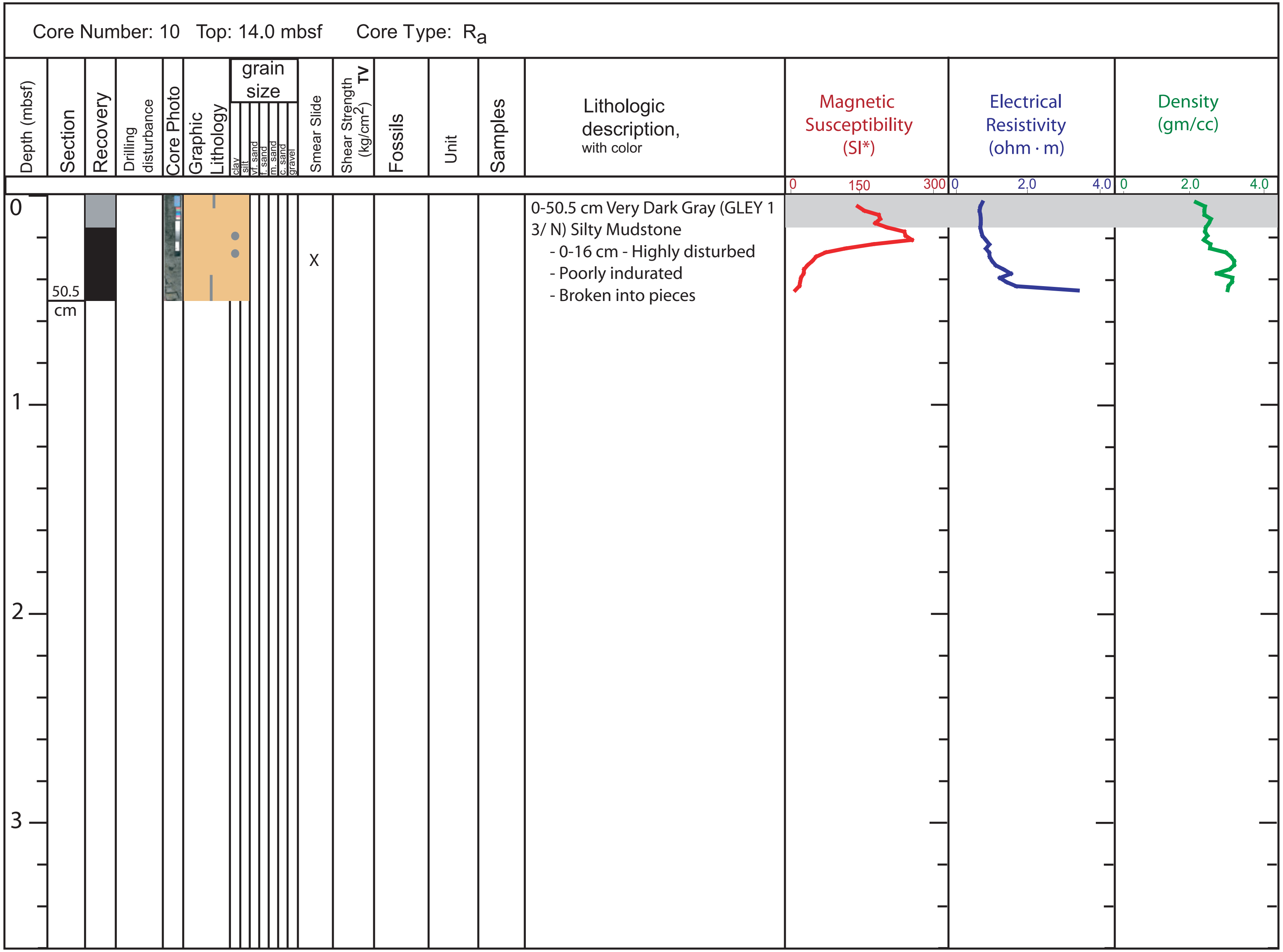
Core Number: 9 Top: 14.0 mbsf Core Type: CC R_a



0-19 cm Very Dark Gray (GLEY 1 3/ N) Silty Mudstone
- Poorly indurated
- Broken into pieces
- Dark patches of bioturbation

NBP0602A Site: 11 Hole: A

Water Depth: 280 m

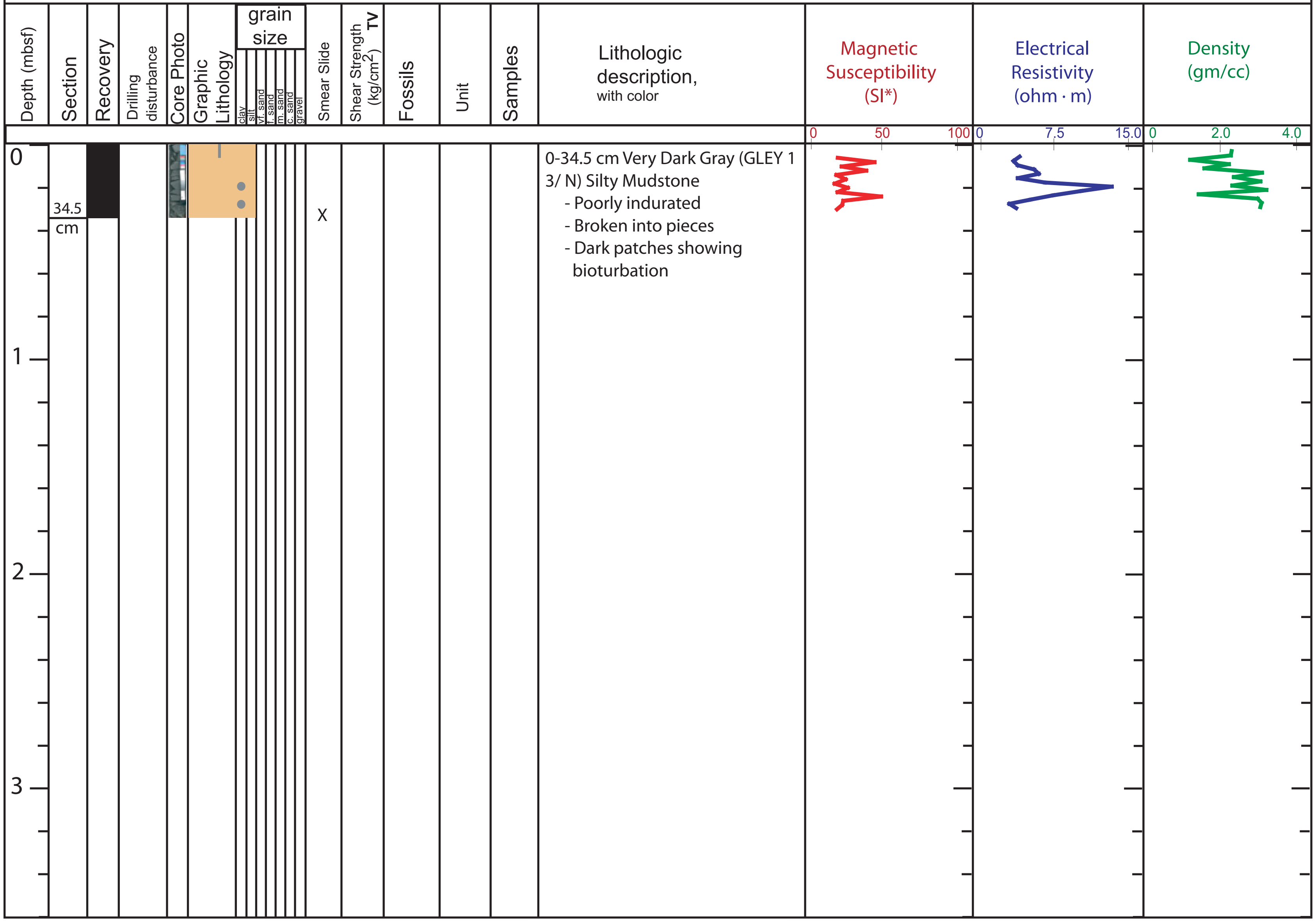


0-50.5 cm Very Dark Gray (GLEY 1 3/ N) Silty Mudstone
- 0-16 cm - Highly disturbed
- Poorly indurated
- Broken into pieces

NBP0602A Site: 11 Hole: A

Water Depth: 280 m

Core Number: 12 Top: 14.64 mbsf Core Type: R_a

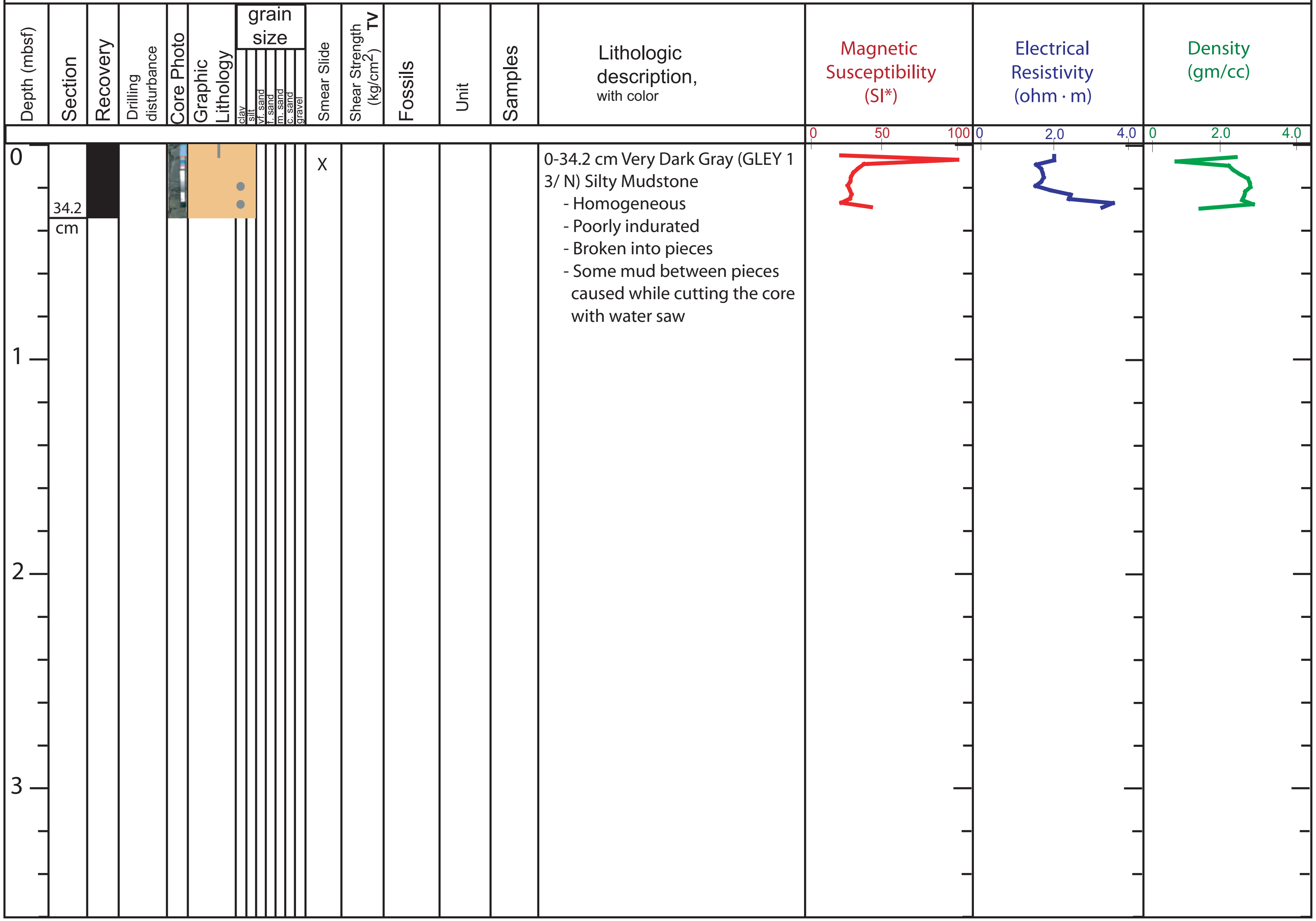


0-34.5 cm Very Dark Gray (GLEY 1 3/ N) Silty Mudstone
- Poorly indurated
- Broken into pieces
- Dark patches showing bioturbation

NBP0602A Site: 11 Hole: A

Water Depth: 280 m

Core Number: 13 Top: 14.64 mbsf Core Type: R_a

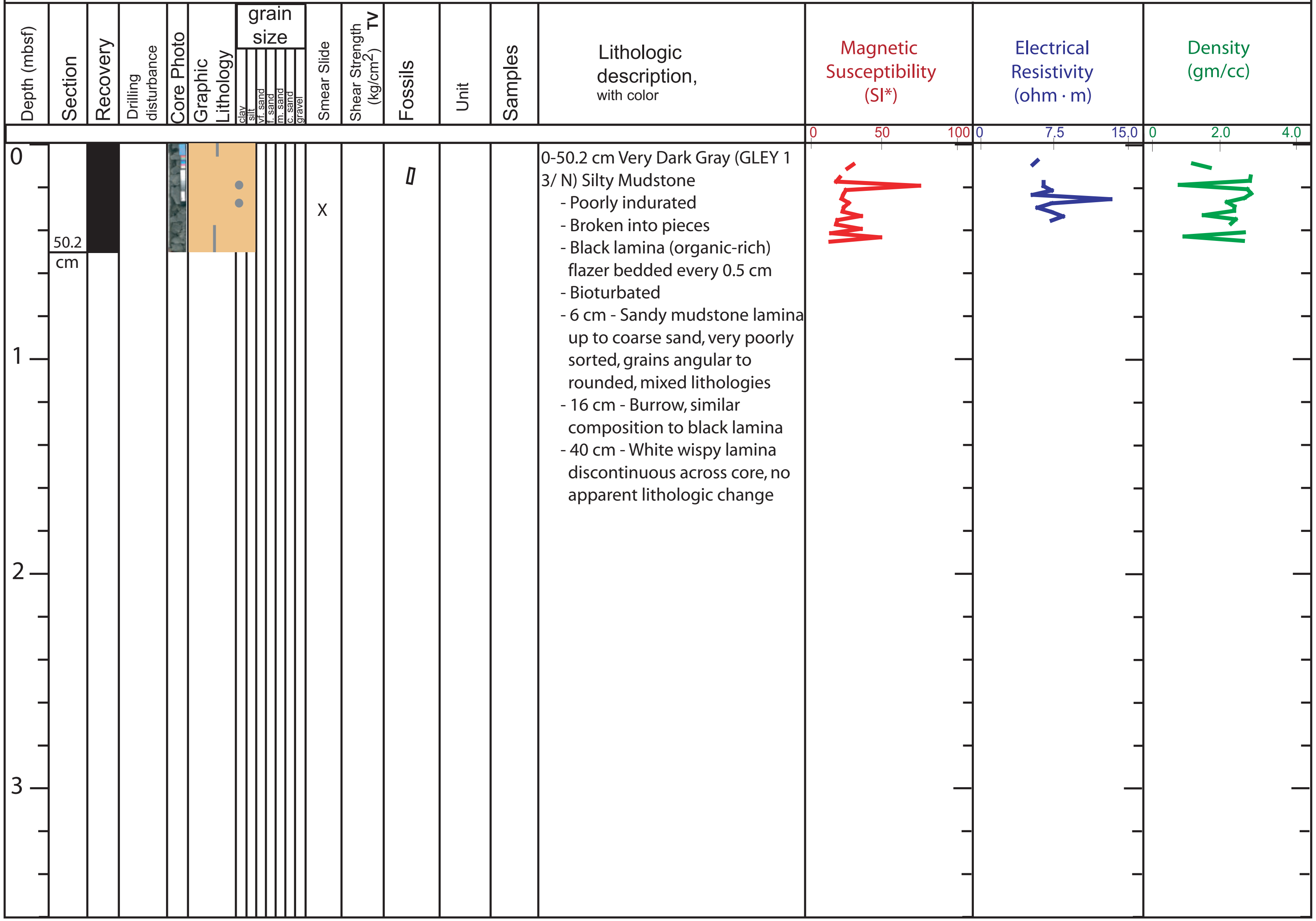


0-34.2 cm Very Dark Gray (GLEY 1 3/ N) Silty Mudstone

- Homogeneous
- Poorly indurated
- Broken into pieces
- Some mud between pieces caused while cutting the core with water saw

NBP0602A Site: 11 Hole: A Water Depth: 280 m

Core Number: 14 Top: 12.64 mbsf Core Type: R_a



Lithologic description, with color

0-50.2 cm Very Dark Gray (GLEY 1 3/ N) Silty Mudstone

- Poorly indurated
- Broken into pieces
- Black lamina (organic-rich) flazer bedded every 0.5 cm
- Bioturbated
- 6 cm - Sandy mudstone lamina up to coarse sand, very poorly sorted, grains angular to rounded, mixed lithologies
- 16 cm - Burrow, similar composition to black lamina
- 40 cm - White wispy lamina discontinuous across core, no apparent lithologic change

CHAPTER 9: SITE 12
Table of Contents

HOLE NBP0602A-12A

Date/time occupied (date; Julian Day; GMT): 31 March 2006; 90; 2145

Date/time departed: 1 April 2006; 91; 1345

Time on station: 16 hrs

Geographic area: Joinville Plateau

Ice coverage during station: $^{1}/_{10}$ to $^{8}/_{10}$

Position: 63° 16.354' S, 52° 49.501' W

Water depth (multibeam, m): 442

Water depth (drill-pipe measurement from sea level, m): 442

Total penetration (m): 7.2

Number of drill runs: 3

Total length of cored section (m): 4.3

Total drill core recovered (m): 2.74

Drill-core recovery (%): 64

Oldest sediment drilled:
  Depth sub-bottom (m): 7.2
  Nature: Silty mudstone
  Age: Oligocene

Principal Results: After voluntarily leaving Site NBP0602A-11, we elected to make one last attempt to sample Oligocene sediment before we had to depart for Punta Arenas. We searched for open water near our primary sites within James Ross Basin, but after finding no suitable areas further south, we selected Site NBP0602A-12 in the Joinville Plateau area where reflectors approximately 200 m below the middle Miocene sampled at Site NBP0602A-5 are located very close to the seafloor. Hole NBP0602A-12A was drilled to 7.2 mbsf in three core runs before the site was abandoned due to an approaching iceberg that was too large to maneuver around. Time constraints for returning to Punta Arenas precluded drilling a second hole.

Sediment recovered from this hole consists of sandy mud and muddy sand. The section has been divided into six lithologic units. Lithologic Unit I extends from 0-0.14

mbsf and consists mostly of modern black sandy mud with few coarse pebbles. A thin olive sand lamina occurs at the base of this unit. Lithologic Unit II (0.14-2.90 mbsf) consists of Oligocene black sandy mud with no pebbles. Lithologic Unit III (2.90-3.76 mbsf) consists of very dark gray muddy sand and no macrofossils. Lithologic Unit IV (3.76-4.20 mbsf) includes a layer of black muddy sand situated in between black sandy mud. Small lenses of clay occur throughout this unit. Lithologic Unit V (4.20-5.35 mbsf) consists of black muddy sand with small clay lenses and few shell fragments. Lithologic Unit VI extends from 5.35 mbsf to the bottom of the hole (7.20 mbsf) and consists of black sandy mud and one coarse pebble.

Both diatoms and calcareous nannofossils occur throughout much of the section in Hole NBP0602A-12A. The uppermost sediment (0-0.13 mbsf) contains a modern diatom assemblage. From 0.15-7.2 mbsf, the diatom assemblage includes rare to few Oligocene taxa, including the age-diagnostic species *Cavitatus jouseanus*, *C. rectus*, *Kisseleviella cicatricata*, and *K. tricoronata*, whose combined ranges provide an age of ~28.6-24.0 Ma for the section. Calcareous nannofossils occur sporadically below 0.15 mbsf. The assemblage is not very diverse, consisting mostly of reticulofenestrids, but the presence of *Dictyococcites bisecta* indicates the section is late Oligocene (~23.8-24.2 Ma) or older in age.

This site was a particular success because we were able to sample the target strata very close to the seafloor within the limited time allowed by drifting icebergs.

SEISMIC STRATIGRAPHY

(See “**Seismic Stratigraphy**” Ch. 5, Sites 5, 6, and 7, p. 176)

SITE 12

A. OBJECTIVES

Site NBP0602A-12 (Fig. 9-1) was drilled to sample the Oligocene strata approximately 200 m below the middle Miocene section targeted at Site NBP0602A-5. The target interval is an acoustically laminated interval where reflectors are located very close to the seafloor (Fig. 9-2).

B. OPERATIONS

Site NBP0602A-12 includes one drill hole and is located at 63° 16.354' S, 52° 49.501' W in 442 m of water. It reached a total depth of 7.2 mbsf in three runs with the alien bit (Table 9-1). The first run was a washed core that recovered 0.97 m of material. The base of that core sampled the target interval, so an operational shift was made to emphasize core recovery. The next run had 88% recovery. The final run was made while ice was about to force the vessel to leave station, so the tools were operated much faster than normal. Only a bag of material from the core catcher was retrieved from this final run.

This site is notable because of its success in recovering the older targeted interval in such a short period of time. Ice was problematic at this site as it was throughout the cruise. The hole succeeded for two reasons. First, a site with almost no overburden was selected so that a truly shallow hole could reach the desired material. Second, the vessel was very adeptly maneuvered around an iceberg that threatened the station early in the hole. The vessel had to move beyond the preferred 5% of water depth distance from the site. Even though the collars were not yet entirely buried, there were no ill effects from this movement. The hole was terminated after the third coring run due to a combination of ice that was too large to maneuver around and time constraints for returning to Punta Arenas.

C. LITHOSTRATIGRAPHY

Site NBP0602A-12 consists of one drill hole that extends from 0-7.2 mbsf. Sediment from this hole varies between sandy mud and muddy sand. This hole is divided into six lithologic units (Fig. 9-3; Appendix 9-1). Lithologic Unit I extends from 0-0.14 mbsf. The sediment from 0-0.13 mbsf consists of black (GLEY 1 2.5/ N), soft, sandy mud with a few coarse pebbles. The principal difference between this unit and units below is this unit is soft and contains pebbles. No macrofossils occur. A very thin lamina included in this unit extends from 0.13-0.14 mbsf, and consists of olive (5Y 4/3), fine to medium, well-rounded, well-sorted sand with almost no mud.

Lithologic Unit II extends from 0.14-2.90 mbsf. From 0.14-0.22 mbsf this unit consists of firm, black (GLEY 1 2.5/ N), sandy mud with no pebbles. From 0.22-0.75 mbsf the sediment is firm, very dark gray (GLEY 1 3/ N) sandy mud. From 0.75-0.97 mbsf the sediment grades into firm, very dark greenish gray (GLEY 1 3/1 10Y) sandy mud. A break in section occurs between 0.97-2.9 mbsf, so the transition from sandy mud above to muddy sand below is unknown, although by convention Lithologic Unit II extends to 2.90 mbsf.

Lithologic Unit III extends from 2.90-3.76 mbsf and the sediment consists of very dark gray (GLEY 1 3/ N) muddy fine to very find sand and no macrofossils. Smear-slide analysis of the <250 μm fraction (Table 9-2) indicates the unit is composed of 47% clay, 30% quartz, 7% heavy minerals, 5% feldspar, and 2% of both mica and calcite. Volcanic glass and glauconite represent 1% of the unit, and hornblende was found in trace amounts. Diatoms comprise 5% and both sponge spicules and calcareous nannofossils comprise trace amounts of the unit.

Lithologic Unit IV extends from 3.76-4.20 mbsf. This unit includes a layer of black (GLEY 1 2.5/ N) muddy sand from 3.92-4.00 mbsf in between black (GLEY 1 2.5/ N) sandy mud on either side. All of the sand in this unit is fine grain. Small lenses of clay exist throughout this unit. It contains no visible macrofossils. Smear-slide analysis of the <250 μm fraction (Table 9-2) indicates the unit is composed of 50-57% clay, 14-25% quartz, 11-16% feldspar, 4-15% calcite, 3-4% heavy minerals, and trace amounts of glauconite. Diatoms comprise trace amounts to 1%.

Lithologic Unit V extends from 4.20-5.35 mbsf and is composed of black (GLEY 1 2.5/ N), muddy fine sand. Small lenses of clay are present, as are several shell fragments. No evidence for bioturbation is evident. Smear-slide analysis of the <250 μm fraction (Table 9-2) indicates the unit is composed of 54% clay, 15% quartz, 10% calcite, 10% feldspar, 5% heavy minerals, and trace amounts of glauconite. Diatoms comprise 1% of this unit.

Lithologic Unit VI extends from 5.35-7.20 mbsf. From 5.35-5.64 mbsf the sediment consists of black (GLEY 1 2.5/ N) sandy mud with no macrofossils, and one coarse, subangular pebble found at 5.48 mbsf. The only sediment collected below 5.64 mbsf came from the core catcher of the last core, and it consists of the same lithology (black sandy mud) as described above.

D. BIOSTRATIGRAPHY

Initial shipboard paleontological work for Site NBP0602A-12 included smear slide examination of diatom and calcareous nannofossil assemblages. Observed diatom and nannofossil taxa are listed in Tables 9-3 and 9-4.

Ten samples from Hole NBP0602A-12A were examined for diatoms (Table 9-3). Sample NBP0602A-12A-1R$_a$, 13 cm contains a moderately preserved assemblage of modern (extant) diatoms. Immediately below this level in Sample NBP0602A-12A-1R$_a$, 15 cm, a pre-Quaternary diatom assemblage is present, suggesting that the uppermost material of Core NBP0602A-12A-1R$_a$ may represent downcore contamination of seafloor muds.

The interval from Sample NBP0602A-12A-1R$_a$, 15 cm to -3R$_a$-CC (0.15-7.2 mbsf) contains an Oligocene diatom assemblage, with rare to few diatoms that are poorly to moderately preserved. Characteristic taxa observed within this interval include *Hemiaulus polycystinorum, Rhizolenia hebetata* f. *hiemalis, Rhizolenia hebetata* group, *Stephanopyxis* spp., and *Trinacria excavata* (Table 9-3). Fragments and whole specimens of *Stephanopyxis* spp. are particularly common in these samples. *Stephanopyxis* represents a diverse group of taxa that have neritic-planktonic habitat preferences and are typical of pre-Quaternary deposits on the Antarctic shelf.

Age diagnostic diatom taxa present within the Oligocene interval of Hole NBP0602A-12A include *Cavitatus jouseanus, C. rectus, Kisseleviella cicatricata,* and *K. tricoronata*. In North Pacific cores, the first occurrence of *C. rectus* has a calibrated age of 28.6 Ma (Barron et al., 2004). Assuming this taxon has a similar range in the Southern Ocean, a maximum age of 28.6 Ma can be interpreted for the Hole 12A section. The two *Kisseleviella* taxa observed in Hole 12A were recently described from the Cape Roberts Project drill core CRP-2A in the Ross Sea (Olney et al., 2005). In the CRP-2A core, the last occurrence of *Kisseleviella cicatricata* is recorded near the Oligocene/Miocene boundary (Scherer et al., 2000; Wilson et al., 2002; Olney et al., 2005), which provides a minimum age of ~24.0 Ma for the strata sampled in Hole 12A. The combined ranges of diatoms present in Hole 12A, therefore, provide a broad late Oligocene age assignment (~28.6 to 24.0 Ma) for this section.

Calcareous nannofossils occur sporadically through the section retrieved from Hole NBP0602A-12A. While some samples are barren, many contain rare to few, moderately preserved calcareous nannofossils (Table 9-4). The predominant taxa are reticulofenestrids, including *Reticulofenestra daviesii*, *R. minutula*, *Cyclicargolithus floridanus*, and *Dictyococcites bisecta*. In addition, *Thoracosphaera* spp. also occur sporadically throughout the section. The limited diversity makes a precise age assignment impossible; however, the presence of *D. bisecta*, which has a last occurrence at the end of the Oligocene (~23.8-24.2 Ma), indicates that the section is late Oligocene or older in age.

E. PHYSICAL PROPERTIES

Site NBP0602A-12 consists of one hole reaching ~7 mbsf with limited recovery. All cores were run on the multisensor core logger (MSCL) (2-cm readings); the

Middlebury College electrical resistivity (MCER) probe was done every 5 cm, with discrete samples taken every 10 to 20 cm.

Hole NBP0602A-12A consists of sandy mud at the surface overlying a series of muddy sands interspersed with sandy mud. The sandy mud in Core NBP0602A-12A-1R_a has higher density (near 3.0 g/cm^3) than the muddy sand found in Core NBP0602A-12A-2R_a (2.5 g/cm^3). This is further demonstrated in Core 2R_a where layers of sandy mud interlayer with the muddy sand. Each layer of sandy mud has a higher density (Lithology Log NBP0602A-12A-2R_a; layers at 90, 120, and 260 cm). With the exception of one large spike in MS at the top of Core 1R_a (associated with a pebble), the magnetic susceptibility (MS) of this hole is around 28 SI. The electrical resistivity (ER) measurements average around 0.9 ohm-m for the MSCL and slightly higher (1.5 ohm-m) for the MCER probe. These physical properties values are consistent for similar lithologies obtained at nearby Sites NBP0602A-5, -6, and -7.

F. SITE SUMMARY

The objective of Site NBP0602A-12 was to sample Oligocene deposits. The site was drilled approximately 200 m stratigraphically below the middle Miocene section drilled at Site NBP0602A-5 in the Joinville Plateau. The site was chosen because seismic records showed very thin overburden above the target strata.

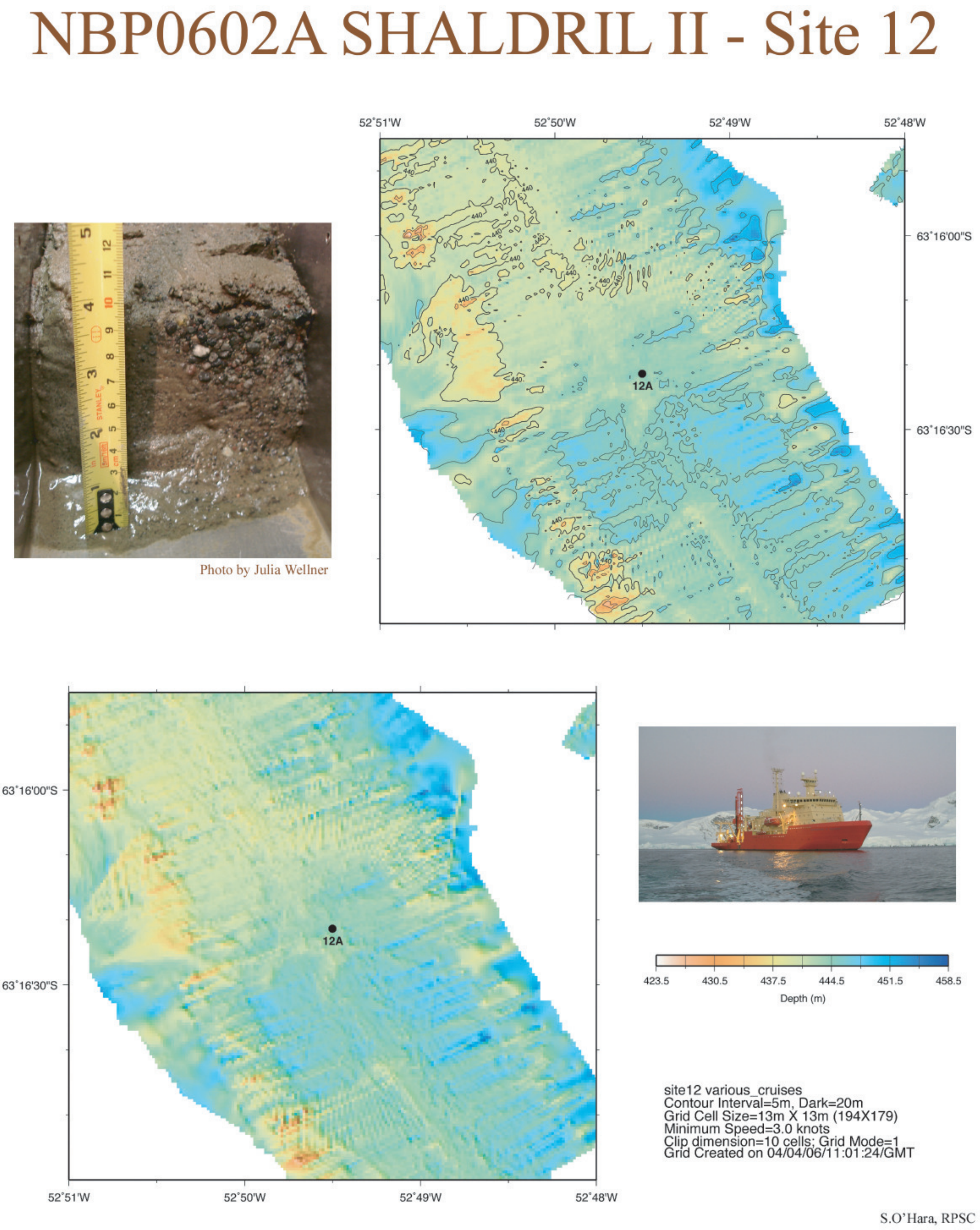
Hole NBP0602A-12A reached a total depth of 7.2 mbsf in three core runs. The first core sampled highly compacted sandy mud in the core catcher. The sandy mud contains one possible dropstone and has a strong odor. The sediment from this hole has been divided into six lithologic units:

Lithologic Unit I (0-0.14 mbsf) consists mostly of modern black sandy mud with few coarse pebbles. A thin olive sand lamina occurs at the base of this unit.
Lithologic Unit II (0.14-2.90 mbsf) consists of black sandy mud with no pebbles or macrofossils.
Lithologic Unit III (2.90-3.76 mbsf) consists of very dark gray muddy sand and no macrofossils.
Lithologic Unit IV (3.76-4.20 mbsf) includes a layer of black muddy sand situated in between black sandy mud. Small lenses of clay occur throughout this unit. There are no visible macrofossils.
Lithologic Unit V (4.20-5.35 mbsf) consists of black muddy sand with small clay lenses and few shell fragments. There is no evidence of bioturbation in this unit.
Lithologic Unit VI (5.35-7.20 mbsf) consists of black sandy mud and one coarse pebble. No macrofossils occur.

The uppermost sediment from Hole NBP0602A-12A (0-0.13 mbsf) contains a modern diatom assemblage. From 0.15-7.2 mbsf, the diatom assemblage includes rare to few Oligocene taxa, including the age-diagnostic species *C. jouseanus*, *C. rectus*, *K. cicatricata*, and *K. tricoronata*, whose combined ranges provide an age of ~28.6-24.0 Ma for the section. The calcareous nannofossil assemblage is not very diverse, consisting mostly of reticulofenestrids, but the presence of *D. bisecta* below 0.15 mbsf indicates the section is late Oligocene (~23.8-24.2 Ma) or older in age.

The hole was terminated after three core runs when drifting ice forced us to abandon the site. Although we were unable to drill a second hole due to time constraints for returning to Puntas Arenas, this site was a particular success because we were able to sample the target Oligocene section very close to the seafloor within the limited time allowed by drifting ice.

Figure 9-1. Multibeam images of Site NBP0602A-12.



NBP0602A SHALDRIL II - Site 12

Photo by Julia Wellner

site12 various_cruises
Contour Interval=5m, Dark=20m
Grid Cell Size=13m X 13m (194X179)
Minimum Speed=3.0 knots
Clip dimension=10 cells; Grid Mode=1
Grid Created on 04/04/06/11:01:24/GMT

S.O'Hara, RPSC

Figure 9-2. Seismic Line NBP0602A-11 showing the location of Hole NBP0602A-12A.

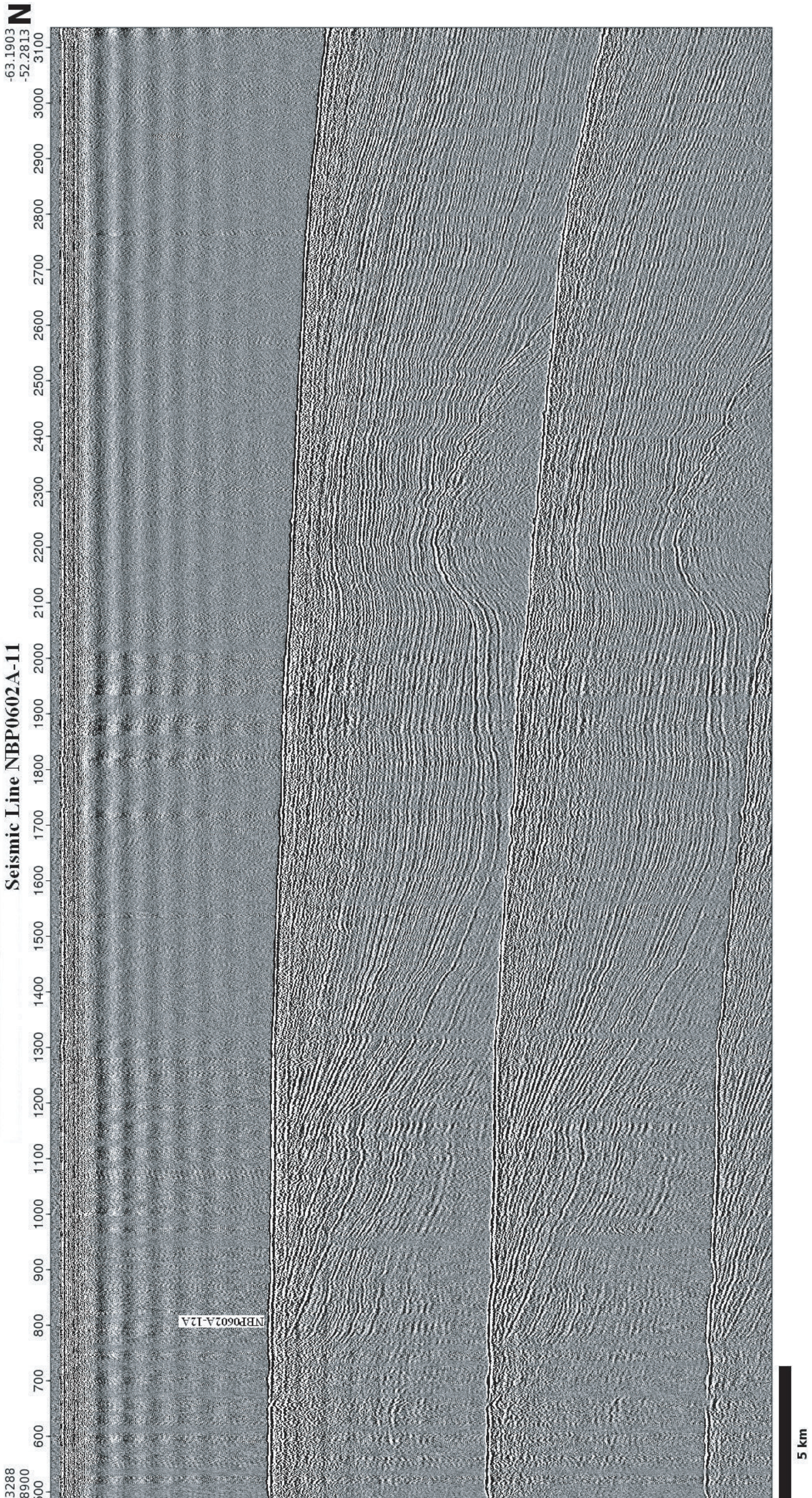
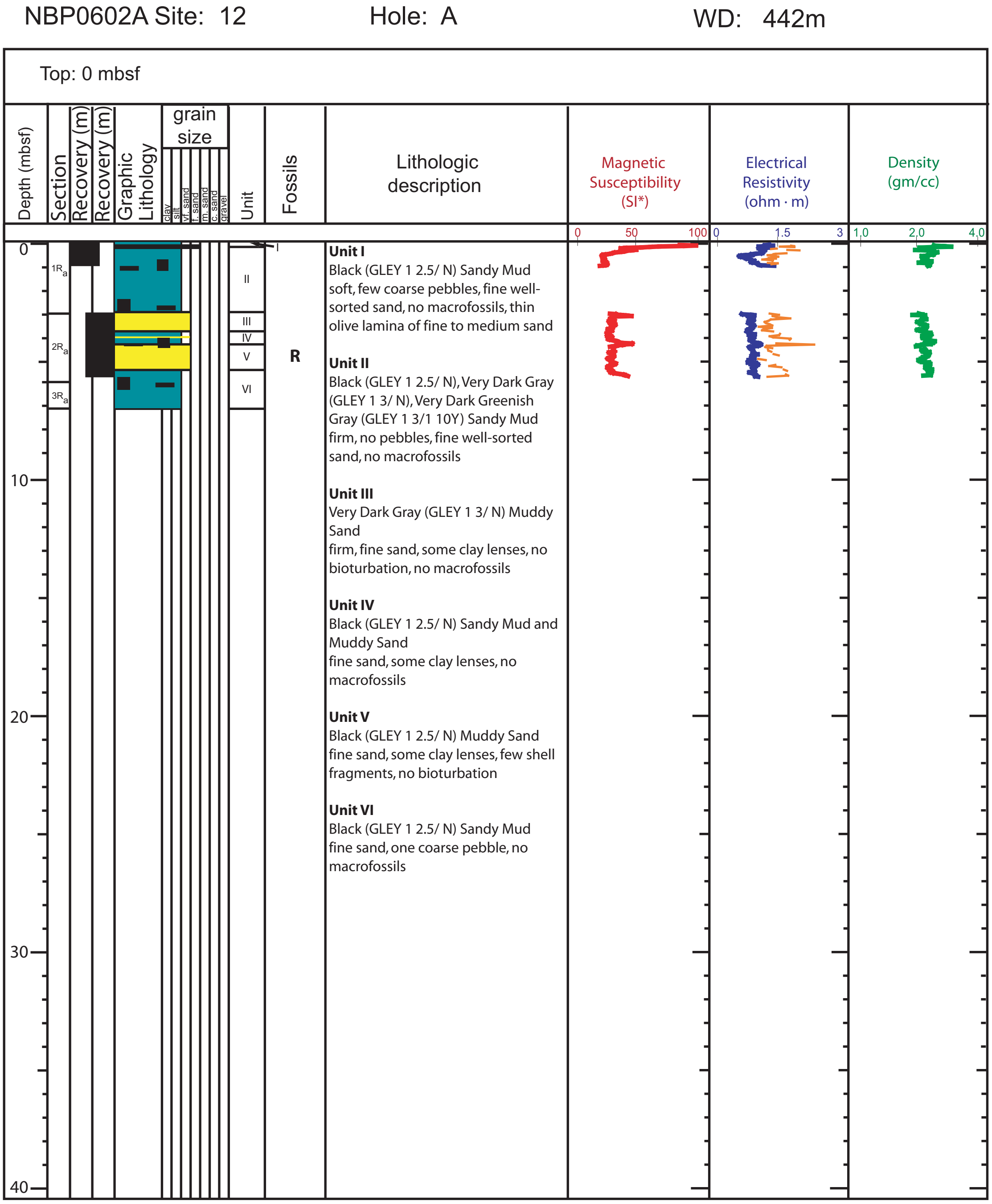


Figure 9-3. Summary lithologic log of Hole NBP0602A-12A.



Unit I
Black (GLEY 1 2.5/ N) Sandy Mud
soft, few coarse pebbles, fine well-sorted sand, no macrofossils, thin olive lamina of fine to medium sand

Unit II
Black (GLEY 1 2.5/ N), Very Dark Gray (GLEY 1 3/ N), Very Dark Greenish Gray (GLEY 1 3/1 10Y) Sandy Mud
firm, no pebbles, fine well-sorted sand, no macrofossils

Unit III
Very Dark Gray (GLEY 1 3/ N) Muddy Sand
firm, fine sand, some clay lenses, no bioturbation, no macrofossils

Unit IV
Black (GLEY 1 2.5/ N) Sandy Mud and Muddy Sand
fine sand, some clay lenses, no macrofossils

Unit V
Black (GLEY 1 2.5/ N) Muddy Sand
fine sand, some clay lenses, few shell fragments, no bioturbation

Unit VI
Black (GLEY 1 2.5/ N) Sandy Mud
fine sand, one coarse pebble, no macrofossils

Table 9-1. Drilling and coring recovery log for Hole NBP0602A-12A.

NBP0602A SHALDRIL II Site 12 (Joinville Plateau)
Multibeam Water Depth: 442 m

Station Number/Hole	Core Number	Core Type	Top (mbsf)	Bottom (mbsf)	Interval Cored (m)	"Push Distance" (m)	Recovery: total (m)	Recovery: competent (m)	Recovery: disturbed (m)	Gaps (m)	Recovery Corrected (m)	Total Recovery (%)	Recovery Corrected (%)	Section Number	Section Lengths (cm)	Date (JD)	Time on Deck (GMT)	Initials	Comments
12A	1	Ra-w	0.0	2.9	0-2.9	2.9	0.97	0.97	0	0	0.97	33.4%	33.4%	1	99	91	0410	JM	We made it!
12A	2	Ra	2.9	6.0	2.9-6.0	3.1	2.74	2.74	0	0	2.74	88.4%	88.4%	1	150	91	0610	JM	
12A	2	Ra												2	124	91	0610	JM	
12A	3	Ra	6.0	7.2	6.0-7.2	1.2	0	0	0	0	0	0.0%	0.0%	baggie	0	91	0715	JSW	Core catcher bagged; End of hole due to ice
							3.71												

Table 9-2. Smear-slide data for Hole NBP0602A-12A.

Sample	Approximate Depth (mbsf)	Components														Grain Size			Sorting	Roundness	Lithology	Comments
		Minerals										Biogenic			Rock							
		Calcite	Clay	Feldspar	Glauconite	Heavy Minerals	Hematite	Hornblende	Mica	Quartz	Volcanic Glass	Calcareous Nannofossils	Diatoms	Sponge Spicules	Fragments	Sand	Silt	Clay				
Hole 12A																						
NBP0602A-12A-1$\mathrm{R}_{\text{a-w}}$, base	0.97	2	47	5	1	7		tr	2	30	1	tr	5	tr		25	25	50	P	sa-sr	Sandy mud	Some clay coated grains
NBP0602A-12A-1$\mathrm{R}_{\text{a-w}}$-CC	(0.97-2.90)	25	41	5	tr	5	tr	1	3	20			tr	tr		10	48	42	P	sa-sr	Mud	Some clay coated grains
NBP0602A-12A-2R_{a}, 100 cm	3.90	4	50	16	tr	4				25			1			5	40	55	P	a-sr	Mud	
NBP0602A-12A-2R_{a}, 120 cm	4.10	15	57	11	tr	3				14			tr			20	20	60	P	a-sr	Sandy mud	
NBP0602A-12A-2R_{a}, 240 cm	5.30	10	54	10	tr	5				15			1			15	20	65	P	a-sr	Sandy mud	

Notes: Sample: R_{a} = cored using alien bit; Components/Grain Size: Numbers represent percentages, tr = trace; Sorting: P = poor; Roundness: a = angular, sa = subangular, sr = subrounded.

Table 9-3. Stratigraphic occurrence and relative abundance of diatom taxa in Hole NBP0602A-12A.

Cruise/Hole/Core/Interval	Depth (mbsf)	Slide Preparation	Diatom Abundance	Preservation	Fragmentation	Diatoms																			
						Actinocyclus actinochilus	*Actinocyclus* sp. 1	*Cavitatus jouseanus*	*Cavitatus miocenicus*	*Cavitatus rectus*	*Chaetoceros* spp. (small veg. cells & resting spores)	*Chaetoceros* spp. (large spores, ornamented)	*Corethron criophilum* (valves & spines)	*Eucampia antarctica* var. *recta*	*Fragilariopsis angulata*	*Fragilariopsis curta*	*Fragilariopsis cylindrus*	*Fragilariopsis obliquecostata*	*Fragilariopsis ritscheri*	*Fragilariopsis sublinearis*	*Fragilariopsis vanheurckii*	*Hemiaulus polycystinorum*	*Kisseleviella cicatricata*	*Kisseleviella tricoronata*	*Paralia* spp.
Hole 12A																									
NBP0602A-12A-1R$_{a-w}$, 8 cm	0.08	smear	B	-	-																				
NBP0602A-12A-1R$_{a-w}$, 13 cm	0.13	smear	C	M	H	F					F		X	X	X	F-C	R	R	fr(X)	F	R				
NBP0602A-12A-1R$_{a-w}$, 15 cm	0.15	smear	R	P	H		X				X											R			
NBP0602A-12A-1R$_{a-w}$, 30 cm	0.30	smear&>10	F	P-M	H		X	X	fr(R)	R	X											F	R	X	
NBP0602A-12A-1R$_{a-w}$, 93 cm	0.93	smear	R-F	P	H						X											R		X	
NBP0602A-12A-1R$_{a-w}$, 96 cm	0.96	smear	R-F	P	H						R											R	X		X
NBP0602A-12A-1R$_{a-w}$-CC	0.97	smear&stewn	X	P	H						X														
NBP0602A-12A-2R$_a$, 70 cm	3.60	smear	R	P	H			X	fr(X)		R	X										X	X	X	X
NBP0602A-12A-2R$_a$, 146 cm	4.36	smear	F	P	H			fr(X)			R	X										F			X
NBP0602A-12A-3R$_a$-CC	6.00	smear	X	P	H						R											X			

Notes: Abundance: C = common, F = few, R = rare, X = present, B = barren, fr = fragment; Preservation: M = moderate, P = poor; Fragmentation: H = high.

Table 9-3 (continued).

						Diatoms											Silicoflagellates & Ebridians	
Cruise/Hole/Core/Interval	**Depth (mbsf)**	**Slide Preparation**	**Diatom Abundance**	**Preservation**	**Fragmentation**	*Porosira* spp.	*Pseudotriceratium radiosoreticulatum*	*Rhabdonema* spp.	*Rhizosolenia hebata* f. *hiemalis*	*Rhizosolenia* sp. 1	*Rhizosolenia* spp.	*Stellarima microtrias*	*Stephanopyxis* spp. (large, heavily silicified)	*Thalassiosira antarctica* var. *antarctica*	*Thalassiothrix/Trichotoxon* spp.	*Trinacria excavata* group	*Dictyocha deflandrei*	*Pseudammodochium lingii*
Hole 12A																		
NBP0602A-12A-1R$_{a-w}$, 8 cm	0.08	smear	B	-	-													
NBP0602A-12A-1R$_{a-w}$, 13 cm	0.13	smear	C	M	H	X						R	X	C	fr(X)			
NBP0602A-12A-1R$_{a-w}$, 15 cm	0.15	smear	R	P	H				X	X	R	fr(X)	fr(X)		fr(X)			
NBP0602A-12A-1R$_{a-w}$, 30 cm	0.30	smear&>10	F	P-M	H		X		R-F	R	X		F-C			fr(X)	X	R
NBP0602A-12A-1R$_{a-w}$, 93 cm	0.93	smear	R-F	P	H				X	X	R	fr(X)	F			fr(X)	X	X
NBP0602A-12A-1R$_{a-w}$, 96 cm	0.96	smear	R-F	P	H				R	X	X		fr(F)			fr(X)	X	X
NBP0602A-12A-1R$_{a-w}$-CC	0.97	smear&stewn	X	P	H				X		X		X					
NBP0602A-12A-2R$_{a}$, 70 cm	3.60	smear	R	P	H		X	X		R	X	fr(X)	R-F			fr(X)		
NBP0602A-12A-2R$_{a}$, 146 cm	4.36	smear	F	P	H			X	R-F	R	X		F			fr(X)		
NBP0602A-12A-3R$_{a}$-CC	6.00	smear	X	P	H			X		X	X		fr(R)			fr(X)		

Notes: Abundance: C = common, F = few, R = rare, X = present, B = barren, fr = fragment; Preservation: M = moderate, P = poor; Fragmentation: H = high.

Table 9-4. Stratigraphic occurrence and relative abundance of calcareous nannofossil taxa in Hole NBP0602A-12A.

				Calcareous Nannofossils							
Cruise/Hole/Core/Interval	**Depth (mbsf)**	**Abundance**	**Preservation**	*Cyclicargolithus floridanus*	*Dictyococcites bisecta*	*Dictyococcites bisecta filewicszi*	*Reticulofenestra daviesii*	*Reticulofenestra minutula*	*Reticulofenestra* sp. (5-8 µm)	*Reticulofenestra* sp. (>8 µm)	*Thoracosphaera* spp.
Hole 12A											
NBP0602A-12A-1R$_{a-w}$, 15 cm	0.15	?									
NBP0602A-12A-1R$_{a-w}$, 30 cm	0.30	tr									
NBP0602A-12A-1R$_{a-w}$, 58 cm	0.58	B									
NBP0602A-12A-1R$_{a-w}$, 72 cm	0.72	R	M								R
NBP0602A-12A-1R$_{a-w}$, 93 cm	0.93	F	M			?	F				F
NBP0602A-12A-1R$_{a-w}$, 96 cm	0.96	F	M	R	R		R	F	F	R	F
NBP0602A-12A-1R$_{a-w}$-CC		B									
NBP0602A-12A-2R$_{a}$, 146 cm	4.36	R	M				R		R		
NBP0602A-12A-2R$_{a}$, 150 cm	4.40	B									

Notes: Abundance: F = few, R = rare, tr = trace, B = barren, ? = questionable; Preservation: M = moderate.

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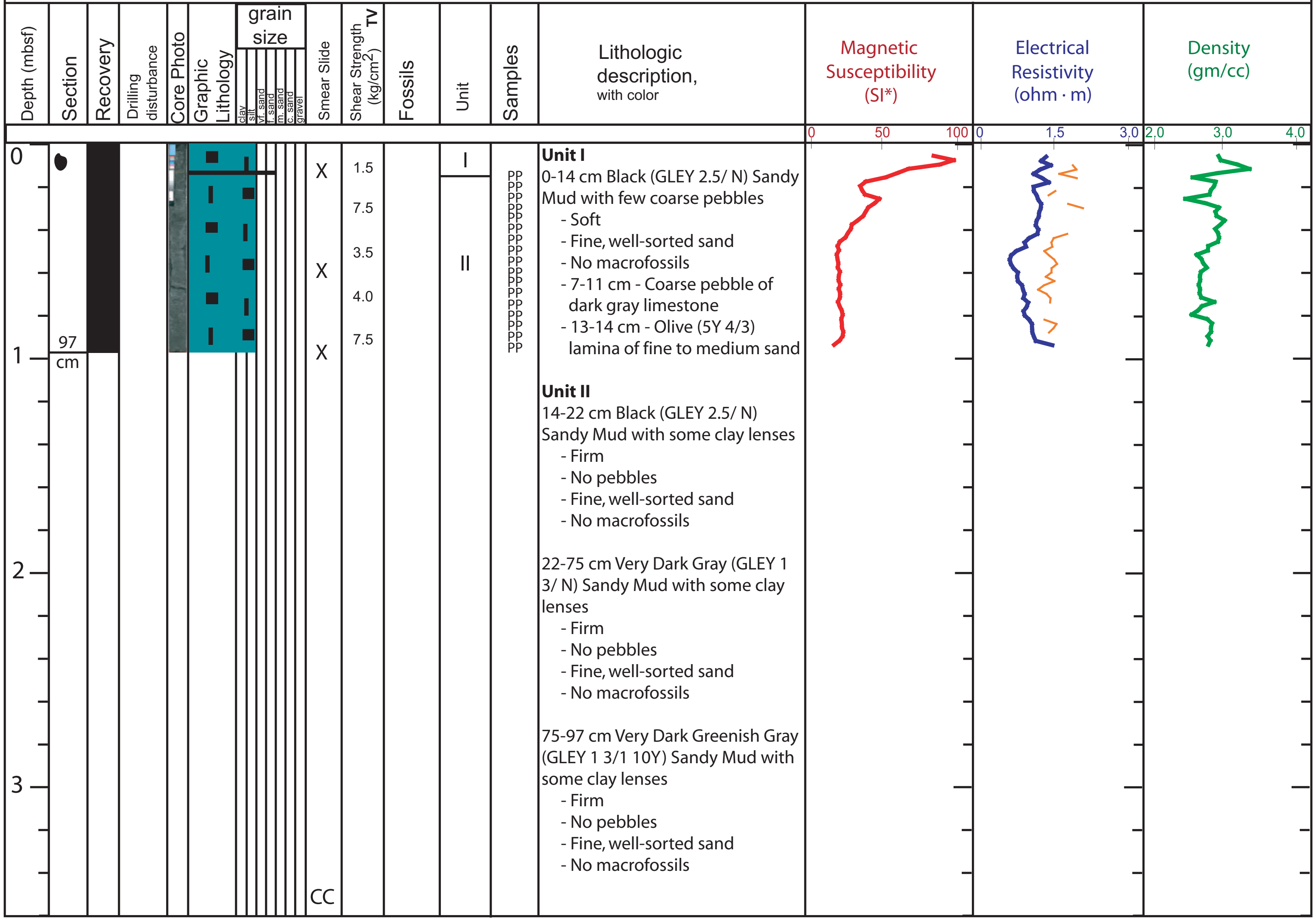
NBP0602A Site: 12 Hole: A

Water Depth: 442m

Core Number: 1 Top 0.0 mbsf Core Type: R_a



Unit I

0-14 cm Black (GLEY 2.5/ N) Sandy Mud with few coarse pebbles

- Soft
- Fine, well-sorted sand
- No macrofossils
- 7-11 cm - Coarse pebble of dark gray limestone
- 13-14 cm - Olive (5Y 4/3) lamina of fine to medium sand

Unit II

14-22 cm Black (GLEY 2.5/ N) Sandy Mud with some clay lenses

- Firm
- No pebbles
- Fine, well-sorted sand
- No macrofossils

22-75 cm Very Dark Gray (GLEY 1 3/ N) Sandy Mud with some clay lenses

- Firm
- No pebbles
- Fine, well-sorted sand
- No macrofossils

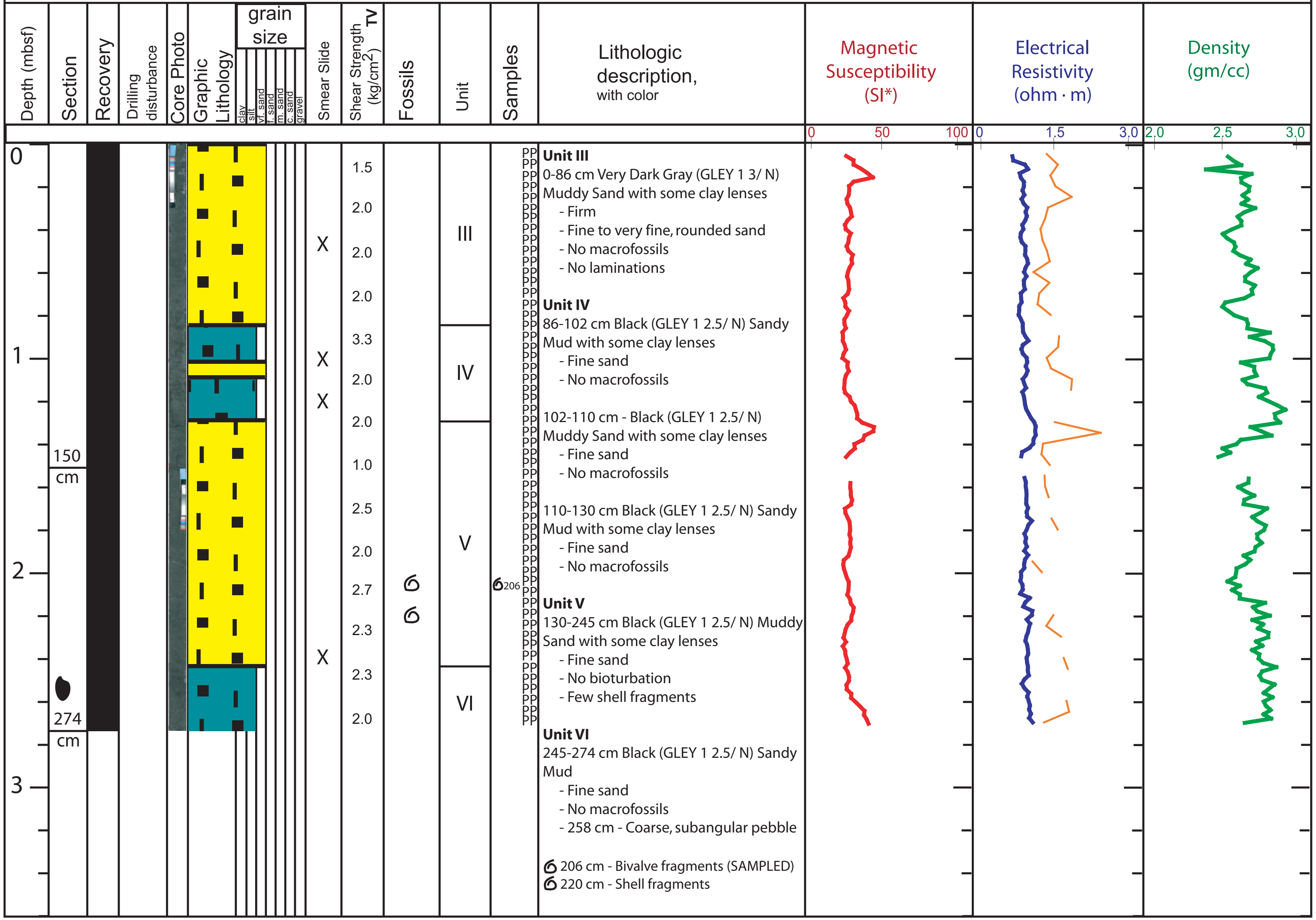
75-97 cm Very Dark Greenish Gray (GLEY 1 3/1 10Y) Sandy Mud with some clay lenses

- Firm
- No pebbles
- Fine, well-sorted sand
- No macrofossils

NBP0602A Site: 12 Hole: A

Water Depth: 442m

Core Number: 2 Top 2.9 mbsf Core Type: R_a



Unit III
0-86 cm Very Dark Gray (GLEY 1 3/ N) Muddy Sand with some clay lenses
- Firm
- Fine to very fine, rounded sand
- No macrofossils
- No laminations

Unit IV
86-102 cm Black (GLEY 1 2.5/ N) Sandy Mud with some clay lenses
- Fine sand
- No macrofossils

102-110 cm - Black (GLEY 1 2.5/ N) Muddy Sand with some clay lenses
- Fine sand
- No macrofossils

110-130 cm Black (GLEY 1 2.5/ N) Sandy Mud with some clay lenses
- Fine sand
- No macrofossils

Unit V
130-245 cm Black (GLEY 1 2.5/ N) Muddy Sand with some clay lenses
- Fine sand
- No bioturbation
- Few shell fragments

Unit VI
245-274 cm Black (GLEY 1 2.5/ N) Sandy Mud
- Fine sand
- No macrofossils
- 258 cm - Coarse, subangular pebble

໒ 206 cm - Bivalve fragments (SAMPLED)
໒ 220 cm - Shell fragments