

**SEDIMENT DESCRIPTIONS**  
for  
***R/V POLAR DUKE***  
**CRUISE I, 1991**

Sedimentology Research Laboratory Contribution No. 62

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DESCRIPTIONS OF SEDIMENT RECOVERED  
BY THE R/V POLAR DUKE,  
UNITED STATES ANTARCTIC PROGRAM  
1991

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## INTRODUCTION

This volume contains the descriptions of sediments recovered by the R/V Polar Duke during the first cruise of 1991 (herein referred to as PD91). Much of this cruise was devoted to collecting approximately 2000 km of high-quality seismic records from the northwestern Weddell Sea and Antarctic Peninsula region (Figure 1). A small number of marine geologic samples (piston cores, trigger cores, gravity cores, and grab samples) were also collected (Table 1) and are described here to assist geoscientists as a guide for sediment sampling.

The sediments are curated at the Antarctic Marine Geology Research Facility, Florida State University, Tallahassee. This facility contains an extensive collection of Antarctic and subantarctic sediments retrieved by coring, dredging, trawling, and grab sampling from a number of research cruises and vessels, and other research initiatives, including: forty-seven cruises of the USNS Eltanin (Goodell, 1964, 1965, 1968; Frakes, 1971, 1973; Cassidy et al., 1977a), five cruises of the ARA Islas Orcadas (Cassidy et al., 1977b; Kaharoeddin, 1978; Kaharoeddin et al., 1979, 1980, 1982), more than 13 cruises of the USCGC Glacier (Goodell et al., 1961; Anderson et al., 1981, 1986; Kellogg et al., 1981; Kaharoeddin et al., 1983, 1984, 1988; Anderson et al., 1987; Bryan, 1992a, b), eight cruises of the R/V Polar Duke (Jeffers, 1987; Jeffers and Anderson, 1986; Anderson, 1988; Domack, 1988; Lawver and Villinger, 1989; Anderson and Bartek, 1990; Anderson, 1991; Domack, 1992; Bryan and Pospichal, 1993; Hovan and Janecek, 1994a, b, c), three cruises of the R/V N.B. Palmer (Lawver, 1993), the Dry Valley Drilling Project (DVDP) (Dry Valley Drilling Project, 1974, 1975, 1976; McGinnis, 1979; Torii, 1981), the Ross Ice Shelf Project (RISP) (Clough and Hansen, 1979; Webb, 1978, 1979), the Eastern Taylor Valley Project (ETV) (Elston et al., 1981, 1983; Robinson, 1983, 1985; Robinson and Jaegers, 1984; Robinson et al., 1984), the Cenozoic Investigations in the Western Ross Sea Project (CIROS-1, CIROS-2) (Barrett, 1982, 1985, 1987; Barrett et al., 1985; Pyne et al., 1985; Robinson et al., 1987), and collections from miscellaneous vessels operating in the Southern Ocean (Anton Brun, Robert Conrad, Hero, and Vema).

This volume includes a summary of the scientific objectives of PD91, a discussion of core recovery and processing, a table and map of station

locations, an explanation of laboratory descriptive procedures, and lithologic descriptions of piston, trigger, and gravity cores.

## R/V POLAR DUKE 1991- CRUISE 1

### Cruise objectives

The objectives and preliminary results of cruise PD91 have been summarized by Anderson (1991). For the convenience of those using this sediment description volume, we have included a brief summary of those objectives below:

1. Acquire a high-resolution seismic reflection data set in the northwestern Weddell Sea suitable for seismic stratigraphic analysis to use in the examination of the Neogene glaciation record on the shelf and to aid in the selection of future drilling sites to further assist in this examination.
2. Collect high-resolution seismic profiles from the northern Antarctic Peninsula continental shelf to map those features that define the grounding line position of the late Wisconsinan ice cap in the region.
3. Acquire piston cores and high-resolution seismic records from Herbert Sound and Maxwell Bay to enhance understanding of the Holocene glacial/climatic record of the Antarctic Peninsula region.

A total of 19 days was devoted to marine geological and geophysical studies resulting in the collection of approximately 2000 km of high-quality seismic records and 10 piston cores. The initial portion of the cruise concentrated on acquiring a high-resolution seismic data set from the continental shelf of Gerlache Strait to Antarctic Sound (Figure 2a). This expands data coverage of the shelf from Marguerite Bay to the northern end of the Antarctic Peninsula. All of the data are being used to map those features that define the grounding line position of the late Wisconsin ice cap in the region and to analyze the Neogene sequence stratigraphic signature.

A second phase of the expedition focused on the northwestern Weddell Sea (Figure 2b). The objective was to collect enough seismic data to permit a

high-resolution sequence stratigraphic analysis of the area to use in the evaluation of the Neogene glacial record and to aid in the selection of possible future drilling sites. Glacial erosion has left virtually the entire 3.5 km-thick section of the basin exposed at one place or another on the shelf. Thus, this area is ideally suited for shallow drilling, and should yield a more complete Paleogene-Neogene stratigraphic record of the Antarctic Peninsula region than any other area studied to date.

A final phase of the project this season was an examination of the Holocene climatic evolution of the Antarctic Peninsula region. Toward this goal, a detailed seismic and coring survey was conducted in selected bays and fjords of the Peninsula. The primary objective was Andvord Bay, located on the Antarctic Peninsula off Gerlache Strait (Figure 2c) and Herbert Sound (Figure 2d). Herbert Sound is of key interest because it is the largest bay south of the Peninsula and, therefore, subject to colder and dryer conditions than Andvord Bay and other bays and fjords of the Gerlache Strait-Bransfield Basin region. Data from both these regions will enable examination of fluctuations in the sharp thermal gradient that separates these regions throughout Holocene time.



Table 1. Coring Summary for PD91 cruise.

Station ID	Latitude (°S)	Longitude (°W)	Depth (m)	Additional samples
PC01	64°49.75'	62°38.65'	461	TC01
PC02	63°05.21'	58°45.49'	161	TC02
PC03	63°10.31'	57°42.59'	385	TC03*
PC04	63°04.41'	57°48.89'	620	TC04
PC05	64°39.79'	58°21.76'	547	TC05
PC06	63°55.56'	57°41.29'	350	TC06
PC07	63°48.80'	57°46.34'	237	TC07
PC08	63°58.75'	57°46.49'	360	TC08
PC09	63°55.70'	57°46.20'	87	TC09*
PC10*	63°53.75'	57.45.34'	127	TC10*
GC1	63°52.82'	57°39.11'	235	
GC2	63°53.00'	57°40.00'	334	
GC3	63°53.15'	57°41.26'	356	
GC4	63°53.36'	57°43.52'	360	
GS1	63°11.51'	58°33.40'	112	
GS2	63°53.87'	57°45.30'	157	

\* No recovery

Insert Figure 2a

Insert Figure 2b

Insert Figure 2c

Insert Figure 2d

## CORE PROCESSING

At the Antarctic Research Facility all cores are cut using an adjustable, track-operated, radial power saw (Cassidy and Devore, 1973). The saw is adjusted to cut only through the thickness of the plastic core liner. Two cuts are made on opposite sides of the core liner. Once the liner is cut, the core sediments are manually split by drawing a wire through the middle of the core. Each half section of core is cleaned of plastic debris (which results from cutting the liners) by scraping the sediment perpendicular to the core axis with a stainless steel spatula. This exposes fresh sediment. Core halves are then measured, labeled every 20 cm (taking into account any bagged sediments), and heat-sealed within polyethylene sleeving to prevent desiccation. Structures in the sediment resulting from disturbance from flow-in or sediment washing are recorded immediately after the core is opened.

All cores are stored in a refrigerated store room (~2°C) at the Antarctic Research Facility, Florida State University. Bagged samples are placed in labeled plastic bags and are also kept in refrigerated storage.

## CORE DESCRIPTION PROCEDURES

### General Description Procedures

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

The description of each core consists of three types of information:

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.).

Most of the primary information is obtained from the deck-log, or from other information provided by the chief scientist 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.

Each core description is accompanied by a graphic log illustrating the main lithologies, boundaries, inclusions, sedimentary structures, and disturbances of the sedimentary units. The same criteria and format used for describing piston cores are used for describing trigger and gravity cores. The positions of the core section breaks are also indicated in the log in order to inform the investigator as to where samples should not be taken, since the 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. Note that a different scale of the graphic log is used for trigger and gravity cores than piston cores.

In addition to the recovery of piston, trigger, and gravity cores, a variety of bagged sediments are normally collected during most cruises. Bagged samples are listed following the graphic core descriptions and are also available for sampling. Bagged sediments include:

1. Sediments representing the total recovery of sediment by the coring attempt (piston and trigger cores).
2. Sediments recovered by grab-sampling.
3. Sediment that has come out of the core liner. Most bagged sediments in this category are from the top or bottom of core sections, and usually result from the accidental spilling of sediment from the liner end either during handling or cutting of the liner into shorter sections, or from difficult extrusion of the core liner from the core barrel.

## Megascopic Examination and Description

The elements of description of each unit are presented in the following order:

1. The upper and lower boundaries of the unit in centimeters. (For bagged sediments, this interval is replaced by the weight of the sediment in grams). Lithologic units are recognized on the basis of compositional, textural, and other sedimentological characteristics.

2. Name, color, and 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 the unit (see the following section on 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, lense, 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.

Other than coarse volcanoclastics, most of the cores consist of muddy lithologies, and classification is based on smear slide observations. Sediments larger than 63  $\mu\text{m}$  in size must usually be avoided in smear slide preparations. In the case of sediments with mixed sizes ( $>$  and  $<$  63  $\mu\text{m}$ ), an estimate of coarse -vs- fine fraction is necessary for sediment classification. If there is an obvious coarse fraction within an otherwise muddy lithology, a small portion of the sediment is wet-sieved (63  $\mu\text{m}$  sieve) and observed under the binocular microscope. A rough visual estimate is then made of the amount of coarse -vs- fine sediment (based on the amount sieved -vs- residual coarse sediment  $>$ 63  $\mu\text{m}$ ). For example, if a smear slide is a diatomaceous mud, but approximately half of the original lithology is sand, the sediment will be a sandy diatomaceous mud. Thus, estimated values of dominant

constituents from smear slide analyses, wet-sieving, and megascopic examination are used in classification.

Glacial marine sediments generally consist of mixed-size classes (such as pebbles in mud). However, no attempt was 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.

The size class and sorting of a sand or pebble unit are always mentioned in the description. Size classes of sand-size fractions were 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 Geological Society of America color chart (Goddard et al., 1970). If the color of a sediment cannot be matched exactly with the color chart, the closest color is used. These charts are designed for rock color determinations and are included here because they represent the only color data recorded for these sediments. The editors, however, recommend using Munsell soil color charts for descriptions of oceanic sediments.

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 (micro-manganese 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 a certain interval. These stainings are described by the terms 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 the color are also described. Each structure is defined as follows: 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 in the smear slide analysis. Layers have a thickness of between 1 to 10 cm and are separated from the main unit by a discrete change in lithology and distinct planes of contact. Laminae are similar to layers, but have a thickness of less than 1 cm. Stringers are laminae which are discontinuous and often irregular in form. In the description of a unit, the following sequence is used: zones, layers, laminae, and stringers.

Inclusions within an unit are described in the following order:

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. 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 (Example: "very fine to fine, subangular to subrounded pebbles common throughout").

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

Slightly: less than 5% bioturbation

Moderately: between 5% to 30% bioturbation

Highly: 30% or more bioturbation

Operational disturbances are disturbances in the sediment usually occurring during the coring operation, transportation, and occasionally during the splitting of the core, resulting in total or partial loss of the primary sedimentary structures and the stratigraphic integrity of the sediment. The degree of the disturbance is described in terms of slightly, moderately, or highly disturbed. Slightly disturbed sediments still retain most of their primary sedimentary structures, particularly along the central axis of the core. Moderately disturbed sediments have lost almost half of their original structures, and must be sampled carefully if they are to be stratigraphically meaningful. Highly disturbed sediments have lost most or all of their primary structures; it is not recommended that these 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 entrapped 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 regular intervals throughout the core during the description process. Slides are made from each

macroscopically visible lithologic unit in the core (as recognized by compositional, textural, and color changes), but if the core is homogeneous in composition (e.g., a diatomaceous ooze), only one or two slides 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 water on a standard 1" x 3" glass slide until the sediment and water are smeared into a very thin film (treatment of the slide with an anti-fogging glass cleaner or saliva prevents cohesion of the water drop and ensures an even smear of the sediment slurry). The slide is then dried on a hot plate (using low temperature). When the slurry is dry, 1 to 3 drops of Norland Optical Adhesive (NOA 61) are put over the dried sediment film and covered with a glass cover slip (care must be taken to exclude air bubbles). The slide is then placed under an ultraviolet lamp for 2 or 3 minutes to cure the adhesive. The slide is then 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 percentage abundance of the following constituents are estimated using the percentage composition chart of Shvetsov (Terry and Chilingar, 1955):

1. Minerals: quartz, feldspar, mica, heavy minerals, volcanic glass, glauconite, pyrite, and micromanganese nodules.
2. Biogenic constituents: foraminifera, calcareous nannofossils, unspecified carbonate, diatoms, radiolarians, sponge spicules, silicoflagellates, ebridians, and ostracodes.

On the basis of the dominant sedimentary constituents, the sediment is classified according to the guidelines outlined below.

## SEDIMENT CLASSIFICATION

The system of sediment classification used in this volume is that used in Bryan (1992b), which is modified from Kaharoeddin et al. (1988). This

classification is strictly descriptive and is based on abundance estimates of constituent particles (from smear slide observations) and megascopic examination.

### Details of Classification

The three major groups of sediment are (Figure 3):

- I. Pelagic sediments, consisting of pelagic clay, siliceous ooze, calcareous ooze, or mixtures of siliceous and calcareous ooze;
- II. Transitional sediments consisting of mixtures of biogenic and clastic sediments; and
- III. Terrigenous and volcanic detrital sediments.

### Pelagic Sediments

#### 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 the smear slide analysis, is necessary to determine whether or not a sediment is a 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.

#### 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 more than 15%. 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 has unspecified carbonate 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).

### Transitional Biogenic Sediments

Included in this group are sediments containing at least 30% silt and clay. Two subdivisions are recognized: the 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. A transitional siliceous sediment is called muddy diatomaceous ooze if diatoms are more abundant than silt and clay; otherwise, it is called diatomaceous mud.
2. The 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.

### Terrigenous and Volcanic Detrital Sediments

#### 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; Figures 4 and 5). The following rules apply for sediments which 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 are named: sandy silt if the silt content is between 50% and 70%; sandy clay if the clay content is between 50% and 70%, or sandy mud if the mud content is less than 70%.
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 glacial marine sediments. The following rules apply to the naming of sediments which 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").

#### VOLCANICLASTICS

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

Fine ash: less than 63  $\mu\text{m}$

Coarse ash: 63  $\mu\text{m}$  to 2 mm

Lapilli: 2 mm 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 particles size grades from ash to lapilli; thus, the name of the unit is graded volcanics. In the case of graded sequences where the size of the particles ranges 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").

Volcanics that have biogenic or terrigenous components in excess of 15% will have a qualifier with the term "bearing" added to the qualifier (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% volcanics (e.g., "ash-bearing diatomaceous ooze").

<b>PELAGIC</b>	<b>NON-BIOGENIC</b>	Authigenic components common (>5%)  < 30% Biogenous  <i>Pelagic clay</i>	
	<b>BIOGENIC</b>	> 30 % Biogenous  >30% Siliceous skeletons (Biogenic-siliceous)  <i>Siliceous ooze</i> <i>Radiolarian ooze</i> <i>Diatomaceous ooze</i>	>30% Calcareous skeletons (Biogenic-calcareous)  <i>Diatomaceous-nannofossil ooze</i> <i>Foraminiferal-diatomaceous ooze</i> <i>Radiolarian-nannofossil ooze</i>
< 30% Silt and Clay			
> 30% Silt and Clay			
<b>TRANSITIONAL</b>		Radiolarian types uncommon  <i>Muddy Diatomaceous ooze</i>	<div style="display: flex; align-items: center; justify-content: center;"> <div style="writing-mode: vertical-rl; transform: rotate(180deg); font-size: small; margin-right: 5px;">&lt; 30% Calcareous Skeletons</div> <div style="border-left: 1px solid black; height: 100%; margin: 0 5px;"></div> <div style="writing-mode: vertical-rl; transform: rotate(180deg); font-size: small; margin-left: 5px;">&gt; 30% Calcareous Skeletons</div> </div>
	Diatoms > Silt and Clay <hr/> Diatoms < Silt and Clay  <i>Diatomaceous Mud</i>	<i>Marly calcareous ooze</i>	
<b>TERRIGENOUS and VOLCANIC DETRITAL</b>	< 15% Diatoms or < 30% Calcareous Skeletons Authigenic Components rare		
	<i>Clay</i> <i>Mud</i> <i>Silt</i> <i>Sand</i> <i>Pebble</i>	<i>Ash</i> <i>Lapilli</i> <i>Breccia</i>	

Figure 3. Classification scheme used for marine sediments.

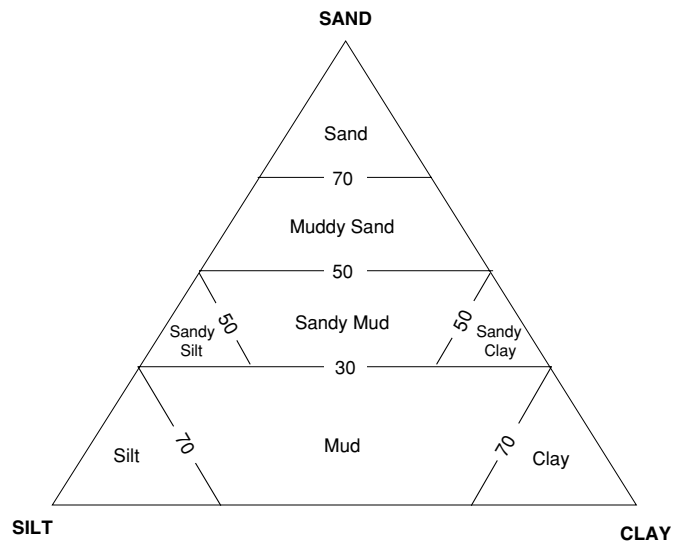


Figure 4. Classification of clastic sediments

















Limiting Size (mm)	SIZE CLASS	
64	Very Coarse Coarse Medium Fine Very Fine	<b>P E B B L E S</b>
32		
16		
8		
4		
2	Very Coarse Coarse Medium Fine Very Fine	<b>S A N D</b>
1		
.5		
.25		
.125		
.062	Coarse Medium Fine Very Fine	<b>S I L T</b>
.031		
.016		
.008		
.004	<b>CLAY</b>	

Standard size classes of sediment  
(modified after Friedman and Sanders, 1978)

Figure 5. Standard size classes of sediments.

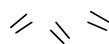
**SEDIMENT CORE DESCRIPTIONS**  
**R/V Polar Duke Cruise 91**

## Graphic Lithology Key

	Diatomaceous Ooze		Zeolitic diatomaceous ooze		Mud		Clay
	Muddy Diatomaceous Ooze		Illitic Diatomaceous ooze		Muddy sand or Sandy mud		Pebbly mud
	Diatomaceous Mud		Diatomaceous sand		Silt		Ash
	Diatomaceous sandy mud		Sandy Silt or Silty Sand		Sand		Muddy volcanic ash



Sedimentary clasts



Common to rare ash



Glaucinite



Pebble



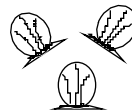
Abundant ash



Zeolite



Shell fragments



Bivalves

## Graphic Structures Key



Slightly to moderately disturbed



Highly Disturbed



Highly laminated



Moderately laminated



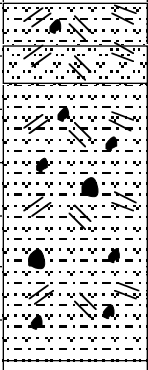

Graded bed

# Piston Cores

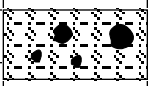

# PD91-01 PC

Length (cm)	Lithology	Structure	Latitude:	64°49.75' S	Water Depth:	461 m
			Longitude:	62°38.65' W	Core Length:	405 cm
LITHOLOGIC DESCRIPTION						
<div style="display: flex; flex-direction: column; align-items: center;"> <div style="margin-bottom: 20px;">100</div> <div style="margin-bottom: 20px;">200</div> <div style="margin-bottom: 20px;">300</div> <div style="margin-bottom: 20px;">400</div> </div>			<p><b>0-98 cm:</b> Diatomaceous mud, moderate olive brown (5Y 4/4); laminae of diatomaceous mud, olive gray (5Y 3/2) between 28-29 cm and 29-30 cm and 32-33 cm; fine to medium basaltic pebbles scattered throughout; slightly washed along the side throughout.</p> <p><b>98-405 cm:</b> Muddy diatomaceous ooze, light olive brown (5Y 5/6); a medium basaltic pebble between 133-135 cm; a bivalve shell between 256-259 cm; shell fragments between 271-322 cm.</p>			

## PD91-02 PC

Length (cm)	Lithology	Structure	Latitude:	63°05.21' S	Water Depth:	161 m
			Longitude:	58°45.49' W	Core Length:	133 cm
<b>LITHOLOGIC DESCRIPTION</b>						
100			<p><b>0-133 cm:</b> Ash-bearing diatomaceous mud, olive gray (5Y 2/1); laminae of ash-bearing diatomaceous sandy mud, olive black (5Y 2/1), between 6-13 cm and 100-120 cm; layer of ash-bearing diatomaceous sandy mud, olive black (5Y 2/1), between 14-23 cm; fine to medium pebbles scattered throughout.</p>			

## PD91-03 PC

Length (cm)	Lithology	Structure	Latitude:	63°10.31' S	Water Depth:	385 m
			Longitude:	57°42.59' W	Core Length:	24 cm
<b>LITHOLOGIC DESCRIPTION</b>						
100			<p><b>0-24 cm:</b> Mud-bearing volcanic ash, grayish red (5R 4/2), fine to coarse pebbles scattered throughout; slightly disturbed throughout; No penetration of trigger core.</p>			

## PD91-04 PC

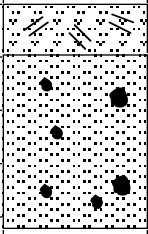
Length (cm)	Lithology	Structure	Latitude:	63°04.41' S	Water Depth:	620 m
			Longitude:	57°48.89' W	Core Length:	81 cm
<b>LITHOLOGIC DESCRIPTION</b>						
100			<p><b>0-22 cm:</b> Ash-bearing muddy sand, olive gray (5Y 3/2); sand is angular, poorly sorted, and very fine to fine; a very coarse subrounded pebble located between 6-11 cm; fine to coarse pebbles scattered throughout.</p> <p><b>22-81 cm:</b> Mud-bearing volcanic ash, grayish red (5R 4/2).</p> <p>Slightly disturbed throughout; slightly washed along the side throughout.</p>			

## PD91-05 PC

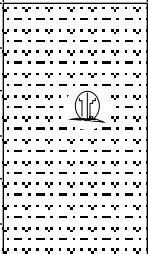
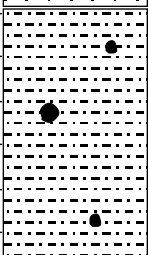
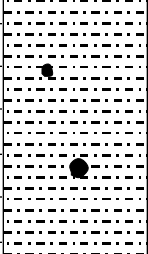
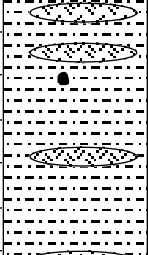
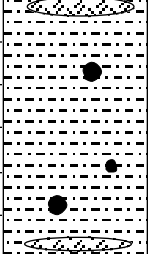
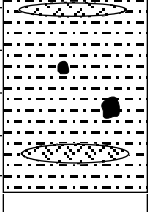

Length (cm)	Lithology	Structure	Latitude:	64°39.79' S	Water Depth:	547 m
			Longitude:	58°21.76' W	Core Length:	37 cm
<b>LITHOLOGIC DESCRIPTION</b>						
100			<p><b>0-9 cm:</b> Diatomaceous mud, olive gray (5Y 4/1).</p> <p><b>9-13 cm:</b> Pebbly mud, medium dark gray (N4).</p> <p><b>13-37 cm:</b> Mud, medium gray (N4).</p> <p>Fine to medium pebbles scattered throughout.</p>			



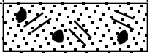
## PD91-07 PC

Length (cm)	Lithology	Structure	Latitude:	63°48.80' S	Water Depth:	237 m
			Longitude:	57°46.34' W	Core Length:	84 cm
<b>LITHOLOGIC DESCRIPTION</b>						
100			<p><b>0-18 cm:</b> Ash-bearing diatomaceous sandy mud, grayish olive (10Y 4/2); gradational contact with unit below; washed from 0-17 cm.</p> <p><b>18-84 cm:</b> Sandy mud, olive gray (5Y 4/1), sand content decreases with depth; fine to medium pebbles scattered throughout.</p>			

# PD91-08 PC

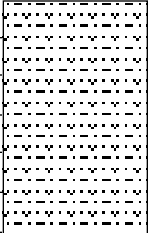
Length (cm)	Lithology	Structure	Latitude:	63°58.75' S	Water Depth:	360 m
			Longitude:	57°46.49' W	Core Length:	833 cm
<b>LITHOLOGIC DESCRIPTION</b>						
100			<p><b>0-144 cm:</b> Diatomaceous mud, olive gray (5Y 3/2), laminated with ash-bearing sand, olive black (5Y 2/1); sand and ash content highest between 0-40 cm; laminae of muddy diatomaceous ooze, light olive brown (5Y 5/6) between 46-47 cm and 50-51 cm; small bivalve shell between 59-60 cm.</p>			
200			<p><b>144-833 cm:</b> Mud, olive gray (5Y 4/1); lens of ash-bearing sand, olive black (5Y 2/1), between 443-446 cm, 460-462 cm, 516-520 cm, 583-585 cm, 722-724 cm, 726-728 cm and 806-810 cm; very fine to coarse pebbles scattered throughout; flow-in at 200-224 cm; washed from 224-531 cm.</p>			
300			<p>Section breaks at 225 and 530 cm.</p>			
400			<p><b>NOTE:</b> Change in scale.</p>			
500						
600						
700						
800						

## PD91-09 PC

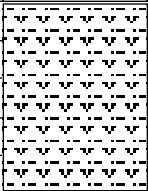
Length (cm)	Lithology	Structure	Latitude: 63°55.70' S	Water Depth: 87 m
			Longitude: 57°46.20' W	Core Length: 16 cm
<b>LITHOLOGIC DESCRIPTION</b>				
100			<p><b>0-16 cm:</b> Ash-bearing sand, olive gray (5Y 3/2); very fine to fine basaltic pebbles common throughout.</p>	

# Trigger Cores

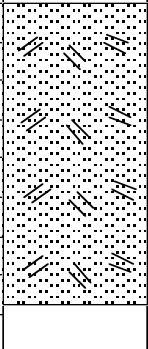
## PD91-01 TC

Length (cm)	Lithology	Structure	Latitude: 64°49.75' S	Water Depth: 461 m
			Longitude: 62°38.65' W	Core Length: 29 cm
<b>LITHOLOGIC DESCRIPTION</b>				
20			<b>0-29 cm:</b> Muddy diatomaceous ooze, moderate olive brown (5Y 4/4).	
40				

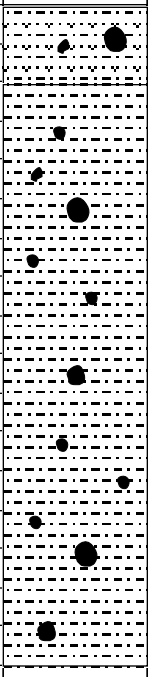
## PD91-02 TC

Length (cm)	Lithology	Structure	Latitude: 63°05.21' S	Water Depth: 161 m
			Longitude: 58°45.49' W	Core Length: 23 cm
<b>LITHOLOGIC DESCRIPTION</b>				
20			<b>0-23 cm:</b> Diatomaceous mud, olive gray (5Y 3/2).	
40				

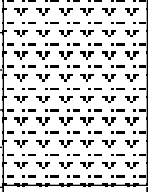
## PD91-04 TC

Length (cm)	Lithology	Structure	Latitude: 63°04.41' S	Water Depth: 620 m
			Longitude: 57°48.89' W	Core Length: 37 cm
<b>LITHOLOGIC DESCRIPTION</b>				
<div style="display: flex; flex-direction: column; align-items: center;"> <div style="margin-bottom: 20px;">20</div> <div style="margin-bottom: 20px;">40</div> </div> 	<p><b>0-37 cm:</b> Ash-bearing sandy mud, olive gray (5Y 3/2).</p>			

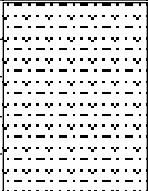
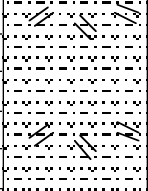
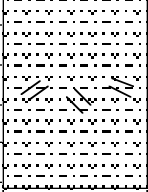

## PD91-05 TC

Length (cm)	Lithology	Structure	Latitude: 64°39.79' S	Water Depth: 547 m
			Longitude: 58°21.76' W	Core Length: 85 cm
<b>LITHOLOGIC DESCRIPTION</b>				
<div style="display: flex; flex-direction: column; align-items: center;"> <div style="margin-bottom: 20px;">20</div> <div style="margin-bottom: 20px;">40</div> <div style="margin-bottom: 20px;">60</div> <div style="margin-bottom: 20px;">80</div> </div> 	<p><b>0-10 cm:</b> Diatomaceous mud, light olive gray (5Y 5/2).</p> <p><b>10-85 cm:</b> Mud, greenish gray (5GY 6/1).</p> <p>Fine and coarse pebbles scattered throughout.</p>			

## PD91-06 TC

Length (cm)	Lithology	Structure	Latitude: 63°55.56' S	Water Depth: 350 m
			Longitude: 57°41.29' W	Core Length: 24 cm
<b>LITHOLOGIC DESCRIPTION</b>				
20			<b>0-24 cm:</b> Muddy diatomaceous ooze, moderate olive brown (5Y 4/4).	


## PD91-07 TC

Length (cm)	Lithology	Structure	Latitude: 63°48.799' S	Water Depth: 237 m
			Longitude: 57°46.345' W	Core Length: 76 cm
<b>LITHOLOGIC DESCRIPTION</b>				
20			<b>0-76 cm:</b> Diatomaceous mud, olive gray (5Y 3/2); ash present between 24-76 cm.	
40				
60				
80				

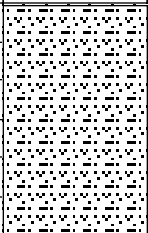


# Gravity Cores

## PD91-01 GC

Length (cm)	Lithology	Structure	Latitude: 63°52.82' S	Water Depth: 235 m
			Longitude: 57°39.11' W	Core Length: 14 cm
<b>LITHOLOGIC DESCRIPTION</b>				
20			<b>0-14 cm:</b> Muddy diatomaceous ooze, olive gray (5Y 4/1).	

## PD91-02 GC

Length (cm)	Lithology	Structure	Latitude: 63°53.00' S	Water Depth: 334 m
			Longitude: 57°40.00' W	Core Length: 30 cm
<b>LITHOLOGIC DESCRIPTION</b>				
20			<b>0-30 cm:</b> Diatomaceous sandy mud, olive gray (5Y 4/1); moderately washed along the sides between 0-8 cm.	
40				



# Bagged Samples

The following bagged samples from cruise PD91 are stored at Antarctic Research Facility but have not been described.

PD91-GS1: Two bags

PD91-GS2: Two Bags

PD91-TC 3: Trigger core catcher

PD91-PC 3: Core top sample

PD91-PC 3: Sample scraped from outside of barrel

PD91-GC 4: Core cutter nose

PD91-TC 4: Trigger core retainer

PD91-TC 5: Trigger core head

PD91-PC 5: Core cutter nose

PD91-PC 6: Core cutter nose

PD91-PC 6: Base of section 2

PD91-PC 7: Core cutter nose

PD91-PC 8: Core cutter nose

PD91-TC 8: Trigger nose

PD91-PC 9: Core cutter nose

PD91-PC10: Core top sample



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Deep Freeze (*Glacier*) cruises 76, 78, 79, 80, 81, 82, 83, 85, 86, 87

International Weddell Sea Oceanographic Expeditions (IWSOE)

Dry Valley Drilling Project (DVDP)

Eastern Taylor Valley (ETV) Project

Cenozoic Investigations of the western Ross Sea (CIROS 1&2)

Ross Ice Shelf Project

R/V *Polar Duke* Expeditions (cruises 86, 88, 89, 90, 91, 92)

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