

**SEDIMENT DESCRIPTIONS**  
**for**  
**R/V *NATHANIEL B. PALMER***  
**Cruise 1, 1994**



**DESCRIPTIONS OF SEDIMENT RECOVERED**

**BY THE R/V *NATHANIEL B. PALMER*,**

**UNITED STATES ANTARCTIC PROGRAM**

**CRUISE 1, 1994**

**Edited by**

Thomas R. Janecek

Rice University  
Ms. Stephanie Shipp  
Dr. John B. Anderson

**Sediment Descriptions**

Hamilton College  
Dr. Eugene Domack  
Mr. Antonio Rodriguez  
Ms. Elizabeth Williams

Colorado University  
Ms. Kathy Licht  
Ms. Nancy Wiener

Instituto Geologia Marina  
Dr. Marco Taviani  
Dr. Fabio Trincardi

Florida State University  
Mr. Matthew Curren

**Antarctic Marine Geology Research Facility  
Florida State University  
Tallahassee, FL 32306-3026**

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## INTRODUCTION

This volume contains the descriptions of sediments recovered by the R/V *Nathaniel B. Palmer* during cruise 1 in 1994 to the eastern, northwestern, and central Ross Sea area (herein referred to as cruise NBP94-01). Over 4100 kilometers of high-resolution seismic data, 27 piston cores, 19 trigger cores, and 17 grab samples were collected during the cruise (Figure 1; Table 1).

The sediments are curated at the Antarctic Marine Geology Research Facility, Florida State University, Tallahassee, Florida. 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), fifteen cruises of the USCGC *Glacier* (Goodell et al., 1961; Anderson et al., 1981; Kellogg et al., 1981; Kaharoeddin et al., 1983, 1984, 1988; Bryan, 1992a, 1992b, 1993), ten cruises of the R/V *Polar Duke* (Bryan and Pospichal, 1993; Hovan and Janecek, 1994a, 1994b, 1994c, 1994d; Janecek, 1995a; Janecek, 1996; and unpublished data), seven cruises of the R/V *Nathaniel B. Palmer* (Janecek, 1995b, 1995c; and unpublished data), the Dry Valley Drilling Project (DVDP) (Dry Valley Drilling Project, 1974, 1975, 1976; McGinnis, 1979; Torii, 1981), the Ross Ice Shelf Project (RISP)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 limited collections from other vessels operating in the Southern Ocean (*Anton Brun*, *Robert Conrad*, *Hero*, and *Vema*).

This volume includes a summary of the scientific objectives and preliminary results of cruise NBP94-01, a table and map of station locations, a discussion of core processing, an explanation of laboratory descriptive procedures, lithologic and smear-slide descriptions of piston and trigger cores, and several appendices containing information on how to obtain samples from cores stored at the Antarctic Marine Geology Research Facility.

## **R/V NATHANIEL B. PALMER, CRUISE 1, 1994**

A brief outline of the objectives and preliminary seismic results of R/V *Nathaniel B. Palmer* cruise 1, 1994 (NBP94-01) are presented here (summarized from Shipp and Anderson, 1994).

### Background and Objectives

An understanding of the past activity of the west antarctic ice sheet is critical to evaluate future behavior of the ice sheet and its potential impact on sea level. Ongoing debate focuses on the extent of ice and how the ice sheet retreated during the last deglaciation. The majority of the west antarctic ice sheet lies below sea level and extensive regions overlie sedimentary basins. This, in conjunction with the foredeepened nature of the Ross Sea continental shelf, means that during deglaciation increased sea level could buoy down the ice sheet causing rapid grounding-line retreat and draw-down of interior ice (Hollin, 1962; Thomas and Bentley, 1978). Alternatively, thinning of the ice sheet could occur by enhanced ice flow across a deforming substrate without being triggered by rising sea level.

Cruise NBP94-01 of the R/V *Nathaniel B Palmer* acquired marine geological and geophysical data that will provide information about the extent of ice advance during the last glacial maximum as well as about the mechanisms of the advance, ice-sheet configuration, and timing of the glacial retreat. Towards this end, approximately 4100 kilometers of high-resolution seismic data, 27 piston cores, 19 trigger cores and 17 grab samples were collected on the Ross Sea continental shelf during the cruise (Table 1 and Figure 1).

Over 2000 kilometers of high-resolution seismic data, 15 piston cores, 11 trigger cores, and 10 grab samples were acquired in the northwestern Ross Sea, adjacent to Victoria Land. Five northwest/southeast transects and two north-south transects were conducted (Figure 1). Unusually dense sea-ice conditions prohibited the completion of the seismic grid to the south of Coulman Island.

The second portion of the cruise concentrated on the Eastern Ross Sea in the vicinity of Ice Stream C. Approximately 2100 kilometers of high-resolution seismic data, 12 piston cores, 8 trigger cores, and 7 grab samples were acquired in this area.

### Preliminary Seismic Results



Preliminary analysis of the seismic data (Shipp and Anderson, 1994) indicates that the majority of the continental shelf has very little late Pleistocene sedimentary cover. The sediment thickens on the outer shelf and slope, and the sediment thickness is even greater at the shelf break. The sediment cover, where present, overlies an erosional unconformity and consists of a single seismic facies with hummocky surface relief and hyperbolic reflectors. The hummocky nature may indicate furrows aligned with the direction of ice movement.

Distinct differences in depositional patterns occur between the western and eastern Ross Sea. The western Ross Sea has more deeply carved troughs in the inner shelf than the eastern Ross Sea. The troughs are filled with 20-60 ms of sediment on the outer shelf, with thick sedimentary packages occurring along the banks. Paleo-ice stream boundaries and bank tops are erosional and the boundaries are deeply cut into older strata and capped by more recent units. The sediments in the eastern Ross Sea are characterized by a less organized depositional pattern. Paleo-ice-stream boundaries tend to be depositional and the banks make up the thickest deposits of the region. In some regions of the troughs the sediment cover is thin to absent, but a 20-40 ms thick sediment package covers the majority of the region. Intra-stream bank tops occur at greater water depths and do not exhibit flat, eroded tops.

With the addition of this new seismic data from cruise NBP94-01, Shipp and Anderson (1994) suggest that interaction between sea-level fluctuations and substrate conditions controlled the retreat of the marine-based ice sheet during the last deglaciation. Distinct topographical signatures and continuous petrographic provinces (Jahns, 1994) suggest that several ice streams were active during the deglaciation. Erosion or limited sedimentation occurred along the trough axes. Thick packages of sediment, however, were deposited along the sides of the troughs. In the western Ross Sea, the bank tops were probably sites of thinner or stagnant ice while in the eastern Ross Sea the ice most likely did not pin on the banks dividing the ice streams. Ice in the shallower eastern Ross Sea would have remained grounded longer in the event of sea level rise.

INSERT FIGURE 1

Table 1. NBP94-01 coring statistics

Station ID	Core Type	Latitude (°S)	Longitude (°)	Depth (m)	PC Length (cm)	TC length (cm)	Bag sample
NBP94-01-01	Piston	77.194	167.888 E	939	268	35	---
NBP94-01-02	Piston	76.284	169.704 E	679	174	25	---
NBP94-01-03	Grab	73.549	178.648 E	365	---	---	yes
NBP94-04-04	Grab	73.549	178.648 E	365	---	---	yes
NBP94-01-05	Piston	73.468	177.874 E	432	102	NR	---
NBP94-01-06	Piston	73.415	177.367 E	509	118	22	yes
NBP94-01-07	Piston	73.383	177.027 E	575	268	NR	yes
NBP94-01-08	Grab	73.235	175.756 E	404	---	---	yes
NBP94-01-09	Grab	73.232	175.774 E	402	---	---	yes
NBP94-01-10	Grab	73.118	174.676 E	340	---	---	yes
NBP94-01-11	Piston	72.934	173.366 E	443	198	Bag	yes
NBP94-01-12	Piston	72.826	172.767 E	533	109	Bag	yes
NBP94-01-13	Piston	72.747	172.296 E	582	320	NR	yes
NBP94-01-14	Grab	74.154	177.239 E	300	---	---	yes
NBP94-01-15	Grab	74.947	176.019 E	325	---	---	yes
NBP94-01-16	Piston	74.652	174.570 E	465	286	61	yes
NBP94-01-17	Piston	74.490	173.801 E	556	370	48	yes
NBP94-01-18	Piston	74.383	173.304 E	560	279	53	yes
NBP94-01-19	Piston	74.306	172.931 E	508	360	NR	---
NBP94-01-20	Piston	74.292	172.863 E	513	12	77	yes
NBP94-01-21	Grab	74.162	172.250 E	356	---	---	yes
NBP94-01-22	Piston	74.038	171.675 E	448	280	84	yes
NBP94-01-23	Piston	73.942	171.242 E	583	264	69	yes

Table 1. continued from previous page

Station ID	Core Type	Latitude (°S)	Longitude (°E)	Depth (m)	PC Length	TC length (cm)	Bag sample
NBP94-01-24	Grab	75.432	174.066 E	293	---	---	yes
NBP94-01-25	Grab	75.399	173.879 E	380	---	---	yes
NBP94-01-26	Grab	76.521	178.883 E	312	---	---	yes
NBP94-01-27	Piston	76.522	178.881 E	312	235	Bag	yes
NBP94-01-28	Piston	76.590	179.677 E	205	NR	NR	yes
NBP94-01-29	Piston	76.590	179.676 E	205	34	NR	---
NBP94-01-30	Piston	76.647	179.636 W	628	233	81	yes
NBP94-01-31	Piston	75.165	178.548 E	473	188	72	yes
NBP94-01-32	Piston	75.300	179.390 E	489	330	63	yes
NBP94-01-33	Piston	75.455	179.615 W	603	424	92	yes
NBP94-01-34	Piston	75.578	178.836 W	507	77	NR	yes
NBP94-01-35	Piston	75.708	177.966 W	567	68	NR	yes
NBP94-01-36	Piston	75.822	177.224 W	622	96	62	yes
NBP94-01-37	Piston	75.014	175.964 W	545	178	Bag	yes
NBP94-01-38	Piston	76.160	174.990 W	579	310	29	yes
NBP94-01-39	Piston	76.581	172.255 W	504	211	NR	yes
NBP94-01-40	Grab	74.782	179.273 E	360	---	---	yes
NBP94-01-41	Grab	77.115	175.554 E	394	---	---	yes
NBP94-01-42	Grab	77.150	175.401 E	405	---	---	yes
NBP94-01-43	Grab	77.184	175.310 E	409	---	---	yes
NBP94-01-44	Grab	77.182	175.328 E	411	---	---	yes
NBP94-01-45	Grab	77.049	175.751 E	371	---	---	yes

\* NR= No Recovery ; Bag= sediment archived in a bag sample

## CORE PROCESSING

At the Antarctic Marine Geology 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. Cuts are made on opposite sides of the core liner. Once the liner is cut, the core sediments are split by drawing a wire through the middle of the core from the bottom to the top of each section. 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. Core halves are then measured, labeled every 20 cm (taking into account any bagged sediments), and heat-sealed within polyethylene sleeving. Disturbance of the sediment structures resulting from flow-in or sediment washing are recorded immediately after the core is opened.

All cores and bag samples are stored in a refrigerated store room ( $\sim 2^{\circ}\text{C}$ ) at the Antarctic Marine Geology Research Facility.

## CORE DESCRIPTION PROCEDURES

### General Description Procedures

Procedures used for describing the cores listed in this volume are similar to those used in previous studies published by the Antarctic Marine Geology Research Facility (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:

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 magnetic susceptibility data. Magnetic susceptibility data were collected on-board the R/V *Nathaniel B. Palmer* and supplied to the Antarctic Marine Geology Research Facility by the NBP94-01 shipboard scientific party. The data are corrected for end-of-core effects and are 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.

Unlike many of the core descriptions found in previous Antarctic Marine Geology Research Facility and Sedimentological Research Laboratory Contributions, the primary megascopic descriptions in this volume are the work of many of the NBP94-01 shipboard scientific party (see title page). Antarctic Marine Geology Research Facility personnel provided supplementary megascopic descriptions, the smear-slide descriptions, and editorial oversight.

Each core description is accompanied by a graphic log illustrating the main lithologic 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 cores. The positions of the core section breaks are also indicated on 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. Most of the piston core graphics are shown at a scale of 320 cm/page with the exception of cores 17, 19, 31, which are plotted at a scale of 500 cm/page. Trigger cores are shown at a scale of 200 cm/page.

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

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

## **Megascopic Examination and Description**

The elements of description of each unit are presented below:

1. The upper and lower boundaries of the unit in centimeters. 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 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 primarily 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 diatomaceous sandy 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 is 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 usually mentioned 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 (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. Layers less than 5 cm thick are usually not included on the graphic lithology column of the core description form but denoted by a symbol in the structure column. *Laminae* are similar to layers, but have a thickness of less than 1 cm. *Stringers* are laminae that 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 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:

- |             |                                |
|-------------|--------------------------------|
| Slightly:   | less than 5% bioturbation      |
| Moderately: | between 5% to 30% bioturbation |
| Highly:     | 30% or more bioturbation       |

Operational disturbances may occur during coring, transportation, and occasionally during the splitting of the core and may result in partial or total loss of the primary sedimentary structures and the stratigraphic integrity of the sediment. The degree of the operational 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 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) 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 distilled water on a standard 1" x 3" glass slide until the sediment and water are smeared into a very thin film. 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. The slide is then placed under an ultraviolet lamp for 2 or 3 minutes to cure the adhesive. After curing, 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) and reported on the core description logs:

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.
3. Sand-silt-clay ratios of the terrigenous fraction.

On the basis of the dominant sedimentary constituents, the sediment is classified according to the guidelines outlined below. On the core description form a symbol “D” by the smear-slide percentage denotes a dominant lithology, a symbol “M” denotes a minor lithology, zone, layer, laminae, or stringer, and “TR” denotes trace quantity.

### **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 (Figure 2):

- 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 principle 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 3 and 4).

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 glacial marine sediments. The following rules apply to 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").

### 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 volcaniclastics. 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").

Volcaniclastics 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% volcaniclastics (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)      > 30% Calcareous skeletons (Biogenic-calcareous)  <i>Siliceous ooze</i> <i>Diatomaceous-nannofossil ooze</i> <i>Calcareous ooze</i> <i>Radiolarian ooze</i> <i>Foraminiferal-diatomaceous ooze</i> <i>Foraminiferal ooze</i> <i>Diatomaceous ooze</i> <i>Radiolarian-nannofossil ooze</i> <i>Nannofossil ooze</i>
< 30% Silt and Clay		
> 30% Silt and Clay		
<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p>Radiolarian types uncommon</p> <p><i>Muddy Diatomaceous ooze</i></p> <p>Diatoms &gt; Silt and Clay</p> <p>Diatoms &lt; Silt and Clay</p> <p><i>Diatomaceous Mud</i></p> <p>&gt; 15% Diatoms</p> </div> <div style="width: 10%; text-align: center; border-left: 1px solid black; border-right: 1px solid black;"> <p>&lt; 30% Calcareous Skeletons</p> <p>&gt; 30% Calcareous Skeletons</p> </div> <div style="width: 45%;"> <p><i>Marly calcareous ooze</i></p> <p>&gt; 30% Calcereous Skeletons</p> </div> </div>		
<b>TERRIGENOUS and VOLCANIC DETRITAL</b>	<p>&lt; 15% Diatoms      or      &lt; 30% Calcareous Skeletons</p> <p>Authigenic Components rare</p> <div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p><i>Clay</i></p> <p><i>Mud</i></p> <p><i>Silt</i></p> <p><i>Sand</i></p> <p><i>Pebble</i></p> </div> <div style="width: 45%;"> <p><i>Ash</i></p> <p><i>Lapilli</i></p> <p><i>Breccia</i></p> </div> </div>	

Figure 2. Classification scheme used for marine sediments.

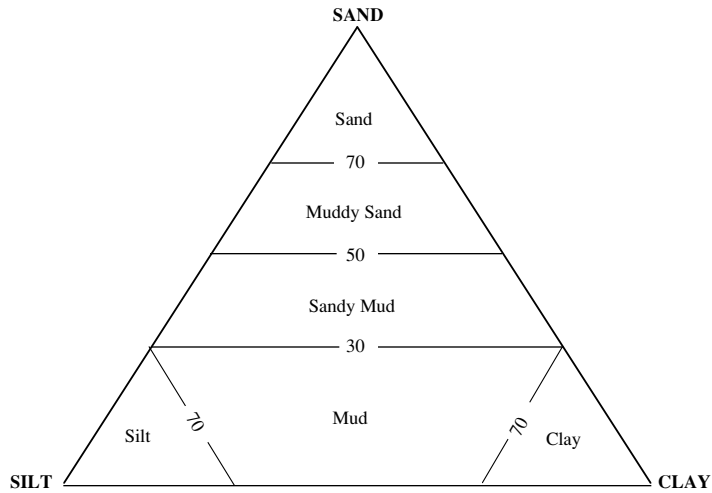


Figure 3. Classification of clastic sediments.

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


















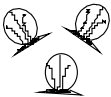





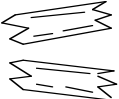




Standard size classes of sediment  
(modified after Friedman and Sanders, 1978)

Figure 4. Standard size classes of sediments.



**SEDIMENT CORE DESCRIPTIONS**  
**R/V *Nathaniel B. Palmer*, Cruise 1, 1994**

## Graphic Lithology Key

 Diatomaceous Ooze	 Clay	 Sandy Clay or Sandy Silt	 Missing Section
 Muddy Diatomaceous Ooze	 Silt	 Pebbles	 Calcareous Hash
 Mud	 Sand	 Ash	 Calcareous Ooze
 Diatomaceous Mud	 Muddy Sand or Sandy Mud	 Diatomaceous Sandy Mud	 Foraminiferal ooze
 Coral			
		Pelecypods	
 Pebble			
 Bryozoa			
		Barnacle Fragments	
 Volcanic Ash			
 Gastropods			
		Plant Fragments	
 Scaphopod			
 Spicules			
		Sedimentary clasts	
 Glauconite			

## Graphic Structures Key

 Slightly to moderately disturbed		Moderately to Highly Disturbed	 Layer	 Laminae	 Graded bed
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Figure 5. Key to graphic lithology column on core logs.