2. EXPLANATORY NOTES FOR DSDP LEG 55 SITE CHAPTERS

The Leg 55 Scientific Staff

INTRODUCTION

The following material is intended as an aid in understanding (1) the terminology, labeling, and numbering conventions used by Deep Sea Drilling Project; (2) the sedimentary, igneous, and metamorphic classification used on Leg 55; and (3) the presentation of lithologic and paleontologic data on the core forms which make up much of this publication.

Persons wishing to obtain samples are directed to the DSDP–NSF sample distribution policy (in this volume). Sample request must be submitted on standard DSDP request forms which may be obtained from

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NUMBERING OF SITES, HOLES, CORES, SAMPLES

Drill site numbers run consecutively from the first site drilled by *Glomar Challenger* in 1968; the site number is thus unique. The first (or only) hole drilled at a site takes the site number. Additional holes at the same site are further distinguished by a letter suffix. The first hole has only the site number; the second has the site number with suffix A; the third has the site number with suffix B; and so forth. It is important, for sampling purposes, to distinguish the hole drilled at a site, since recovered sediments or rocks usually do not come from equivalent positions in the stratigraphic column at different holes.

Cores are numbered sequentially from the top down. In the ideal case, each core consists of 9.3 meters of sediment or rock in a plastic liner 6.6 cm in diameter. In addition, a short 20-cm sample, may be obtained from the core catcher (a multi-fingered device at the bottom of the core barrel which prevents cored materials from sliding out during core-barrel recovery). During Leg 55, the core-catcher sample for basalt cores was normally split, described, and placed at the bottom of the material recovered in the core barrel, taking care to maintain its proper vertical orientation. This sample represents the lowest sample recovered in a particular cored interval. For sediment cores and a very few basalt cores the core-catcher sample is described by CC (e.g., 433-4,CC is the core-catcher sample of the fourth core taken in the first Hole at Site 433).

The cored interval is the interval in meters below the sea floor, measured from the point at which coring for a particular core was started to the point at which it was terminated. This interval is generally about 9.5 meters (nominal length of a core barrel), but may be shorter or longer if conditions dictate.

When a core is brought aboard the *Glomar Challenger* it is labeled and the plastic liner and core cut into 1.5-meter sections. A full, 9.5-meter core, consists of seven sections, number 1 to 7 from the top down. (Section 7 is 0.5 meters long, or 0.3 meters if there is a core catcher.) Generally, something less than 9.5 meters is recovered. In this case, the sections are still numbered starting with 1 at the top, but the number of sections is the number of 1.5-meter intervals needed to accommodate the length of core recovered. If a core contains a length of material less than the length of the cored interval, the recovered material is measured from the top of the recovered material, with the top of Section 1 equal to the top of the cored interval. Figure 1 illustrates the

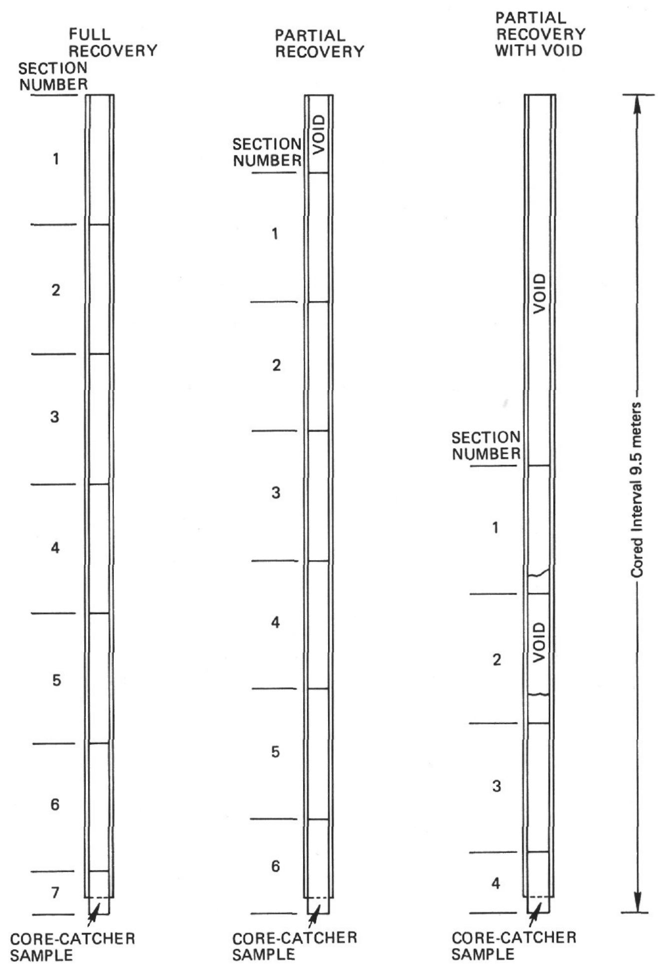

Figure 1. *Labeling of sections for various kinds of recovery.*

possible core configurations and the section labeling procedure. For basalts the voids in the core are closed and styrofoam spacers put between pieces which cannot be fit together. For some basalt cores, the addition of these spacers requires an eighth section, even though the actual rock recovered still does not exceed 9.5 meters.

In the core laboratory on the *Glomar Challenger*, after routine processing, the 1.5-meter sections of cored material and liner are split in half lengthwise. One half is designated the "archive" half, which is photographed; and the other is the "working" half, which is sampled by the shipboard scientists for further shipboard and shore-based analysis.

Samples taken from core sections are designated by the interval in centimeters from the top of the core section from which the sample was extracted; the sample size, in cm^3, is also given. Thus, a full sample designation would consist of the following information:

Leg
Site
Hole
Core Number
Section Number
Interval in centimeters from top of section

Sample 433A-1-3, 122–124 cm (10 cm^3) designates a 10-cm^3 sample taken from Section 3 of Core 1 from the second hole drilled at Site 433, Hole A. The depth below the sea floor for this sample would then be the depth to the top of the cored interval plus 3 meters for Sections 1 and 2, plus 122 cm (depth below the top of Section 3), or 4.2 meters. Note, however, that subsequent sample requests should refer to a specific interval within a core section (in centimeters) rather than depth in meters below the sea floor.

SEDIMENT DESCRIPTION CONVENTIONS

Sediment descriptions are given on sediment core description sheets. (Figure 2 is an example.) Conventions for descriptions are discussed below. The symbols used on Leg 55 are presented in Figure 3.

Core Disturbance

Unconsolidated sediments are often quite disturbed by the rotary drilling/coring technique, and there is a complete gradation of disturbance style with increasing sediment induration. An assessment of degree and style of drilling deformation is made on board ship for all cored material, and shown graphically on the core description sheets. The following symbols are used:

- - - - - Slightly deformed; bedding contacts slight bent.

— — — Moderately deformed; bedding contacts have undergone extreme bowing.

~~~~~~ Severely deformed; bedding completely disturbed, often showing symmetrical diapir-like structures.

O O O Soupy, or drilling breccia; water-saturated intervals that have lost all aspects of original bedding and sediment cohesiveness.

Smear Slides

The lithologic classification of sediments is based on visual estimates of texture and composition in smear slides made on board ship. These estimates are of areal abundances on the slide and may differ somewhat from the more accurate laboratory analyses of grain size, carbonate content, and mineralogy. Experience has shown that distinctive minor components can be accurately estimated (±1 or 2%), but that an accuracy of ±10 per cent for major constituents is rarely attained. Carbonate content is especially difficult to estimate in smear slides, as is the amount of clay present. The locations of smear slides made are given on the core description sheets.

Color

Colors of the geologic material were determined with a Munsell or Geological Society of America Rock-Color or soil-color Charts. Colors were determined immediately after the cores were split and while they were in a wet condition.

Graphic Lithology Column

A graphic lithologic column is presented. This graphic column is based on the lithologic classification scheme (see the following and Figure 3).

Carbonate Data

The lithologies and their corresponding symbols are given in Figure 3. Often a single lithology will be represented by a single pattern. Some lithologies are represented by a grouping of two symbols. The symbols in this grouping may correspond to end-member sediment constituents, such as clay and nannofossil ooze. Normally, the symbol for the dominant constituent is placed on the right side of the column, and the symbol for the subordinate constituent will be on the left side of the column (see examples in Figure 3). The percentage of components may be represented by proportional symbols in the graphic column. For example, if the left 20 per cent of the column has a clay symbol and the right 80 per cent of the column has a nannofossil ooze symbol, this means the sample is about 80 per cent nannofossils and 20 per cent clay. The vertical lines separating the symbols are shown in Figure 3 with their corresponding percentages and positions in the column.

Text of Core Description

Format, style, and terminology of the descriptive portion of the core description sheets (Figure 2) are not controlled by the "Mandatory Graphic Lithologic Column Scheme," beyond the minimal name assignment derived from the lithologic classification (described below). Colors and additional information such as structure and textures are normally included in the text portion of the core description.

LITHOLOGIC CLASSIFICATION

The basic classification system used here was devised by the JOIDES Panel on Sedimentary Petrology and Physical Properties (SPPP) and adopted for use by the JOIDES Planning Committee in March 1974. For the
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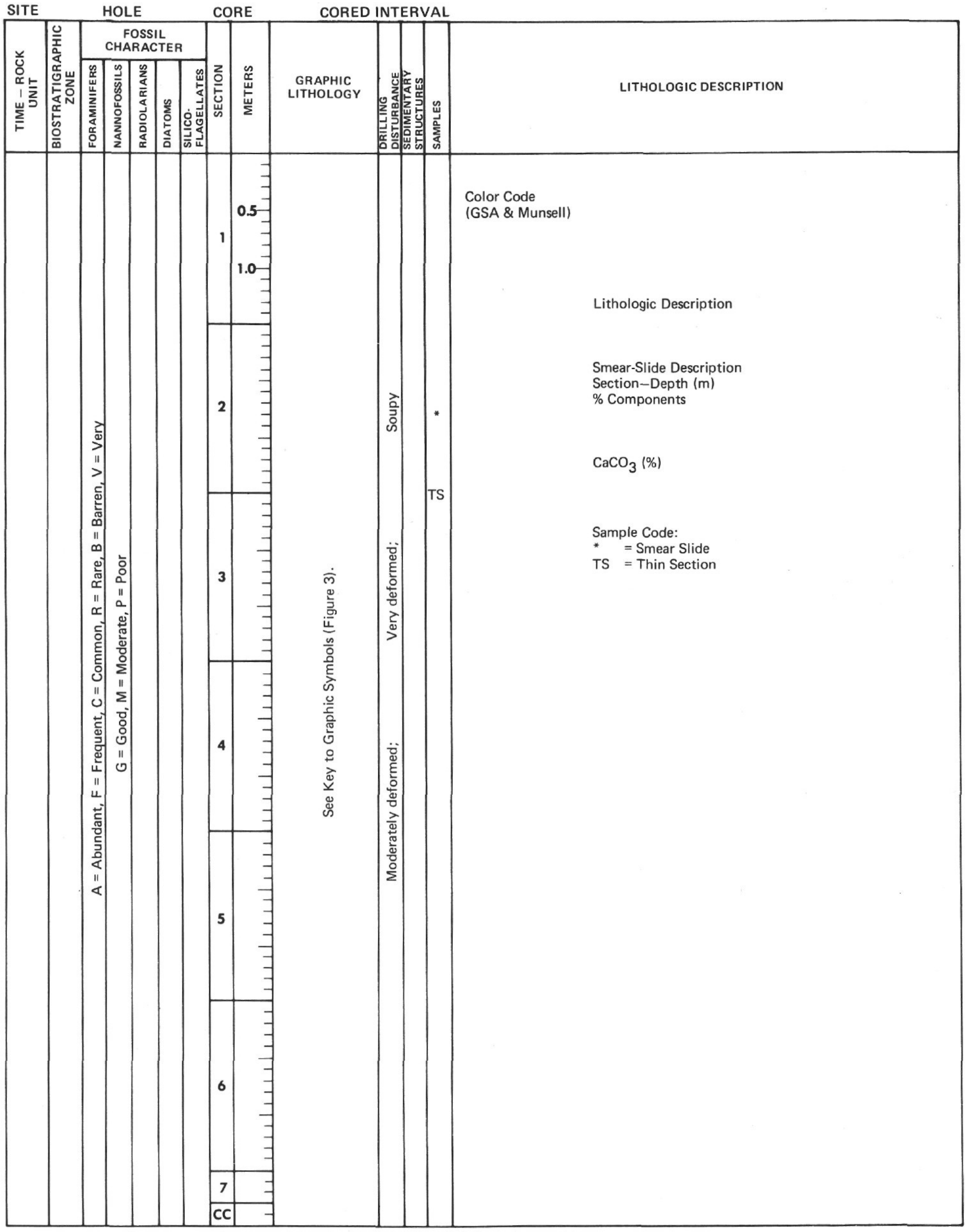


Figure 2. *Sample core form (sediment).*

sake of continuity, the Leg 55 shipboard scientists have used this classification.

Descriptive Data

Sediment and rock names are defined solely according to composition and texture. Composition is most important for descriptions of those deposits more characteristic of open marine conditions; texture becomes more important for classification of hemipelagic and near-shore facies. These data are primarily determined onboard the ship by (1) visual estimates "in smear slides" with the aid of a microscope, (2) visual observation using a hand lens, and (3) simple unaided visual observations. Calcium carbonate content was estimated in smear slides, by using the Carbonate Bomb Technique, or the LECO WR-12 (DSDP shore-based laboratory) Technique.

Firmness

Criteria for different classes of firmness are those of Gealey et al. (1971).

1. Biogenic calcareous sediments containing more than 60 per cent $CaCO_3$: three classes of firmness, as follows:
   a. Soft: Sediments with little strength and readily deformed under the finger or broad blade of the spatula are soft and are termed ooze.
   b. Firm: Partly lithified ooze and friable limestone are called chalk. Chalks are readily deformed under the fingernail or the edge of a spatula blade. More lithified chalks are termed limestones (see below).
   c. Hard: Limestone is a term restricted to nonfriable cemented rock.

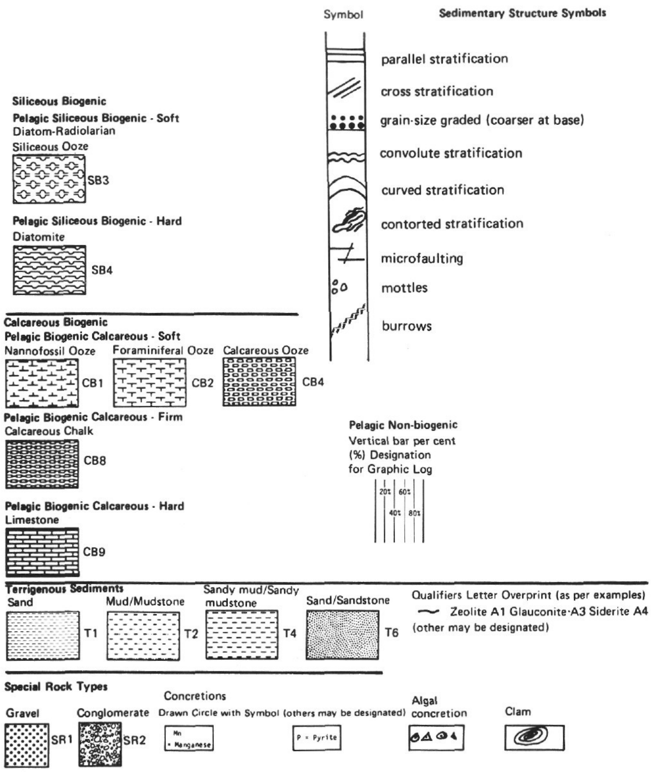


Figure 3. *Graphic and sedimentary structure symbols corresponding to the lithologic classification.*

2. Transitional carbonates with less than 60 per cent $CaCO_3$, biogenic siliceous sediment, pelagic clay, and terrigenous sediments: only two classes of firmness, as follows:
   a. Soft: A sediment is soft if the sediment core may be split with a wire cutter. The following sediment terms are used for soft sediment:
      1) Soft biogenic siliceous sediments (with more than 30% siliceous fossils) are termed ooze; for example, radiolarian ooze, diatom ooze, or siliceous ooze.
      2) Soft terrigenous sediment, pelagic clay, and transitional calcareous biogenic sediments are termed as follows: sand, silt, clay, mud, or marl.

BASIC SEDIMENT TYPES

Pelagic Clay

Pelagic clay refers principally to authigenic pelagic deposits accumulated at very slow rates. The class is often termed brown clay or red clay, but since these terms are confusing, we do not use them here.

1. Boundary of pelagic clay with terrigenous sediments is where authigenic components (Fe/Mn micronodules, zeolites), fish debris, etc., become common ($>10\%$) in smear slides, indicating pelagic clay. The accumulation rates of pelagic clay and terrigenous sediments are very different, so transitional deposits are exceptional.
2. Boundary of pelagic clay with siliceous biogenic sediments is where siliceous remains comprise <30 per cent.
3. Boundary of pelagic clay with calcareous biogenic sediment is uncommon. Generally, the facies passes from pelagic clay through siliceous ooze to calcareous ooze, with one important exception: at the base of many oceanic sections, black, brown, or red clays occur directly on basalt, overlain by or grading up into calcareous sediments. Most of the basal clayey sediments are rich in iron, manganese, and metallic trace elements. For proper identification, they require more elaborate geochemical work than is available on board ship. These sediments would be placed in the Special Rock Category.

Pelagic Siliceous Biogenic Sediment

Pelagic siliceous biogenic sediment is distinguished from pelagic clay because the siliceous biogenic sediment contains more than 30 per cent siliceous microfossils. Siliceous biogenic sediments are distinguished from a calcareous category by a calcium carbonate content of less than 30 per cent.

For a pelagic biogenic siliceous sediment with ~ 30 to 100 per cent siliceous fossils, the following terminology is used:

1. Soft: Siliceous ooze (radiolarian ooze, diatom ooze, etc. depending on the dominant fossil component).
2. Hard: Radiolarite, diatomite, chert, or porcellanite. The term "chert" in the past has been used in a very broad sense to designate almost any form of recrystallized silica. The term porcellanite (which had a very broad usage in the past) will be used here to refer to low density, more or less porous and dull-lustered varieties of 'chert' made of opaline silica or cristobalite . "Chert" here will have a narrower meaning than past usage allowed, and will refer to hard nodules and sometimes beds, that are largely quartz and/or chalcedony, and show a conchoidal fracture and a vitrous luster .
3. Compositional Qualifiers. Diatoms and radiolarians may be the principal components; thus one or two qualifiers may be used, as in these examples:

Indeterminate siliceous fossils:	Siliceous ooze, Chert, or Porcellanite
Radiolarians only:	Radiolarian ooze, or Radiolarite
Diatoms only:	Diatom ooze, or Diatomite
Diatom < radiolarians:	Radiolarian diatom ooze, or Radiolarian diatomite

The order of the two modifiers in the terms depends on the dominant fossil type: the dominant component is listed last and the minor component is listed first.

Terminology for the pelagic clay transition with diatom sediments is as follows:

% Biogenic Siliceous Fossil Particles	% Clay	Lithologic Type	
< 10	> 90	Clay:	Soft
		Claystone:	Hard
30 to 10	70 to 90	Diatom mud:	Soft
		Diatom mudstone:	Hard
60 to 30	40 to 70	Muddy diatom ooze:	Soft
		Muddy diatomite:	Hard
100 to 60	0 to 40	Diatom ooze:	Soft
		Diatomite:	Hard

Other terms may be substituted for the terms diatom and diatomite, respectively, as follows: (1) radiolarian and radiolarite if radiolarians predominate, or (2) siliceous or chert if the fossil type is indeterminate.

Pelagic Biogenic Calcareous Sediments

Pelagic calcareous sediments are distinguished by a biogenic $CaCO_3$ content in excess of 30 per cent. They are of two classes: (1) pelagic biogenic calcareous sediments which contain 60 to 100 per cent biogenic $CaCO_3$, and (2) transitional biogenic calcareous sediments which contain 30 to 60 per cent biogenic $CaCO_3$.

1. For the pelagic biogenic calcareous sediment with 60 to 100% $CaCO_3$, the following terminology is used:
   a. Soft: Calcareous ooze
   b. Firm: Chalk
   c. Hard and cemented: Limestone
   d. Compositional Qualifiers: If nannofossils and foraminifers are the principal components, then one or two qualifiers may be used, as in the following examples:
      Indeterminate carbonate fossils:
         Calcareous ooze,
         Calcareous chalk, or
         Calcareous limestone
      Foraminifers (0–10%) - nannofossils (90–100%):
         Nannofossil ooze,
         Nannofossil chalk, or
         Nannofossil limestone
      Foraminifers (10–25%) - nannofossils (75–90%):
         Foraminiferal nannofossil ooze,
         Foraminiferal nannofossil chalk, or
         Foraminiferal nannofossil limestone
      Foraminifers (25–50%) - nannofossils (50–75%):
         Nannofossil-foraminiferal ooze,
         Nannofossil-foraminiferal chalk, or
         Nannofossil-foraminiferal limestone
2. The Transitional Biogenic Calcareous Sediments with 30–60% $CaCO_3$ are termed marl or marlstone, as follows:
   a. Soft: Calcareous marl,
      Foraminiferal marl, or
      Nannofossil marl
   b. Hard: Calcareous marlstone,
      Foraminiferal marlstone, or
      Nannofossil marlstone

Note that the use of the terms marl or marlstone differs from the SPPP panel's classification. The panel's classification used marly as an adjective with ooze, chalk, or limestone (e.g., marly limestone) to denote sediments containing 30 to 60 per cent biogenic carbonate. Terminology for the pelagic clay transition with the nannofossil sediments is as follows:

% Biogenic Calcareous Particles	% Clay	Lithologic Type	
0 to 10	90 to 100	Clay:	Soft
		Claystone:	Hard
30 to 10	70 to 90	Nannofossil mud:	Soft
		Nannofossil mudstone:	Hard
60 to 30	40 to 70	Nannofossil marl:	Soft
		Nannofossil marlstone:	Hard
100 to 60	0 to 10	Nannofossil ooze:	Soft
		Nannofossil chalk:	Firm
		Nannofossil limestone:	Hard

Other terms may be substituted for nannofossil, such as (1) foraminiferal, nannofossil-foraminiferal, foraminiferal nannofossil, if foraminifers are present in the percentages as discussed, or (2) calcareous, if the fossil type is indeterminate.

Carbonate Bomb

Per cent $CaCO_3$ was also determined on board ship by the "Karbonat Bombe" technique (Müller and Gastner, 1971). In this simple procedure, a sample is powdered and treated with HCl in a closed cylinder. Any resulting CO_2 pressure is proportional to the $CaCO_3$ content of the sample. Application of the calibration factor to the manometer reading ($\times 100$) yields per cent $CaCO_3$. The error can be as low as 1 per cent for sediments rich in $CaCO_3$, and in general an accuracy of ± 2 to 5 per cent can be obtained.

These data are presented on the Core Description Forms.

Description of Igneous Rock

Core Forms

Initial Core Description forms for igneous and metamorphic rocks are not the same as those used for sediments. The sediment barrel sheets are substantially those published in previous *Initial Reports*. Representation of igneous rock on barrel sheets, however, is too compressed to provide adequate information about the rocks sampled. Consequently, Visual Core Description forms, modified from those used aboard ship, are used for more complete graphic representation. Shipboard magnetic data, as well as a summary of the hand-specimen and thin-section descriptions, are presented for each core. Symbols for igneous and metamorphic rocks are presented in Figure 4.

All basalts collected on Leg 55 were split, using a rock saw, into archive and working halves. The working halves were described and sampled on board ship. In the basalt description forms (Figure 5), the left box for each section is a visual representation of the working half, using the symbols of Figure 4. Pairs of closely spaced horizontal lines in this column indicate the locations of sty-

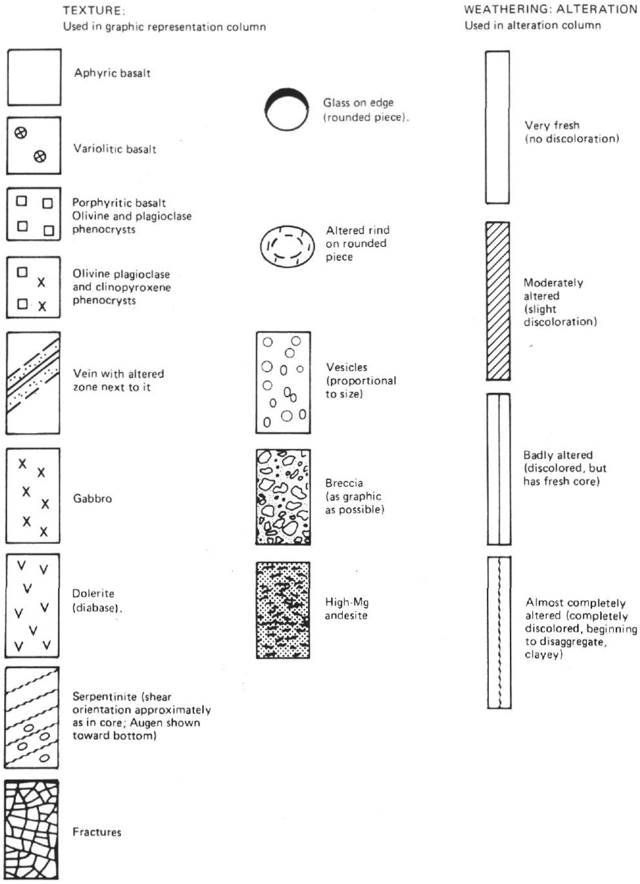


Figure 4. *List of symbols, igneous rocks, Leg 55.*

rofoam spacers taped between basalt pieces inside the liner. Each piece is numbered sequentially from the top of each section, beginning with the number 1. Pieces are labeled on the rounded, not the sawed, surface. Pieces which could be fit together before splitting are given the same number, but lettered separately and consecutively as 1A, 1B, 1C, etc. Spacers were placed between pieces with different numbers, but not between those with different letters and the same number. In general, addition of spacers represents a drilling gap (no recovery). All pieces which are cylindrical and longer than the liner diameter have orientation arrows pointing upward on both the archive and working halves. Special procedures were adopted to ensure that orientation was preserved through every step of the sawing and labeling process. All orientable pieces are indicated by upward-pointing arrows to the right of the graphic representation on the description forms. Since the pieces were rotated during drilling, it is not possible to sample for declination studies.

Samples were taken for various measurements onboard ship. The type of measurement and approximate location are indicated in the column headed "Shipboard Studies," using the following notation:

X = X-ray fluorescence and CHN chemical analysis
M = magnetics measurements
V = sonic velocity measurements
T = thin section
D = density measurements
P = porosity measurements

The state of alteration (see Figure 5 for symbols) is shown in the column labeled "alteration".

Igneous Rock Classification

The igneous rocks recovered on Leg 55 were classified primarily by their chemistry and mineralogy. All are volcanic. The classification used follows that of Macdonald and Katsura (1964) and Macdonald (1968).

BASIS FOR PALEONTOLOGICAL AGE DETERMINATIONS

The integrated Cenozoic biostratigraphic framework and time-scale used for Leg 55 (Figure 6) is based on the time scales of Berggren (1972) and Berggren and van Couvering (1974). The planktonic foraminifer zonation is after Bolli (1957a, 1957b, 1966), Blow (1969), Berggren and van Couvering (1974), and Stainforth et al. (1975). For the calcareous nannofossils, the standard zonation of Martini (1971) and Bukry (1973a, 1973b, 1975) was used. The radiolarian zonation is that of Hay (1970), Riedel and Sanfilippo (1971), and Foreman (1975).

For the Neogene sediments recovered in Holes 433 and 433A, it was necessary to supplement the foraminifer zonation of Figure 6 with data from Echols (1973) and from Vincent (1975). The silicoflagellate zones of Ling (1975, 1977) and the diatom zonation of Koizumi (this volume) were also used to obtain additional data on the age of the Neogene sediments at Site 433.

The assignment of time in millions of years to the Cenozoic stages and faunal zones is based primarily on a framework established by K–Ar dating. In 1976, the IUGS Subcommission of Geochronology recommended adoption of new potassium decay and abundance constants (Steiger and Jager, 1977), and nearly all K–Ar laboratories worldwide have adopted these new constants. Because of the logarithmic term in the K–Ar age equation, the effect of the new constants on calculated ages is not linear. For example, K–Ar ages calculated with the new constants are 2.68 per cent greater than those calculated with the old constants at 0.1 m.y., but 1.73 per cent smaller at 4500 m.y. For the Cenozoic, however, the logarithmic effect is very small; ages at 70 m.y. calculated with the new constants are 2.54 per cent greater than those calculated with the old constants. For Leg 55, we have used the time scale based on the new constants, and readers should keep this in mind when comparing Leg 55 results with results published before about 1978. For convenience, time scales in millions of years, based on both the old and the new constants, are shown in Figure 6.

REFERENCES

Berggren, W. A., 1972. A Cenozoic time-scale—some implications for regional geology and paleobiogeography, *Lethaia*, v. 5, pp. 195–215.

Berggren, W. A., and Van Couvering, J. A., 1974. The Late Neogene, *Palaeogeography, Palaeoclimatology, Palaeoecology*, v. 16, pp. 1–216.

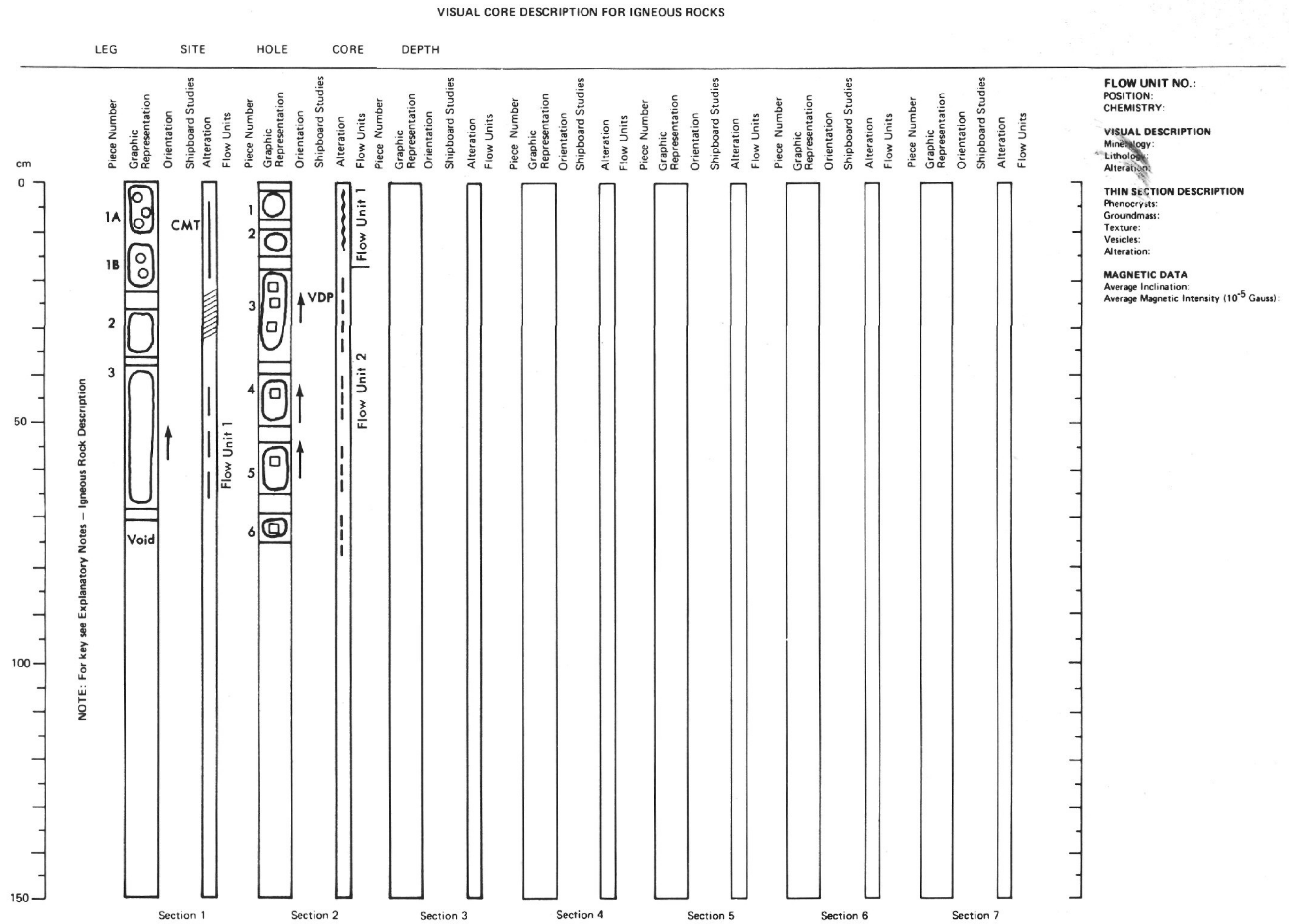


Figure 5. *Sample core form (hard rock).*

Blow, W. H., 1969. Late Middle Eocene to Recent planktonic foraminiferal biostratigraphy. *In* Brönnimann, P. I. and Renz, H. H. (Eds.), *Proc. Int. Conf. Planktonic Microfossils, 1st:* Geneva, 1967, v. 1, pp. 199–421.

Bolli, H. M., 1957a. Planktonic Foraminifera from the Oligocene–Miocene Cipero and Lengua Formations of Trinidad, B.W.I., *U.S. Nat. Mus. Bull.*, v. 215, pp. 97–123.

________, 1957b. The genera Globigerina and Globorotalia in the Paleocene–Lower Eocene Lizard Springs Formation of Trinidad, B.W.I., *U.S. Nat. Mus. Bull.*, v. 215, pp. 61–81.

________, 1966. Zonation of Cretaceous to Pliocene marine sediments based on planktonic foraminifera, *Bol. Inf. Asoc. Venez. Geol. Min. Pet.*, v. 8, pp. 119–149.

Bukry, D., 1973a. Coccolith stratigraphy—Leg 13, Deep Sea Drilling Project. *In* Ryan, W. B. F. and Hsü, K. J., et al., *Initial Reports of the Deep Sea Drilling Project,* v. 8: Washington (U. S. Government Printing Office), pp. 817–822.

________, 1973b. Low-latitude coccolith biostratigraphic zonation. *In* Edgar, N. T., Saunders, J. B., et al., *Initial Reports of the Deep Sea Drilling Project,* v. 15: Washington (U. S. Government Printing Office), pp. 685–703.

________, 1975. Coccolith and silicoflagellate stratigraphy, northwestern Pacific Ocean, Leg 32. *In* Larson, R. L., Moberly, R., et al., *Initial Reports of the Deep Sea Drilling Project,* v. 32: Washington (U. S. Government Printing Office), pp. 677–701.

Echols, R., 1973. Foraminifera, Leg 19, Deep Sea Drilling Project. *In* Creager, J. S. and Scholl, D. W., et al., *Initial Reports of the Deep Sea Drilling Project,* v. 19: Washington (U. S. Government Printing Office), pp. 721–735.

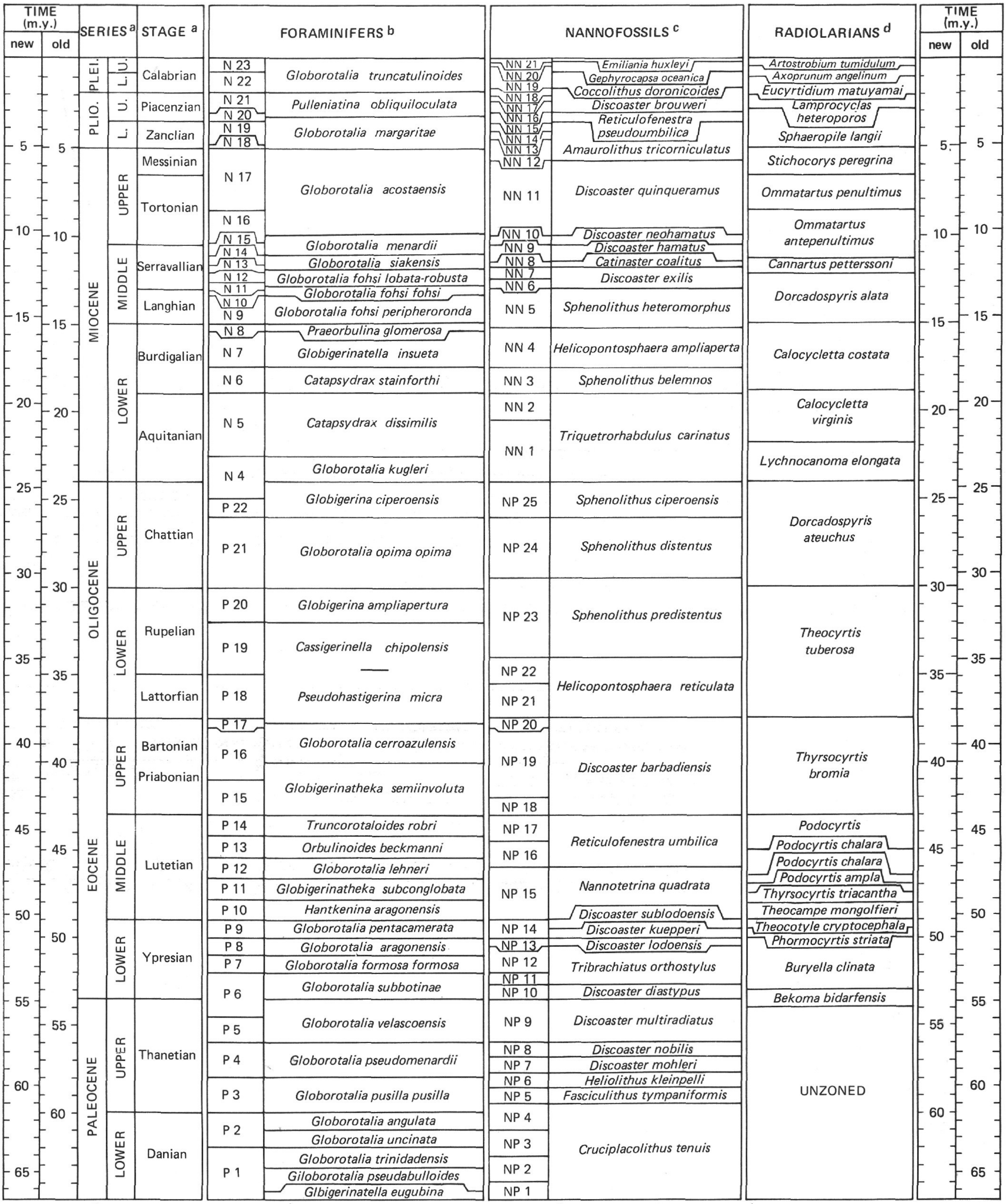
Foreman, H. P., 1975. Radiolaria from the north Pacific, Deep Sea Drilling Project, Leg 32. *In* Larson, R. L., Moberly, R., et al., *Initial Reports of the Deep Sea Drilling Project,* v. 32: Washington (U. S. Government Printing Office), pp. 579–676.

Gealy, E. L., Winterer, E. L., and Moberly, R., 1971. Methods, conventions and general observations. *In* Winterer, E. L., Riedel, W. R., et al., *Initial Reports of the Deep Sea Drilling Project,* v. 7, Pt. 2: Washington (U. S. Government Printing Office), pp. 9–26.

Hay, W. W., 1970. Calcareous nannofossils from cores recovered on Leg 4. *In* Bader, R. G., Gerard, R. D., et al., *Initial Reports of the Deep Sea Drilling Project,* v. 4: Washington (U. S. Government Printing Office), pp. 455–501.

Ling, H. Y., 1975. Silicoflagellates and ebridians from Leg 31. *In* Karig, D. E., Ingle, J. C., et al., *Initial Reports of the Deep Sea Drilling Project,* v. 31: Washington (U. S. Government Printing Office), pp. 763–778.

________, 1977. Late Cenozoic silicoflagellates and ebridians from the eastern North Pacific region, *Proc. of the First International Congress on Pacific Neogene Stratigraphy,* Tokyo, pp. 205–233.



a After Berggren (1972) and Berggren and van Couvering (1974)

b After Blow (1969), Berggren and van Couvering (1974), Bolli (1966), and Stainforth, et al. (1975)

c After Martini (1971) and Bukry (1973a, b, 1975)

d After Hays (1970), Foreman (1975), and Riedel and Sanfilippo (1971)

Figure 6. *Biostratigraphic framework and time scale for Leg 55.*

Macdonald, G. A., 1968. Composition and origin of Hawaiian lavas, *G.S.A. Mem. 116*, pp. 477–522.

Macdonald, G. A. and Katsura, T., 1964. Chemical composition of Hawaiian lavas, *J. Pet.*, v. 5, pp. 82–133.

Martini, E., 1971. Standard Tertiary and Quaternary calcareous nannoplankton zonation. *In* Farinacci, A., (Ed.), *Proc. Planktonic Conf., 2nd*, Rome, 1970: Rome (Edizioni Tecno-Scienza), pp. 739–785.

Müller, G. and Gastner, M., 1971. The "Karbonat Bombe," a simple device for the determination of the carbonate content in sediments, soils and other materials, *N. Jb., Miner, Mh.*, v. 10, pp. 466–469.

Riedel, W. R. and Sanfilippo, A., 1971. Cenozoic Radiolaria from the western tropical Pacific, Leg 7. *In* Winterer, E. L., Riedel, W. R., et al., *Initial Reports of the Deep Sea Drilling Project,* v. 7, Pt. 2: Washington (U. S. Government Office), pp. 1529–1672.

Stainforth, R. M., Lamb, J. L., Luterbacher, H., Beard, J. H., and Jeffords, R. M., 1975. Cenozoic planktonic foraminiferal zonation and characteristics of index forms, *Kansas Univ. Paleont. Contr.*, v. 62, pp. 1–425.

Steiger, R. H. and Jager, E., 1977. Subcommission on Geochronology: Convention on the use of decay constants in geo- and cosmochronology, *EPSL*, v. 36, pp. 359–362.

Vincent, E., 1975. Neogene planktonic foraminifera from the central North Pacific, Leg 32, Deep Sea Drilling Project. *In* Larson, R. L., Moberly, R., et al., *Initial Reports of the Deep Sea Drilling Project,* v. 32: Washington (U. S. Government Printing Office), pp. 756–801.