4. EXPLANATORY NOTES, DEEP SEA DRILLING PROJECT LEG 82[1]

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RESPONSIBILITY FOR AUTHORSHIP

Authorship of the site chapters includes the complete scientific party, with the ultimate responsibility lying with the two co-chiefs. Within the site chapters the assigned responsibilities are as follows: Site summary and Principal Results (Bougault and Cande); Operations (Cande, Hill, and Bougault); Sediment Lithology and Biostratigraphy (Clark, Curtis, Echols, and Mills); Igneous Petrology and Geochemistry (Bougault, Brannon, Christie, Drake, Neuser, Rideout; and Weaver); Magnetics (Khan); Physical Properties (Hill); Downhole Measurements (Hill and Cande); and Summary and Conclusions (Bougault and Cande).

We also acknowledge the help of Drs. Thomas Sachtleben and Russell Merrill in the final preparation of the site chapters at our postcruise meeting.

The interpretations of individual authors have been retained in the section for which they were responsible. Therefore, conflict between interpretations in a particular section and in the summary are sometimes apparent. Authors of special-topic chapters and the synthesis chapters are cited in the text.

SURVEY AND DRILLING DATA

The survey data used for specific site selections are given in each site-report chapter. Underway geophysical data can be found in Appendix I. On passage between sites, continuous observations were made of depth, magnetic field, and sub-bottom structure. Short surveys were made on *Glomar Challenger* before dropping the beacon, using a precision echo sounder, seismic profiles, and magnetometer.

Depths were continuously recorded underway on a EDO graphic recorder. The depths were read on the basis of an assumed 1500 m/s sounding velocity compensated for two-way traveltime. The sea depth (in meters) at each site was corrected (1) according to the tables of Matthews (1939), and (2) for the depth of the hull transducer (6 m) below sea level. In addition, any depths referred to the drilling platform have been calculated on the assumption that this level is 10 m above the water line.

The seismic-profiling system consisted of two Bolt air guns, a Scripps-designed hydrophone array, Bolt amplifiers, two bandpass filters, and two EDO recorders, usually recording at two different filter settings.

SHIPBOARD SCIENTIFIC PROCEDURES

Number of Sites, Holes, Cores, and Samples

DSDP drill sites are numbered consecutively from the first site drilled by *Glomar Challenger* in 1968. Site numbers are different from hole numbers. A site number refers to one or more holes drilled while the ship was positioned over one acoustic beacon. These holes could be within a radius as great as 900 m from the beacon. Several holes may be drilled at a single site by pulling the drill pipe above the seafloor (out of one hole), moving the ship away from the previous hole any distance within the 900 m radius of the beacon, and then drilling another hole.

The first (or only) hole drilled at a site takes the site number. A letter suffix distinguishes each additional hole at the same site. For example: the first hole takes only the site number; the second takes the site number with suffix A; the third takes the site number with suffix B, and so forth. It is important, for sampling purposes, to distinguish the holes drilled at a site, because recovered sediments or rocks from different holes usually do not come from equivalent positions in the stratigraphic column.

The cored interval is measured in meters below the seafloor. The depth interval of an individual core is the depth below seafloor that the coring operation began to the depth that the coring operation ended. Each coring interval is generally 9.5 m long, which is the nominal length of a core barrel; however, the coring interval may be shorter or longer (rare). "Cored intervals" are not necessarily adjacent to each other, but may be separated by "drilled intervals." In soft sediment, the drill string can be "washed ahead" with the core barrel in place, but not recovering sediment, by pumping water down the pipe at high pressure to wash the sediment out of the way of the bit and up the space between the drill pipe and wall of the hole; however, if thin, hard rock layers are present, it is possible to get "spotty" sampling of these resistant layers within the washed interval, and thus have a cored interval greater than 9.5 m.

Cores taken from a hole are numbered serially from the top of the hole downward. Core numbers and their associated cored interval in meters below the seafloor are normally unique for a hole; however, problems may arise if an interval is cored twice. When this occurs, the core number is assigned a suffix, such as "S" for supplementary. The designation "S" has been used in pre-

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[1] Bougault, H., Cande, S. C., et al., *Init. Repts. DSDP*, 82: Washington (U.S. Govt. Printing Office).
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vious legs as a prefix to the core number for sidewall core samples.

Full recovery for a single core is normally 9.28 m of sediment or rock, which is in a plastic liner (6.6 cm inside diameter), plus about a 0.2-m-long sample (without a plastic liner) in the core catcher. The core catcher is a device at the bottom of the core barrel; it prevents the core from sliding out when the barrel is being retrieved from the hole. The sediment core, which is in the plastic liner, is then cut into 1.5-m-long sections and numbered serially from the top of the sediment core (Fig. 1). When full recovery is obtained, the sections are numbered from 1 through 7, the last section possibly being shorter than 1.5 m. The core catcher sample is placed below the last section when the core is described, and labeled core-catcher (CC); it is treated as a separate section (for sediments only).

When recovery is less than 100%, and if the sediment is placed in the top of the cored interval, then 1.5-m-long sections are numbered serially, starting with Section 1 at the top. There will be as many sections as needed to accommodate the length of the core recovered (Fig. 1); for example, 3 m of core sample in plastic liners will be divided into two 1.5-m-long sections. Sections are cut

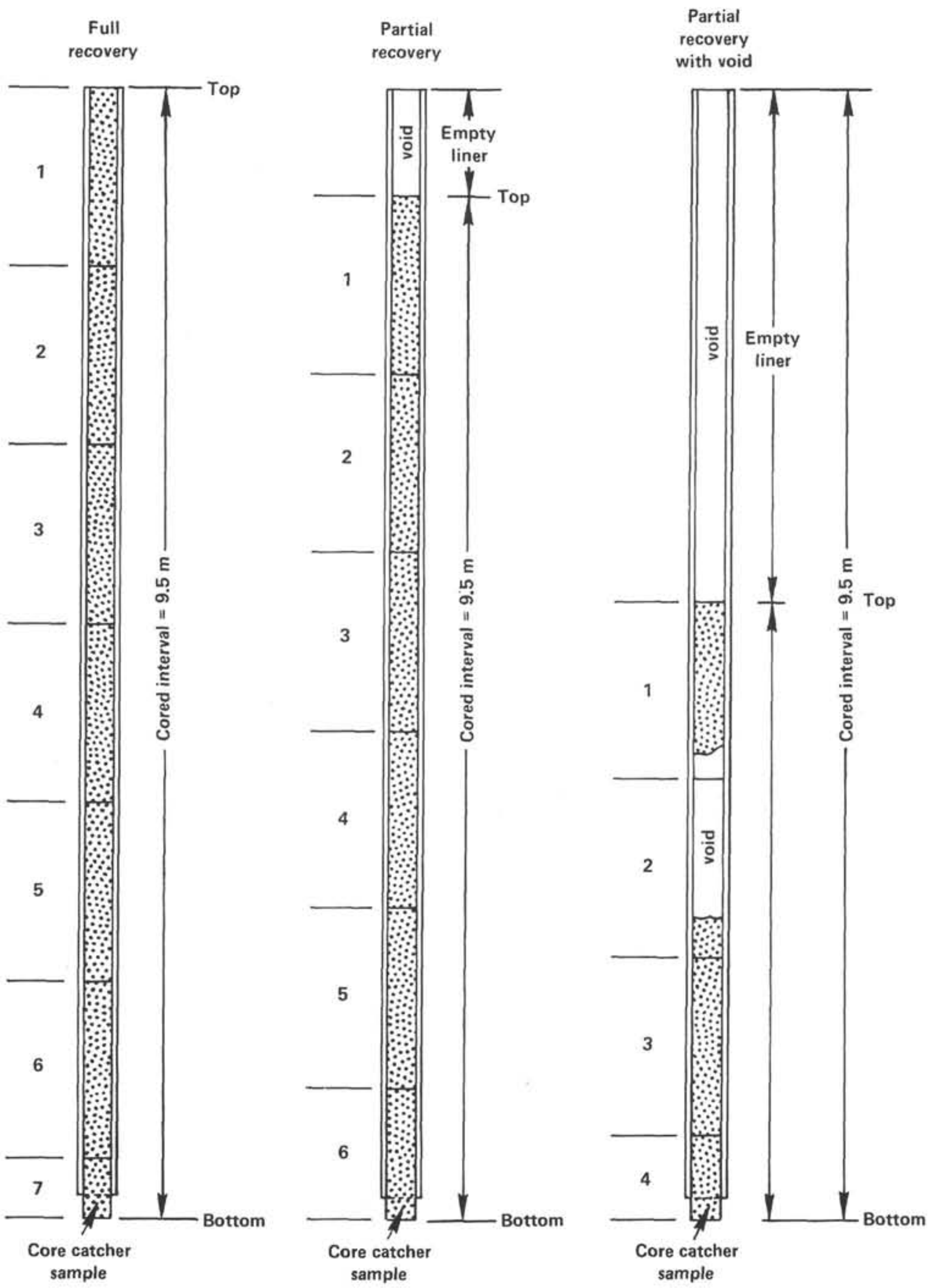

Figure 1. Diagram showing procedure in cutting and labeling of core sections.

starting at the top of the recovered sediment, and the last section may be shorter than the normal 1.5-m length.

When recovery is less than 100%, the original stratigraphic position of the sediment in the cored interval is unknown; we conventionally attribute the top of the recovered sediment to the top of the cored interval. This is done for convenience in data handling and for consistency. If recovery is less than 100%, if the core is fragmented, the sections are still numbered serially and the intervening sections are noted as void, whether the fragments as found were contiguous or not.

Samples are designated by distances in centimeters from the top of each section to the top and bottom of the sample in that section. A full identification number for a sample consists of the following information: (1) leg, (2) site, (3) hole, (4) core number, (5) section number, and (6) interval in centimeters from the top of the section. For example, the sample identification number "82-558A-11-3, 98–100 cm" means that a sample was taken between 98 and 100 cm from the top of Section 3 of Core 11, from the second hole drilled at Site 558 during Leg 82. A sample from the core catcher of this core is designated 82-558A-1,CC (8–9 cm).

The depth below the seafloor for a sample numbered "82-558A-11-3, 98–100 cm" is the sum of the depth to the top of the cored interval for Core 11 (77.0 m) and the 3 m included in Sections 1 and 2 (each 1.5 m long) and the 98 cm below the top of Section 3. The sample in question is located at 80.98 m sub-bottom, which in principle is the sample depth below the seafloor. (Sample requests should refer to a specific interval within a core section, rather than the depth below seafloor.)

Conventions regarding the cataloging of the hydraulic piston cores are the same as those for the rotary cores.

Handling of Cores

A core was normally cut into 1.5-m sections, sealed, and labeled; the sections then were brought into the core laboratory for processing. The following determinations were normally made before the sections were split; gas analysis, thermal-conductivity analysis (soft sediment only), and continuous wet-bulk density determinations using the Gamma Ray Attenuation Porosity Evaluator (GRAPE).

The cores were then split longitudinally into "working" and "archive" halves, either by wire cutter, or by "super-saw." The contrast in appearance between cores cut by the two methods can be significant. Samples extracted from the "working" half included samples for the determination of mineralogy by X-ray diffraction, measurement of sonic velocity by the Hamilton Frame method, measurement of wet-bulk density by a GRAPE technique, measurement of water content by gravimetric analysis, measurement of calcium-carbonate percentage (carbonate bomb), geochemical analysis, paleontologic studies, and other studies.

Whenever the archive half was sufficiently firm, it was washed on the cut surface to emphasize the sedimentary features. The color, texture, structure, and composition of the various lithologically different parts of a section were described (Fig. 2) on standard visual core description sheets (one per section), and any unusual features were noted. A smear slide was made, usually at 75 cm if the core was uniform. However, two or more smear slides were often made for each area of distinct lithology in the core section. The smear slides were examined by petrographic microscope. The archive half of the core section was then photographed.

After the cores were sampled and described, they were maintained in cold storage aboard *Glomar Challenger* until transferred to the DSDP East Coast Repository (Lamont-Doherty Geological Observatory). Core sections that were removed for organic geochemistry studies were frozen immediately aboard ship and kept frozen. All Leg 82 frozen cores are presently stored at the DSDP West Coast Repository (Scripps Institution of Oceanography).

Rock and sediment obtained from core catchers and not used in the initial examination were retained in core liners for subsequent work.

Visual core descriptions, smear-slide descriptions, and carbonate bomb (%$CaCO_3$) determinations (all done aboard ship) provide the data for the core descriptions in this volume. This information is summarized and sample locations in the core are indicated on the core description sheets (Fig. 2).

SEDIMENTS AND SEDIMENTARY ROCKS

Core Description Forms

Drilling Disturbance

Recovered rocks, particularly soft sediments, may be extremely disturbed. This mechanical disturbance is a result of the coring technique, which uses a 25-cm-diameter bit with a 6-cm-diameter opening for the core sample. Symbols for the four disturbance categories used for soft and firm sediment are shown in Figure 2. These symbols are used on the core description sheets. The disturbance categories are defined as: (1) slightly deformed: bedding contacts are slightly bent; (2) moderately deformed: bedding contacts have undergone extreme bowing, firm sediment is fractured; (3) very deformed: bedding is completely disturbed or homogenized by drilling, sometimes showing symmetrical diapirlike structure; (4) soupy: water-saturated intervals that have lost all aspects of original bedding; (5) breccia: indurated sediments broken into angular fragments by the drilling process, perhaps along pre-existing fractures; and (6) biscuited: sediment firm and broken chunks about 5–10 cm in length. These categories are coded on the core description form in the column headed "Drilling Disturbance" (Fig. 2).

Sedimentary Structures

In the soft, and even in some harder, sedimentary cores, it may be extremely difficult to distinguish between natural structures and structures created by the coring process. Thus the description of sedimentary structures was optional. Locations and types of structures appear as

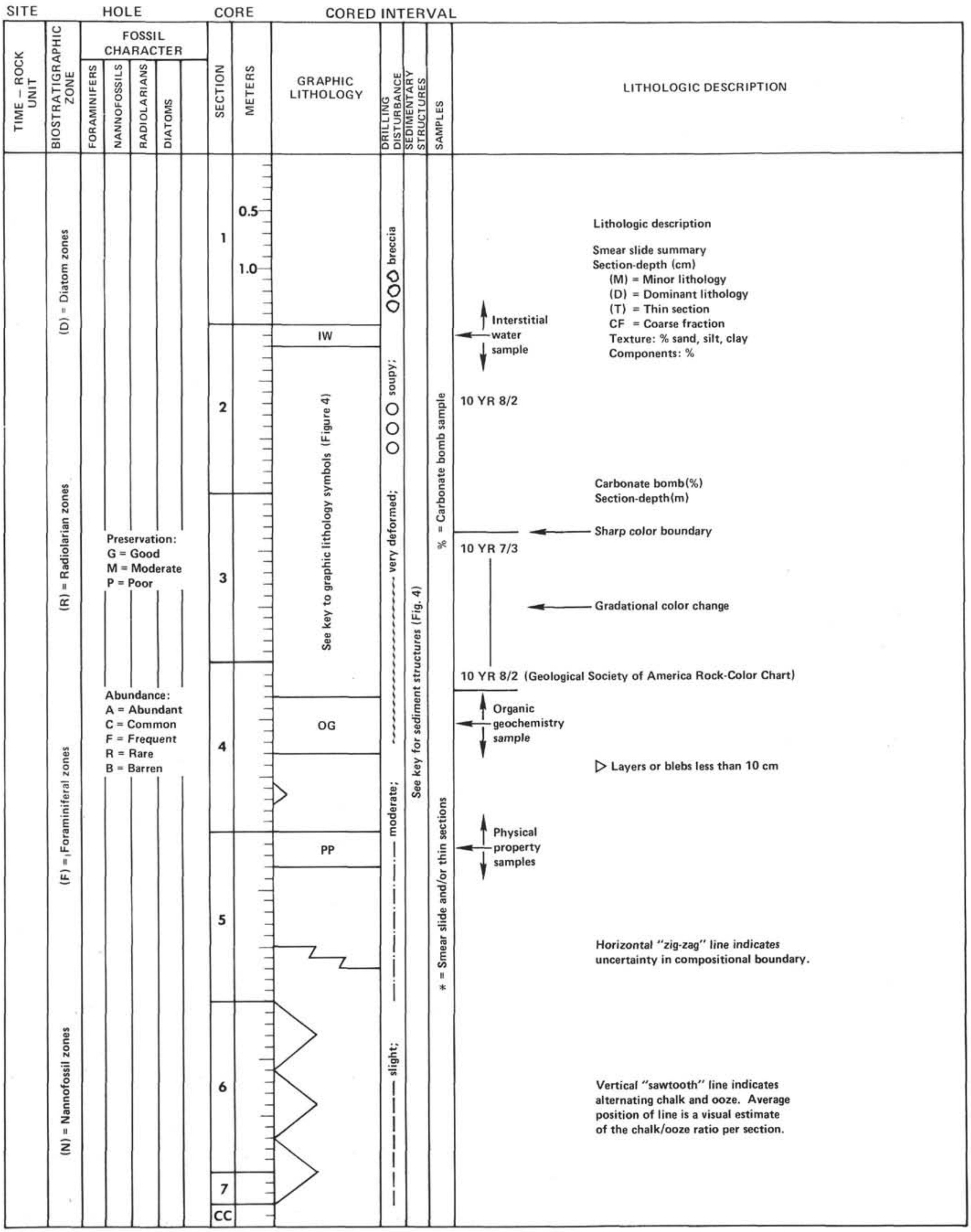

Figure 2. Sample core description sheet (sediment).

graphic symbols in the column headed "Sedimentary Structures" on the core description form (Fig. 2). The keys to these symbols are shown in Figure 3.

Bioturbation is difficult to recognize in the monotonous hemipelagic muds but is noted, where distinguishable, on the graphic column.

Color

Colors of the core samples are determined with a Geological Society of America Rock-Color Chart. Colors are determined immediately after the cores are split and while wet color codes are placed to the right of the sample column on the core description forms (Fig. 2). Solid short horizontal lines between color codes indicate sharp contacts; dashed horizontal lines indicate vague color contacts; and vertical lines indicate intervals of gradational color change.

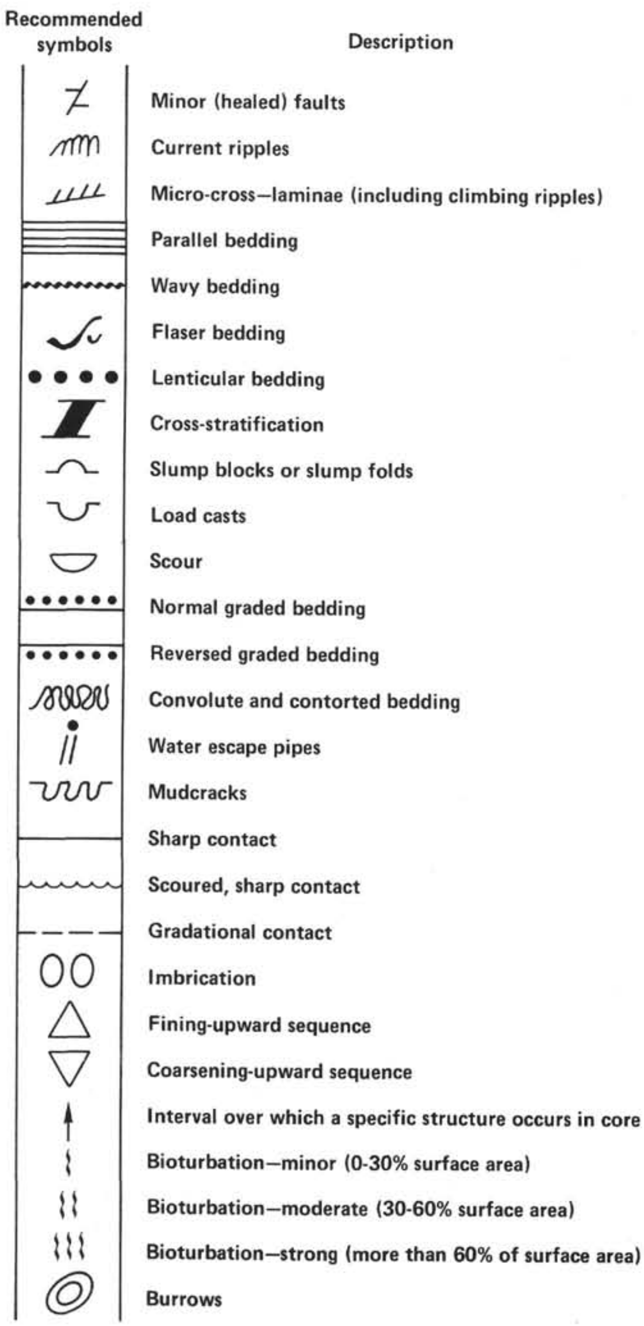

Figure 3. Symbols for sedimentary structures.

Lithology

In the graphic column on the core description form, different lithologies are represented by a single pattern or by a grouping of two or more lithologic component symbols (Fig. 4). The abundance of any lithologic component approximately equals the percentage of the width of the graphic column its symbol occupies. For example, the left 20% of the column may have a diatom ooze symbol, whereas the right 80% may have a silt-clay symbol, indicating sediment composed of 80% mud and 20% diatoms.

Because of the difference in the length-to-width ratio between the actual sediment core and the graphic lithology column, it is not possible to reproduce structures as they appeared in the core; in the graphic representation they are highly flattened and distorted. The same is true for rock fragments or pebbles in the cores. As a result, the locations of pebbles are shown by a solid square and the depth of small "patches" of ash or other lithologic changes are given by triangular inset of the appropriate lithologic symbol on the left side of the lithologic column (Fig. 2). This convention applies also to beds thinner than 1 cm. Voids less than 10 cm are not shown.

Smear-slide (or thin-section) compositions and carbonate content (%$CaCO_3$) determined on board are listed below the core description; the two numbers separated by a hyphen refer to the section and centimeter interval, respectively, of the sample. The locations of these samples in the core and a key to the codes used to identify these samples are given in the column headed "Samples" (Fig. 2). Locations and intervals of organic geochemistry (OG), interstitial water (IW), and physical property (PP) samples are given in the lithology column.

Lithologic Classification of Sediments

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. This classification is descriptive rather than generic, and divisions between different types of sediment are somewhat arbitrary. We treat lithologic types not covered in this classification as a separate category termed Special Rock Types. A brief outline for the conventions and descriptive data used to construct this classification follows.

Conventions and Descriptive Data

Composition and Texture

In this classification, composition and texture are the only criteria used to define the type of sediment or sedimentary rock. Composition is more important for describing sediments deposited in the open ocean, and texture becomes significant for hemipelagic and nearshore sediments. These data come principally from the use of a petrographic microscope for visual estimates of smear slides. They are estimates of areal abundance and size components on the slide and may differ somewhat from

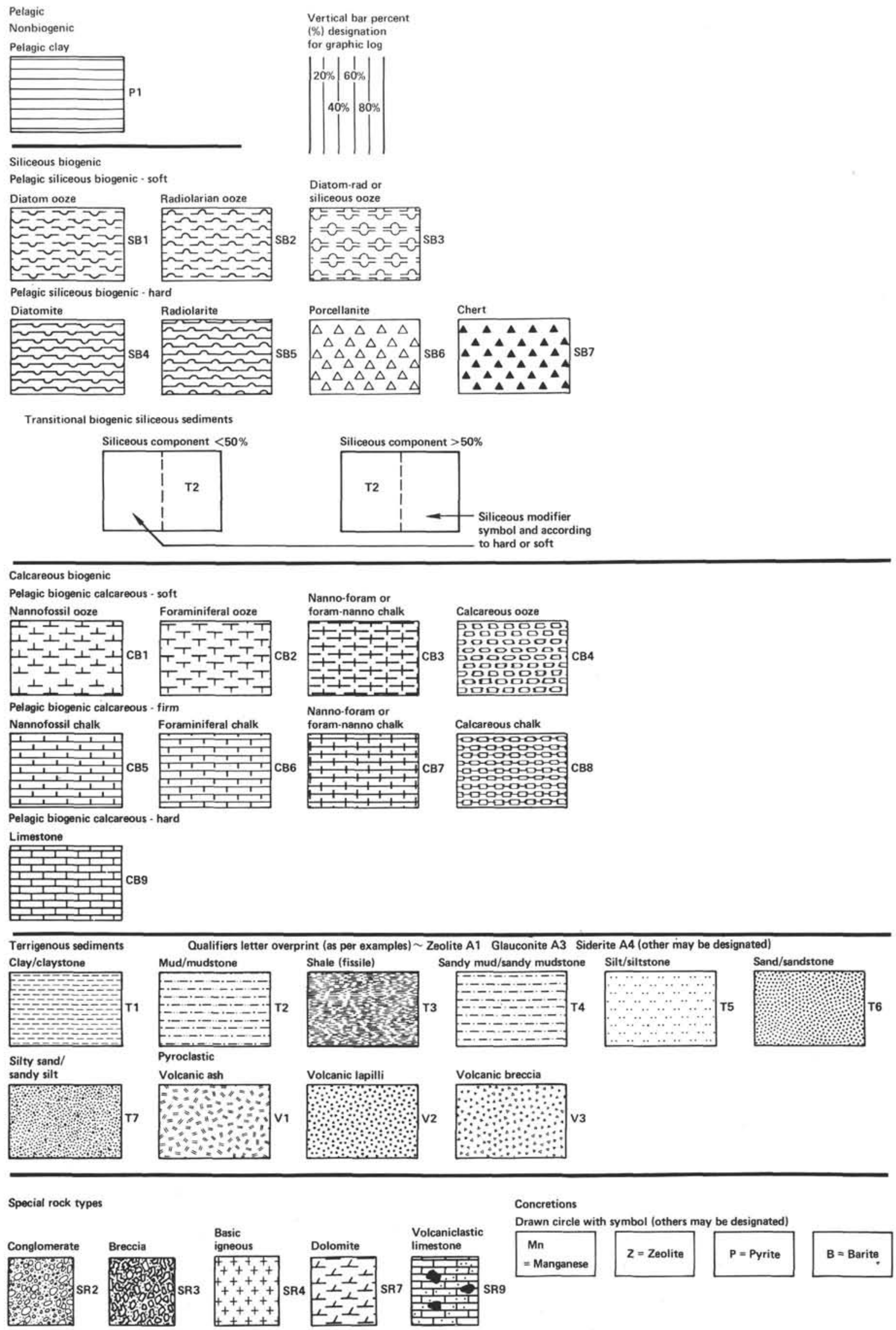

Figure 4. Symbols used to identify lithology on sediment core description forms.

more accurate analyses of grain size, carbonate content, and mineralogy. From past experience, we find quantitative estimates of distinctive minor components to be accurate to within 1-2%, but for major constituents accuracy is poorer, ±10%. All smear-slide estimates were done on board.

Induration of Sediments

We recognize three classes of induration or lithification for all sediments. In the next two paragraphs, these classes are defined for two types of sediments.

1. For calcareous sediments and sedimentary rocks, categories after Gealey and others (1971): soft = ooze, has little strength and is readily deformed under pressure of finger or broad blade of spatula; firm = chalk, partially lithified, readily scratched with fingernail or edge of spatula; hard = limestone, dolostone, well lithified and cemented, resistant or impossible to scratch with fingernail or edge of spatula.

2. For transitional carbonates, siliceous, pelagic, and terrigenous sediments: soft = sediment core that may be split with wire cutter; firm = partially lithified, but fingertip pressure leaves an indentation; hard = cannot be compressed with fingertip pressure.

Basic Sediment Types

Biogenic Siliceous Sediments

Biogenic siliceous sediments are those that contain more than 30% siliceous microfossils. Sediments containing between 10 and 30% siliceous microfossils should contain the name(s) of the microfossil(s) as qualifiers. The following terminology is used for siliceous biogenic sediments:

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 procellanite (which also 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..." (Lancelot, 1973). "Chert," as used here, will have a narrower scope than that of past usage, and will refer to "hard nodules and sometimes beds that are largely quartz and (or) chalcedony, and show a conchoidal fracture and a bitreous luster..." (Lancelot, 1973).

3. Compositional qualifiers: diatoms and radiolarians may be the principle components; thus, one or two qualifiers may be used, for example: indeterminate siliceous fossils (siliceous ooze, chert, or porcellanite); radiolarians only (radiolarian ooze, or radiolarite); diatoms only (diatom ooze or diatomite); diatom < radiolarians (diatom radiolarian ooze or diatom radiolarite); diatom > radiolarians (radiolarian diatom ooze or radiolarian diatomite).

The order of the two modifiers in the terms is dependent on the dominant fossil type. The dominant component is listed last and the minor component is listed first. The terminology for mixtures of clay with diatom sediments is:

Biogenic siliceous fossil particles (%)	Nonbiogenic particles (example: clay) (%)	Lithologic type
<10	90	Clay (soft) Claystone (hard)
30–10	70–90	Diatom clay (soft) Diatom claystone (hard)
60–30	40–70	Clayey diatom ooze (soft) Clayey diatomite (hard)
100–60	0–40	Diatom ooze (soft) Diatomite (hard)

If radiolarians are the dominant siliceous microfossil, the terms "radiolarian" and "radiolarite" are substituted for "diatom" and "diatomite", respectively. The term "siliceous" may be used if the fossil type is indeterminate. Likewise, other textural terms for the nonbiogenic components can be substituted for clay (e.g., silty diatom ooze, diatom silty clay, etc.).

Biogenic Calcareous Sediment

Calcareous biogenic sediments are distinguished by a $CaCO_3$ content in excess of 30%. There are two classes: (1) biogenic calcareous sediments, that contain 60–100% biogenic $CaCO_3$, and (2) transitional biogenic calcareous sediments, that contain 30–60% biogenic $CaCO_3$.

1. For biogenic calcareous sediment, with 60–100% biogenic $CaCO_3$, the following terminology is used: soft: calcareous ooze, firm: chalk, and hard and cemented: limestone.

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 10–30%, nannofossils 60–90%: foraminiferal-nannofossil ooze, foraminiferal-nannofossil chalk, or foraminiferal-nannofossil limestone; foraminifers 30–60%, nannofossils 40–70%: nannofossil-foraminiferal ooze, nannofossil-foraminiferal chalk, or nannofossil-foraminiferal limestone.

2. For transitional biogenic calcareous sediments, with 30 to 60% biogenic $CaCO_3$ the following terminology is used: marl or marlstone: 30–60% $CaCO_3$, nonbiogenic components greater than siliceous biogenic component; soft: calcareous marl, foraminifer marl, or nannofossil marl; hard: calcareous marlstone, foraminiferal marlstone, or nannofossil marlstone.

Note that the use of the terms "marl" or "marlstone" differ from the SPPP classification. The panel's classification used "marly" as an adjective modifying ooze, chalk, or limestone (e.g., "marly limestone"), to denote sediments that had 30–60% biogenic carbonate. Our terminology for mixtures of clay with nannofossil sediments is as follows:

Biogenic calcareous fossil particles (%)	Nonbiogenic particles (%)	Lithologic type
0–10	90–100	Clay (soft) Claystone (hard)
30–10	70–90	Nannofossil clay (soft) Nannofossil claystone (hard)
60–30	40–70	Nannofossil marl (soft) Marly nannofossil chalk (firm) Nannofossil marlstone (hard)
100–60	0–40	Nannofossil ooze (soft) Nannofossil chalk (firm) Nannofossil limestone (hard)

Other terms may be substituted for nannofossil, such as (1) "foraminiferal, nannofossil-foraminiferal," if foraminifers are present in the percentages as discussed, or (2) "calcareous," if the fossil type is indeterminate. Likewise, other textural terms for the nonbiogenic components can be substituted for clay (e.g., silty nannofossil ooze, foraminifer silty clay, etc.).

Biogenic ooze: 30–60% $CaCO_3$, siliceous biogenic components greater than nonbiogenic components.

Calcareous components greater than siliceous components (examples: radiolarian-nannofossil ooze [chalk], diatom-foraminiferal ooze, siliceous limestone).

Siliceous components greater than calcareous components (examples: nannofossil-diatom ooze [diatomite], foraminiferal-radiolarian ooze [radiolarite]).

Volcanogenic Sediments

Pyroclastic rocks are described according to the textural and compositional scheme of Wentworth and Williams (1932): The textural groups are: more than 32 mm, volcanic breccia; 4–32 mm, volcanic lapilli; less than 4, volcanic ash (tuff, if indurated). These pyroclastic rocks are described as vitric, crystal, or lithic.

IGNEOUS AND METAMORPHIC ROCK DESCRIPTION CONVENTIONS

Core Forms

Core description forms for igneous and metamorphic rocks are not the same as those used for sediments. The latter are essentially those published in previous *Initial Reports*. Igneous rock representation on such sheets, however, is too compressed to provide adequate information for rock sampling. Consequently, visual core description forms, modified from those used aboard ship, are used here for more complete graphic representation. Each of these forms covers one 1.5-m section. All shipboard chemical and physical-property data, as well as summary hand-specimen and thin-section descriptions, are presented for each section.

All basalts are split with a rock saw into archive and working halves. The latter is described and sampled aboard ship. In a typical basalt description form (Fig. 5), the left box is a visual representation of the working half. Lithologies are indicated in the graphic representation column using the symbols shown on Figure 6. Two closely spaced horizontal lines in this column indicate the location of styrofoam 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 that could fit together before splitting are given the same number, but are lettered consecutively as "1a, 1b, 1c," etc. Spacers are placed between pieces with different numbers, but not between those with different letters and the same number. In general,

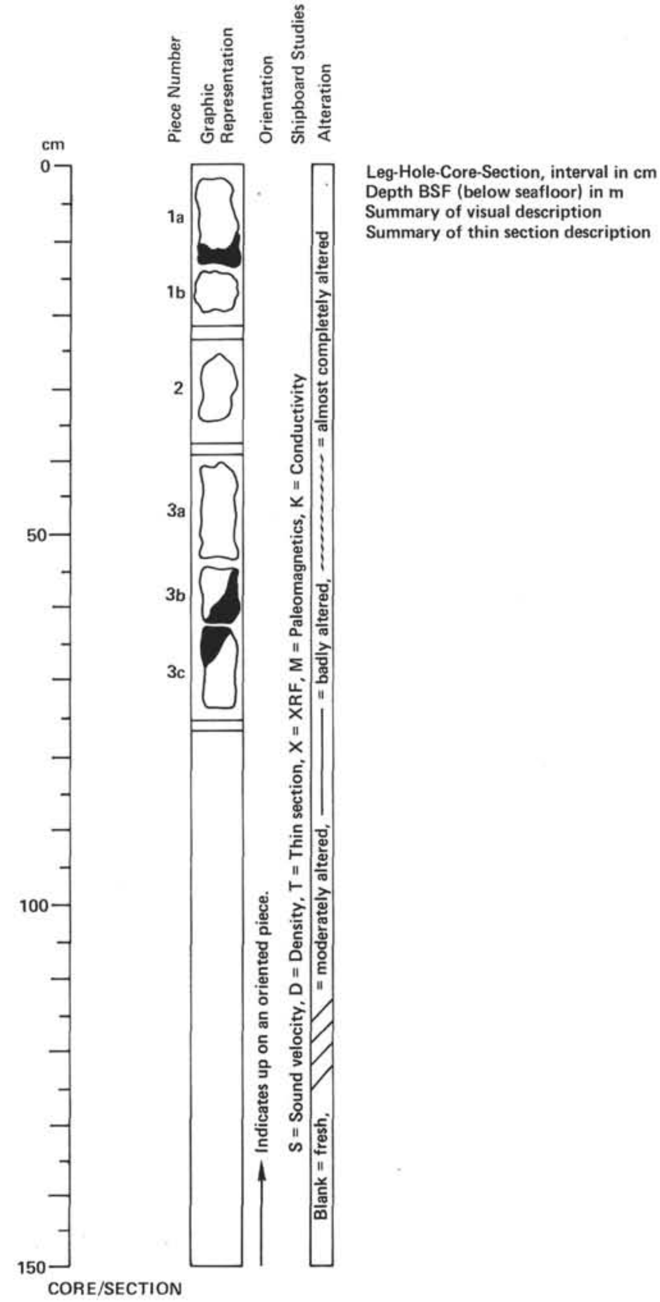

Figure 5. Sample core description form (igneous rocks).

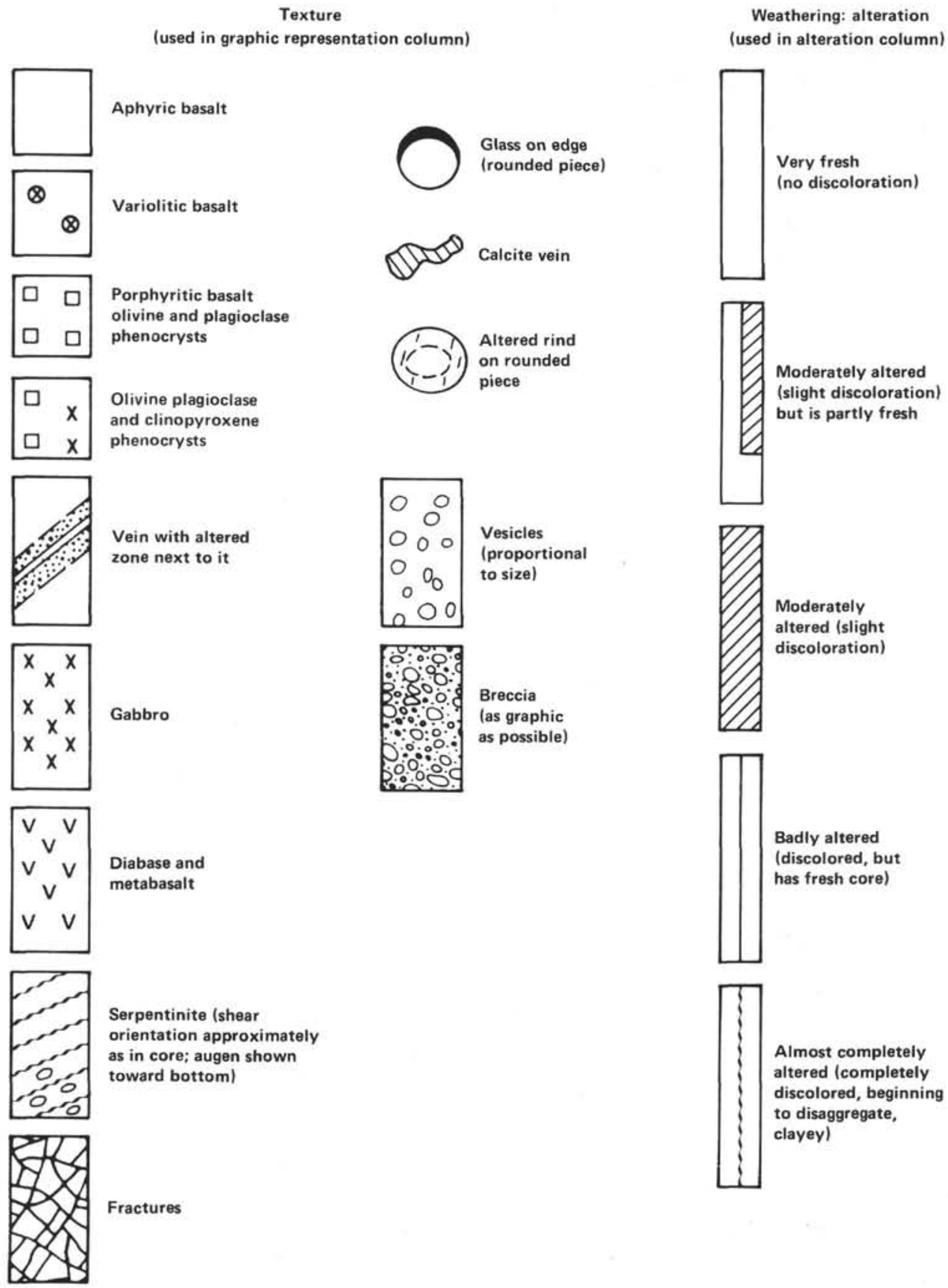

Figure 6. List of symbols for igneous and metamorphic rocks, Leg 82.

addition of spacers represents a drilling gap (no recovery). All pieces that are cylindrical and longer than the liner diameter have orientation arrows pointing up, both on the archive and working halves. Special procedures are used to ensure that orientation is 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. Because the pieces are rotated during drilling, it is not possible to sample for declination studies.

Samples are taken for various measurements aboard 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 measurement; S = sonic velocity measurement; T = thin section; D = density measurement; and P = porosity measurement.

The state of alteration (see Fig. 6 for symbols) is shown in the Alteration column.

Classification of Igneous Rocks

We informally classified igneous rocks recovered on Leg 82 according to mineralogy and texture determined from visual inspection of hand specimens and thin sections. We agreed upon the following conventions while we were at sea, and we realize that they are generalized.

It is possible that gradations may exist within and among textural groups in a single sample:

A. *Quench textures recognized and described*:

1. Glassy: matrix is amorphous, basaltic glass with no visible, incipient crystallization.

2. Variolitic: texture characterized by the presence of varioles, which are spherical bodies, usually consisting of radiating plagioclase and/or clinopyroxene microlites or crystals; individual crystals are indistinguishable with the microscope.

3. Subvariolitic: texture in which variolites coalesce.

4. Immature sheaf: a bundled arrangement of small crystals (which cannot be individually distinguished with the microscope) assuming a sheaflike appearance; a central axis of crystal growth often occurs.

5. Mature sheaf: same as above, but, discrete skeletal crystals can be distinguished with the microscope (usually greater than 0.005 mm wide).

6. Plumose: plumelike or featherlike arrangement of microlites or crystals; may grade from immature to mature (as in sheaf texture) because of crystal size.

B. *Major textural classification for basaltic samples*:

1. Phyric: a term describing igneous rocks in which larger crystals (phenocrysts) are set in a finer groundmass, which may be crystalline or glassy, or both. Aphric: no phenocrysts; sparsely phyric: 1-2% phenocrysts; moderately phyric: 2-10% phenocrysts; high phyric: more than 10% phenocrysts.

2. Glomerophyric: a term applied to phyric rocks containing clusters of equant crystals larger than the matrix crystals.

3. Ophitic: a term applied to a texture in which euhedral or subhedral crystals of plagioclase are embedded in a mesostasis of pyroxene crystals.

4. Subophitic: a term applied to the ophitic texture of an igneous rock in which the feldspar crystals are approximately the same size as the pyroxene and are only partially included by them.

5. Intergranular: a term applied to volcanic rocks in which there is an aggregation of grains of clinopyroxene, not in parallel optical continuity (as in subophitic texture), between a network of feldspar laths that may be diverse, subradial, or subparallel. It is distinguished from an intersertal texture by the absence of both interstitial glass and other quenched places that may fill the interstices between the feldspar laths.

6. Intersertal: a term applied to volcanic rocks wherein a base of mesostasis or glass and small crystals fill the interstices between unoriented feldspar laths, the base forming a relatively small proportion of the rock. When the amount of the base increases and feldspar laths decrease, the texture becomes hyalophitic, and with a still greater increase in the amount of the base, the texture becomes hyalopilitic.

Designation of Informal Lithologic Units and Petrographic or Chemical Groups

For Leg 82 arabic numerals (1, 2, 3...) are used to designate lithologic units. Lithologic units are numbered sequentially from the top to the bottom of the hole, including both sedimentary, igneous, and metamorphic rocks. Petrographic or chemical groups involve igneous rocks only and are designated with Roman numerals (I, II, III,...). The groups are numbered sequentially as each new group is identified from the first occurrence of igneous rocks to the bottom of the hole. This does not exclude a group from reoccurring further downhole from where it was first identified.

SHIPBOARD MEASUREMENTS

Physical Properties Procedures

A thorough discussion of physical properties is presented by Boyce (1976) with respect to equipment, methods, errors, correction factors, and problems related to coring disturbance. Only a brief review of methods employed on Leg 82 is given here.

Velocity

Compressional-wave velocity was measured on the Hamilton Frame Velocimeter by timing a 400-kHz pulse between two transducers and by measuring the distance across the sample with a dial gauge. Measurements were made at laboratory temperature and pressure. With consolidated sediments, a piece was removed from the core and trimmed carefully to form two parallel surfaces to ensure good contact with the transducer heads. Water was used to make good acoustical contact between the sample and the transducers.

Calibration of the velocimeter consisted of making numerous measurements through lucite, aluminum, and brass standards of varying thicknesses to obtain a calibration constant for each of three μs/cm settings on the DSDP Tektronix 485 oscilloscope used to make the travel-time measurements. This calibration constant reflects the position picked by the operator as representing the first break from horizontal of the sonic signal. Data from the calibrations remained constant throughout the duration of Leg 82.

GRAPE

The Gamma Ray Attenuation and Porosity Evaluator (GRAPE) was used to determine wet-bulk density based on the attenuation of gamma rays by the sample. Boyce (1976) discusses the theoretical aspects in detail. During Leg 82 the GRAPE was used in two modes: (1) continuous GRAPE, in which most sections of the core were irradiated; continuous "corrected" wet-bulk density (relative to quartz) was plotted on an analog graph: and (2) two-minute GRAPE, in which the gamma count through a small piece of the core was measured for two minutes, followed by a similar count through air and/or a quartz standard.

Continuous GRAPE

Before each core was run through the device, an aluminum standard was measured. A density of 2.60 Mg/m^3 was assigned to the 6.61-cm (diameter) aluminum standard analog record and a density of 1.0 Mg/m^3 to the 2.54-cm (diameter) aluminum standard analog record. Linear interpolation of the GRAPE analog data between these values yielded an "empirical" wet-bulk density of the sediment sample in the core (ρ_{bcz}). If the sample completely filled the core, then $\rho_{bc} = \rho_{bcz}$, where ρ_{bc} = "corrected" wet-bulk density (relative to quartz). Then:

$$\rho_b = \frac{(\rho_{bc}\text{-}\rho_{fc})(\rho_g\text{-}\rho_f)}{(\rho_{gc}\text{-}\rho_{fc})} + \rho_f,$$

where ρ_g = true grain density ($\simeq 2.7$ Mg/m^3 for sediments), ρ_{gc} = corrected grain density ($\simeq 2.7$ Mg/m$_3$ for sediment); ρ_f = true fluid density ($\simeq 1.025$ Mg/m^3); ρ_{fc} = corrected fluid density ($\simeq 1.125$ Mg/m^3); and ρ_b = true wet-bulk density.

Using the above values,

$$\rho_b = 1.066\ (\rho_{bc} - 1.125) + 1.025. \qquad (1)$$

Shipboard reduction of analog GRAPE records involved the selection of high-density portions of each core section on the analog record, and the calculation of true wet-bulk density (ρ_b) by formula (1). The porosity ϕ is obtained by

$$\phi(\%) = \frac{\rho_g\text{-}\rho_b}{\rho_g\text{-}\rho_f} \times 100.$$

Two-Minute GRAPE

For two-minute GRAPE calculations,

$$\rho_{bc} = \frac{\ln (I_o/I)}{d\ \mu\text{qtz}},$$

where I_o = two-minute gamma count through air, I = two-minute gamma count through the sample, d = gamma ray path length through the sample, and μqtz = quartz attenuation coefficient determined daily by measuring through a quartz standard. Then as in the continuous GRAPE calculation (assuming a 2.7 grain density),

$$\rho_b = 1.066\ (\rho_{bc} - 1.125) + 1.025,$$

and

$$\phi(\%) = \frac{100(2.70\text{-}\rho_b)}{1.675}.$$

Boyce (1976) estimates $\pm 5\%$ accuracy for continuous GRAPE data and $\pm 2\%$ for two-minute GRAPE data. In practice, it was found that the error on Leg 82 seemed to be higher, because of the highly disturbed nature of many of the cores. However, good agreement exists between the GRAPE data and gravimetric methods.

Samples for the two-minute GRAPE counts were also used for gravimetric methods. One of three different sampling techniques was used depending on the stiffness and the fissility of the sediments and rocks. In soft sediments, Boyce cylinders were inserted and cut from the split cores to produce the most undisturbed sample possible. The upper and lower sample surfaces were gradually trimmed flush with the cylinder to minimize sediment remolding. The resulting disturbance was small enough to have a negligible effect either on the GRAPE counts or on the gravimetric analysis. In harder sediments, when cylinders could no longer be inserted without causing severe deformation or cracking, slices (10–20 cm^3) were removed using razor blades. Parallel surfaces were trimmed on four sides to allow GRAPE counts both perpendicular and parallel to bedding. When increased induration allowed, mini-cores were cut from the drilling biscuits and coherent sections. Again, the surfaces were carefully trimmed.

Gravimetric Technique: Boyce Cylinder, Chunk, and Mini-Core

After the two-minute GRAPE counts, the samples prepared as described above were used for water content and porosity determinations. No salt corrections were applied in any of these techniques. Drying and weighing equipment on board *Glomar Challenger* was used for these measurements.

Water content (% wet wt.) =

$$100 \times \frac{[(\text{wt. wet sediment}) - (\text{wt. dry sediment})]}{(\text{wt. wet sediment})}.$$

For porosity determinations, a grain density of 2.65 g/m^3 and a water density of 1.03 g/m^3 were assumed.

$$\text{Porosity } (\%) = 100 \times \frac{\text{vol. evaporated water}}{\text{vol. wet sediment}}$$

$$= 100 \times \frac{[(\text{wt. evaporated water})/(1.03\ \text{Mg/m}^3)]}{\left[\frac{(\text{wt. dry sediment})}{(2.65\ \text{mg/m}^3)} + \frac{(\text{wt. evaporated water})}{(1.03\ \text{mg/m}^3)}\right]}.$$

Shear Strength

A Soiltest Torvane was used on board to determine the undrained shear strength of clayey sediments. The Torvane was hand-rotated at a rate designed to reach failure in about 10 s with constant loading. Repeated determinations yielded results that were generally reproducible to $\pm 15\%$. Measurements were made in the least disturbed sediments.

Conductivity is determined from the relation that applies for a line source in an infinite medium:

$$K = \frac{AI^2 \ln(t_2/t_1)}{T_2 - T_1} - B,$$

where K = the thermal conductivity, I = the current flowing in the heater wire, t_1 and t_2 are two times in the measurement period, T_2 and T_1 are temperatures at times t_2 and t_1, and A and B are constants. For the needle probe device, B = 0 and A is determined directly from probe parameters.

Geochemical Procedures

Carbonate Bomb

Percent $CaCO_3$ was also determined on board ship by the "Karbonate Bombe" technique (Müller and Gastner, 1971). In this simple procedure, a sample is powdered and treated with HC1 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 reaching ($\times$ 100) yields %$CaCO_3$. Percent error can be as low as 1% for sediments high in $CaCO_3$, and in general an accuracy of about 2 to 5% can be obtained.

These data are presented on the core-description sheets. The sample interval is designated by two numbers: the section number, followed by the top of the sample interval. For example, a sample from Section 558-9-2, 11 to 12 cm, with 90% calcium carbonate will be represented on the core description sheet for Core 558-9 as "2-11 (90%)."

On-board analyses for pH, alkalinity, salinity, calcium, magnesium, and chlorinity are conducted routinely. Interstitial waters are routinely analyzed for pH, alkalinity, salinity, calcium, magnesium, and chlorinity. Sediments are squeezed using a stainless steel press; the water collects in plastic syringes and is then filtered through 0.45-μm, 1-in. millipore filters. Interstitial waters collected with the *in situ* Water Sampler are filtered through 0.4-μm, 13-mm filters before analysis.

A Corning Model 130 pH meter and a Markson combination electrode were used to determine pH. The pH meter is calibrated with 4.01 and 7.42 buffer standards, all readings are originally in millivolts and later are converted to pH. All pH measurements are made in conjunction with alkalinity.

Alkalinites are determined potentiometrically. Five to ten ml samples are first tested for pH then titrated with 0.1 N HCL. Near the endpoint acid is added in 0.01-ml and 0.005-ml increments, and the millivolt readings noted for each increment. The exact endpoint is then calculated using the Gran Factor method (Gieskes and Rogers, 1973).

Salinity (‰) is calculated from the fluid refractive index, as measured by a Goldberg optical refractometer, using this expression:

$$\text{Salinity (‰)} = 0.55 \times \Delta N,$$

where ΔN is the refractive index multiplied by 10^4. The refractometer's calibration is checked periodically using IAPSO seawater standard and deionized water.

Calcium is determined by titrating a 0.5-ml sample with EGTA (a complexing agent), using GHA as an indicator. To sharpen the endpoint, the calcium-GHA complex is extracted into a layer of butanol. No correction is made for strontium, which is also included in the result.

Magnesium is determined by titrating a buffered 0.5-ml sample to an Ereochrome Black-T endpoint, using EDTA (sodium salt) as a titrant. This method analyzes all alkaline earths, including calcium, strontium, and magnesium; concentrations are obtained by subtracting the calcium (which includes strontium) from this analysis.

Chlorinity is determined by titrating a 0.1-ml sample (diluted with 1 ml of deionized water) with silver nitrate to a potassium chromate endpoint.

Methods and equipment are checked and standardized at each site using IAPSO standard seawater. As a further check, a surface seawater sample is also analyzed and archived. This sample is also used to test for possible drill water contamination of the interstitial water samples.

Paleomagnetic Techniques

Remanent magnetization of sediment and rock samples is measured with a Digico balanced fluxgate rock magnetometer, calibrated frequently with a shipboard standard. Error direction of remanent magnetization is less than 4°. The noise level is 2.3 $\pm$ (1.1×10^{-7}) emv/cm^3.

A Schonstedt A. C. geophysical specimen demagnetizer (Model GSD-1) is used for alternating field (AF) demagnetization of the samples. With this single-axis system demagnetizer, every sample was demagnetized three times, about each of the three orthogonal axes.

Samples for paleomagnetic analysis are taken from unconsolidated and semiconsolidated sediments in the upper parts of the cores by inserting plastic 2.5-cm cubes into the split sections. In more lithified samples from deeper levels, cylindrical samples (2.5 cm in diameter) are taken from the split core sections with a diamond corer ("mini-core drill"). An orientation is marked with an arrow in the uphole direction on every sample before removal from the split core section.

Photography

Sets of color and black-and-white negatives of whole cores are available for consultation. In addition, negatives in black and white for closeup documentation of special structures are archived at DSDP.

Obtaining Samples

Potential investigators who desire to obtain samples should refer to the DSDP-NSF Sample Distribution Policy. Sample request forms may be obtained from The Curator, Ocean Drilling Program, Texas A&M University, College Station, Texas 77843. Requests must be as specific as possible; include site, core, section, interval within a section, and volume of sample required.

BIOSTRATIGRAPHY-MAGNETIC STRATIGRAPHY CORRELATION CHART

Biostratigraphic zonations are placed under the column heading "Biostratigraphic Zone" on the core description form. Under the column heading "Fossil Character," the following letters are used to indicate fossil abundance: A = abundant (flood, many species and specimens); C = common (many species, easy to make age assignment); R = rare (enough for age assignment); T = trace (few species and specimens, not enough for age assignment); and B = barren.

Letters used to designate fossil preservation are: E = excellent (no dissolution or abrasion); G = good (very little dissolution or abrasion); M = moderate (dissolution and/or abrasion and/or recrystallization very noticeable); and P = poor (substantial or very strong evidence of dissolution and/or abrasion, and/or recrystallization).

Figure 7 shows the zonation used on board ship for nannofossils, foraminifers, and magnetostratigraphic correlations.

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Figure 7. Biostratigraphy and magnetostratigraphy correlation chart, Leg 82. Black is normal polarity; white is reversed.