1. EXPLANATORY NOTES, LEG 79[1]

Shipboard Scientific Party[2]

ORGANIZATION AND AUTHORSHIP

This volume, covering Leg 79 of the cruises of *Glomar Challenger*, is divided into two sections: the first includes the site chapters, containing reports of objectives, operations, and initial scientific results worked out aboard ship and immediately after the cruise for each site. The remainder of the volume incorporates specialty chapters, detailed studies of specific subjects conducted after the cruise by shipboard scientists and shore-based investigators.[3]

The authorship of the site chapters is shared collectively by the shipboard scientific party; the ultimate responsibility lies with the Co-Chief Scientists.

The four site chapters (Chapters 2 through 5) follow the general outline below; the primary authorship of each section is given in parentheses:

Site Summary (Hinz and Winterer)
Background and Objectives (Hinz and Winterer)
Operations (Hinz and Winterer)
Lithologic Summary: Site 544 (Jansa), Site 545 (Bradshaw), Site 546 (Steiger), Site 547 (Moore)
Biostratigraphy: Summary (Baumgartner, Sites 544, 545; Leckie, Sites 546, 547)
  Nannofossils (Wiegand)
  Foraminifers (Jaffrezo, neritic; Leckie, deep water)
  Radiolarians (Baumgartner)
  Sedimentation Rates (Leckie, Wiegand, Winterer)
  Geochemistry (Rullkötter, Vuchev)
  Physical Properties (Schaftenaar)
  Paleomagnetism (Channell)
  Correlation of Seismic Data with Drilling Results (Hinz and Winterer)
  Summary and Conclusions (Hinz and Winterer)
  Core Description Sheets (Baumgartner and Steiger)

The interpretations of individual scientists have been retained in those parts of the reports for which they were responsible. Where possible, we have included data and interpretations from the specialty chapters; the authors of those chapters are cited where appropriate.

NUMBERING OF SITES, HOLES, CORES, AND SAMPLES

Drill site numbers run consecutively from the first site drilled by *Glomar Challenger* in 1968; the site number is unique. A site refers to the hole or holes drilled while the ship is positioned over one acoustic beacon. Several holes may be drilled at a single locality (site) by pulling the drill string above the seafloor ("mud line") and moving the ship some distance (usually 100 m or more) from the previous hole.

The first (or only) hole drilled at a site takes the site number (e.g., Hole 544). A letter suffix distinguishes each additional hole at the same site (e.g., Hole 544A). Note that recovered sediments or rocks from different holes at the same site usually do not come from equivalent positions in the stratigraphic column; thus this distinction is important.

Serial "cored intervals" are not necessarily adjacent, but may be separated by "drilled intervals" without recovery. In soft sediment, this is accomplished by "washing down," drilling with core barrel in place but circulating water with sufficient pressure to wash the sediment out of the way of the bit and up the annulus between the drill pipe and the wall of the hole. If thin, hard rock layers are present, or if pump pressure is insufficient, it is possible to get "spotty" sampling within the washed interval and thus to core an interval greater than 9.5 m. Likewise, if recovery is expected to be low, it is possible to "overcome" an interval of more than 9.5 m and recover less than 9.5 m of material.

Cores are numbered sequentially from the top down. Full recovery comprises 9.28 m of sediment or rock in a plastic liner (6.6 cm diameter) and a short sample (~ 22 cm) in the core catcher (a multifingered device at the bottom of the core barrel which prevents cored materials from sliding out). Cores are cut into 1.5-m sections and numbered sequentially (1 through 7) from top to bottom (Fig. 1). Section 7 is generally shorter than 1.5

[1] Hinz, K., Winterer, E. L., et al., *Init. Repts. DSDP*, 79: Washington (U.S. Govt. Printing Office).

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[3] The descriptions of sites, cores, and data included in these site reports were completed within one year of the cruise, but many of the topical chapters that follow were completed at a later date. More data were acquired and authors' interpretations matured during this interval, so readers may find some discrepancies between site reports and topical papers. This is particularly true of biostratigraphic age assignments. The timely publication of the *Initial Reports* series, which is intended to report the early results of each leg, precludes incurring the delays that would allow the site reports to be revised at a later stage of production.

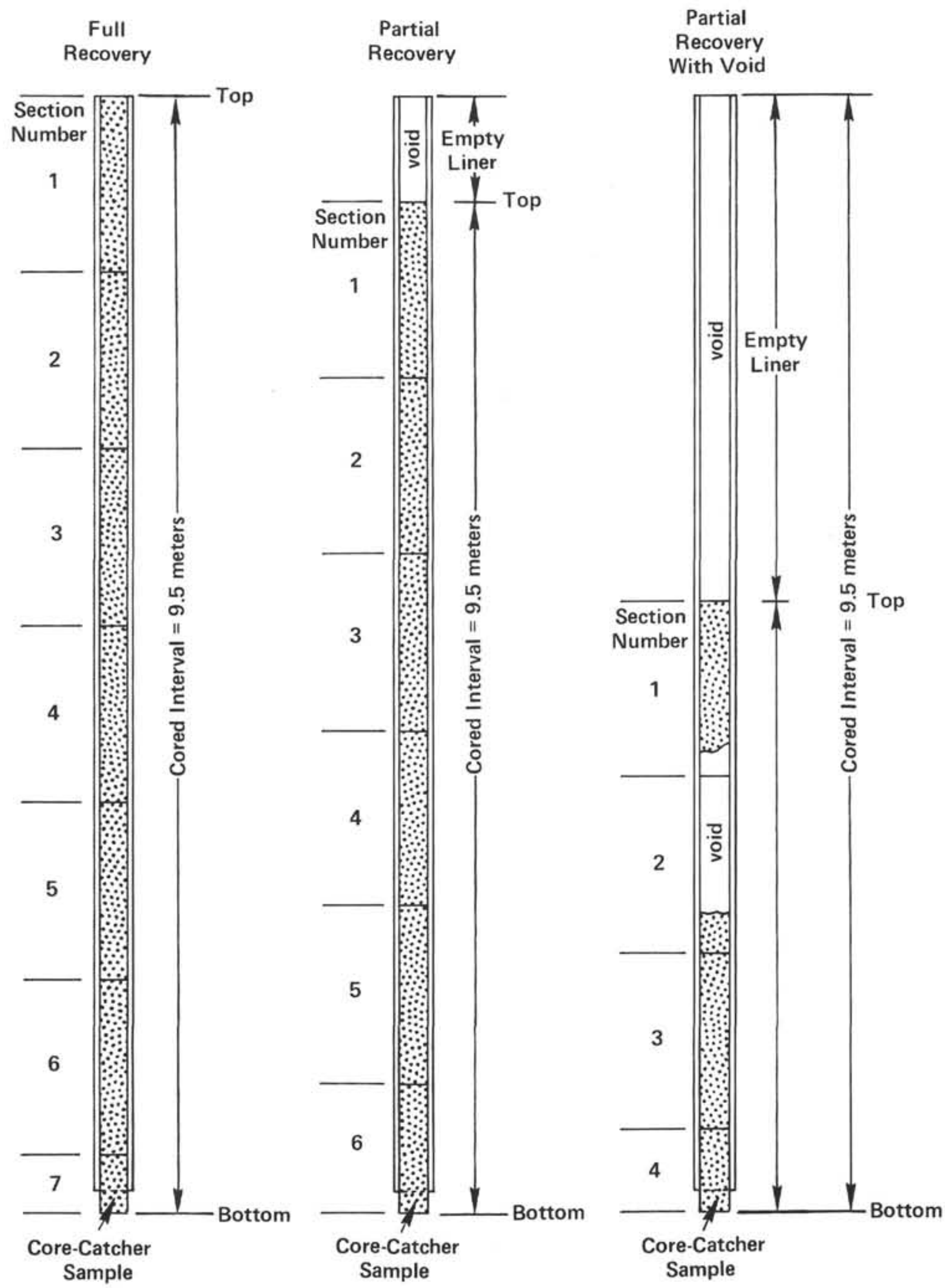

Figure 1. Diagram showing procedure in cutting and labeling of core sections.

m. The core-catcher sample is placed below the last section when the core is described, and labeled CC; it is treated as a separate section.

Recovery is often less than 100%. In cases of partial recovery, if the sediment core is continuous, the recovered material is assigned to the top of the cored interval, and 1.5-m sections—as many as needed to accommodate the length of core recovered—are numbered sequentially (starting with Section 1 at the top). Sections are cut starting at the top of the recovered material; hence, the bottom section is usually shorter than 1.5 m when the recovered sediment is not evenly divisible into 1.5-m long sections. When recovery is partial, the original position of recovered material in the cored interval is unknown, so we employ this convention for consistency and for convenience in data handling. If recovery is partial and core fragments are separated, and if shipboard scientists believe the fragments of sediments were not continuous, the intervening spaces are noted as "void." Whether it is continuous or not, the core-catcher sample is described in the visual core descriptions beneath the lowest section recovered, and depth below seafloor is assigned on this basis. Core labeling is graphically depicted in Figure 1.

Samples are designated by the interval (cm) from the top of the core section from which the sample was extracted. A full sample designation would consist of the following information:

Leg-site-hole-core-section, interval (in cm from top of section); thus 79-544A-4-3, 122–124 cm designates a sample taken at 122 to 124 cm from the top of Section 3 of Core 4, from the second hole drilled at Site 544 during Leg 79. The depth below the seafloor for this sample would then be the depth to the top of the cored interval plus 3 m for Sections 1 and 2, plus 122 cm (depth below the top of Section 3). For example, if the top of the cored interval were 100 m, this would equal 104.2 m. (Note that sample requests refer to a specific interval within a core/section rather than level below seafloor.) A sample from the core catcher of this core is designated 544A-4,CC.

Hydraulic Piston Corer

As in the case of the drilled cores, Hydraulic Piston Corer (HPC) recovery is also measured from the top of the cored section to the bottom of the cored section; however, since the maximum length of the HPC section is 4.4 m, there is a maximum length of three sections per core instead of seven.

CORE HANDLING

The paleontologists make initial assessment of core material from samples taken from the core catcher as soon as the core is brought aboard. The core is cut into 1.5-m sections, sealed, labeled, and moved into the core laboratory for processing. On Leg 79, "vacutainer" samples for gas analysis were withdrawn and standard gamma-ray attenuation porosity evaluation (GRAPE) analyses for bulk density were made on the unsplit core sections.

The cores are then split longitudinally inito the "working" and "archive" halves. The archive half is described; color, texture, structure, and composition of the various lithologic units are noted on the standard visual core description forms. The archive half is then photographed and stored. Samples and measurements are taken from the working half. Samples include those for grain size, carbon–carbonate, physical properties, and paleontological determinations.

After sediment cores are sampled and described, they are maintained in cold storage aboard *Glomar Challenger* until they can be transferred to the shore repositories. Leg 79 cores are kept at the East Coast Repository (Lamont-Doherty Geological Observatory, Palisades, New York).

GRAPHIC CORE DESCRIPTION

The core descriptions, smear slide descriptions, and carbonate bomb (% $CaCO_3$ data—all obtained aboard ship), serve as the bases for the graphic core descriptions presented at the end of each site chapter.

Sediment Disturbance

The coring technique, which uses a 25-cm diameter bit with a 6-cm diameter core opening, may result in extreme disturbance, particularly of the soft sediments.

The following disturbance categories are recognized for soft and firm sediments:

a. *Slightly deformed*: Bedding contacts are slightly bent.

b. *Moderately deformed*: Bedding contacts have undergone extreme bowing.

c. *Highly deformed*: Bedding is completely disturbed, sometimes showing symmetrical diapirlike structure.

d. *Soupy*: Intervals are water-saturated and have lost all aspects of original bedding.

The following categories recognize the degree of fracturing in hard sediments and igneous rocks:

a. *Slightly fractured*: Core pieces in place, very little drilling slurry or breccia.

b. *Moderately fragmented*: Core pieces in place or partly displaced, but original orientation is preserved or recognizable. Drilling slurry may surround fragments.

c. *Highly fragmented*: Pieces from interval cored and probably in correct stratigraphic sequence (although may not represent entire section), but original orientation totally lost.

d. *Drilling breccia*: Core pieces have completely lost original orientation and stratigraphic position. May be completely mixed with drilling slurry.

These categories are coded on the core description sheet (see 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, and thus the description of sedimentary structures for Leg 79 cores was optional. However, because the graphic lithology column is mainly a compositional diagram, we tried to include as much graphic representation as possible in the sedimentary structures column, in order to give shape, size, and distribution of sedimentary and diagenetic structures (e.g., distribution of pebbles or cobbles in conglomerates). The key to the set of structural symbols used on Leg 79 is in Figure 3.

Color

Colors of the geologic material were determined with a Geological Society of America Rock-Color Chart. Colors were determined immediately after the cores were split and while they were still wet.

Graphic Lithology Column

The lithological classification scheme presented here is represented graphically on the core description sheets (Fig. 2) using the symbols illustrated in Figure 4.

Transitional biogenic lithologies are represented by a grouping of two symbols separated by a broken vertical line. The symbols in this grouping may correspond to the end-member constituents, such as clay and nannofossil ooze. Normally the symbol for the dominant constituent is placed on the right-hand side of the column, and the symbol for the subordinate constituent will be on the left-hand side of the column. The percentage of one component to another may be graphically represented

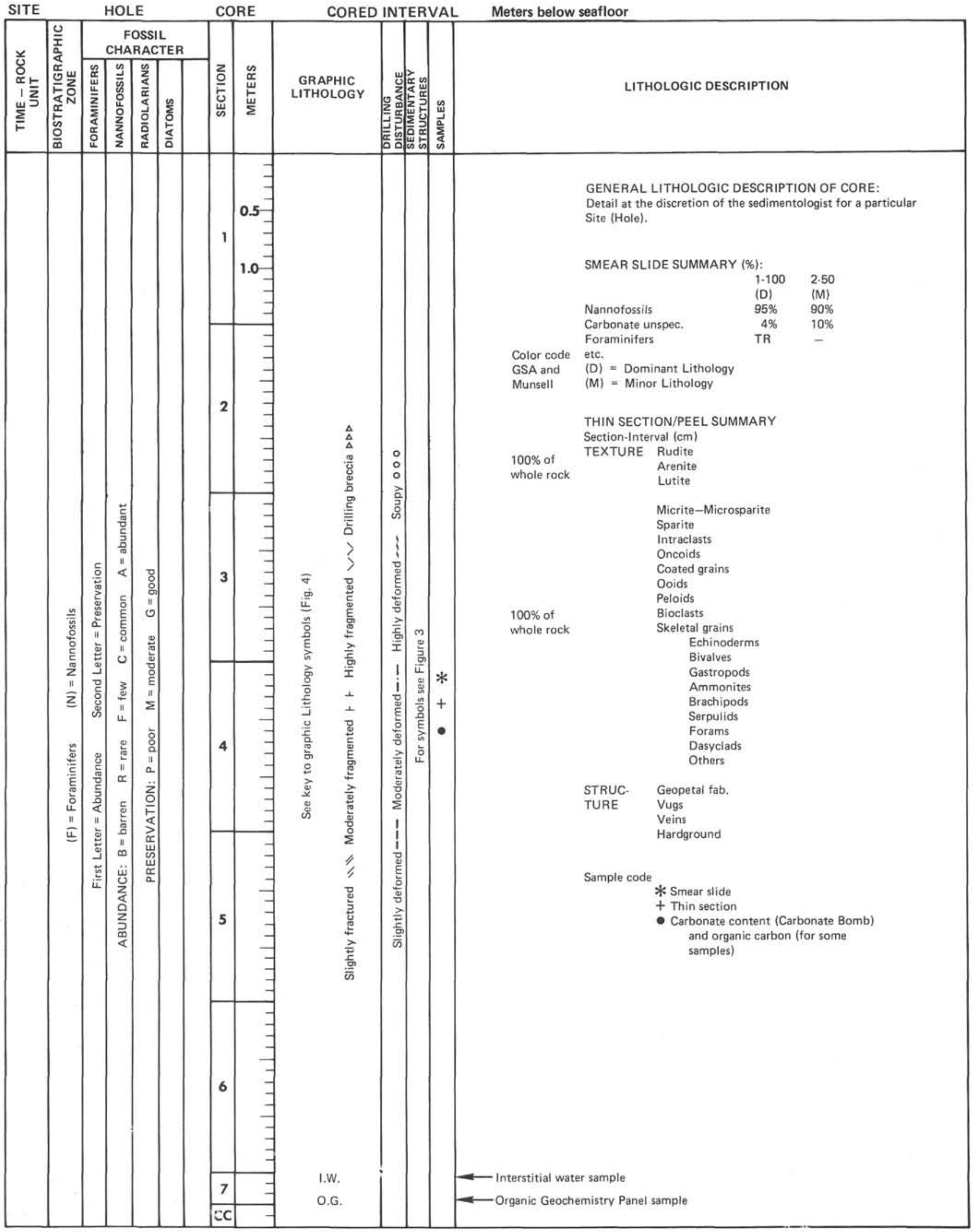

Figure 2. Typical core description sheet, with sediment deformation symbols, sample codes, and other general information.

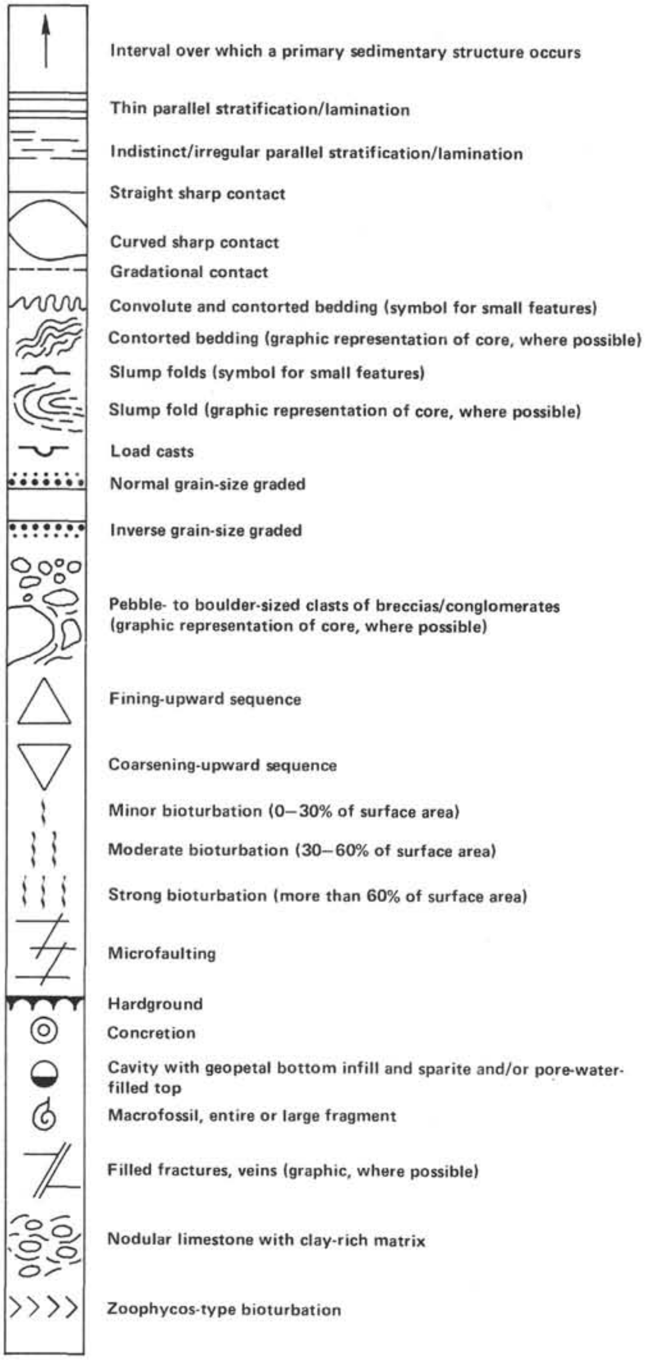

Figure 3. Key to sedimentary structure symbols.

by the relative proportion of the symbols. (For example, the left 30% of the column may have a clay symbol, the right 70% a nannofossil ooze symbol: thus the sample was ~70% nannofossils and 30% clay.)

A grouping of two or more symbols separated by a vertical, unbroken line represents interlayering on too fine a scale for each layer to be individually represented.

We have made the following modifications and additions to the recommended usage of the JOIDES Panel on Sedimentary Petrology and Physical Properties (SPPP).

1. Muddy sand is represented by symbol T7, which is not used for silty sand/sandy silt as in the JOIDES Panel's graphic scheme.

2. "Other limestones" (see Special Rock Types, later) are represented by the symbol SR8, with the following overprints: m = micrite, w = wackestone, p = packstone, g = grainstone, b = boundstone, d = dolomitized/dolomitic.

3. Gravel, conglomerate, and breccia symbols contain the qualifiers Ca if carbonate and Te if terrigenous.

4. In the absence of acid igneous rocks on Leg 79, the symbol SR5 is retained for granitic gneiss.

TEXT OF CORE DESCRIPTION

The text of the core description sheets includes the lithologic name assignment, and other information such as color, structures, and textures.

Lithologic Classification

For continuity, the sediment classification scheme used on Leg 79 essentially followed that devised by the JOIDES SPPP Panel and adopted for use by the JOIDES Planning Committee in March 1974. For compositional classification, we divided the component frequencies into four major groups: $<10\%$; 10–30%; 30–60%; $>60\%$. To be consistent, these boundaries were used for both calcareous and siliceous sediments, and a common style of terminology was developed. A few other minor departures from the SPPP Panel's classification are pointed out in the appropriate sections below.

Descriptive Data

Sediment and rock names were defined solely on the basis of composition and texture. Composition is most important for description of those deposits more characteristic of open marine conditions, with texture becoming more important for the classification of hemipelagic and near-shore facies. These data were primarily determined aboard the ship by (1) visual estimates in smear slides and thin sections with the aid of a microscope, (2) visual observation using a hand lens, and (3) unaided visual observation. Calcium carbonate content was estimated in smear slides or by using the Carbonate Bomb technique (Müller and Gastner, 1971). Other geologic features determined were color, sedimentary structures, and firmness.

Firmness

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

1. Biogenic calcareous sediments with greater than 50% $CaCO_3$ have 3 classes of firmness:
   a. *Soft*: Sediments which have little strength and are readily deformed under the finger or broad blade of the spatula are termed *ooze*.
   b. *Firm*: Partly lithified ooze or friable limestone is called *chalk*. Chalks are readily deformed under the fingernail or the edge of a spatula blade. More lithified chalks are termed *limestones* (see below.)

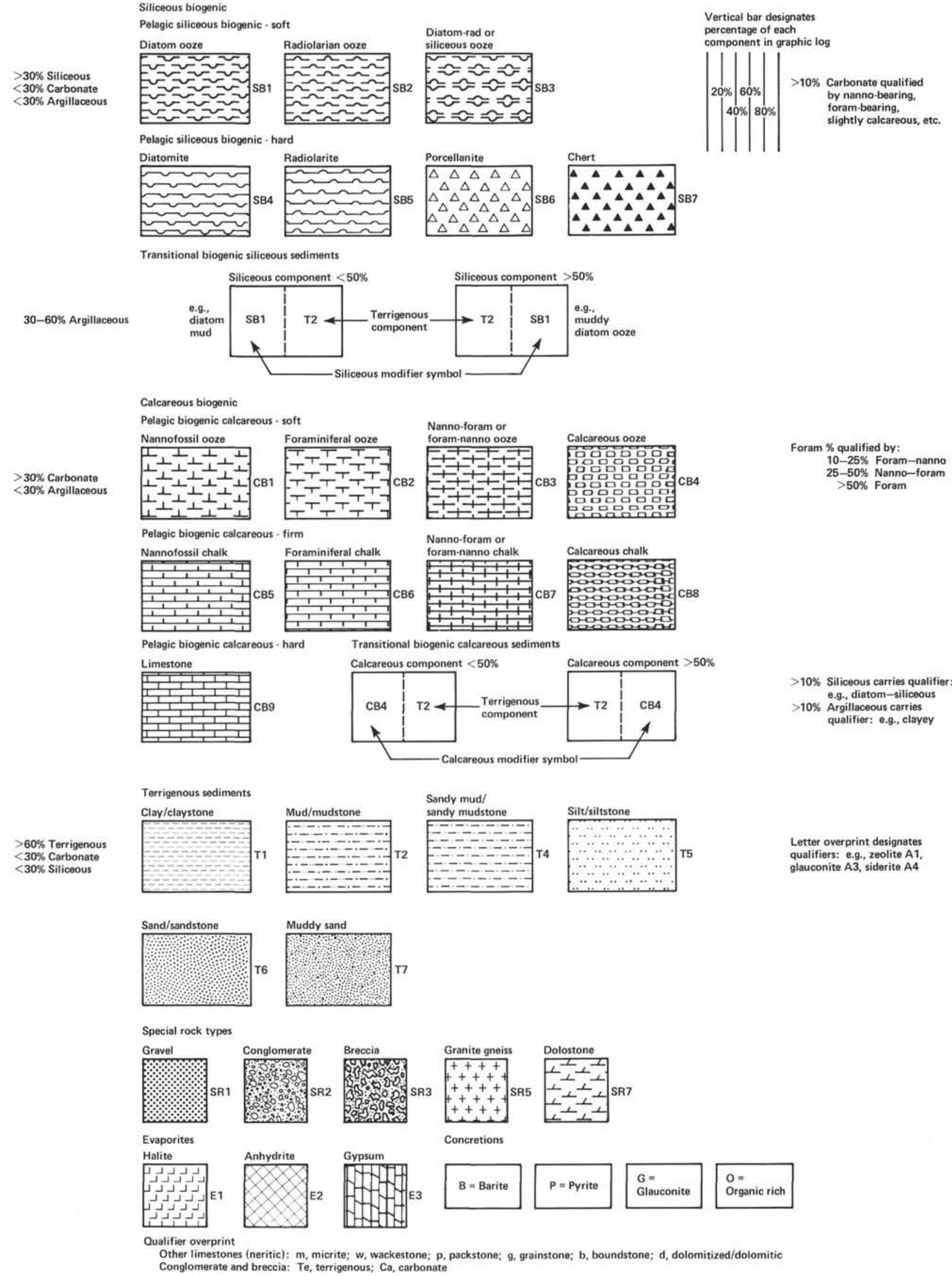

Figure 4. Graphic symbols corresponding to the lithologic classification.

c. *Hard*: *Limestone* is restricted to nonfriable cemented rock.
2. Only two classes of firmness are used for transitional carbonates with less than 50% $CaCO_3$, biogenic siliceous sediment, pelagic clay, and terrigenous sediments:
   a. *Soft*: Sediment core may be split with a wire cutter. Sediment terms used for soft sediment are:
      i. Soft biogenic siliceous sediment (with greater than 30% siliceous fossils): *ooze* (e.g., radiolarian ooze, diatom ooze, or siliceous ooze).
      ii. Soft terrigenous sediment, pelagic clay, and transitional calcareous biogenic sediments: *sand, silt, clay*, or *mud*.
   b. *Hard*: The core is hard (i.e., consolidated or well indurated) if it must be cut with a band saw or diamond saw. Sediment terms used are:
      i. Hard siliceous biogenic sediment (greater than 30% siliceous): radiolarite, diatomite, chert, or porcellanite.
      ii. Hard terrigenous sediment, transitional calcareous biogenic sediment, and pelagic clay: the suffix - *stone* is added to the soft-sediment name (e.g., sandstone, siltstone, claystone, mudstone [shale, if fissile].

Basic Sediment Types

Pelagic Clay

Pelagic clay is principally authigenic pelagic deposits that accumulate at very slow rates. Since all clay-rich sediments cored during Leg 79 show an evident terrigenous origin, this category was not used.

Pelagic Siliceous Biogenic Sediment

Pelagic siliceous biogenic sediment is distinguished by a siliceous microfossil content exceeding 30% and calcium carbonate content of less than 30%. There are two classes: (1) *pelagic biogenic siliceous sediments* (containing less than 30% argillaceous material), and (2) *transitional biogenic siliceous sediments* (containing between 30 and 60% argillaceous material).

1. For *pelagic biogenic siliceous sediments* with ~30 to 100% siliceous fossils, the following terminology is used:
   a. *Soft*: Siliceous ooze (radiolarian ooze, diatom ooze, etc., depending on the dominant fossil component).
   b. *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." (Lancelot, cited in Lancelot, Winterer, et al., 1980, p. 17). *Chert* 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 vitreous luster" (Lancelot, cited in Lancelot, Winterer, et al., 1980, p. 17).
   c. *Compositional qualifiers*: Diatoms and radiolarians may be the principal components; thus one or two qualifiers may be used, for example:
   Indeterminate siliceous fossils: Siliceous ooze, chert, or porcellanite
   Radiolaria 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 most dominant component is listed last and the minor component is listed first.
2. For *transitional biogenic siliceous sediments* (30–60% argillaceous material) terminology is as follows:

Siliceous component <50%:	Diatom-rich mud—soft Diatom-rich mudstone—hard
Siliceous component >50%:	Very muddy diatom ooze—soft Very muddy diatomite—hard

Other terms may be substituted for *diatom-rich* and *diatomite*, for example, *radiolarian-rich* or *radiolarite, very siliceous*, or *chert* if the fossil type is indeterminable. A calcareous content of between 10 and 30% in siliceous biogenic sediments carries a qualifier such as "calcareous," "nannofossil."

Pelagic Biogenic Calcareous Sediments

Pelagic biogenic calcareous sediments are distinguished by a biogenic $CaCO_3$ content in excess of 30%. There are two classes: (1) *pelagic biogenic calcareous sediments* which contain less than 30% argillaceous material, and (2) *transitional biogenic calcareous sediments* which contain 30 to 60% argillaceous material.

1. For *pelagic biogenic calcareous sediments* 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, for example:
   Foraminifer % (of the combined foraminifer-nannofossil fraction)

<10%	Nannofossil ooze, chalk, limestone
10–25%	Foraminiferal nannofossil ooze
25–50%	Nannofossil foraminiferal ooze
>50%	Foraminiferal ooze

If the carbonate fossils are indeterminable, then *calcareous ooze, chalk*, or *limestone* may be used, with no qualifiers. Calcareous sediment containing a siliceous component >10% carries the qualifier *diatomaceous, siliceous*, and so on.

2. For *transitional biogenic calcareous sediments* (30–60% argillaceous material) we have abandoned the terms *marly* or *marly calcareous* for the more informative *clayey, muddy,* or *silty*. Our terminology is as follows:

Calcareous component <50%	Very calcareous mud—soft
	Very calcareous mudstone—hard
Calcareous component >50%	Very muddy calcareous ooze—soft
	Very muddy calcareous chalk—hard

Other terms may be substituted for *calcareous*, for example, *nannofossil foraminiferal*, etc. Terms such as *nannofossil-rich* and *foraminifer-rich* may also be substituted for *very calcareous*.

The terminology of nonpelagic limestones encountered during Leg 79 is discussed later under special Rock Types.

Terrigenous Sediment

Terrigenous sediments are subdivided into textural groups on the basis of the relative proportions of their grain-size constituents, i.e., clay, silt, and sand size. Rocks coarser than sand size are treated as special rock types. The size limits of these constituents are defined by Wentworth (1922) (Fig. 5).

The six major textural groups recognized on the accompanying diagram (Fig. 6) are defined, in accordance with the SPPP Panel's classification (and not by the popularly accepted classification of Folk, 1954), by the abundance of clay (>90%, 90–10%, <10%) and the ratio of sand to silt (greater or less than 1:1). The terms clay, mud, sandy mud, silt, and sand are used for soft sediment. The hard or unconsolidated equivalents for the same textural groups are claystone, mudstone, sandy mudstone, siltstone, and sandstone.

	Millimeters		Phi (ϕ) units	Wentworth size class
	2.00	2	1.0	Granule
Sand	1.68		0.75	Very coarse sand
	1.41		0.5	
	1.19		0.25	
	1.00	1	0.0	
	0.84		0.25	Coarse sand
	0.71		0.5	
	0.59		0.75	
	0.50	1/2	1.0	
	0.42		1.25	Medium sand
	0.35		1.5	
	0.30		1.75	
	0.25	1/4	2.0	
	0.210		2.25	Fine sand
	0.177		2.5	
	0.149		2.75	
	0.125	1/8	3.0	
	0.105		3.25	Very fine sand
	0.088		3.5	
	0.074		3.75	
	0.0625	1/16	4.0	
Silt	0.053		4.25	Coarse silt
	0.044		4.5	
	0.037		4.75	
	0.031	1/32	5.0	
	0.0155	1/64	6.0	Medium silt
	0.0078	1/128	7.0	Fine silt
	0.0039	1/256	8.0	Very fine silt
Mud	0.0020		9.0	Clay
	0.00098		10.0	
	0.00049		11.0	
	0.00024		12.0	
	0.00012		13.0	
	0.00006		14.0	

Figure 5. Terminology and class intervals for sediment grade scales.

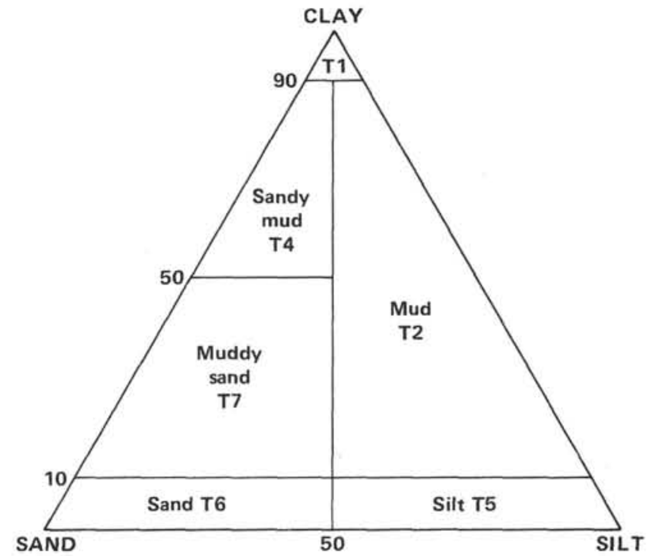

Figure 6. Textural groups for terrigenous sediments.

Terrigenous sediment containing a calcareous *or* siliceous component >10% carries qualifiers such as *calcareous* or *nannofossil, siliceous*, or *diatom*. Cemented terrigenous lithologies may also carry such qualifiers as *calcite-cemented* or *dolomite-cemented*. If considered sufficiently important, miscellaneous minor constituents (<10%) may be included in the petrographic name by the use of such adjectives as *glauconite-bearing, mica-bearing, pyrite-bearing*, or *gypsum-bearing*.

Sands and sandstones may be subdivided further into very fine (0.0625–0.125 mm), fine- (0.125–0.25 mm), medium- (0.25–0.50 mm), coarse- (0.50–1.00 mm), or very coarse grained (1.0–2.0 mm) according to their estimated median grain size.

Terrigenous clast designations (e.g., arkose, quartz arenite) follow Folk (1968).

Special Rock Types

In this category fall:

1. *Evaporites* such as halite, anhydrite, and gypsum rocks.
2. *Neritic limestones*, or limestones other than pelagic limestones, which are described using Dunham's (1962) classification with one modification, in that we prefer in places the terms *micrite* and *microsparite* (whichever is appropriate) for Dunham's *lime mudstone* (Fig. 7).

   We recognize the following particle categories:

   a. *Bioclast*: or more specifically *bivalve, echinoid, brachiopod*, etc.
   b. *Ooid*: <2 mm diameter
   c. *Pisoid*, most probably algal pisoids or *oncoids*; concentrically laminated grains superficially similar to ooids but generally >2 mm in diameter.

<table>
<tr><th colspan="5">Depositional texture</th></tr>
<tr><td colspan="4">Original components not bound together during deposition</td><td rowspan="4">Original components were bound together during deposition, as shown by intergrown skeletal matter, lamination contrary to gravity, or sediment-floored cavities that are roofed over by organic or questionably organic matter and are too large to be interstices.</td></tr>
<tr><td colspan="3">Contains mud (particles of clay and fine silt size)</td><td rowspan="3">Lacks mud and is grain supported</td></tr>
<tr><td colspan="2">Mud supported</td><td rowspan="2">Grain supported</td></tr>
<tr><td><10% grains</td><td>>10% grains</td></tr>
<tr><td>MICRITE, MICROSPARITE, or MUDSTONE</td><td>WACKESTONE</td><td>PACKSTONE</td><td>GRAINSTONE</td><td>BOUNDSTONE</td></tr>
</table>

Figure 7. Textural classification of nonpelagic limestones, modified after Dunham (1962).

d. *Peloid*: spheroidal or ellipsoidal particle of structureless cryptocrystalline carbonate, <2 mm in diameter.

e. *Coated grain*: carbonate or terrigenous particle coated, sometimes only partly, by mostly structureless cryptocrystalline carbonate.

f. *Intraclast*: sand-sized or larger particle of carbonate sediment apparently reworked from material accumulating within the depositional basin, which is understood here in its broadest sense. Intraclast includes pieces of structureless cryptocrystalline carbonate >2 mm in diameter, whether angular or rounded, but only irregularly shaped particles <2 mm in diameter (well-rounded particles are termed *peloids*).

This particle classification is descriptive and no specific genetic implication is intended; for example, some coated grains may be reworked fragments of coherent sediment, but are *not* included in the descriptive category *intraclast*.

The particle categories are used as qualifiers in Dunham's terminology; where more than one is used, the most abundant component is listed farthest to the right—for example, bioclast ooid grainstone. The size scale for particles uses the terms of Grabau (1913) but retains the finer divisions of Wentworth (1922) except in the calcirudite range (see Fig. 8, which also presents Folk's [1968] size scale for authigenic constituents, e.g., cements). Many of the Leg 79 limestones are clearly biomodal in their grain-size distribution; they are typically coarse, sand-sized particles set in a silt-sized flocculent peloidal fabric. In applying Dunham's terminology in these cases, we believe that a more meaningful statement on depositional texture can be made by considering the peloidal fabric as "matrix." If the limestone contains over 10% replacement dolomite, then the qualifier *dolomitized* may be used. If the dolomite is of uncertain origin, then *dolomitic* is appropriate.

The qualifiers *sandy, silty, clayey*, or *muddy* are used where the terrigenous content exceeds 10%.

3. *Dolostone* contains over 50% dolomite minerals. We recognize two types: (a) *dolostone*, containing greater than 90% dolomite, and (b) *calcareous dolostone*, containing between 10 and 50% $CaCO_3$.

The crystal size of these rocks is a very important characteristic and may be shown by the terms illustrated in Figure 8. If ghost ooids, bioclasts, intraclasts, peloids, or the like are present, that fact can be indicated by a qualifier: medium crystalline oolitic dolostone.

As with limestones, the qualifiers *sandy, silty, clayey*, or *muddy* are used where the terrigenous content exceeds 10%.

mm	Transported constituents	Authigenic constituents	mm
	Very coarse calcirudite	Extremely coarsely crystalline	
64			
	Coarse calcirudite		
16			
	Medium calcirudite		
4			4
	Fine calcirudite	Very coarsely crystalline	
2			
	Very coarse calcarenite		
1			1
	Coarse calcarenite	Coarsely crystalline	
0.5			
	Medium calcarenite		
0.25			0.25
	Fine calcarenite	Medium crystalline	
0.125			
	Very fine calcarenite		
0.062			0.062
	Coarse calcilutite	Finely crystalline	
0.031			
	Medium calcilutite		
0.016			0.016
	Fine calcilutite	Very finely crystalline	
0.008			
	Very fine calcilutite		
0.004			0.004
		Aphanocrystalline	
0.002			
0.001			0.001

Figure 8. Grain-size scale for carbonate rocks.

4. *Gravels, conglomerate* and *breccia: gravels* are unconsolidated rocks containing over 30% of clasts exceeding 2 mm in diameter. Their textural classification follows Folk (1954) and is illustrated by Figure 9. The grade scale follows Wentworth (1922):

Size (mm)	Class
>256	Boulder
64–256	Cobble
4–64	Pebble
2–4	Granule

Two varieties of consolidated gravels are distinguished by the degree of rounding of the gravel-sized clasts (or *phenoclasts*): *conglomerate* is formed by the consolidation of rounded gravel, whereas *breccia* is formed by the consolidation of angular gravel.

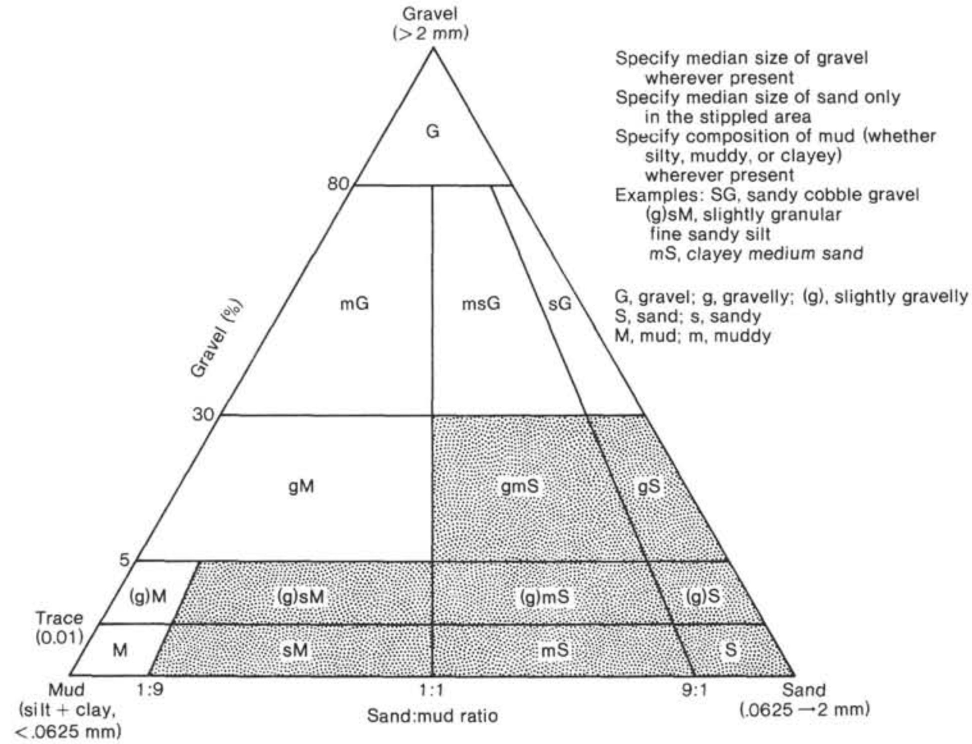

Figure 9. Textural groups for gravels.

Composition may be considered in terms of the number of rock types represented by the phenoclasts, e.g., monomictic, oligomictic, or polymictic.

5. *Concretion* will refer to a nodular or irregular concentration of various authigenic minerals, such as pyrite or glauconite.

ORGANIC GEOCHEMISTRY

Safety and Pollution Prevention Program

The safety and pollution prevention program for Leg 79 principally followed those programs successfully applied during previous legs. Great care was taken during site selection before and during Leg 79 to avoid drilling into closed structures potentially containing hydrocarbon accumulations.

Visual inspection of each core as soon as it arrived on deck was a first measure to rate the free gas content of the sediments according to a list of standard criteria (e.g., Lancelot, Winterer, et al., 1980). In addition, routine procedures aboard the ship allowed constant monitoring of any significant hydrocarbon quantities in the sediments recovered. These included inspection of rocks for hydrocarbon-staining under ultraviolet light (Halliburton UV Ray Box), two gas chromatographs for gaseous hydrocarbon analysis (Carle GC Model 800 and Hewlett-Packard 5710A) and a Rock-Eval pyrolysis instrument.

All instruments were calibrated and ready for use throughout the Leg. Since, however, there were never any drilling hazards from hydrocarbons during Leg 79 and no free hydrocarbon gases were found in any of the sediment cores recovered, we refer to previous publications for calibration and operation procedures of those instruments which are normally used for the safety and pollution-prevention program (e.g., Lancelot, Winterer, et al., 1980). Other methods routinely applied during Leg 79 are described in the Organic Geochemistry section, later. This includes the new technique of carrier gas stripping gas chromatography, first applied aboard ship during Leg 79, which allows quantitative determination of light hydrocarbons in the sediments and thus may also be of great help for the safety and pollution prevention program on future legs.

Organic Geochemistry

A flowchart of the sediment sampling routine and the analytical procedures for organic geochemistry applied during Leg 79 is shown in Figure 10. The methods include carbon and nitrogen determination, pyrolysis, and carrier gas stripping gas chromatography for light hydrocarbons.

Sampling for the Organic Geochemistry Panel was performed at a rate of 30 cm of entire core for every 30 m of sedimentary section cored, but with flexibility to obtain geologically representative and well-presented samples. No acetone was used to seal the Organic Geochemistry samples, which were frozen immediately. Two 10-cm^3 samples, from just above and below the 30 cm interval, were taken for shipboard analysis. They were analyzed together with the other samples for shipboard organic geochemistry studies, which were selected to be representative for the sedimentological units at any site.

Carbon and nitrogen analysis was performed using a Hewlett-Packard 185 + B CHN analyzer. Sediment samples were dried at 110°C for 24 hr. (splits taken for Rock-Eval pyrolysis and Carbonate Bomb), allowed to

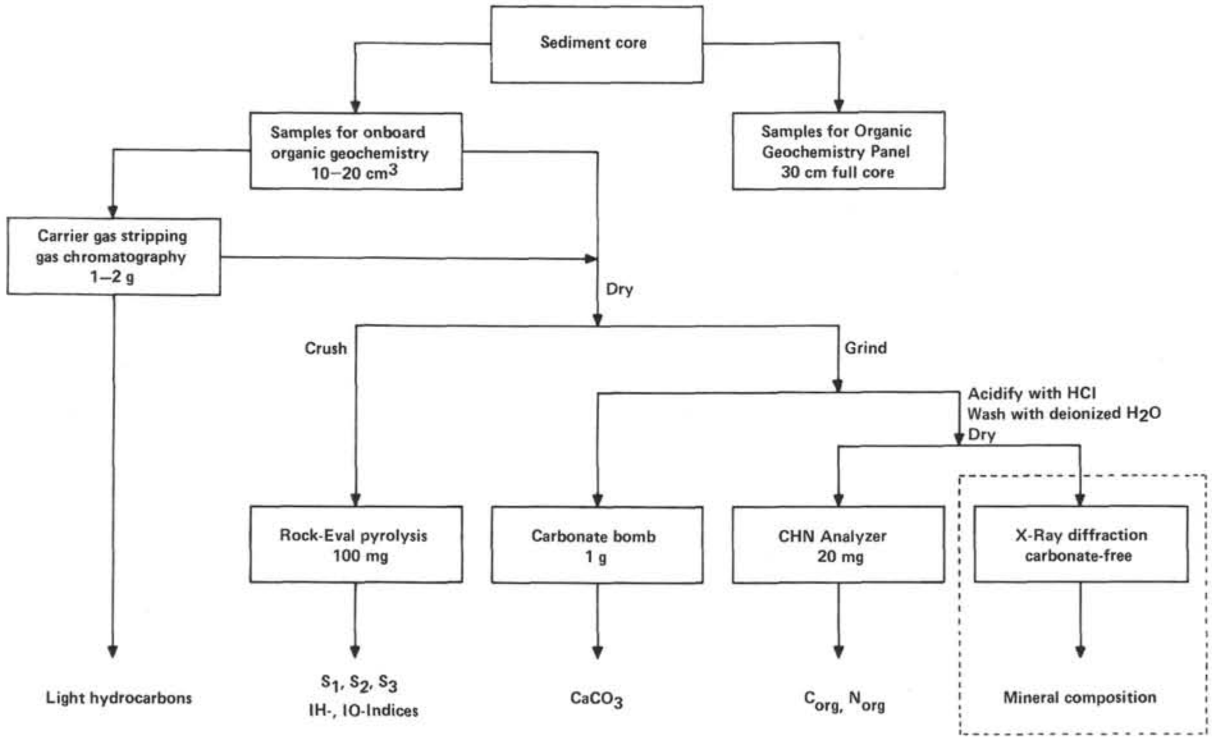

Figure 10. Scheme of sediment sampling routine and shipboard analytical procedures for organic geochemistry during Leg 79.

react with HCl to remove the carbonate, washed with deionized water and dried again at 110°C. A Cahn electrobalance was used to weigh 20 mg samples of sediment for CHN analysis. Samples were combusted at 1050°C in the presence of an oxidizing catalyst (MnO_2), and the volumes of N_2, CO_2, and H_2O representative of the C, H, and N contents of the sedimentary organic matter determined with a CSI minilab integrator. Samples of known carbon content (AUB-2, 66-488, and 467-58) were used to calibrate the instrument response. The calibration curves for both C and N were obtained by approximation with a linear function. An attempt was also made to fit the data with a power function. By standard deviation, the linear fit was better than that of the power function, but for the low values of C_{org} which were common in many sediments during Leg 79, the power function curve gives much better resolution.

The total carbonate content was determined by Carbonate Bomb analysis and expressed as the percentage of calcium carbonate. The instrument was calibrated for every series of analyses with weighed quantities of 0.1, 0.3, 0.5, 0.7, and 1.0 g $CaCO_3$ treated with 5 ml concentrated HCl. Good linear fits were obtained in each case. Analyses were done on 1 g of dry, finely ground sediment treated with 5 ml of concentrated HCl in the bomb. The accuracy of this analysis is less than 5% absolute $CaCO_3$ content in the sediments.

Two statistical procedures were applied to the carbonate, C_{org}, and N_{org} data, grouped by lithostratigraphic units. First, we calculated the mean variance and standard deviation for each sample set. Since the sets were small, we used unbiased estimates of the standard deviation. The results were clear, so no statistical hypotheses were tested. Second, we calculated the Spearman's rank of the linear correlation coefficient as a measure of similarity between two major geochemical attributes of the sediments: noncarbonate material and C_{org}. Other correlations mentioned in the text are also estimated by the same measures (see site chapters, this volume).

Rock-Eval pyrolysis was performed on selected sediment samples (see Espitalié et al., 1977, and earlier shipboard reports, for example, Legs 48, 50, and 61). Samples of 100 mg were heated in a stream of helium from 250°C to 550°C at a temperature program rate of 25°C/min. The gas stream carrying the pyrolysis products was split, with one portion going to the flame ionization detector for measuring the hydrocarbon-type compounds. The other portion of the carrier gas stream went to a molecular sieve trap for retaining pyrolytic CO_2 released from organic matter (up to 390°C only). At the end of the temperature program, the CO_2 trap was heated up and the CO_2 was measured by a thermal conductivity detector. The detector responses were calibrated with the IFP standard rock No. 27251 (S_2 = 8.2 mg/g; S_3 = 0.85 mg/g; T_{max} = 427°C; C_{org} = 2.48%; IH = 331 mg HC/g C_{org}; IO = 34 mg CO_2/g C_{org}) and an IFP standard diluted with pure SiO_2 for sediments containing low amounts of C_{org}. If was found that calibration differed in alternating runs. This was attributed to the possibility that the two CO_2 traps (switched alternatingly) were not packed identically, which affected the split ratio. Instead of changing the traps on this delicate instrument, two calibrations for alternating runs were used. Peak areas were calculated by triangulation.

The Hewlett-Packard 5710A gas chromatography system was modified in order to be able not only to measure gas concentrations in gas pockets, but also to determine absolute concentrations of hydrocarbons in the sediment pore water and to relate these to organic carbon contents. A device was attached which allows carrier gas stripping of hydrocarbons from sediment samples according to the method of Schaefer et al. (1978). For the extraction procedure, a metal tube containing freshly crushed wet sediment (about 1-2 g) and granular anhydrous $CaCl_2$ to trap the water (the $CaCl_2$ was kept in a drying oven at 300°C in sample tube prior to use) were placed between the carrier gas supply and the cold trap, parallel to the conventional line (Figure 11). The sample was stripped by passing a measured volume of helium through the sample (e.g., 10 min. at 20 ml/min.). After this, the carrier gas flow was switched to the conventional line, bypassing the sample tube, and the analysis was performed in the way described below. With the system on board and the present background level (no vacutainer contamination), hydrocarbon concentrations in the order of 0.1 nl/g sediment could be detected. After the gas chromatographic analysis, the sediment sample was dried, weighed, and the organic carbon content was determined.

The gas chromatographic procedure involves trapping of the hydrocarbons in an alumina-packed precolumn, chilled to -70°C, which is placed in the carrier gas line before the column. Ethane and the higher hydrocarbons are retained while air and methane pass through the cold trap. After 1.5 min., the cold trap is closed and heated in a ~90°C water bath for 1 min. The carrier gas effluent from the cold trap is then directed to the column in the gas chromatograph (1/8 in. x 12 ft., packed with 20% OV 101 on Anakrom AS; carrier gas helium, 70 psi, 20 ml/min.). The column oven temperature is programmed from 60 to 200°C at a rate of 8°C/min. The FID detector is connected to a CSI Supergrator and an attenuation between 4 and 16 is selected according to the suspected hydrocarbon concentrations. Retention times for compound identification and response factors for quantitative analysis were obtained by measuring known amounts of pure compounds from Scotts reference gas mixtures (Nos. 1, 2, 7 for *n*-alkanes, isoalkanes, and cycloalkanes, respectively). Figure 12 shows the separation efficiency of the column and the most likely elution order of the reference hydrocarbons, assuming that the more branched compounds are eluted first, that is, 2,2 dimethylbutane (2,2-dime-4) before 2- and 3-methylpentane (*i*- and *ai*-5), which obviously could not be separated and methylcyclopentane (*me-c*-5) before cyclohexane (*c*-6).

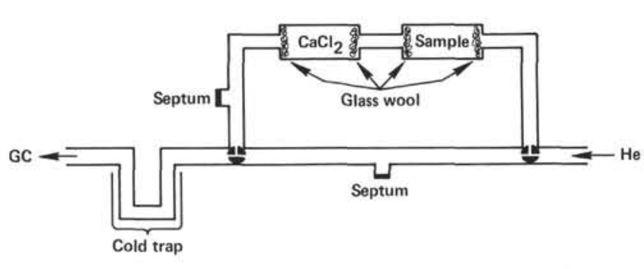

Figure 11. Schematic outline of the modification to the Hewlett-Packard gas chromatography system for carrier gas stripping of light hydrocarbons (after Schaefer et al., 1978).

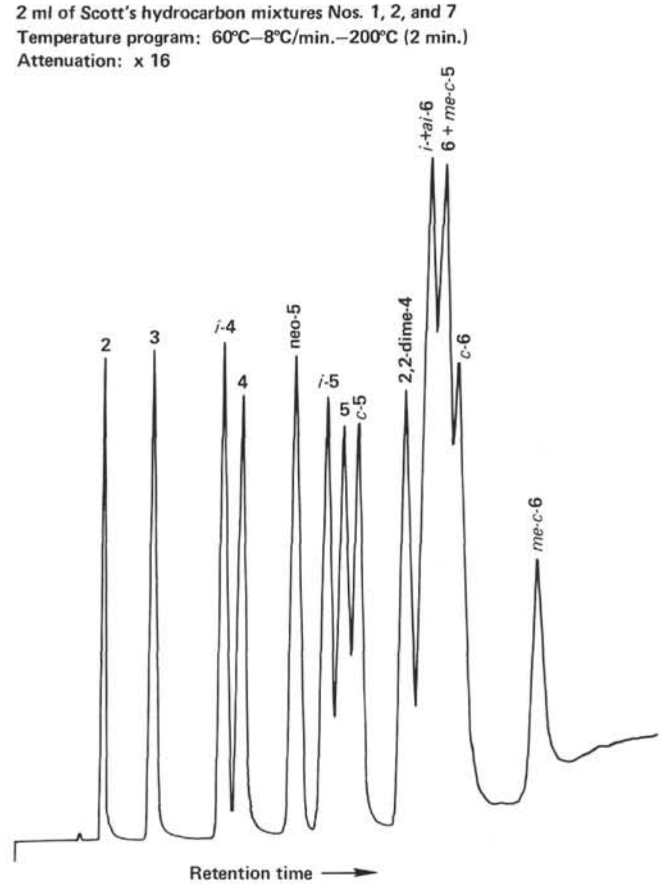

Figure 12. Gas chromatogram showing the separation efficiency of the column in the Hewlett-Packard gas chromatograph and the most likely elution order of reference hydrocarbons in standard mixtures available aboard ship during Leg 79.

Problems had occurred during carrier gas stripping gas chromatography of light hydrocarbons in DSDP sediments which were analyzed in shore-based laboratories, because of the presence of large amounts of acetone, introduced into the sediment when the core sections were capped on deck (Schaefer et al., in press). Thus, great care was taken that samples for light hydrocarbon analysis were taken *before* the sections were capped. This applied to samples taken for shipboard as well as shore-based studies. In view of the value and the sensitivity of the light hydrocarbon stripping method, modifying the capping procedure so that less contamination occurs should be considered.

PHYSICAL PROPERTIES

The physical properties that were routinely measured during Leg 79 include compressional-wave velocity, wet-bulk density, porosity, water content, and shear strength.

Sonic velocity was measured at atmospheric pressure and room temperature with a Hamilton Frame velocimeter. Measurements were made normal to the core axis through the split core liner on soft sediments. The appropriate corrections were applied for liner thickness and traveltime through the liner. On sufficiently firm sediments, small cubes (15–20 cm^3) were hand-trimmed from the split core and velocity measurements were made both perpendicular and parallel to the core axis. These measurements are reported as horizontal and vertical velocities, respectively.

Wet-bulk density, water content, and porosity were determined gravimetrically using the immersion method. Whenever possible, these measurements were made on the sample on which velocity was measured. In addition, wet-bulk density was estimated using the Gamma Ray Attenuation Porosity Evaluator (GRAPE) in the static mode (2-min. GRAPE count). In order to estimate porosity from 2-min. GRAPE data, reasonable values for grain density and pore fluid density must be assumed. Unless otherwise noted, a grain density of 2.70 g/cm^3 and fluid density of 1.025 g/cm^3 were assumed.

Shear strength measurements were made on soft sediments in split core liners with the hand-held Soiltest CL-600 Torvane. During all measurements, the axis of rotation of the vanes was perpendicular to the core axis.

Acoustic impedance, the product of velocity and density, was calculated from the gravimetric density values only. Vertical velocity was used in the calculation whenever available.

A complete description of the Hamilton Frame velocimeter, as well as the velocity, gravimetric density, and GRAPE density techniques can be found in Boyce (1976).

PALEOMAGNETISM

Procedures

The nannofossil oozes at Site 544 were sampled by pressing perspex (10 cm^3) cubic sample holders into the working half of the core sections. One of the three orthogonal sides of the cubes was maintained parallel to the axis of the core, and an arrow was placed on the outer surface of the cube, pointing upcore, providing the sample orientation. The sampling interval was controlled by the occurrence of drilling disturbance; where drilling disturbance was low, samples were collected about every 50 cm.

The measurements were made on the samples as soon as possible after the cores were split and sampled, to minimize the growth of viscous (VRM) and chemical (CRM) magnetization components. Alternating field partial demagnetization was undertaken aboard ship, but no thermal demagnetization was undertaken because of the problem presented by mineralogical changes during dessication and removal of samples from their perspex holders.

The Mesozoic limestones from Site 544 and 547 were sampled by marking an arrow upcore, parallel to the core axis. A cylindrical sample was then drilled perpendicular to the arrowed surface. Natural remanent magnetization (NRM) measurements were made aboard ship. Thermal demagnetization and rock magnetic analyses were made subsequently on shore.

BIOSTRATIGRAPHY

The various planktonic zonal schemes applied to Sites 544–547 are as follows:

Neogene (Fig. 13): Bolli (1966) and Stainforth et al. (1975) for planktonic foraminifers; Martini and Worsley (1970), Martini (1971), Müller (1974), Bukry (1973, 1975), and Okada and Bukry (1980) for calcareous nannofossils. The Neogene time scale and correlation of zonal schemes is after Berggren and Van Couvering (1974) and Vincent (1975).

Paleogene (Fig. 14): Bolli (1966) and Stainforth et al. (1975) for planktonic foraminifers; Martini (1970, 1971), Müller (1974), Bukry (1973, 1975), and Okada and Bukry (1980) for calcareous nannofossils. The Paleogene time scale and correlation of zonal schemes is after Hardonbol and Berggren (1978).

Cretaceous (Fig. 15): van Hinte (1976a) for planktonic foraminifers; tentatively correlated with cosmopolitan and tropical nannofossil biohorizons of Thierstein (1976).

Jurassic (Fig. 16): The Jurassic time scale is after van Hinte (1976b).

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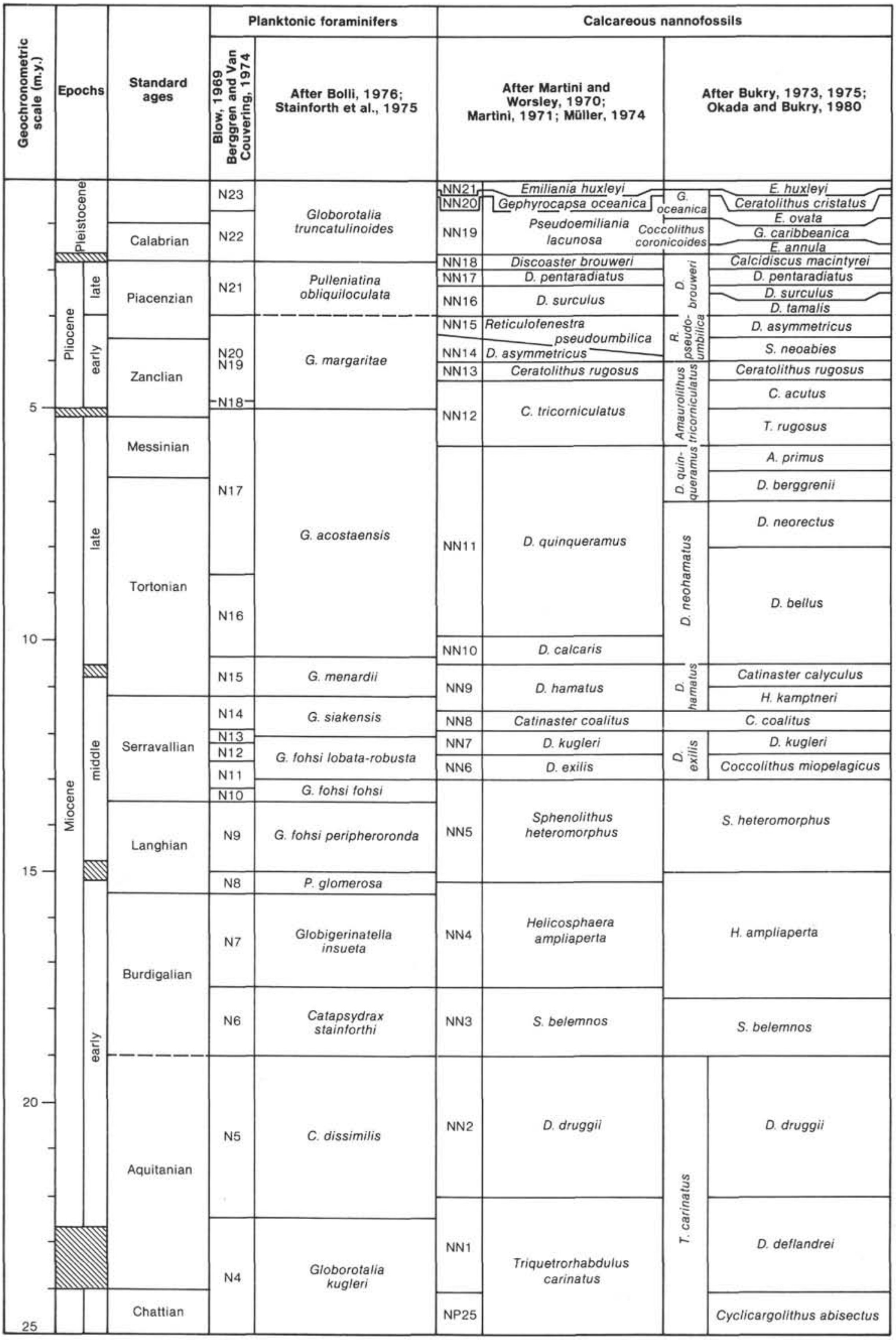

Figure 13. Neogene time scale and correlation of planktonic foraminiferal and calcareous nannofossil zonal schemes (after Berggren and Van Couvering, 1974; Vincent, 1975).

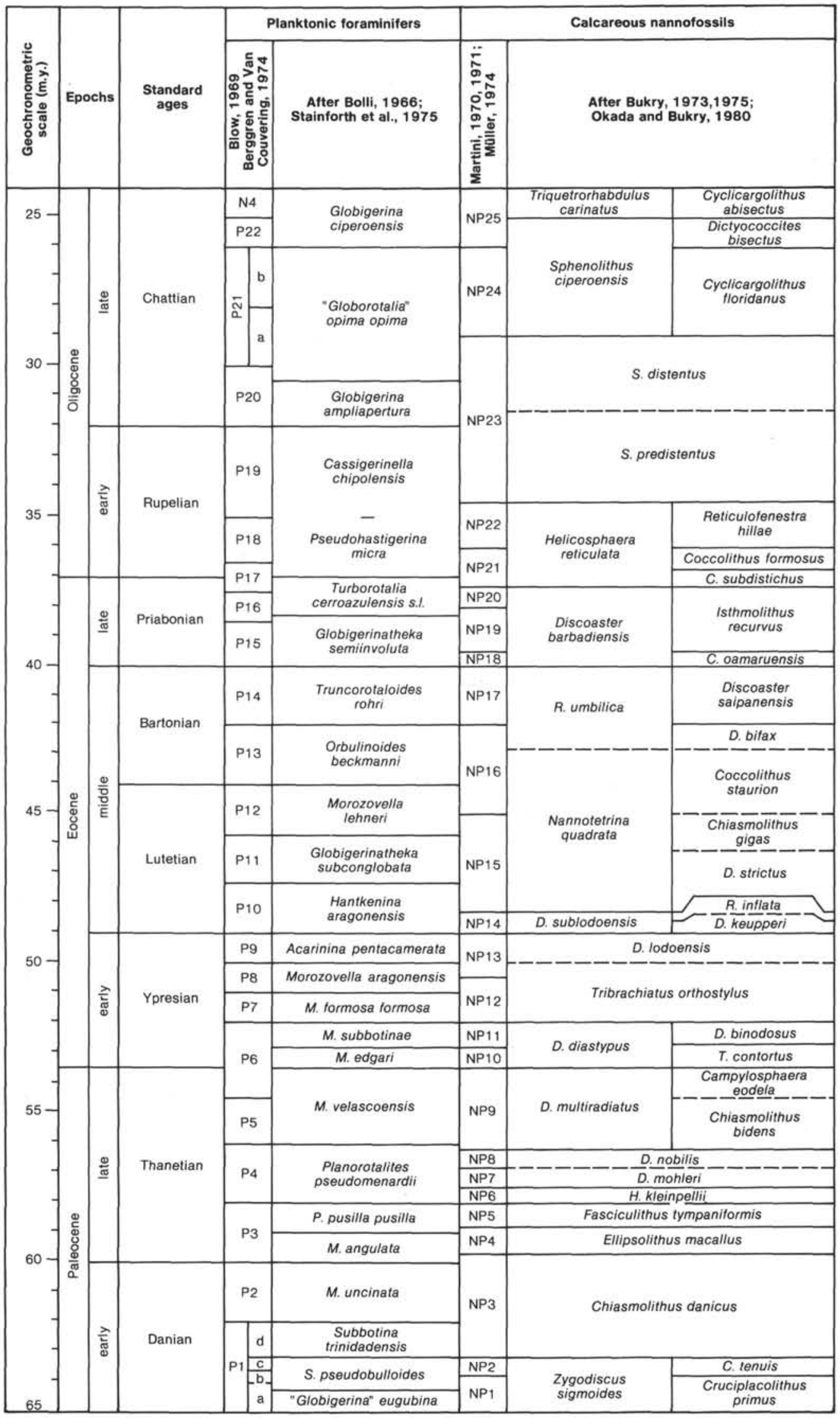

Figure 14. Paleogene time scale and correlation of planktonic foraminiferal and calcareous nannofossil zonal schemes (after Hardenbol and Berggren, 1978).

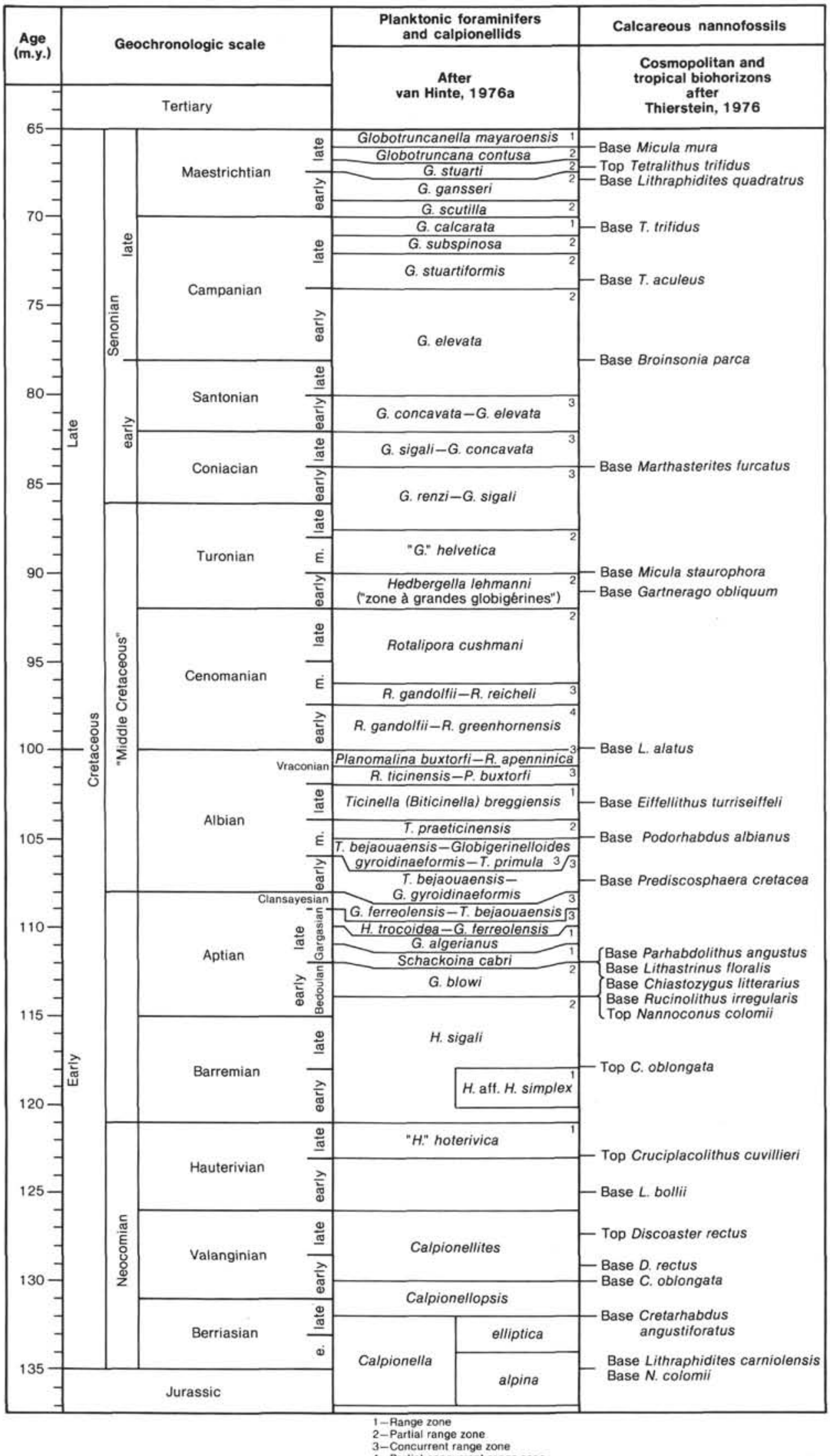

Figure 15. Tentative correlation between Cretaceous planktonic foraminiferal zonation (van Hinte, 1976a) and nannofossil biohorizons of Thierstein (1976).

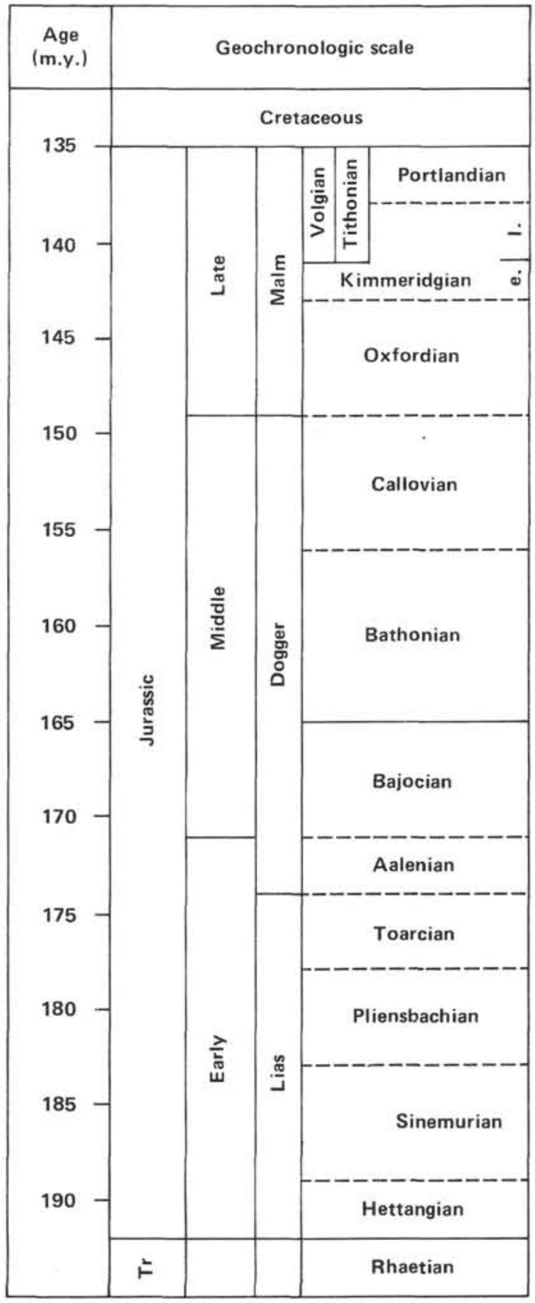

Figure 16. Jurassic time scale (after van Hinte, 1976b).