2. EXPLANATORY NOTES

RESPONSIBILITIES FOR AUTHORSHIP

This Initial Report volume is divided into three parts. The first part consists of the various site summaries which, although largely founded upon the work accomplished aboard *Glomar Challenger* during Leg 30, incorporate additional information produced by shore studies following completion of the shipboard work. The second part consists of more detailed discussions of various aspects of the rocks recovered from several or all of the sites occupied during the cruise. The final part of the volume is a summary of the results of Leg 30, putting these results into the broader context of the results of drilling elsewhere in the Indian Ocean.

The authorship of the site summary chapters (Chapters 3-7) is shared collectively by the shipboard scientific party, the ultimate responsibility lying with the two co-chief scientists. Each chapter of Part II follows the same general outline. Sections on background and operations were prepared by J.E. Andrews and G.H. Packham; sections on lithology were prepared by D.A. Jones, G. van der Lingen, G. deV. Klein, J.V. Eade, D. Stoeser, and L. Kroenke; sections on physical properties by L. Kroenke; sections on the correlation of seismic results with drilling results by L. Kroenke and J. Andrews; sections on paleontology by T. Saito, B.K. Holdsworth and S. Shafik; sections on sedimentation rates by G.H. Packham; and the discussion sections were prepared by J.E. Andrews and G.H. Packham in consultation with the other members of the shipboard group. In some chapters specific additional authorship is cited by name. In these cases the contributions of the individually cited colleagues were substantial and warrant more than a simple acknowledgment.

Authorship of the chapters in Parts III and IV (Chapters 8-26) is cited by chapter. In general, these chapters are more speculative than those of Part II and should be considered interpretations based on information available at the time this Initial Report was submitted for publication. Nevertheless, each chapter from Parts III and IV has been subjected to rigorous review by one or more of our colleagues. In many cases the contributions of the reviewers have been substantial and are recognized appropriately in the chapters.

SURVEY DATA

Site selection and survey data for Leg 30 came from a number of sources. Leg 21 had previously visited the region and provided a series of specific questions for examination. In addition to the stratigraphic data, Leg 21 provided geophysical data and Site 285 was initially selected on a *Glomar Challenger* profile. Other geophysical data were provided by the R/V *Kana Keoki* (Sites 286, 287, 288, and 289), and University of Hawaii

cruises of the R/V *Machaias, Taranui,* and *Mahi* (Sites 288 and 289).

BATHYMETRIC CHARTS

Bathymetric charts for the South Fiji Basin, the Coral Sea Basin, and the Ontong-Java Plateau are presented in this volume. Data for these charts were provided by the Office of the Australian Hydrographer, the New Zealand Oceanographic Institute, the Organization pour Recherche Scientifique et Technique Outre Mere (ORSTOM) New Caledonia, the Hawaii Institute of Geophysics, Scripps Institution of Oceanography, Lamont-Doherty Geological Observatory, and the Deep Sea Drilling Project. The chart of the South Fiji Basin was prepared by G.H. Packham and A. Terrill; the chart of the Coral Sea Basin was prepared by C. Landmesser (Landmesser, 1974); and the charts of the Ontong-Java Plateau were prepared by L. Kroenke (Kroenke, 1972).

Except for the detailed information on the Ontong-Java Plateau (Sites 288 and 289) (Kroenke, 1972), all sites were selected on the basis of single seismic profiles. At Site 287 a more extensive survey was run by *Glomar Challenger*. Details of site approach and final locations of sites are presented in the background and operations sections of the Site Reports.

Between stations geophysical data were obtained including seismic profiles, echo sounding, and magnetic profiling. Position control throughout was by satellite navigation.

BASIS FOR NUMBERING SITES, HOLES, CORES, AND SECTIONS

A site number refers to a single hole or group of holes drilled in essentially the same position using the same acoustic beacon. The first hole at a site (for example, Site 285) was given the number of the site (for example Hole 285). Second holes drilled by withdrawing from the first hole and redrilling were labeled "A" holes (Hole 285A). Any additional holes drilled under comparable conditions are given succeeding letters, e.g., B, C, etc.

A core was usually taken by dropping a core barrel down the drill string and coring for 9.5 meters as measured by lowering of the drill string before recovery. The sediment was retained in a plastic liner 9.28 meters long inside the core barrel and in a 0.20-meter-long corecatcher assembly below the liner. The liner was not normally full.

On recovery, the liner was cut into sections of 1.5 meters measured from the lowest point of sediment within the liner (Figure 1).

In general, the top of the core did not coincide with the top of a section. The sections were labeled from 1 for the top (incomplete) section to a figure as high as 6 for the bottom (complete) section, depending on the total length of core recovered.
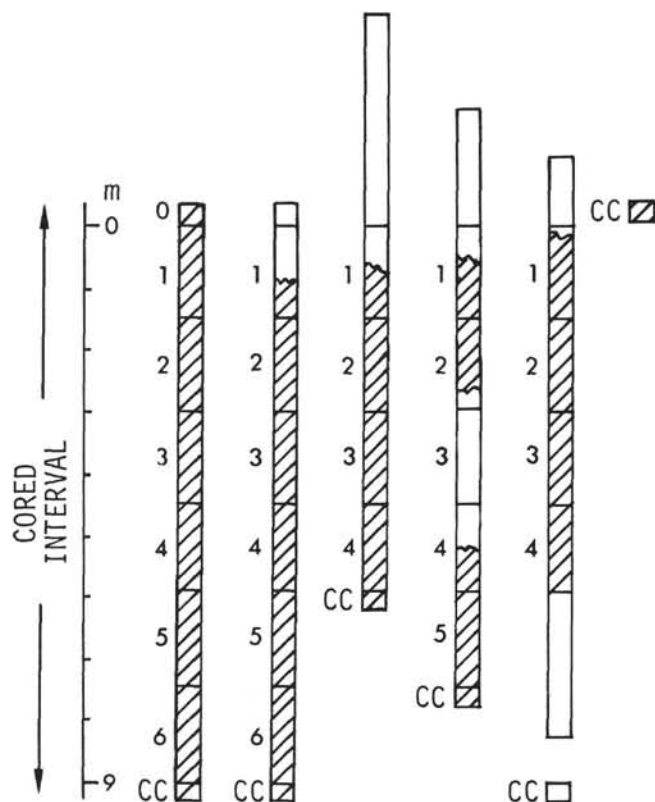
Figure 1. *Method of labeling sections of cores when recovery is complete, incomplete, and divided. The cores have been lined up so that the top of Section 1 is always coincident with the top of the cored interval, according to the method of calculating down-hole depth of samples. Core-catcher samples are always considered to have come from the bottom of the recovered material.*

In the event there were gaps in the core resulting in empty sections, these were still given numbers in sequence. In illustrations the core-catcher samples are always considered to come from the bottom of the recovered material, although in interpretation they are often assumed to represent the base of the cored interval.

On occasions, over 9 meters of core were recovered. The small remainder was labeled Section 0 (zero), being above Section 1. On other occasions the sum of the lengths of numbered sections exceeds the total length of core recovered and also the cored interval, resulting in an overlap of nominal depth down hole of the bottom of one core and the top of the core below. In such cases a special note has been made.

In some holes it was found desirable to drill with high water circulation but with a core barrel in place in order to penetrate faster. The drilled interval was often considerably greater than the 9.5 meters of the core barrel, the principle being that the high water circulation prevented sediments from being recovered. However, some of the harder layers were probably recovered during this procedure. It was difficult, therefore, to assign the correct depth in the hole to these sediments and each case had to be considered on its merits.

All samples taken from cores, before being processed, were numbered according to the system described in the Shipboard Handbook for Leg 30. The label "30-285-3-2, 25 cm" thus refers to Leg 30, Hole 285, Core 3, Section 2, sampled at 25 cm from the top of that section. The label "30-285-3, CC" refers to the core-catcher sample at the base of Core 3.

It is appreciated that with this labeling system, the top of the core material recovered may be located at say, 1.3 meters below the top of Section 1 and the bottom will be at 1.5 meters in, say, Section 2 (if the total recovery is 1.7 m). In relating this to down-hole depths, there is an arbitrariness of several meters. However, it is impossible to assess where exactly in the hole the sample came from. Sometimes the core barrel will jam up with a hard sediment after sampling a few meters; this will then really represent the first few meters penetrated. At other times the circulation of water may wash away the upper softer part of a core and recovery will represent the lower part. Separated lengths of core in core liner may come from the drill bit being lifted away from the bottom of the hole during coring in rough sea conditions. Similarly, there is no guarantee that the core-catcher sample represents the material at the base of the cored interval.

The labeling of samples is therefore rigorously tied to the position of the samples within a section as the position appears when the section is first cut open and is logged in the visual core description sheets. The section labeling system implies that the top of the core is within 1.5 meters of the top of the cored interval. Thus, the downhole depth of "30-285-3-2, 25 cm" is calculated as follows. The top of the cored interval of Core 3 is 35.5 meters. The top of Section 2 is 1.7 (Section 0 = 0.2 m, Section 1 = 1.5 m) meters below the top of the cored interval, that is, at 37.2 meters. The sample is 25 cm below the top of Section 2, that is, 37.45 meters.

For the purposes of presenting the data for the entire hole in the hole summary sheets, where 1 meter is represented by less than 1 mm, the top of the recovered sediment is always drawn at the top of the cored interval. The error involved in this presentation is always less than 1.5 meters compared with depths calculated from the sample label.

Finally, in referring to cores, sections, and samples in the text of this Initial Report, the leg designation is usually omitted. Also, the hole designation is frequently omitted when it is obvious from which hole the referenced sample was taken.

HANDLING OF CORES

The first assessment and age determination of the core material was rapidly made on samples from the core catcher. After a core section had been cut, sealed, and labeled, it was brought into the core laboratory for processing. The core section was first weighed for mean bulk density measurement. Then GRAPE (gamma ray attenuation porosity evaluation) analysis was made for detailed bulk density determination.

After the physical measurements were made, the core liner was cut on a jig using Exacto-type blades, and the end caps cut by knife. The core was then split into halves

with a cheese cutter, if the sediment was a soft ooze. At times, when compacted or partially lithified sediments were included, the core had to be split by a machine bandsaw or diamond wheel.

One of the split halves was designated a working half. Sonic velocity determinations using a Hamilton frame were made on pieces from this half. Samples, including those for grain size, X-ray mineralogy, interstitial water chemistry, and total carbonate content, were taken, labeled, and sealed. Larger samples were taken from suitable cores for organic geochemical analysis.

The working half was then sent to the Paleontology Laboratory. There, samples for shipboard and shore-based studies of nannoplankton, foraminifera, and radiolarians were taken. The other half of a split section was designated an archive half. The cut surface was smoothed with a spatula to bring out more clearly the sedimentary features. The color, texture, structure, and composition of the various lithologic units within a section were described on standard visual core description sheets (one per section) and any unusual features noted. A smear slide was made, usually at 75 cm if the core was uniform. Otherwise, two or more smear slides were made, each for a sediment of distinct lithology. The smear slides were examined microscopically. The archive half of the core section was then photographed. Both halves were sent to cold storage onboard after they had been processed.

Material obtained from core catchers—and not used up in the initial examination—was retained for subsequent work in freezer boxes. Sometimes significant pebbles from the core were extracted and stored separately in labeled containers. On other occasions, the liners would contain only sediment-laden water. This was usually collected in a bucket and allowed to settle, the residue being stored in freezer boxes.

At several sites, hard cores were obtained either of basement or indurated sediment. Each separate core fragment was numbered and labeled consecutively from the top downwards and its orientation indicated by an upward-pointing arrow. Where possible, the fragments were arranged into their original relative orientation, and a few were then sliced longitudinally for examination.

All samples are now deposited in cold storage at the DSDP West Coast Repository at the Scripps Institution of Oceanography, La Jolla, California. These samples may be obtained for further study.

BASIS FOR AGE DETERMINATION

In the site reports biostratigraphic information is given in three different places: in the Paleontology section, in the core summary sheets, and in the summarized stratigraphic sections (summary and conclusions). Specialized chapters on planktonic foraminifera, radiolarians, and nannofossils are included in Part II of this volume. The text of the paleontology section in the Site Reports is therefore generally restricted to information of a more general character, essential for the age determination and for the paleoecologic interpretation. The nannofossil zonal scheme used is given in Figure 2, minor deviations from this scheme are employed at some sites.

Regarding abundance and preservation of the fossil assemblages, the following abbreviations were used in the core summary sheets:

Abundance:
  A = abundant
  C = common
  F = few
  B = barren
Preservation:
  R = rare
  G = good
  M = medium
  P = poor

LITHOLOGIC NOMENCLATURE AND SYMBOLS

The sediment classification scheme used during Leg 30 is based on a series of premises, the most important ones being:

1) It has to be mainly descriptive.
2) The proper sediment name should be determinable with the aid of a petrographic microscope.
3) It should be possible to indicate all major and minor constituents of the sediment in the sediment name.
4) Quantitative class limits should be used.
5) As much as possible, adopted terms should be in common use.

As can be seen from these premises, the emphasis is on practicality.

Classification of Biogenic Sediments

Sediment names are obtained from percentage estimates in smear slides. Admittedly, such estimates vary greatly between individuals, but they are a big improvement over vague terms like "abundant," "common," and "rare." Difficulties are encountered when dealing with sediments containing constituents of greatly different size classes. A good example is a sediment consisting of a mixture of foraminifera and nannofossils. Almost certainly, the nannofossil percentage will tend to be estimated too high.

Percentage limits used in determining the sediment name are 2, 10, and 25. Major constituents present in quantities over 25% provide the sediment name. In order of decreasing abundance, the names of these major constituents are listed progressively further to the left. Minor constituents are those present in quantities under 25%. Their names are added to the sediment name with a suffix: rich, for constituents present in percentages between 10% and 25%; bearing, for those with percentages between 2% and 10%. They again are listed from right to left in order of decreasing abundance. Constituents present in amounts smaller than 2% may be added with the suffix trace.

Terrigenous and authigenic constituents can be present in biogenic sediments. As long as they do not constitute major components, their names are added in the same way as the biogenic components. For unconsolidated biogenic sediments, the term ooze is added as a suffix to the name. For indurated biogenic sediments, the common terms chalk and limestone are used.

Example: Given an unconsolidated sediment consisting of 35% foraminifera, 30% nannofossils, 20% clay,

		NANNOFOSSIL ZONES/SUBZONES	
HOLOCENE		*Emiliania huxleyi-Gephyrocapsa oceanica*	
PLEISTOCENE		*Gephyrocapsa caribbeanica*	
		Pseudoemiliania lacunosa	
PLIOCENE	Upper	*Discoaster brouweri*	
		"Discoaster" pentaradiatus	
		Discoaster tamalis	
	Lower	*Reticulofenestra pseudoumbilica*	
		Ceratolithus rugosus	
		Ceratolithus tricorniculatus	*Ceratolithus acutus*
			Triquetrorhabdulus rugosus
MIOCENE	Upper	*Discoaster quinqueramus*	
		Discoaster berggrenii	
		Discoaster neohamatus	
	Middle	*Discoaster hamatus*	*Catinaster calyculus*
			Helicopontosphaera kamptneri
		Catinaster coalitus	
		Discoaster exilis	
	Lower	*Sphenolithus heteromorphus*	Upper
			Lower
		Sphenolithus belemnos	
		Triquetrorhabdulus carinatus	*Discoaster druggii*
			Discoaster deflandrei
OLIGOCENE			*Cyclicargolithus abisectus*
		Sphenolithus ciperoensis	
		Sphenolithus distentus	
		Sphenolithus predistentus	
		Reticulofenestra hillae	
		Cyclococcolithina formosa	

Figure 2. *Nannofossil biostratigraphy of Site 289.*

		NANNOFOSSIL ZONES/SUBZONES	
EOCENE	Upper	*Discoaster barbadiensis*	Upper
			Lower
	Middle	*Discoaster saipanensis*	
		Cyclicargolithus reticulatus	
		Reticulofenestra umbilica	
		Chiasmolithus gigas	
		Nannotetrina fulgens	
	Lower	*Discoaster sublodoensis*	*Rhabdosphaera inflata*
			Discoasteroides kuepperi
		Discoaster lodoensis	
		Tribrachiatus orthostylus	
		Discoaster diastypus	
PALEOCENE		*Discoaster multiradiatus*	
		Discoaster nobilis	
		Discoaster mohleri	
		Heliolithus kleinpelli	
		Fasciculithus tympaniformis	
		Cyclococcolithina robusta	
		Cruciplacolithus tenuis	
MAESTRICHTIAN		*Micula mura*	
		Lithraphidites quadratus	
		Tetralithus trifidus	
CAMPANIAN		*Broinsonia parca*	
		Eiffellithus augustus	
SANTONIAN		*Gartnerago obliquum*	
CONIACIAN TURONIAN		*Marthasterites furcatus*	
		Micula decussata	
ALBIAN		*Eiffellithus turriseiffeli*	
APTIAN			

Figure 2. *(Continued).*

8% zeolites, and 7% volcanic glass shards. The name of this sediment would be "glass shard and zeolite-bearing clay-rich nannofossil foraminiferal ooze."

This example highlights a difficulty of which readers should be aware. The total percentage numbers have, of course, to add up to 100. In practice, minor and trace constituent estimates are rounded off to make the total for all constituents 100. Percentage figures like 8 and 7, do not, of course, indicate that estimates can be made within a 1% accuracy. An accuracy of 10% is already considered to be very good.

Abbreviations of names are occasionally employed, for convenience's sake. The most common are "foram" for foraminifera, "nanno" for nannoplankton or nannofossil, and "rad" for radiolarians.

Classification of Clastic Sediments

A classification of clastic sediments presents more problems and is likely to provoke more discussion than one for biogenic sediments. But again, practicability has been the underlying principle.

When detrital grains are the only constituents, the sediment is given a simple grain-size name. Detrital in this scheme means clastic grains derived from the erosion of pre-existing rocks, except for those of fossil or authigenic origin. Grain-size classes and percentages are again measured and estimated from smear slides. The Wentworth scale is used for the size-class boundaries, and Shepard's (1954) sand-silt-clay triangle is used to derive textural terms. Percentage limits in this triangle

are 20, 50, and 75. When gravel is present, a gravel term may be used as a prefix or suffix. Gravel is used as the only name, when the sediment consists of over 80% gravel. Gravel is used as a suffix for percentages between 30 and 80, while the prefixes gravelly and slightly gravelly are used for percentages between 5 and 30, and below 5, respectively.

When the clastic components are redeposited fossils or fossil fragments, they are also given a grain-size name, like the detrital sediments. However, this name is preceded by the appropriate fossil constituent names, in a fashion similar to that used for the biogenic sediment classification.

It can happen that a sediment consists of a mixture of equal amounts of detrital grains and clastic fossil grains, both of similar size. In that case, the same grain term would have to appear twice at the end of the name. This difficulty can be overcome by adding the prefix detrital. For example, a sediment consisting of equal amounts of reworked foraminiferal tests and detrital grains, both of silt size, would have to be called a "foraminiferal silt." In this case, the name becomes "foraminiferal detrital silt."

A sediment can also consist of a mixture of detrital grains and nonreworked (nonclastic) fossil tests. When the detrital grains are a major component, the size term is determined from the textural triangle. The fossil component will not receive a size term, but will be named as in the biogenic sediment classification. A hyphen is placed between the nonclastic and clastic terms.

Example: Given a sediment consisting of 40% non-reworked foraminifera, 20% detrital silt, and 40% clay. The recalculated detrital percentages are 33 and 67. The sediment name will be foraminifera-silty clay.

Classification of Sediments with Volcanic or Authigenic Constituents

For fragmental volcanic constituents, the common particle size classification: volcanic breccia (particles larger than 32 mm), volcanic lapilli (between 32 and 4 mm), and volcanic ash (smaller than 4 mm) has been adopted.

Authigenic constituents are treated in the same way as nonclastic biogenic constituents. An example (zeolite) is already given in the section on the biogenic sediment classification. However, when authigenic constituents are clearly reworked, they are treated in the same way as reworked fossil tests.

A special case is minerals composed of calcium carbonate. During Leg 30, in certain cores, abundant carbonate particles were observed which received the shipboard term micarb. They are generally too small to be determined under an ordinary microscope. Some may be authigenic, others may be fossil debris. It is only with the aid of a scanning electron microscope that such particles can be analyzed. Even then, an estimate of their relative abundance is extremely difficult. The term micarb has, therefore, been retained in the core descriptions for all carbonate particles of unknown origin.

Carbonate Solution Terminology

Because foraminifera and nannofossils exhibit different rates of solution with increasing depth in the marine environment, it was felt practical to define

decrease in carbonate content of sediments sampled on the basis of the loss of biogenic components. This is in preference to the terms compensation depth and lysocline which appear to have developed working definitions somewhat different from the original definitions of the terms. For sediment descriptions on Leg 30 the terms Foram Solution Depth and Nanno Solution Depth are used to describe sea-floor depths at which all forams and nannofossils, respectively, are removed from the sediments. Nannofossil Solution Depth is deeper than the Foram Solution Depth, and is the point at which all carbonate has been removed from the sediment.

Sedimentation Rates

In order to compare sedimentation rates through a cored sequence that is progressively more compacted downwards, the sediment thickness has been recalculated to correspond to original sediments with porosities the same as the present surface porosities at the site. The source of the porosity data is from shipboard determinations (see discussion of physical properties).

The method of initial thickness calculation is based on Schlanger et al. (1973) from which the following statement has been extracted. If no solids are added to the system and water is allowed to leave, then the volume changes during diagenesis can be calculated as if the system was simply compacting as follows:

$$\text{Let } H_{ooze} = \frac{(1 - \phi_{limestone})}{(1 - \phi_{ooze})} \cdot H_{limestone}$$

where

H_{ooze} = the original thickness of an ooze interval
$H_{limestone}$ = the thickness of a limestone derived from the ooze
ϕ_{ooze} = original porosity of ooze (e.g., 80%)
$\phi_{limestone}$ = porosity of limestone (e.g., 40%)

Substituting the appropriate values and setting $H_{limestone}$ equal to 1 cm.

$$H_{ooze} = \frac{(-0.40)}{(1 - 0.80)} \cdot 1 \text{ cm}$$

$$H_{ooze} = 3 \text{ cm}$$

Thus approximately 3 cc of foraminiferal-nannofossil ooze at a density of 1.35 and a porosity of 80% will reduce to 1 cc of nannofossil limestone at a density of approximately 2 and a porosity of 40% in going from Quaternary ooze to the Aptian limestone at Site 289.

The time scale used for the construction of the sediment accumulation curves is that compiled by Vincent (1974). At sites where the Miocene sequence is important, sedimentation rates have also been calculated using the time scale Saito has modified for that interval on the basis of foraminiferal zone thicknesses at Site 289. The modified scale is given in Figure 3 and the relationship to Vincent's scale is shown in Figure 4.
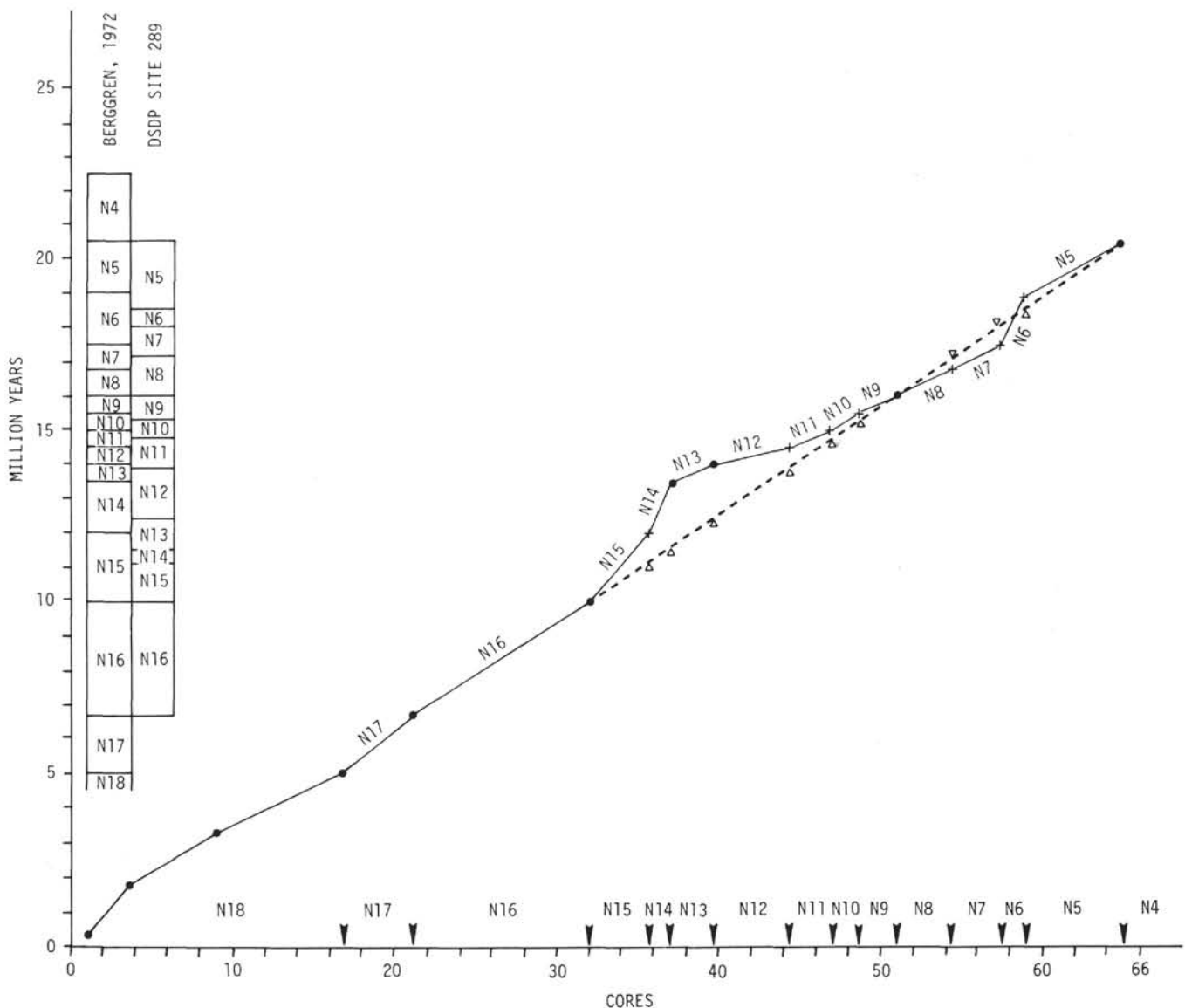
Figure 3. *Modified time scale for foraminiferal zone boundaries (Saito, unpublished data).*

Drilling Deformation

Four degrees of drilling deformation were recognized as follows: A scale of 0 to 5 was used: 0—indicates undeformed core; 1—slightly deformed cores exhibit a slight bending of bedding contacts; 2—moderate bending defines moderate deformation; 3—in the next stage of deformation the bedding exhibits strong deformation; 4—in highly deformed cores, injected bedding planes may approach the vertical; and 5—in extreme deformation all bedding has been destroyed. Occasionally, bedding may be completely disrupted to produce a "drilling breccia."

Down-hole Contamination

Down-hole contamination is a serious problem. Hard objects (manganese nodules, chert, lithic fragments, and pebbles) are often washed or dragged hundreds of meters down hole. They commonly are lodged in the top of cores or will become incorporated into the middle of cores at levels far below their proper stratigraphic position. Displaced manganese nodules can usually be

recognized. However, displaced chert, lithic fragments, and pebbles are more difficult to recognize. This information is recorded on the core forms.

Color Name and Munsell or GSA Number

The reader is advised that colors recorded in core barrel summaries were determined during shipboard examination immediately after splitting core sections. Experience with carbonate sediments shows that many of the colors will fade or disappear with time after opening and storage. Colors particularly susceptible to rapid fading are purple, light and medium tints of blue, light bluish-gray, dark greenish-black, light tints of green, and pale tints of orange. These colors change to white or yellowish-white or pale tan.

Symbols

The lithologic symbols used in the core and hole summaries of Leg 30 are reproduced in Figure 5.

Complex lithologies have been represented on the core summary forms using a vertical striping system. To
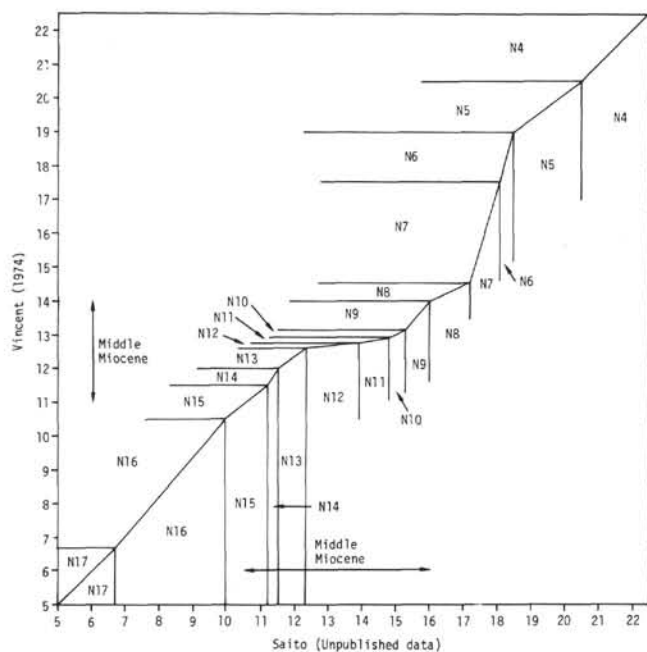
Figure 4. *Relationship between ages of Miocene foraminiferal zone boundaries according to Vincent (1974) and Saito (unpublished data).*

do this, the constituents are divided into the following percentage classes: 0-2, 2-10, 10-25, 25-50, 50-75, and 75-100. The lithologic column is subdivided into five sub-columns, their boundaries being the midpoints of the percentage classes (Figure 6). Percentages under 10% cannot be represented this way. For constituents between 2% and 10%, a letter or other symbol can be sparsely overprinted on the main symbols. Constituents under 2% are ignored in the lithology columns. They are, however, mentioned in the text, in the smear-slide compositions.

GRAIN-SIZE ANALYSES

Grain-size distribution was determined by standard sieving and pipette analysis. The sediment sample was dried, then dispersed in a Calgon solution. If the sediment failed to disaggregate in Calgon, it was dispersed in hydrogen peroxide. The sand-sized fraction was separated by a 62.5 μm sieve with the fines being processed by standard pipette analysis following Stokes settling velocity equation (Krumbein and Pettijohn, 1938, p. 95-96), which is discussed in detail in Volume 9 of the Initial Reports of the Deep Sea Drilling Project. Step-by-step procedures are in Volume 5. In general, the sand-, silt-, and clay-sized fractions are reproducible within ±2.5% (absolute) with multiple operators over a long period of time. A discussion of this precision is in Volume 9. Grain-size data for all holes of Leg 30 appear in a single chapter elsewhere in this volume.

CARBON AND CARBONATE ANALYSES

In addition to the routine measurements on Leg 30, CaCO₃ measurements were taken for analysis by the "carbonate-bomb method." The carbonate-bomb is merely a plexiglas, cylinder-shaped container with a screw-on pressure gauge top.

Method of Analysis: Weigh 1 g of CaCO₃ (99%), place inside the cylinder. Measure out 5 ml concentrated HCl (37%) and pour into a plastic vial. Insert the vial into the cylinder, screw on the pressure release valve. Mix the acid with CaCO₃, making sure the top is tightly in place as the pressure increases. Record the pressure. Repeat this same procedure with 0.1 g CaCO₃. This will give a curve of pressure versus weight CaCO₃ at that particular atmospheric pressure. It is important to run these standards with each batch of samples because changes in the ambient pressure cause changes in the curve. This established, begin analyzing the samples using the same method. The samples, prior to analysis, must be dried, ground to a fine powder, and weighed out in 1-g portions. The percent CaCO₃ of the samples is determined by comparing the sample pressure with the pressure-weight CaCO₃ relation determined by the curve. The sample pressure will correspond to a weight of CaCO₃ which is read directly as a percent CaCO₃ (i.e., a sample pressure corresponding to 0.5 g CaCO₃ is therefore 50% CaCO₃ because the sample has been weighed out to 1 g. The remaining portion of the sample after weighing out 1 g was split into two portions. One was put into a plastic vial and sent to Scripps for a more accurate measure of CaCO₃ to determine the accuracy of the shipboard method. The other portion was acidified with 10% HCl, washed, and dried. The insoluble residue was given back to the Leg 30 sedimentologists.

The shore-lab carbon-carbonate data were determined by a Leco induction furnace combined with a Leco seventy-second analyzer.

The sample was burned at 1600°C, and the liberated gas of carbon dioxide and oxygen was volumetrically measured in a solution of dilute sulfuric acid and methyl red. This gas was then passed through a potassium hydroxide solution, which preferentially absorbs carbon dioxide, and the volume of the gas was measured a second time. The volume of carbon dioxide gas is the difference between the two volumetric measurements. Corrections were made to standard temperature and pressure. Step-by-step procedures are in Volume 4 of the Initial Reports of the Deep Sea Drilling Project and a discussion of the method, calibration, and precision is in Volume 9.

Total carbon and organic carbon (carbon remaining after treatment with hydrochloric acid) are determined in terms of percent by weight, and the theoretical percentage of calcium carbonate is calculated from the following relationship:

Percent calcium carbonate (CaCO₃) =
(% total C-%C after acidification) × 8.33

However, carbonate sediments may also include magnesium, iron, or other carbonates; this may result in "calcium" carbonate values greater than the actual content of calcium carbonate. In our determinations, all carbonate is assumed to be calcium carbonate.
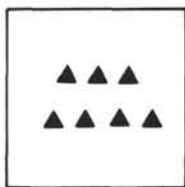
Precision of the determination is as follows:

Total carbon (within 1.2 to 12%)   = ±0.3% absolute
Total carbon (within 0 to 1.2%)   = ±0.06% absolute
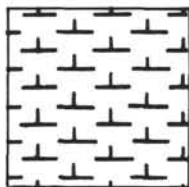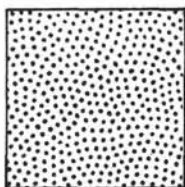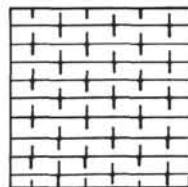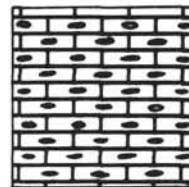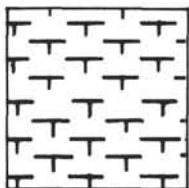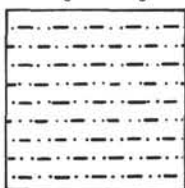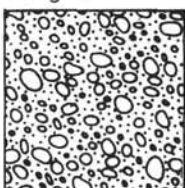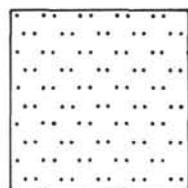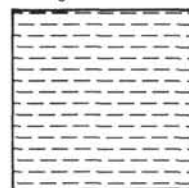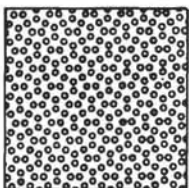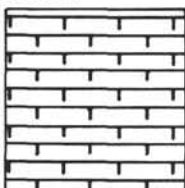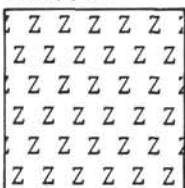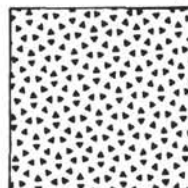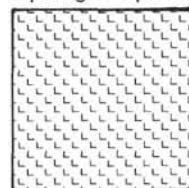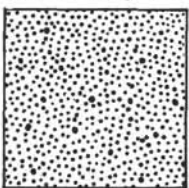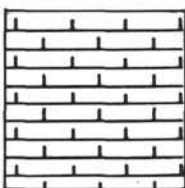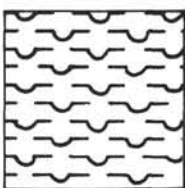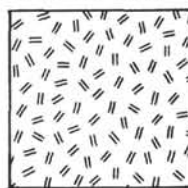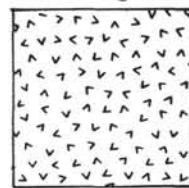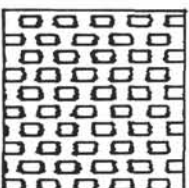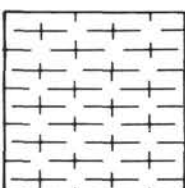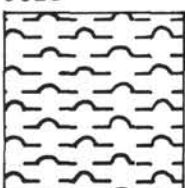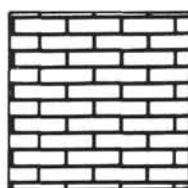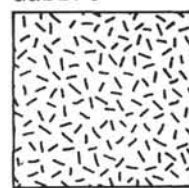
Figure 5. *Lithologic symbols.*
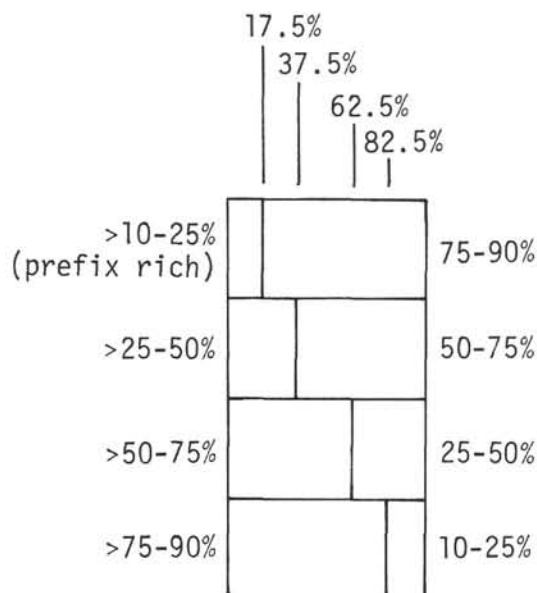
Figure 6. *Vertical bar width representation of class limits.*

Organic carbon	= ±0.06% absolute
Calcium carbonate (within 10-100%)	= ±3% absolute
(within 0-10%)	= ±1% absolute

Carbon and carbonate analyses for all holes of Leg 30 appear elsewhere in this volume.

X-RAY METHODS

Samples of sediment were examined using X-ray diffraction methods at the University of California at Riverside, under the supervision of I. Zemmels. The data are tabulated and discussed by Zemmels (this volume).

Treatment of the raw samples was: washing to remove seawater salts, grinding to less than 10 μm under butanol, and expansion of montmorillonite with trihexylamine acetate. The sediments were X-rayed as randomized powders. A more complete account of the methods used at Riverside can be found in Appendix III of Volume 4 of the Initial Reports.

Smear Slides

Smear slides are the basic means of mineral identification on shipboard. The shipboard party tried to be as specific as possible with regard to mineral identifications. Smear-slide descriptions are included as an appendix to each site chapter.

Smear-slide estimates of mineral abundances were based on area of the smear slide covered by each component. Specific mineral identification and quantification were attempted for sands, but for silts and clays, only the textural categories were quantified. Past experience

has shown that accuracy may approach a percent or so for very distinctive minor constituents but that, for major constituents, accuracy of ±10 to 20% is considered very good. Of more importance to the geologist than absolute accuracy are relative changes in component abundances.

A comment by shipboard sedimentologists is pertinent to this problem. The percentage of nannos was frequently overestimated in smear slides of foram nanno ooze, probably because of the smear slides that were too thin. A demonstration of this error, one recognized on earlier legs, is given by taking a 5-cc sample of ooze with a syringe (the needle tip is cut off), extruding it, screening out the greater than 63 μm fraction, and packing this coarse fraction back into the syringe. The volume of the coarse fraction is read from the graduated scale on the syringe. In many instances smear-slide and syringe estimates of foram percentages differed by as much as 70%.

MEASUREMENT OF GEOCHEMICAL AND PHYSICAL PROPERTIES

The physical properties measured on Leg 30 were bulk density, water content, porosity, sonic velocity, and thermal conductivity. Densities and porosities were determined from the total weight and volume of each core section, by the syringe technique involving weighing and oven drying 0.5-1.0 cc of sediment, and by the GRAPE method. The section weight method gives values that are of poor reliability being generally too low, because of incomplete filling of the liner and mixing and disturbance of the sediment. Even well-preserved cores have a thick layer slurry between the core and liner so the densities determined in this way are a lower limit. Densities by the syringe method have less bias, but the amount of material is so small that the results are of low accuracy (Bennett and Keller, 1973, have given a critical discussion of these methods).

Syringe samples and cube samples were both taken for water content, porosity, and density (specific gravity in the case of the cubes). Syringe samples refer to samples taken in soft sediments where a syringe could be inserted into the sediment. Cube samples refer to cubes cut (usually by band-saw) out of hard sediments. The syringe samples were analyzed in the usual manner. A measured volume of sediment was extruded into a preweighed aluminum boat, weighed, dried for 24 hr at 105°C, and reweighed. The weighings were made on a Cahn microelectrobalance. The cube method involves weighing the cubes on an Ohaus 311 centogram balance. First, the cubes are weighed in air, then weighed in water, then dried for 24 hr at 105°C, then reweighed dry. The weight in air (wet weight)-weight in water = mass of an equal volume of water (distilled) as the volume of sediment. This mass of water is taken as volume of sediment since the density of water = 1. Therefore, the measurement is actually specific gravity as opposed to density, but since specific gravity = density for all practical purposes, we record the measurement as density.

Equations for the two methods are as follows:

Syringe Method:

1) $\% \text{ Water content} = \dfrac{\text{wt. water}}{\text{wet wt.}} \times 100$

wt. water = wt. of wet sample + container − wt. dry sample + container
wet wt. = wt. of wet sample + container − wt. of container

2) $\% \text{ Porosity} = \dfrac{\text{wt. of water}}{\text{sample volume}} \times 100$

3) $\text{Wet-bulk density (g/cc)} = \dfrac{\text{wet wt.}}{\text{sample volume}}$

Cube Method:

1) $\% \text{ Water content} = \dfrac{\text{wt. water}}{\text{wet wt.}} \times 100$

wt. water = wt. of sample in air − wt. of dry sample
wet wt. = wt. of sample in air

2) $\% \text{ Porosity} = \dfrac{\text{wt. of water}}{\text{vol. sediment}} \times 100$

Vol. sediment (assuming density $H_2O = 1$ g/cc)
= wt. of sample in air - wt. of sample in water
= mass of vol. of water at 22°C equal to the vol. of sediment

3) Wet-bulk density (g/cc) (specific gravity) =

$$\frac{\text{wet wt.}}{\text{sample volume}}$$

The GRAPE technique utilizes the attenuation of gamma-ray intensity in a beam passing through a sediment sample. For the 0.30-0.36 Mev Barium-133 source, Compton electron scattering is the dominant attenuation process. The attenuation thus depends on the electron density in the material, which in turn is approximately proportional to the bulk density for common geological materials (e.g., calcite, quartz, dolomite, and some clays). Aluminum cylinders of different diameters are used for calibration.

A shore-based program is used to correct for variations in electron densities of different core materials, particularly for the seawater component. The method is described by Evans (1965), Harms and Choquette (1965), and, as used on *Glomar Challenger*, by Boyce (1973, 1974). Cores are passed continuously through the gamma beam on a carriage so that a nearly continuous profile of counts per unit time is obtained. The data are averaged over 3-cm-long core length intervals. Cores with significant gaps or voids give an irregular trace. The envelope of the maximum values gives the best estimate of in situ density.

GRAPE densities are computed for 150 points along each core section or every centimeter. These data include many low density points associated with voids, breaks, or disturbances in the core. In order to obtain
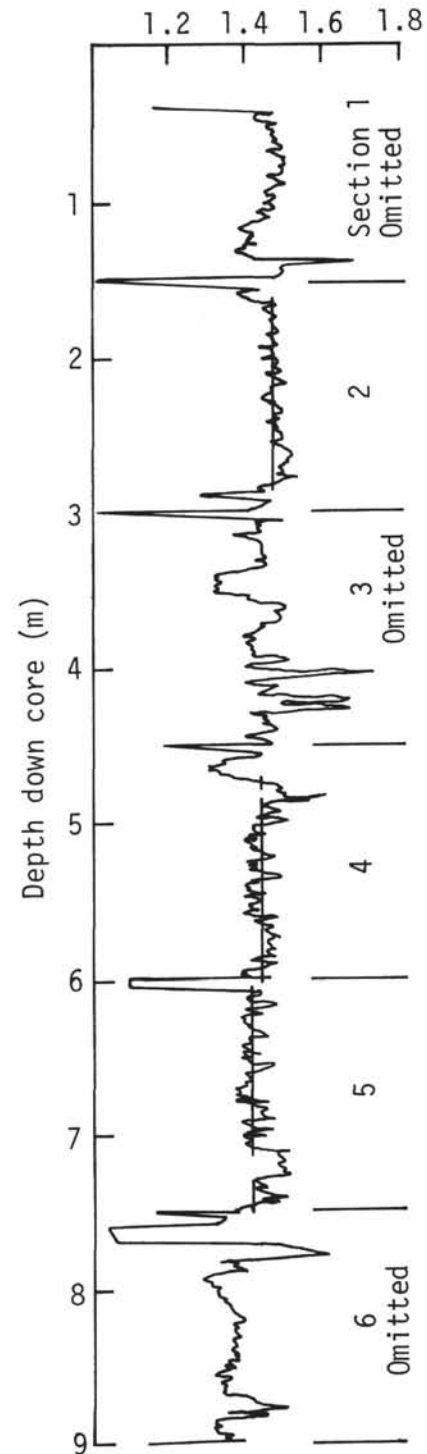
Figure 7. *Example of truncated average densities (Site 68, Core 2).*

estimates of the average in situ density in the sea floor, these points must be removed. An example is shown in Figure 7. Particularly at the ends of the core sections there are points of apparent low density that represent simply unfilled core liner. We have used a simple truncation procedure to eliminate the spurious points. The procedure must be simple and universally applicable since the large amount of data precludes subjective evaluation.

The program starts by computing the average of the 150 densities in a core section. It then truncates or removes all points that are outside prescribed limits above and below this average (a "window"). Out limits are +10% and −5%. The smaller lower limit is an attempt to compensate for the bias toward too low densities (gaps and voids) rather than too high densities. The remaining points are averaged again. If the new average differs from the first by more than a prescribed factor (we are using 0.5%), a second truncation with the same window is applied, and so on until a stable average is reached. Two iterations are usually sufficient. If more than 20% of the data points have been truncated for the final average, we consider the section average to be unreliable and the value is not plotted.

Estimates of average density for each core are presented in this volume. The complete data are available from the Deep Sea Drilling Project. The cores giving irregular GRAPE traces probably have many gaps or voids and the computed densities have not been presented. Unfortunately, some data on cores with real, large density variations also are discarded.

Sonic (acoustic, seismic) velocities on cores are needed for the interpretation of seismic reflection and refraction data, particularly for converting seismic reflection times to depths in the sedimentary column. Acoustic impedance, given by the product of the sonic velocity and bulk density, is closely related to reflection coefficients. Thus, rapid changes in acoustic impedance may be associated with seismic reflectors. The velocities were measured by determining the time delay of a high-frequency pulse transmitted through sediment or rock samples using a Hamilton frame (Hamilton, 1965; Cernock, 1970). The resolution is better than 0.01 km/sec and accuracy about ±0.02.

Cubes of sediment and syringe samples or chips were extracted from the same or proximal horizons within each core section. Using the Hamilton frame method, sonic velocities of the sediment cubes were measured in both longitudinal and transverse directions relative to the core (parallel to the length, and across the diameter of the liner). Basalt velocities were measured in two orthogonal directions on samples "in the round" across the unsplit core diameter. Syringe samples were taken from unlithified sediments for determination of water content, porosity, and wet bulk density. Samples which showed obvious voids or any other indications of error in volumetric measurement were excluded. Similarly, chips were taken from semilithified sediments for determinations of these same physical properties. Wherever possible, every attempt was made to avoid sampling areas which appeared to be affected by coring disturbances.

The sonic velocities were all measured at room temperature (20° to 25°C) and 1 atm pressure. The in situ temperatures range from 0° to 35°C with most below 10° and pressures range between 0.3 and 0.6 kbar. The data of Schreiber et al. (1972) suggest that the velocities will be 5% to 10% higher at 0.5 kbar. Wilson (1969) finds an increase in velocity for seawater of 5.4% from 1 bar to 0.5 kbar and a decrease of 5.1% from 20°

to 0°. Thus, the effects of temperature and pressure approximately cancel for seawater. The effects are likely similar for unconsolidated sediments.

A 6-cm length of core liner (approximately 200 cc) is taken at approximately 50-meter intervals subdepth. As soon as this sample reaches room temperature, the sample is squeezed to yield 20-30 ml, if possible, of interstitial water through utilization of a stainless steel squeezer mounted in a Carver Press. Minicores sampled at night are stored in a refrigerator at 10°C until the chemist can analyze them the following day. Except for a 2-3 ml volume used in shipboard analyses, this water is packaged in two aliquots (one in a fused glass ampoule and one in a fused polyvinyl tube) and stored at 4°C. In addition, a 1-ml sample in a glass ampoule is sent to Dr. Irving Friedman, USGS, Denver, Colorado. A 20-cc volume of unsqueezed sediment is placed in a plastic vial, and the squeezed sediment is heat-sealed in a plastic bag, and both are stored at 4°C. These samples (the two water samples, unsqueezed, and the squeezed sediment) are shipped to Scripps for archive storage.

pH is determined by two different methods. One is a flow-through electrode method, the other is a punch-in electrode method. pH is determined on all samples via the flow-through method, which is a glass capillary electrode in which a small portion of unfiltered pore water is passed. In the softer sediments a "punch-in" pH is also determined by inserting pH electrodes directly into the sediment at ambient temperature prior to squeezing. The pH electrodes for both methods are plugged into an Orion digital millivolt meter. These readings are converted to pH using the following formula:

$$pH = 7.41 + \frac{EMF\ 7.41\ buffer - EMF\ sample}{Slope}$$

$$Slope = \frac{\Delta EMF}{\Delta pH} = \frac{EMF\ 4.01\ buffer - EMF\ 7.41\ buffer}{pH^1\ 7.41\ buffer - pH^1\ 4.01\ buffer}$$

Alkalinity is measured by a colorimetric titration of a 1-ml aliquot of interstitial water with 0.01N HCl using a methyl red/blue indicator.

Alkalinity (meq/kg) − (ml HCl titrated) (9.7752)[1] (9.7752 has been used for at least eight DSDP legs, however, if one assumes a specific gravity of 1.025 for interstitial water, this constant becomes 9.756.)

Salinity is calculated from the fluids refractive index as measured by a Goldberg optical refractometer, using the ratio:

Salinity °/oo = (0.55) (ΔN)
where ΔN = refractive index difference × 10[4]

Local surface seawater is regularly examined by each of the above methods for reference.

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[1]Temperature adjusted values.

DATA PRESENTATION

As many of the primary data as possible concerning each site are presented in the site summary chapters (Chapters 3-7). The sections of each site chapter, in general, have the following sequence).

Background and Objectives
Operations
Lithology
Shipboard Geochemical Measurements
Physical Properties
Correlation of Seismic Reflection Profile with Drilling Results
Paleontology
Sedimentation Rates
Summary and Conclusions
References

At the end of each site chapter are graphical summaries of each core showing the age, lithology, composition, and positions of samples and smear slides, followed by photographs of the cores and a graphical summary, at a scale of 200 meters per page, of the overall results of drilling at the site.

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