1. INTRODUCTION

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JOIDES PLANNING FOR THE PACIFIC OCEAN

The DSDP program in the Pacific Ocean for 1973-1974 was based on the plans of the JOIDES Pacific Advisory Panel, within the operational constraints of the DSDP and the long-term objectives of the JOIDES Executive and Planning committees. The Pacific Advisory Panel had assessed a number of first-order scientific problems of broad interest to earth scientists. Topical problems and regional problems were arranged in a matrix so that many sites in the Pacific could be chosen where the highest-priority topical problems could be investigated by drilling where regional information might also be obtained. The major topical problems, not listed in any order of priority, are: (1) composition, structure, and physical properties of oceanic basement; (2) plate genesis and evolution; (3) plate motions; (4) diagenesis and geochemical evolution of sedimentary rocks; (5) structure, history, and origin of various continental margins; (6) biostratigraphy; (7) paleooceanography; and (8) geodynamics and geophysics.

PROGRAM AND OBJECTIVES OF LEG 32

The northwestern Pacific Ocean is the largest expanse of old oceanic lithosphere, and so the principal theme of Leg 32 set by the Pacific Advisory Panel was the late Mesozoic history of the Pacific Ocean. The main scientific goals originally set for the leg were to:

1) Determine the development of the very deep sea floor of the western Pacific, including the nature of its basement rocks and the age, lithology, and fossil content of the sedimentary rocks overlying acoustic basement. Patterns of linear magnetic anomalies that do not match the sequence of well-dated latest Cretaceous to present-day reversals are present east of Japan, west of the Hawaiian Ridge, near the Phoenix Islands, and bordering the North Atlantic. A principal aim of Leg 32 was to test correlations of these old anomalies by drilling specific sites on the Japanese and Hawaiian sets.

2) Establish standard mid-Mesozoic to Recent paleontological-biostratigraphic reference sections for the (present-day) northwest Pacific. Shatsky Rise and Hess Rise are the northern-most of the few broad and irregularly shaped areas of the sea floor that are sufficiently shallow so calcareous fossils are likely to be preserved and yet are isolated from dilution by terrigenous components.

3) Determine the paleolatitude for a specific period of volcanicity on Kōko Guyot of the Emperor Seamount Chain, which, when compared with the paleolatitude of Midway Islands and the present-day latitude of the active volcanoes on Hawaii, can test a version of the hot-spot theory—that a source of magma generation has remained fixed in the earth's mesosphere while the Pacific lithospheric plate has moved across it, with resultant volcanoes forming first the Emperor Seamounts and, after a change in direction of plate motion, the Hawaiian Ridge.

Several other geological and operational goals were to include: tracing the paleoequator in the stratigraphic records at the deep-water and rise sites; gathering cores for isotope analysis for paleooceanography studies; determining effects of diagenesis in carbonate and zeolite facies; geochemical and geophysical studying of mid-Mesozoic basalts; first DSDP operational testing of a heave compensation system and a system for taking oriented cores; drilling in very deep water on several sites; and using a transducer on the drill string.

PRESENTATION OF DATA AND AUTHORSHIP

The scientific results of Leg 32 are presented in this volume in the same manner as for earlier volumes of this series. The first section contains one chapter for each of the 11 sites. The routine contributions to the Site Reports were written by members of the Shipboard Scientific Party as follows: Background and Objectives by Roger L. Larson (Sites 303, 304, 307, and 311) and by Ralph Moberly (Sites 305, 306, 308, 309, 310, and 313). Operations by Roger L. Larson (Sites 305, 306, 308, 309, 310, and 313) and by Ralph Moberly (Sites 303, 304, 307, and 311). Lithology by Yves Lancelot (Sites 303 and 310); James V. Gardner (Sites 304, 308, and 309); Albert Matter (Sites 305 and 306); John B. Keene (Sites 307, 311, and 313); and Monte Marshall (all igneous petrology). Geochemical measurements were written by John B. Keene and physical properties by Monte C. Marshall. Correlation of seismic reflection profiling with drilling results were written by Yves Lancelot. Foraminiferal paleontology was written by Hanspeter Luterbacher; nannofossil, silicoflagellate, and diatom paleontology by David Bukry; and radiolarian paleontology by Helen P. Foreman. Sedimentation rates were compiled by David Bukry and James V. Gardner. Conclusions were contributed by the entire scientific party and assembled by Roger L. Larson and Ralph Moberly.

LEG 32 OPERATIONAL SUMMARY

After spending 11.5 days in port, D/V *Glomar Challenger* departed Hakodate, Japan, at 06:30 on 16 August 1973 and terminated the voyage in Honolulu, Hawaii, at 14:15 on 10 October 1973.

During this 67.6-day leg, *Glomar Challenger* cruised 4712 nautical miles, drilled 12 holes while investigating 11 sites, and cored 2210.5 meters of material in 241 coring attempts. A total of 738.8 meters of core was recovered for an average of 33.4%. In addition to the coring, 1369 meters were drilled for a total penetration of 3579.5 meters.

The major time distribution for the 67.6 days consisted of 11.5 days in port; 21.3 days cruising; 34.77 days on site; 1.72 days drilling; 18.25 days coring; 9.87 days making trips with the drill string; 2.06 days waiting on weather; 0.29 days working stuck drill pipe; 0.32 days of rig repair; and 2.26 days that included servicing equipment, locating the mudline, picking up new drill collars, and other miscellaneous operations.

The lithological sequence on the first three sites consisted of soft pelagic clay or ooze overlying thick sections of chert embedded in soft pelagic clay or chalk. These sites had more than 100 meters of soft sediment over the chert layers that caused considerable trouble with hole conditions and core recovery. One of these sites was continuously cored, but the others were drilled to the first reflector and then continuously cored to bottom. Recovery in the soft oozes was very good; recovery in the chert stringers was poor, however.

Previous legs in the western Pacific had experienced many operational problems, such as the loss of bottom-hole assemblies due to thin sediment cover, stuck drill pipe, plugged bits, deep-water, inoperative bumper subs, rough seas, and below-average core recovery. These problems led to several tool modifications. Bumper subs without mud slots in the outer body had been tested for the past year and were successful in eliminating the tools from "sanding up" and becoming inoperative. Journal-bearing bits were made available to extend bit life. The near-bit float valve eliminated the back flow through the drill pipe that usually caused the bit to plug. The chert, however, continued to frustrate core recovery as did bad weather, which accounted for 2 days of lost time.

Oriented coring was scheduled for Leg 32 to study the magnetic anomalies of the western Pacific. A specialist from the Sperry Sun Well Survey Company was onboard to supervise the oriented coring and to interpret the oriented cores. A survey in basalt basement at Site 304 was unsuccessful when the inner core barrel unscrewed leaving the scriber, the lower part of the core barrel, and some core in the hole. Scribed marks on the recovered core could not be related to any fixed reference, and so the survey film had no value. Basalt was reached on two later sites, but oriented cores were not attempted because of very poor, unstable hole conditions. Oriented coring requires that the drill string remain motionless on the bottom, without pumping, for several minutes, which is hazardous in these areas.

Heave compensation and the use of a transducer in the drill string had also been planned for Leg 32. They met with a variety of logistics difficulties and were not available by the time the ship left Hakodate.

EXPLANATORY NOTES AND CONVENTIONS

System of Numbering Sites, Holes, and Cores and of Locating Samples

Each drilling site is a location at sea that was surveyed and for which one or more acoustic beacons were dropped. Drilling sites are identified by a number, for example, Site 303. The first hole at each site has the site number, for example, Hole 303. Additional holes at the same site have a letter following the number. For example, Hole 303A is the second hole drilled at Site 303.

The cores recovered from each hole are numbered successively in the order in which they were taken: Core 1, Core 2, etc. When the core barrel is recovered on deck, the core catcher is removed from the barrel, and any material in the catcher (as much as 25 cm in length) is labeled "core catcher," or CC. The plastic core liner is withdrawn from the steel barrel and cut into 150-cm lengths called sections, beginning at the lower end of the barrel. A 9.3-meter liner can be cut into six such sections, with a short section about 28 cm in length left over at the top end. The numbering scheme for the sections depends on how much material is recovered. In a full barrel, the short top section is called the "zero" section, and the first 150-cm section below that is Section 1, the next, Section 2, etc. When the barrel is only partly filled, the cutting of the plastic liner proceeds as usual, starting from the bottom of the liner. The labeling, however, begins with the uppermost 150-cm section in which there is core material. That section, even if only partly full, is Section 1; the next below is Section 2, etc. Figure 1 illustrates the two cases.

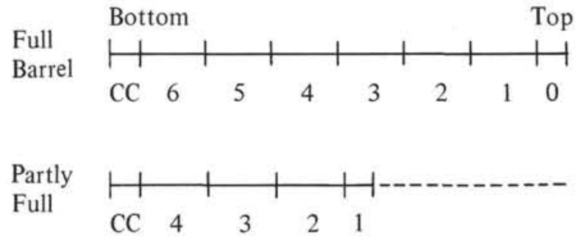

Figure 1. *Convention for numbering core sections.*

Individual samples or observations within each section are located in centimeters measured down from the top of the section. This is true even when a section is not full of material, either because of original lack of material (a short Section 1, for example) or because of voids produced by compaction or shrinkage.

Samples or observations are identified by a notation, such as 303-4-2, 140, which denotes a depth of 140 cm from the top of Section 2 of Core 4 of Hole 303.

In using the core descriptions or core photographs as a guide to ordering samples, the reader is cautioned that the core material, especially if it is unconsolidated or watery, has a tendency to shift up or down within the core liner, so that a feature located at, say, 43 cm on the photograph, may now have shifted to 46 cm because of compaction caused by handling of the core.

In reporting the depths of samples below the sea floor, or below the derrick floor of the drilling vessel, the convention is adopted that for partly filled core barrels, all the recovered material comes from the upper portion of the cored interval. The true location is, of course, unknown, and in some cores, where only a small amount of material was recovered, the uncertainty can be as much as 9 meters. Two "adjacent" samples could be nearly 19 meters apart because of this uncertainty alone.

Additional uncertainties about depths arise from the play in the bumper subs and the heave of the vessel.

Drilling and Coring

Because most of the results reported in this volume are based on cores retrieved on Leg 32, and because future scientific work will be based on samples taken from these cores and on data related to them, the question of how representative these cores are of in situ conditions becomes important. Not only does the representativeness of the cores vary widely from sample to sample, but the reliability of the information that can be extracted from the cores depends on the type of information being sought. This section describes the drilling, coring, recovery, and sampling processes in terms of their effects on the cores and how these effects may be related to some of the properties being studied.

Cores are retrieved aboard D/V *Glomar Challenger* by the punch core-rotary drilling method, wherein a drilling assembly approximately 10.75 in. in diameter, which has a bit opening of 2.5 in. in diameter, is lowered on a drilling string to the ocean floor. In semiconsolidated sediments, the drilling assembly is rotated, and drilling fluid (most commonly seawater but occasionally a mud slurry) is forced down the drill pipe around the outside of the coring assembly and out of openings above the bit. The sediment material cut away by the bit becomes mixed with the drilling fluid and is lifted to the sea floor along the annulus between the drill string and the wall of the hole. The cores are retrieved in a free-floating core barrel. The bottom of the core barrel rests on a lower support bearing; the upper end is held down by a latch, and there is a swivel bearing between the barrel itself and the latch. Thus, the core barrel can remain fixed in space as the drilling assembly rotates around it. Commonly, the core barrel rotates with the drilling assembly until friction between the barrel and the cored material entering the barrel is sufficient to hold the barrel stationary.

A perfect balance must be maintained among the rate of descent of the drill string, the fluid pressure, and the speed of rotation to avoid the extremes of washing out a hole by fluid jetting ahead of the bit (whereby no core is retrieved) and using so little water and rotating at so slow a speed that core cutting is inhibited, the risk of sticking in the hole is increased, or the sediments retrieved are excessively compacted.

The desirable balance differs with the nature of the rocks being penetrated. In soft sediments, if no cores are required, it is common to "wash down," using only the jet action of the water plus the weight of the drill string. If a core is desired in soft sediments, it is common to allow the drilling assembly to sink into the sediments under its own weight, with little or no fluid pressure and little or no rotation at the drilling assembly. In some cases, this technique permits the recovery of good, relatively undisturbed cores; in other cases, much of the volume of the sediments displaced by the drilling assembly (more than 10 times the capacity of the core barrel) is forced into the core barrel. Distortion produced by this phenomenon is usually quite obvious. Color variations in the sediment due to mottling or bedding may be highly contorted. The sediment layers have a diapiric appearance, and some are vertically oriented. The amount of distortion varies from complete intrusion to intact cores with horizontal bedding planes.

In more indurated rocks, it is necessary to use higher fluid pressures and to rotate the drilling assembly more rapidly in order to cut the cores. The driller commonly releases the drawworks brake, increasing the weight of the drilling assembly on the bit face, then rests while circulating and rotating until a drop in fluid pressure indicates that some drilling progress has been made. The brake is released again, and another segment is cut, and so on. In some instances when the brake was released, a segment of rock several centimeters in length would be cut. This segment would then be broken off, and the next segment of rock would be ground into a paste and the paste forced into the core barrel. This alternation of intact core and drilling paste is especially common in chalks. After recovery, cores are cut into sections of 1.5 meters length and processed as described in the later sections of this chapter.

Most core sections are then split longitudinally. Sections containing material in a very liquid state may not be opened. For cores of plastic sediments, the core liner is cut on either side with knife blades in a frame pulled by a windlass device. Then the core is sliced with a wire. Most such cores are little damaged by the cutting process, except that the surface is smeared. Where pyrite nodules, loose cavings of chert or rust flakes, or the plastic sock used as a core catcher are present, the plastic sediments are disturbed by the slicing process—sometimes severely. Semiindurated sediments are cut with a band saw. This technique tends to be more damaging, particularly in sequences of alternating layers of indurated chalk and soft calcareous ooze, where the splitting process completes the fragmenting begun by the coring process. Sections of indurated rock are split with a diamond saw. It is obvious that some cores retrieved are representative of the rocks in situ with respect to some properties. In other cases, it is obvious that they are not. Most cores retrieved are between those two extremes.

Three fundamental problems result from the coring and handling techniques described above. First, the materials retrieved undergo a shift in properties simply by being removed from their in situ environment to the laboratory environment. Second, the coring process causes mechanical disturbance which tends to mix, displace, disrupt, or contaminate the retrieved materials. Third, the process of splitting the core sections and sampling them in the laboratory introduces more disturbances. These effects are discussed at length in the introductory chapters of earlier volumes of the initial reports (for example, Gealy et al., 1971).

Processing Cores

During Leg 32, the first lithologic assessment and age determination of the core material was made on samples from the core catcher as soon as possible after the core was recovered. After a core section had been cut, sealed, and labeled, it was brought into the core laboratory for processing. GRAPE (gamma ray attenuation porosity evaluation) analysis, made for detailed density determinations, was the only routine measurement before the core was split, as described above.

One of the split halves was designated a "working" half. Sonic-velocity determinations using a Hamilton frame velocimeter 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. In indurated rocks, thin sections were cut from pieces of this half of the core. 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, structures, 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. One or more smear slides were made for each distinct lithology. The smear slides were examined with a petrographic microscope. 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 the core catcher and not used up in the initial examination was retained in freezer boxes for subsequent work. 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, and then the residue was stored in freezer boxes.

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

All sediment samples are now deposited in cold storage at the DSDP West Coast Repository at the Scripps Institution of Oceanography, La Jolla, California.

Lithologic Conventions

Nearly all sediments cored during Leg 32 are of pelagic, volcanic, or mixed pelagic and volcanic origin. Only the shallow-water fossiliferous sediments from Site 308 on Kōko Guyot are an exception. Therefore, a classification of sediments could be used that is simpler than ones used for most DSDP legs, where greater varieties of lithologies were encountered. The sediment names, listed in Figure 2 with the pattern shown on the core sheets for the Site Reports, are in common use today among marine geologists. As with most rocks, the nomenclature is based on composition and texture.

Pelagic clay is the deep-sea red clay or brown clay of older literature. If indurated and blocky fractured, it is pelagic claystone; and if indurated and fissile, it is pelagic shale. Sediments with more than 25% of the skeletal remains of a particular group of organisms are termed oozes, for example, radiolarian ooze. Abbreviated modifiers may be used, such as foram ooze for foraminiferal ooze.

Partly indurated calcareous oozes are foram chalks and nanno chalks. Oozes are readily deformed under a finger or the broad blade of a spatula, whereas chalks are friable limestones that are readily deformed under the fingernail or the edge of a spatula blade. Chalks more indurated than that are simply termed limestones. Under the microscope, individual fossils in chalks show overgrowths of cement, and limestones are recrystallized.

During the coring process, bedding in ooze is commonly folded but remains coherent, whereas chalk fractures. Generally the chalk in cores is badly shattered, and most of the fragments have irregular tabular shapes normal to the core axis, so that they would be described as shale (for example, fissile) if the rock were argillaceous. Fragments of chalk as thick as 2 or 3 cm are rare; most chips are only a few millimeters thick. On the other hand, limestone has been recovered in pieces many centimeters thick. Portions of cores with any of these lithologies may alternate with portions of mud or slurry of the same color and grain composition as the adjacent ooze, chalk, or limestone; however, these sediments have been ground up and mixed with water and injected into the core barrel during some periodic action that affected the bit on bottom, such as the ship's motion or letting out on the drawworks brake. The mud so formed differs from ooze in being wetter, in showing near-vertical flow-folding and diapir-like structure, and in grading to or containing less-homogenized portions that still contain recognizable pieces of ooze or chalk.

The cherty rocks are subdivided on the basis of their degree of silicification. Porcellanites are waxy and dull in luster, and commonly show abundant pores under a hand lens. Where cored specimens are allowed to dry out, their surfaces show a matte or checked appearance. Thin-section and X-ray analysis show that the silica in porcellanite is opal and cristobalite and that a large component of the composition is montmorillonite or other nonsilica minerals. On the other hand, the name chert is restricted for the dense, glassy rocks. Cherts are markedly purer than porcellanites, and their silica is present as chalcedony or microcrystalline quartz. Both porcellanite and chert have conchoidal fracture and both can scratch steel. The more porous and impure porcellanites commonly can be scratched in return by knife-point.

Volcanic clay, silt, and sand are based on texture. Mud is a mixture of clay and silt. Volcanic ash shows bogen structure (shards). Indurated equivalents encountered on Leg 32 are volcanic claystone, siltstone, and sandstone. Volcanic breccia is hyaloclastite fragments that are indurated.

These basic names may be modified as shown in Table 1. For fragmental volcanic rocks, additional modifiers in the terminology are genetic wherever the origin can be determined (pyroclastic, epiclastic, hyaloclastic).

The class limits are used when two or more major components are present. The one in greatest abundance is listed farthest to the right, and the others are listed, in order of decreasing abundance, progressively farther to

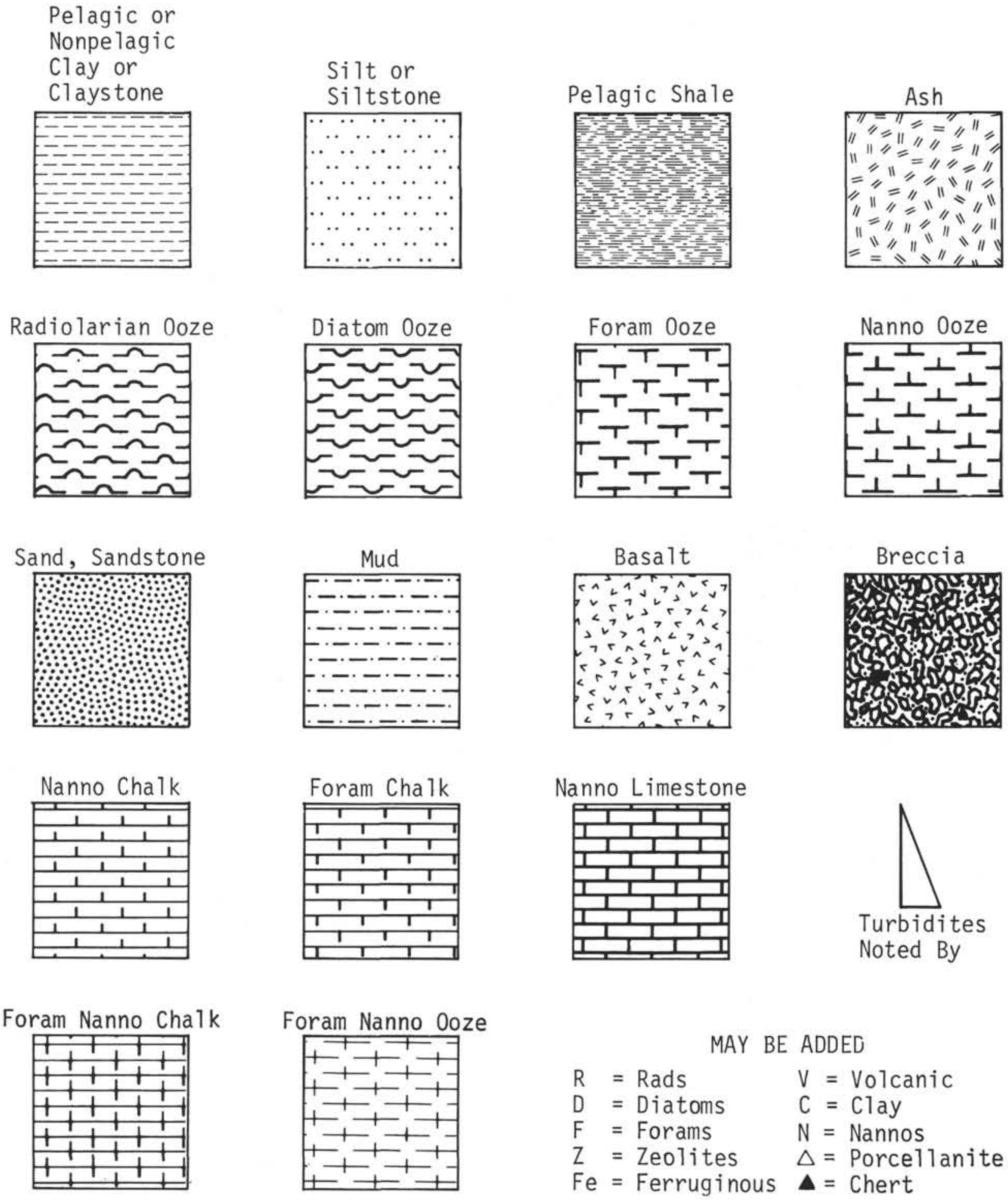

Figure 2. *Lithologic symbols used for Leg 32 core forms.*

the left. For eample, a sediment of 50% nannofossils, 30% radiolarians, and 20% zeolites would be a zeolite-bearing rad nanno ooze.

Details of texture and composition generally are given in the visual core descriptions, thin-section and smear-slide descriptions, and shore-laboratory reports on grain-size and X-ray mineralogy. They enable the reader to name the sediment or rock according to the classification he prefers.

Color symbols for lithologic descriptions are from the Munsell system. Both the soil color charts (Munsell Color Company, 1954) and the rock color charts (God-

TABLE 1
Sediment Modifiers

Class Limits of Components (Percentage)	Smear Slide Record	Name	Example (Increasing Foram Content)
1-5	Rare (R)		
5-25	Common (C)	Modifier-bearing	Foram-bearing nanno ooze
25-75	Abundant (A)	Modifier basic name	Foram nanno ooze or nanno foram ooze
75-100	Dominant (D)	Basic name	Foram ooze

dard et al., 1948) were used for comparing with the cores. For the reds, yellows, and browns, the soil color charts had more color chips and were used more frequently. However, the terminology in the rock color chart was always used, whether the symbol was obtained by matching it to the soil chart or to the rock chart. The colors, recorded and photographed onboard ship soon after splitting the core sections, may be ephemeral. Many colors of the carbonate oozes in the Neogene section of Site 310 faded or changed with time after opening and storage. Colors particularly susceptible to rapid fading were purple, light and medium tints of blue, and some shades of green. These colors commonly change to orangish-white or light gray.

Terminology of sedimentary structures is generally that of the Pettijohn and Potter (1964) atlas and glossary. The term turbidite is used for graded, partly laminated, sandy beds and laminated silt and clay beds, commonly containing grains of various lithologies (such as foraminifer tests, palagonite grains, large shards, etc.) at the same level, and sharply separated from the underlying sediment.

Grain-size terminology is that of Wentworth (1922). The standard sand-silt-clay divisions were employed for granulometric analysis (boundaries at 62μm and 4μm).

Both optical and X-ray diffraction methods were used for mineralogical determinations. Terminology of minerals identified optically is that of Deer, et al. (1962). The method of mutual standards and the degree of development of recognition criteria in the programs to interpret the digital X-ray diffraction patterns are discussed by Rex (1970).

Basement rocks were recovered from four sites during Leg 32. All were basalt showing various degrees of alteration. The criteria for classification into ocean-ridge-type theoliitic basalts and alkalic basalts are those of Bass et al. (1973).

The biostratigraphic zonation schemes used during Leg 32 are summarized in Tables 2 and 3. The ages for the Cenozoic epoch boundaries are from Berggren (1972) and for the Mesozoic age boundaries are from Harland et al. (1964), Lambert (1971), and Izett et al. (1971). The references to the biostratigraphic zonations, listed for each fossil group used, are as follows:

Biostratigraphic Zonations Used During Leg 32

Fossil Group	Cenozoic	Mesozoic
Radiolaria	Hays (1970) Riedel and Sanfilippo (1971) Foreman (1973a)	Foreman (1973b) Foreman (this volume) Riedel and Sanfilippo (1974)
Nannofossil	Bukry (1973)	Bukry (1974)
Foraminifera	Oligocene to Recent: Blow (1969) Oligocene to Recent: Bolli (1966) Eocene thru Paleocene: Stainforth et al. (in press)	Late Cretaceous: Pessagno (1967) Early Cretaceous: Preliminary Subdivision

Diatoms and silicoflagellates were not used for age determinations.

Uncertainty of the placement of zonal boundaries against the time scale is indicated by a dashed boundary. Correlations of the Cenozoic foraminifera zones of Blow (1969) with the time scale is taken from Berggren (1972).

When it was necessary to use ages of zonal boundaries, for instance, in constructing accumulation rate curves, the correlations of Bukry (1973, 1974) were followed.

Accumulation rates were calculated without correcting for compaction and without calculating error bars for the age of zonal boundaries. Accumulation rates are expressed in meters per million years and are indicated on each line segment of the plots. Unconformities indicated by biostratigraphy are shown as horizontal wavy lines and the word "unconf."

Measurements of Physical Properties

Sediment porosity and density were determined by the GRAPE and syringe methods. GRAPE is a device which measures the attenuation of gamma radiation passing from an emitter through the core to a detector. As the core passes automatically by the emitter, variations in sediment density cause variations in attenuation. The density is assumed to be due to porosity, with pore water less dense than some assumed or measured

TABLE 2
Cenozoic Faunal and Floral Zonations Used for Leg 32 Data

TIME (m.y.)		SERIES	RADIOLARIAN ZONES: HAYS (1970)	RADIOLARIAN ZONES: RIEDEL AND SANFILIPPO (1971)	RADIOLARIAN ZONES: FOREMAN (1973)	NANNOFOSSIL ZONATION BUKRY (1973)	FORAMINIFERA ZONATION: BLOW (1969)	FORAMINIFERA ZONATION: BOLLI (1966)
0.7	L	PLEI	A, B			I; Gephyrocapsa oceanica	N23	
1.8	E		Eucyrtidium matuyamai			Coccolithus doronicoides	N22	
	L	PLIO	Sphaeropile langii	Lamprocycias heteroporous		Discoaster brouweri	N21	
	E					Reticulofenestra pseudoumbilica	N19, N20	
5.0			Stichocorys peregrina			Ceratolithus tricorniculatus	N18	
				Ommatartus penultimus		Discoaster quinqueramus	N17	
	L	MIOCENE		Ommatartus antepenultimus		Discoaster neohamatus	N16	
10.4							N15	
	M			Cannartus petterssoni		Discoaster hamatus	N14	
						J; Discoaster exilis	N13	
				Dorcadospyris alata		Sphenolithus heteromorphus	N12, N10	
16.0						Helicopontosphaera ampliaperta	N8, N9	
				Calocycletta costata		Sphenolithus belemnos	N7	
	E					Triquetrorhabdulus carinatus	N6, N5, N4	
22.5	L	OLIGOCENE		Calocycletta virginis		Sphenolithus ciperoensis	P22	
29.4						Sphenolithus distentus	P21	
				Lychnocanium bipes		Sphenolithus predistentus	P20	
32.0	E			Dorcado spyrsis ateuchus			P19	
				Theocyrtis tuberosa		Helicopontosphaera reticulata	P18	
37.5	L	EOCENE				Discoaster barbadiensis		Globorotalia cerroazulensis; Globigerapsis mexicana
43.1	M					Reticulofenestra umbilica		Truncorotaloides rohri; Orbulinoides beckmanni
					C/D; E	Nannotetrina quadrata		Globorotalia lehneri; Globigerapsis kugleri
					F/G/H	Discoaster sublodoensis		Hantkenina dragonensis; Globorotalia palmerae
49.0	E				Buryella clinata	Discoaster lodoensis		Globorotalia aragonensis
						Tribrachiatus orthostylus		Globorotalia formosa formosa
					Bekoma bidarfensis	Discoaster diastypus		Globorotalia rex
53.5	L	PALEOCENE				Discoaster multiradiatus		Globorotalia velascoensis
						Discoaster nobilis		Globorotalia pseudomenardii
						Discoaster mohleri		Globorotalia pusilla pusilla
						Heliolithus kleinpellii		
						Fascicolithus tympaniformis		Globorotalia angulata
60	E					Cruciplacolithus tenuis		Globorotalia uncinata; Globorotalia trinidadensis; Globorotalia pseudobulloides
						UPPER CRETACEOUS		Globigerina euqubina
65	CRETACEOUS							CRETACEOUS

A = Artostrobium tumidulum
B = Axoprunum angelinum
C = Podocyrtis mitra
D = Podocyrtis ampla
E = Thyrsocyrtis triacantha
F = Theocampe mongolfieri
G = Theocampe (T.) cryptocephala cryptocephala(?)
H = Phormocyrtis striata striata
I = Emiliania huxleyi
J = Catinaster coalitus

TABLE 3
Mesozoic Faunal and Floral Zonations Used for Leg 32 Data

TIME (m.y.)	EPOCH	AGE	RADIOLARIA ZONATION: FOREMAN (1973)	RADIOLARIA ZONATION: RIEDEL AND SANFILLIPO (1974)	RADIOLARIA ZONATION: FOREMAN (THIS VOLUME)	NANNOFOSSIL ZONATION: BUKRY (1974)	FORAMINIFERA ZONATION
60	E	PALEOCENE					
	LATE CRETACEOUS	MAASTRICHTIAN		Theocampsomma comys		Micula mura; Lithraphidites quadratus	Globotruncana mayaroensis; Globotruncana contusa, G. rugata; Globotruncana stuartiformis and Globotruncana elevata
71	LATE CRETACEOUS	CAMPANIAN		Amphipyndax enesseffi		Tetralithus trifidus; Broinsonia parca; Effellithus augustus	Globotruncana calcarata; Globotruncana calcarata; Globotruncana fornicata and Globotruncana stuartiformis
80	LATE CRETACEOUS	SANTONIAN		Artostrobium urna	Artostrobium urna	Gartnerago obliquum	Globotruncana concavata concavata; Globotruncana angustis
82	LATE CRETACEOUS	CONIACIAN				Marthasterites furcatus; Micula decussata or Tetralithus pyramidus	Globotruncana primitiva, G. schneegunsi, G. imbricata
86	LATE CRETACEOUS	TURONIAN		Dictyomitra veneta	Dictyomitra somphedia	Corollithian exiquum	Globotruncana schneegansi, G. sigati; Globotruncana helvetica; Globotruncana heloctia
91	LATE CRETACEOUS	CENOMANIAN				Lithraphidites alatus	Rotalipora brotzeni, R. greenhornensis, and R. gandolfii; Interval with Rotalipora apenninica
95	EARLY CRETACEOUS	ALBIAN				Effellithus turriseiffeli; Prediscosphaera cretacea	Ticinella primula
106	EARLY CRETACEOUS	APTIAN		Eucyrtis tenuis	Acaeniotyle umbilicata	Parhabdolithus angustus; Chiastozygus litteranus or Tetralithus malticus	Globigerinelloides ferreolensis
112	EARLY CRETACEOUS	BARREMAIN	Acaeniotyle tribulosa "assemblage"			Micrantholithus hoschulzii	Dorothia zedlerae and Dorothia hauteriviana
118	EARLY CRETACEOUS	HAUTERIVIAN		Stauroshaera septemporata	Eucyrtis tenuis	Cruciellipsis cuvillieri; Tubodiscus jorapelagicus	Dorothia hauteriviana
124	EARLY CRETACEOUS	VALANGINIAN	Sethocapsa trochyostraca "assemblage"		Sethocapsa trochyostraca	Watznaueria britannica or Cretachabdus crenulatus	
130	EARLY CRETACEOUS	BERRIASIAN	Sethocapsa cetia "assemblage"	Sphaerostylus lanceola	Spherostylus lanceola	Nannoconus colomi	
136	LATE JURASSIC	TITHONIAN					
141	LATE JURASSIC	PORTLANDIAN				Parhabdolithus embergeri	
146							

mean grain density. A fuller description is given in Evans and Cotterell (1970). Actual water content of sediment was measured from the loss of weight upon evaporation of a small cylindrical volume of wet sediment extracted by a syringe.

Sonic velocity was measured on sediment and basalt specimens by timing a 400-kHz sonic pulse from one transducer through the sample to another and measuring the distance across the sample. This Hamilton frame velocimeter method has been more completely described by Boyce (1973).

Shipboard Geochemical Methods

Alkalinity, *p*H, and salinity were measured routinely on cored sediments that were soft enough to give up interstitial water when squeezed by a method similar to that described by Manheim (1966). Surface seawater, which was the drilling fluid at the sites, was also measured to give an indication of possible contamination.

Shipboard laboratory measurements have been described at length in several recent DSDP volumes, for example, by Whitmarsh et al. (1974). For *p*H, the flow-through method (Waterman, 1970), which had been discontinued on more recent DSDP legs, was again used along with the punch-in method, which had become the standard procedure.

Shore-Based Studies

Work onboard *Glomar Challenger* has been supplemented by work ashore on samples obtained for special purposes. X-ray mineralogy, grain-size, and carbon-carbonate analyses were made at DSDP laboratories. Other special shore-based studies include geochemical and petrographic studies of basalts and cherts, diagenetic studies of limestones and volcanic-rich sediments, oxygen isotopic studies on foraminifers, paleomagnetic properties of basalts, and studies of several groups of organisms: foraminifers in general, Neogene foraminifers, benthonic foraminifers, larger foraminifers, Oligocene foraminifers, Eocene planktonic foraminifers, Late Cretaceous foraminifers, nannofossils and silicoflagellates, radiolarians, diatoms, bryozoans, favreinas, and fish debris. The methods and results of each of these studies comprises a chapter in this volume following the site report section.

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