1. INTRODUCTION

Shipboard Scientific Party[1]

The primary objective for drilling the sites on Leg 8 of the *Glomar Challenger*, in the east central equatorial Pacific Ocean, was to obtain information on the sedimentary section across the Equator along the 140th Meridian West, information that would bear on the geologic history of this region and, in particular, on the Tertiary history of the equatorial current system. Six sites were chosen tentatively by the Pacific Advisory Panel (JOIDES, 1967) between 6°30′N and 30°S. These sites were an extension of the longitudinal section already drilled to the north along longitude 140°W during Leg 5 (Sites 37-42; McManus *et al.*, 1970).

Of the six sites recommended by the panel, two were north and south of the Clipperton Fracture Zone for comparison of the sedimentary record and the age and nature of the basement rocks on either side of this structural and topographic feature. The two southernmost sites, at 25°S and 31°S, were selected to obtain information south of the Tuamotu Archipelago; however, these two sites were not drilled since preliminary site surveys indicated insufficient sediment thickness.

In addition to the sites recommended by the Pacific Advisory Panel, two were drilled during Leg 8 that were not on the longitudinal section. Site 68 (16° 43½′N, 164°10½′W), a site recommended for Leg 7, was selected to obtain stratigraphic information in the basin southwest of the Hawaiian Ridge; and Site 69 (6°N, 152°52′W) was chosen for additional stratigraphic information between our line of holes and the near-equatorial holes drilled during Leg 7 (Sites 62-66; *Geotimes*, December 1969). Two additional sites were drilled along the 140°W section (Site 72, 0°26.49′N, 138°52′W, and Site 73, 1°55′S, 137°28′W) to obtain better stratigraphic correlation across the Equator. While Leg 8 was in progress, R. Raitt and associates aboard RV *Argo* carried out detailed surveys for several sites to be occupied by the *Glomar Challenger* during the leg. As mentioned above, their surveys south of the Tuamotu Archipelago showed no areas of sediment thick enough for drilling. A minimum of about 100 meters—enough to support the bottom assembly of the drill string—was required to prevent twisting off in attempting to core hard rock. Consequently, the two sites south of the Tuamotus were deleted, permitting additional holes and more complete coring of the sediments in the Equatorial section.

The *Glomar Challenger* departed Honolulu at 0630 hours on 8 October and arrived at Papeete, Tahiti at 0624 hours on 2 December, 1970. During the 55 days at sea the ship covered 4616 nautical miles, drilled 17 holes on 8 sites (Figure 1), and recovered a total of 1216 meters of core, of 1452 meters attempted (Table 1).

The ship was on site for 33 days (60 per cent), and spent 22 days (40 per cent) steaming including about 2 and one-half days spent on site surveys approaching and leaving the sites. Of the time on site, about 23 and one-half days were spent in the normal operations of drilling and coring soft sediments, including trip time (time required to assemble and disassemble the drill string from ship to sea floor). About 4 days were used coring "hard rock"—Eocene chert or siliceous limestone—chiefly in Holes 70A and 71B. A total of about 12 meters of lithified rock core were recovered from all holes. An additional two days time was required in order to replace worn bits and redrill down to the hard rock on Sites 70 and 71, so that the total time allocated to hard rock coring was about 6 days—one fifth of the time spent on site. Coring rates ranged from approximately two hours to break through about 4 inches of chert, to about 4 to 5 feet per hour in limestone. Penetration rates in limestone were slow, probably because the cutting action of the diamond bits was ineffective in the fine-grained, tough rock.

About two days time, including trip time in and out of the hole, were used in testing a turbocorer in Holes 68A and 75A. The turbocorer had been developed for the Mohole project, and successfully tested on land at Uvalde, Texas, in 1965.

All logging was done with a "Welex drill pipe logger," a self-contained tool that records on magnetic tape. The

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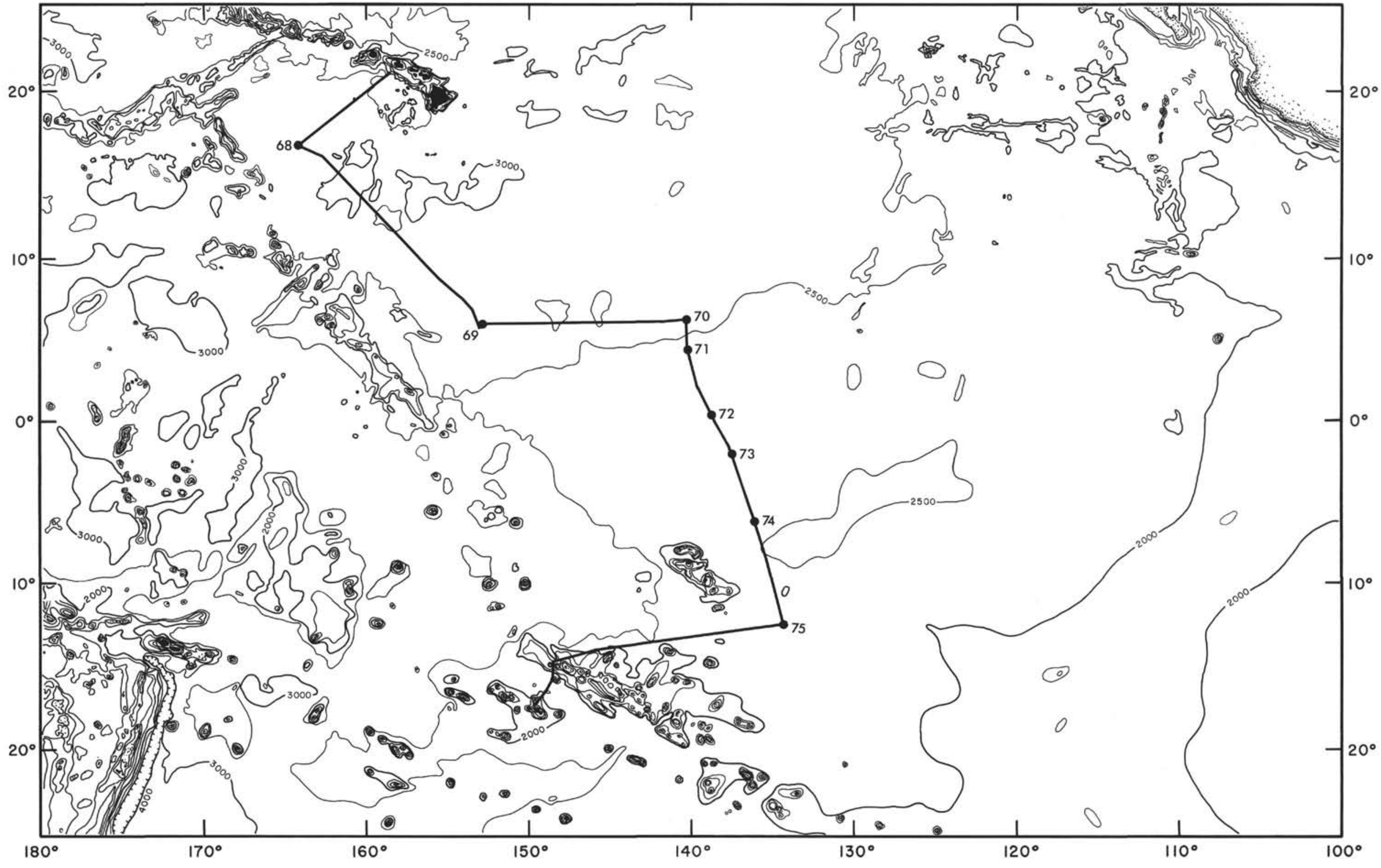

Figure 1. *Generalized track and site locations, Leg 8.*

TABLE 1
Holes Drilled on Leg 8, Hawaii to Tahiti

Site	Latitude	Longitude	Dates of Drilling	Water Depth (Meters)	Penetration (Meters)	Number of Cores	Amount Cored (Meters)	Core Recovered (Meters)
68	16°43.32'N	164°10.36'W	October 10-12	5466	15	2	15	15
69	6°00.00'N	152°51.93'W	October 17-20	4978	230	21	165	132
70	6°20.08'N	140°21.72'W	October 23-November 1	5059	388	46	331	249
71	4°28.28'N	140°18.91'W	November 2-10	4419	558	53	442	375
72	0°26.49'N	138°52.02'W	November 12-15	4326	345	17	143	135
73	1°54.58'S	137°28.12'W	November 17-19	4387	302	21	173	170
74	6°14.20'S	136°05.80'W	November 21-22	4431	102	12	102	74
75	12°31.00'S	134°16.00'W	November 24-27	4181	82	9	82	66
			TOTALS		2022	181	1453	1216

tool is dropped through the pipe to the bit, and records as the pipe is pulled. Logs were attempted on Sites 69 through 75, and the logging was mechanically successful on all runs except the first. The data recorded (16-inch normal, amplified normal, 64-inch lateral, and self-potential) in the pelagic ooze of the equatorial sediments are of doubtful value and the results are not reported in this volume. The method, however, is of great interest for holes to be drilled in hard rock in later phases of the Deep Sea Drilling Project. The self-contained logger required no more than 50 minutes additional time to log a hole, even in the deepest water.

Two attempts were made to obtain heatflow measurements in Holes 71B and 72B. Approximately two days were spent making these measurements.

SUMMARY OF DRILLING OPERATIONS AND RESULTS

Site 68

Site 68 was selected by the JOIDES Pacific Advisory Panel (PAP Site 22) as a second priority site on the southwest side of the Hawaiian Ridge for correlation with the former Mohole site (Leg 7, Site 67; PAP Site 23) on the northeast flank of the Ridge. It is located at latitude 16°43.32'N, longitude 164°10.36'W, in a water depth of 5467 meters. This site was scheduled for Leg 7, but was omitted in order that an originally unplanned site west of the Line Islands could be occupied. It was chosen for the first hole on Leg 8 as an appropriate location to try a newly acquired turbocorer. The objective at Site 68 was, by means of the turbocorer, to penetrate expected chert layers and reach igneous basement. In the west-central Pacific, most previous holes using conventional drilling had been terminated above igneous basement by chert layers of Eocene age.

Two holes were drilled at Site 68: Hole 68 by means of a conventional wire line core assembly, and Hole 68A using the turbocorer. Complete recovery of 15 meters of middle Eocene, dusky brown clay, overlain by a few centimeters of mixed Quaternary, Miocene and Eocene pelagic ooze, was obtained in Hole 68. Drilling was stopped by thin, indurated claystone and chert layers, beginning at about 9 meters below bottom. Hole 68A, the test site for the turbocorer, was washed to the first hard layer at 9 meters below bottom. Drilling was then begun using the turbocorer, with apparently no penetration after several hours. A rotation indication showed that the turbine was operating, but the rotation fluctuated violently from 0 to as much as 1000 rpm, probably because a 6-foot swell made it impossible to keep a steady weight on the bit.

Site 69

As mentioned in the introduction, the main objective of Leg 8 was to provide a stratigraphic section, approximately along the 140th Meridian West, of the sediments across the equatorial Pacific belt of high productivity that stretches west of the American continents. This cross section is provided by the Leg 8 Sites 70 through 75. Site 69, located at latitude 6°00.0'N, longitude 152°51.93'W, in a water depth of 4978 meters, was drilled primarily to provide lateral control for the N-S section of Leg 8, and stratigraphic information for the E-W section to be drilled across the East Pacific Rise by Leg 9.

Two holes were drilled at Site 69 using a conventional wire line coring assembly with "massive set" tungsten carbide bit. Both holes bottomed in hard chert beds of middle Eocene age at a depth of about 230 meters. From the sediment surface to bottom, an almost complete stratigraphic section from middle Miocene to middle Eocene was cored. The section consists of middle and upper Eocene cherts and radiolarian ooze overlain by approximately 110 meters of highly calcareous lower Oligocene to lower Miocene radiolarian-nannofossil and nannofossil ooze; which is, in turn, overlain by approximately 30 meters of lower and middle Miocene radiolarian ooze. The upper Eocene-lower Oligocene contact is a sharp disconformity.

Site 70

Site 70 and the following site (71) were drilled north and south, respectively, of the Clipperton Fracture Zone in order to compare the stratigraphic successions and nature and age of the basement on either side of this feature. Site 70 is located at latitude 6°20.08'N, longitude 140°21.72'W, in a water depth of 5059 meters.

Three holes were drilled at Site 70 and an almost complete stratigraphic succession from Quaternary to middle Eocene was cored. The sediments consist dominantly of radiolarian, radiolarian-nannofossil, and nannofossil oozes, with upper Eocene chert at 328 to 331 meters, and middle Eocene chert at 384 to 388 meters below bottom. Noteworthy was the recovery of chert cores rather than chips. The interval from 331 to 384 meters was not cored, and presumably consists mostly of semi-indurated Eocene radiolarian ooze. The contact between Eocene radiolarian ooze and Oligocene radiolarian-nannofossil chalk was very sharp. A mixed zone above the contact was only 42 centimeters in thickness.

Site 71

Site 71 is located south of the Clipperton Fracture Zone at latitude 04°28.28'N, longitude 140°18.91'W, in a water depth of 4419 meters. Hole 71 was continuously cored to a depth of 436 meters, providing an excellent record of the stratigraphic succession from Quaternary into middle Oligocene. The hole bottomed at 475 meters in chert of upper Oligocene age. Hole 71A was drilled in order to obtain deeper penetration into the section. A total penetration of 558 meters was achieved and spot cores recovered lower Oligocene chalk and probable upper Eocene siliceous limestone and calcareous chert. Hole 71B was drilled as a heat probe hole; two measurements were made at 100 and 250 meters below bottom (see Von Herzen *et al.*, this volume).

Site 72

Three holes (including a heat flow hole) were drilled at Site 72, located at latitude 00°26.49'N, longitude 138°52.02'W, in a water depth of 4326 meters. Continuous coring was accomplished from the sediment surface to a depth of 69 meters and 312 to 345 meters below bottom; four spot cores were taken between. The section recovered comprises Quaternary to upper Miocene nannofossil and nannofossil-radiolarian ooze; upper Miocene to lower Oligocene highly calcareous nannofossil ooze, which becomes somewhat chalky below 150 meters; and upper Eocene bedded radiolarian ooze and radiolarian-nannofossil ooze, separated by thin beds or lenses of chert. Reflection profiles show that Site 72 is located on the flank of a buried hill over which the sediments are compressed, particularly towards the base of the section. Therefore, sediment thicknesses at this site are probably not representative for the area. Hole 72B was a heat flow hole; two measurements were made at 51 and 105 meters below bottom (see Von Herzen *et al.*, this volume).

Site 73

The drilling plan at this site was to core continuously from the sea floor into the upper Miocene, spot core down into the Oligocene, and core continuously to bottom. Continuous coring to 94 meters encountered Quaternary to middle Miocene pelagic ooze. Especially noteworthy was the presence in the upper and middle Miocene sediments of abundant reworked lower Miocene radiolarian species, suggesting an unconformity between middle and upper Miocene which may correlate with a reflector on the seismic profiler records of the site. Spot cores taken at 140 and 206 meters encountered highly calcareous middle Miocene and lower Oligocene radiolarian-nannofossil and nannofossil ooze; and continuous coring from 243 to 302 meters retrieved upper and middle Eocene carbonate ooze and (288 to 302 meters) siliceous chalk and chert.

Site 74

Site 74, located at latitude 06°14.20'S, longitude 136°05.80'W in a water depth of 4431 meters, was cored continuously to a depth of 102 meters; and bottomed in basalt, immediately overlain by middle Eocene carbonate ooze. The section comprises Eocene, Oligocene, Miocene, Pliocene and Quaternary pelagic ooze, although the upper Miocene to Quaternary is highly condensed.

Site 75

Like Site 74, Site 75 bottomed in basalt, at 82 meters, overlain by lower Oligocene carbonate ooze. Two holes were drilled at this site at latitude 12°31.0'S, longitude 134°16.0'W in water depth of 4181 meters. The first was cored continuously to bottom and encountered a thin layer of Quaternary foraminiferal ooze separated from the underlying lower Miocene-Oligocene by a mixed zone of partially dissolved foraminifera of various ages and abundant fish remains. Hole 75A was a second attempt to use the turbocorer to core hard rock at the bottom of the hole. The attempt was unsuccessful, but six small basalt fragments were recovered in the bit watercourses.

EXPLANATORY NOTES

Authorship

In Parts I and II of this report, C. von der Borch, J. S. Galehouse, W. D. Nesteroff, and J. I. Tracey, Jr. are primarily responsible for sections concerned with lithology and stratigraphy; J. P. Beckmann (foraminifera), U. Z. B. Haq and J. H. Lipps (nannofossils), and T. C. Moore, Jr. (Radiolaria) for discussions of paleontology and biostratigraphy; and G. H. Sutton for sections relating to site surveys, geophysics, and physical properties. Authorship is stated for each chapter in Part III, Special Reports.

Presentation of Information

Summary descriptions, interpretations, and conclusions regarding the cores obtained on Leg 8 are presented in the Cruise Leg Synthesis, Part I of this volume. Part II contains the detailed site reports including background information on the site, the drilling operation, and detailed descriptions, logs, and tables of the lithology, physical properties, and fossils. A graphic log is presented for each core recovered (core summary), and a Hole Summary Log is prepared for each site. Part III, Special Reports, includes detailed studies of paleontology, mineralogy, site surveys, heat flow, and shore laboratory reports.

Survey Data and Site Background

Results of site surveys conducted by R/V *Argo* (SCAN) and the *Glomar Challenger* are presented in Chapter 25. Included there are the following:

> A track chart, showing topography, for the entire track of Leg 8 and similar charts for each of the site surveys; photo copies of air-gun records, keyed to the track charts for most of the track of Leg 8 and for each of the individual site surveys; a general description of the topography, sediment configuration, and magnetic field near each site; and a brief summary of any piston-core or heat-flow observations taken near each site.

In Chapter 2 a cross-section of water depth and depth to acoustic basement for the north-south track between Sites 70 and 75 is presented along with a photo copy of the air-gun record across the Clipperton Fracture Zone. A summary of reflecting horizons in the vicinity of each site and correlation between depth to seismic reflectors and variations with depth in sonic velocity, sonic impedance, and penetrometer readings of cored sediments are also illustrated in Chapter 2.

Included in each site report, Chapters 3-10, in addition to a summary of the survey findings, is a photo copy of an air-gun record across the drilling site along with a line-drawing interpretation.

Shipboard Procedures

Procedures used during this leg were closely similar to those described in preceding volumes, and the reader is referred especially to Volume II for information concerning the ship and equipment, and to Volume III for a discussion of core handling and sampling procedures.

Water depth at each site was determined from the length of drill pipe below the drilling platform, less 10 meters (elevation of platform above water line). The depth to sea floor "felt" by the driller generally checked very closely with the corrected depth determined by the fathometer.

Numbering of Sites, Cores and Sections

The first hole drilled at a site was given the site number: e.g. Hole 73. Subsequent holes were designated 73A, 73B whether the redrill was to continue coring beyond that cored in the first hole, or to core intervals missed during the first drilling, or whether the redrilling was for a different purpose, such as heat flow measurement.

Numbering of cores, sections, and samples follows previous practice. Drilled cores were generally contained in a 9-meter long plastic liner inside the core barrel. After the core was pulled out of the barrel, it was cut into sections of 150-centimeter length. These sections were labeled consecutively, with the first section at the top, and the sixth at the bottom. The sections were, however, measured from the bottom up. Consequently, when recovery was slightly less than 9.0 meters the first section of each core would be less than 150 centimeters long. When less than 7.5 meters of core were recovered, the core could only be divided into five, or fewer, 150-centimeter sections, yet the top section of a short core would still be labeled Section 1. On some occasions more than 9.0 meters were obtained, so that a small remainder, 10 or 20 centimeters long, would be left after six sections were cut off from a core. This remainder would be called Section 0 of that core, denoting its position above Section 1.

Core sections and samples taken from the cores were numbered before being processed. The numbering system adopted for this report, recommended in the Core Description Manual (May, 1968), includes a designation for leg-site-hole-core-section-interval. Thus, Sample 8-73A-1-2, 75 centimeters was taken during Leg 8, at Site 73, where a second hole (73A) was drilled in addition to the original hole (73), and was cut from the first core, the second section, and at 75 centimeters from the top of that section.

A core-catcher about 20 centimeters long was attached to the lower end of the metal core barrel. Samples recovered from the core catcher were designated by the abbreviation CC (e.g., 8-73A-1, CC). A core catcher sample was commonly the first sample studied on board ship; and, in some cases, it may represent the only sample from a core when recovery was poor.

If recovery was incomplete, an attempt was made to assign core loss. This is indicated in the core summary logs in Part II, where depth below sea floor, in meters, is assigned to the top and bottom of the recovered core.

Handling of Cores

After a core section was cut, sealed and labeled, the following procedure was usually followed:

1. Weighing of the core section.
2. GRAPE analysis for bulk density and porosity.
3. Gamma ray counting for radioactivity.
4. Sonic velocity determinations.

Sonic velocity determinations were made at 25, 50, 75, 100 and 125 centimeters of the section if the core within the tube contained no voids at these points.

Thermal conductivity measurements were made on relatively few sections.

After the physical measurements, the cores were cut, sampled, and described.

On the working half of the core, penetrometer measurements were made at 3 of the 5 points at which sonic velocity had been measured: generally at 25, 75 and 125 centimeters if the core was relatively undisturbed at these points. One-half cubic centimeter samples were taken at the same locations for determination of bulk density, porosity, grain matrix density and water content. Samples were also collected for grain size, X-ray mineralogy, interstitial water chemistry, total carbonate content, and some oriented samples were taken for paleomagnetic studies. The working half was then sent to the paleontology laboratory for sampling.

The archive half of the core was examined by a geologist, and its features described. One or more smear slides were made and examined for each section. A visual estimate was made of the calcium carbonate ($CaCO_3$) content of the slide, which for most cores meant estimating the relative proportions of calcareous nannofossils and siliceous radiolarian tests.

After the archive half of the core was described, it was photographed in color and black and white. An X-ray photograph was made of any sections showing unusual sedimentary features, but these did not prove to be helpful in the unconsolidated sediments.

Some core sections were not split and described because they were too watery or "soupy." Occasionally during continuous coring of thick sedimentary sections, alternate sections or selected sections were unopened.

In rare instances the plastic liner was not used and the core was extruded from the core barrel into a holder. In such cases the core was described and smear slides were made, but physical properties were not measured, except that sonic velocity measurements were made of all lithified core pieces.

Hard core pieces, limestone and chert, were washed, numbered consecutively from top down, and each piece was marked with an arrow to show the top.

Following the processing, description and sampling, each half of the core section was sealed in a plastic D-tube and placed in cold storage. All samples are now deposited at the core laboratory of the Deep Sea Drilling Project, Scripps Institution of Oceanography, La Jolla, California.

Drilling Disturbances

Only a small part of the sediments were lithified enough so that the core was a cut core rather than being an intruded or "stamped" core; therefore, most cores were disturbed to the extent that they contained diapirs or swirls, although the material in general preserved proper stratigraphic sequence. A small proportion of the cores was badly disturbed or contained much contaminating material or "Core" from above. Such cores are usually obvious upon inspection, and are so described in the core summaries in Part II of this volume. Scientists investigating samples of the cores should be alert to the possibility that contaminating material may be present in cores between relatively undisturbed sections.

Physical Properties

In each of the site reports, Chapters 3-10, the following physical properties of the cored sediments are shown plotted on hole-summary and core-summary depth scales: bulk density, porosity, grain-matrix density, sonic velocity, sonic impedance, and natural gamma radiation. Penetrometer readings are presented only on hole-summary scale. Plots of sonic velocity versus porosity for three ranges of calcium carbonate ($CaCO_3$) content (0 to 35 per cent, 36 to 64 per cent and 65 to 100 per cent) are also shown for each site. (At some sites no data fell in one or two of the calcium carbonate ($CaCO_3$) ranges and no plots are shown for these ranges.)

In Chapter 2, smoothed plots versus depth of natural gamma radiation, sonic velocity, sonic impedance, and penetrometer are presented for comparison among the sites. Also presented are plots of sonic velocity versus porosity in each calcium carbonate ($CaCO_3$) range for all sites combined. Results of velocity and density measurements on indurated sediments and igneous rock are also summarized in Chapter 2.

Results of thermal conductivity measurements are given in the Heat Flow Report, Chapter 18.

Methods of laboratory measurement of physical properties were essentially the same as those described in Volume III of this series. The reader is directed to that volume for details not presented here.

Lithologic Descriptions

A simplified terminology for describing the cores was adapted to the almost wholly biogenic sediments encountered which were chiefly mixtures of siliceous (Radiolaria; accessory diatoms) and calcareous (nannofossils, accessory foraminifera) components.

Terms	Explanation
Nannofossil ooze	Consists dominantly of calcareous nannofossils ($CaCO_3$ estimated $>$ 80 per cent)
Radiolarian-nannofossil ooze	Dominantly calcareous nannofossils ($CaCO_3$ 50 to 80 per cent). Radiolarians subordinate but generally $>$ 20 per cent.
Nannofossil-radiolarian ooze	Radiolarians dominant, nannofossils subordinate ($CaCO_3$ 20 to 50 per cent)
Radiolarian ooze	Radiolarians dominant ($CaCO_3$ 0 to 20 per cent).

If foraminifera or diatoms are significant accessories they may be indicated in the name; for example, foraminiferal-radiolarian-nannofossil ooze; diatom nannofossil ooze.

Basis for Age Determinations

During Leg 8 complete sections of Oligocene through Quaternary sediments were obtained that contain planktonic foraminifera, calcareous nannoplankton and Radiolaria. The co-occurrences of these fossils enabled us to relate biostratigraphic zonations based on different groups of organisms to one another. These relationships are shown in Figure 2.

Detailed information on the fossils from each site is included in the site reports (Part II, this volume), and reports on the Paleontology of the Foraminifera by J. P. Beckmann (Chapter 2), nannofossils by B. Haq and J. Lipps (Chapter 13) and Radiolaria by T. Moore (Chapter 12) are included in Part III, Special Reports.

The interrelations of the three biostratigraphic schemes vary from hole to hole, as shown in Figure 3. In general, the most detailed zonation was possible through calcareous nannoplankton, although these fossils are also most subject to reworking and contamination by drilling. Unless such contamination was obvious, the samples were assigned to zones by means of the total contained flora. Selective solution and possible mixing of larger microfossils caused difficulty in relating the zonations and account for the variation between zonations in each hole. We believe that the relationships shown in Figure 2 are reliable.

We have subdivided the Cenozoic rocks encountered during Leg 8 into nine age units, as follows:

Quaternary
Pliocene
Upper Miocene
Middle Miocene
Lower Miocene
Upper Oligocene
Lower Oligocene
Upper Eocene
Middle Eocene

The boundaries between each of these units in terms of planktonic foraminiferal biostratigraphic zones are in close agreement with the placement of boundaries recommended by the Deep Sea Drilling Project advisory panel on biostratigraphy (see Appendix 1, Time-Stratigraphic Framework, in Volumes I through VI). We have extended these age assignments to the calcareous nannoplankton and radiolarian zonations.

Tertiary-Quaternary boundary: The boundary is placed at the base of planktonic foraminiferal Zone N. 22 (Banner and Blow, 1965) (*Globorotalia truncatulinoides* Zone as used in this report). The boundary is equivalent to the base of the *Pseudoemilia lacunosa*

AGE	Boundary (m.y.)	PLANKTONIC FORAMINIFERA		CALCAREOUS NANNOPLANKTON	RADIOLARIA
Quaternary				*Emiliania huxleyi*	
		Globorotalia truncatulinoides	N 22-23	*Gephyrocapsa oceanica*	*unzoned*
	2			*Pseudoemilia lacunosa*	
Pliocene			N 21	*Discoaster brouweri*	*Pterocanium prismatium*
				Discoaster pentaradiatus	
				Discoaster surculus	
			N 20	*Reticulofenestra pseudoumbilica*	*Spongaster pentas*
			N 19	*Discoaster asymmetricus*	
	5			*Ceratolithus rugosus*	
Upper Miocene			N 18	*Ceratolithus tricorniculatus*	*Stichocorys peregrina*
			N16-17	*Discoaster quinqueramus*	*Ommatartus penultimus*
	10.5	*Globorotalia menardii*	N 15	*Discoaster calcaris*	*Ommatartus antepenultimus*
Middle Miocene		*Globorotalia mayeri*	N 14	*Discoaster hamatus*	*Cannartus petterssoni*
				Catinaster coalitus	
		Globorotalia fohsi robusta	N 13		
		Globorotalia fohsi lobata	N 12	*Discoaster kugleri*	*Cannartus laticonus*
		Globorotalia fohsi praefohsi	N 11	*Discoaster exilis*	
		Globorotalia fohsi peripheroacuta	N 10	*Sphenolithus heteromorphus*	*Dorcadospyris alata*
	14	*Globorotalia fohsi peripheroronda*	N 9		
Lower Miocene			N 8		
			N 7	*Helicopontosphaera ampliaperta*	*Calocycletta costata*
		{*Catapsydrax stainforthi* / *Catapsydrax dissimilis*}	N 5-6	*Sphenolithus belemnos*	*Calocycletta virginis*
				Discoaster druggi	
	22.5	*Globorotalia kugleri*	N 4	*Triquetrorhabdulus carinatus*	*Lychnocanium bipes*
Upper Oligocene		*Globigerina ciperoensis*	P 22	*Sphenolithus ciperoensis*	*Dorcadospyris papilio*
	31	*Globorotalia opima opima*	P 21	*Sphenolithus distentus*	*Theocyrtis annosa*
Lower Oligocene		*Globigerina ampliapertura*	P 20	*Sphenolithus predistentus*	*Theocyrtis tuberosa*
	36	*Pseudohastigerina micra* — *Cassigerinella chipolensis*	P 18-19	*Discoaster tani ornatus*	

Figure 2. *Biostratigraphic zones for planktonic foraminifera, calcareous nannoplankton, and Radiolaria, used for this report. Radiometric ages at the base of each age unit, in millions of years, are from Berggren (1969b, Table 5, Column 4).*

Zone (calcareous nannoplankton) and possibly slightly higher than the top of the *Pterocanium prismatium* radiolarian zone.

Miocene-Pliocene boundary: This boundary falls at or a little below the top of foraminiferal Zone N. 18 (Berggren, 1969a). The boundary corresponds to the top of the *Ceratolithus tricorniculatus* nannoplankton zone and lies near the base of the *Spongaster pentas* radiolarian zone.

Middle Miocene-Upper Miocene boundary: This boundary appears to lie at about the middle of Zone N. 15 (*Globorotalia menardii* Zone) (Berggren, 1969a), and it corresponds to the base of the *Discoaster calcaris* nannoplankton zone and approximately to the base of the *Ommatartus antepenultimus* radiolarian zone.

Lower Miocene-Middle Miocene boundary: The boundary lies at the base of foraminiferal Zone N. 9, within the lower part of the *Sphenolithus heteromorphus* nannoplankton zone and within the lower part of the *Dorcadospyris alata* radiolarian zone.

Oligocene-Miocene boundary: Following the recommendation of the Neogene Stratigraphic Committee (Bologna, 1967), this boundary is set at the base of foraminiferal Zone N. 4 and corresponds with the *Globigerinoides* datum. This is approximately equivalent to the base of the Aquitanian Stage (Berggren, 1969a). The boundary falls within the middle part of the *Triquetrorhabdulus carinatus* nannoplankton zone and apparently within the top part of the *Lychnocanium bipes* radiolarian zone.

Lower Oligocene-Upper Oligocene boundary: We have placed this boundary within the *Globigerina ampliapertura* (P. 20) foraminiferal zone, and in the upper part of the *Theocyrtis tuberosa* radiolarian zone.

Eocene-Oligocene boundary: The Eocene-Oligocene boundary is commonly placed between foraminiferal Zones P. 17 and P. 18 (Berggren, 1969a), at the base of the *Ellipsolithus subdistichus* nannoplankton zone (Roth and Hay, in Hay *et al.*, 1967) which is approximately equivalent to our *Discoaster tani ornatus* Zone, and at the base of the *Theocyrtis tuberosa* radiolarian zone as recognized herein. In the equatorial east Pacific, calcareous fossils are either poorly preserved or absent from the sediments at and near the Eocene-Oligocene boundary. We recognized this boundary on the basis of changes in the radiolarian faunas, changes in lithology, and on the presence of characteristically Eocene benthonic foraminifera (*Nuttallides truempyi, Alabamina dissonata* and *Spiroplectammina trinitatensis*).

Middle Eocene-Upper Eocene boundary: This boundary is placed at the base of foraminiferal Zone P. 15 (Berggren, 1969a), and at the top of the *Podocyrtis chalara* radiolarian zone as recognized herein.

In order to derive the graphic interpretations of the rates of sedimentation at each site (Part II, this volume), we have used the revised radioactive ages assigned to the planktonic foraminiferal zones by Berggren (1969b; Table 3, Column 4).

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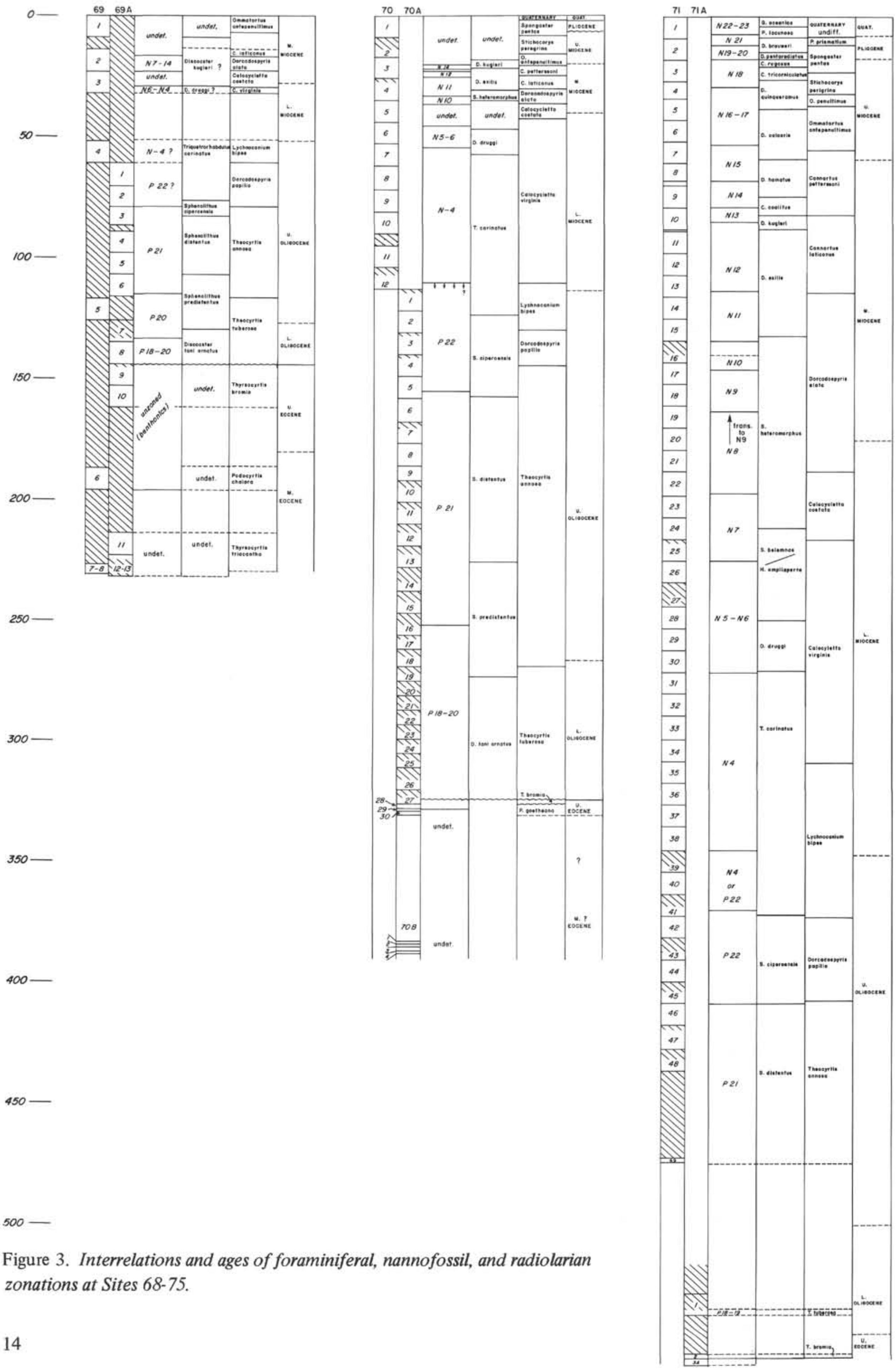

Figure 3. *Interrelations and ages of foraminiferal, nannofossil, and radiolarian zonations at Sites 68-75.*

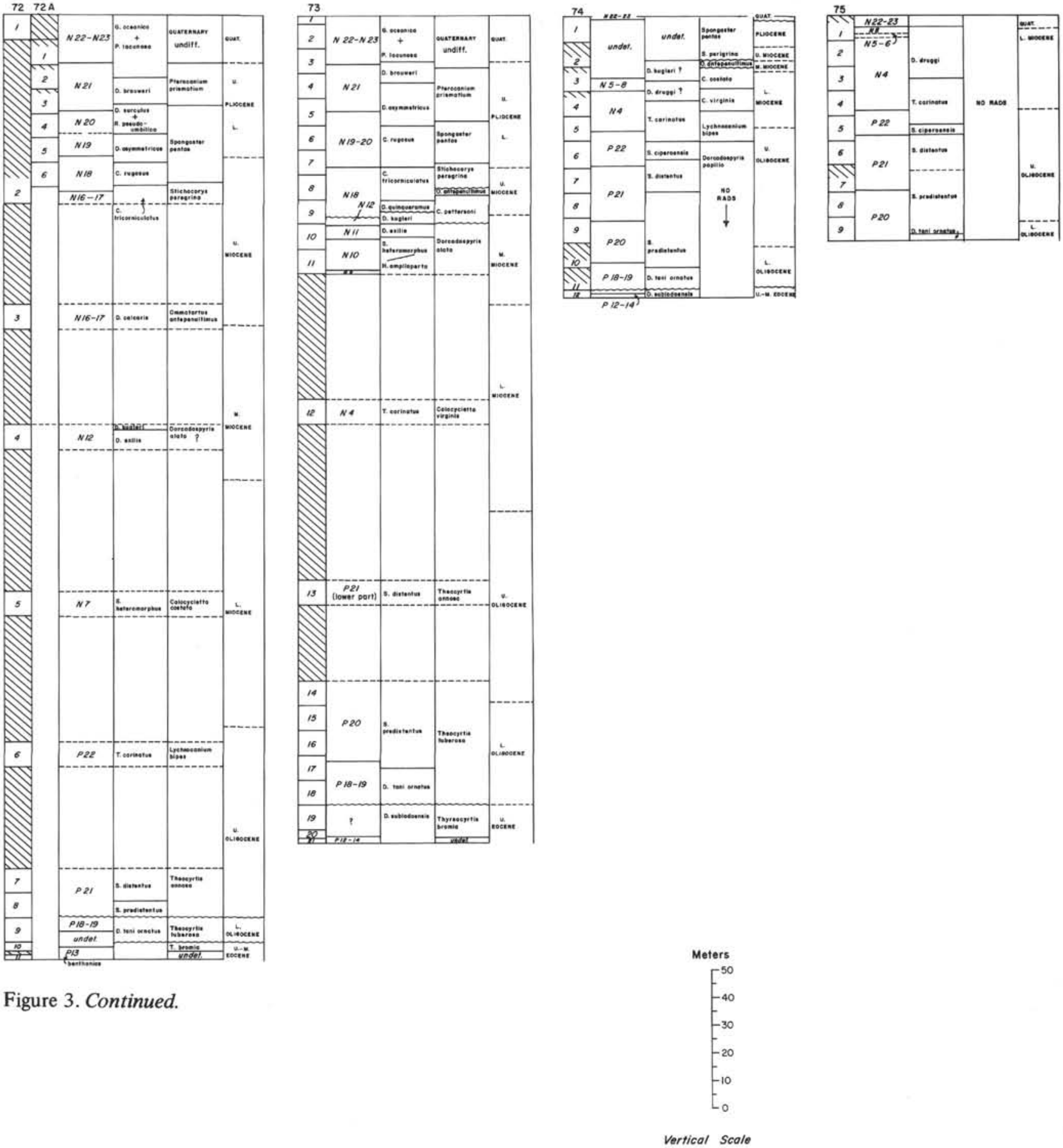

Figure 3. *Continued.*