The Shipboard Scientific Party¹

SITE DATA

Position:

Latitude: 08°10.7'N Longitude: 164°51.6'W.

Geography: On sediment apron west of Line Island chain, about 300 km NW of Kingman Reef.

Water Depth:

PDR, to derrick floor: 5040 meters From drill pipe measurement from derrick floor: 5053 meters (adopted).

Date Occupied: 12-16 Apr 71.

Time On Location: 90 hours.

Depth of Maximum Penetration: 490 meters.

Cores Taken: 29.

Total Length of Cored Section: 385 meters.

Total Recovery:

Length: 139.4 meters Percentage: 36.

Percentage of Penetrated Section Cored: 76.

Principal Results: The stratigraphic column at Site 165, just 50 km from an unnamed guyot in the Line Island chain, is made up of about 240 meters of Eocene to lower Miocene calcareous turbidites interbedded with radiolarian ooze, 50 meters of Eocene and Upper Cretaceous interbedded chert and limestone, 140 meters of Upper Cretaceous volcanogenic turbidites, and 50 meters of alternating basalt flows and volcanogenic sediments resting on basalt. The oldest sediments cored are Late Cretaceous (probably Santonian or Campanian) in age. The results suggest that the Line Island seamount chain is somewhat younger than its surroundings as predicted by a westward extrapolation of crustal ages from the magnetic anomaly patterns and drilling results from the eastern Pacific. (See Figure 1.)

BACKGROUND AND OBJECTIVES

The previous holes drilled to basement in the Clipperton-Clarion block (van Andel et al., 1971) had indicated that the westward increase in crustal age in the region of the



Line Islands follows approximately the pattern predicted by extending the Cenozoic spreading rate into the late Mesozoic. However, the paucity of fossils (particularly calcareous) in the older material caused some uncertainty in dating, and another hole near the Line Islands was needed. The seismic profiler section at the site selected (Figures 2a and 2b) indicated the presence of ponded turbidites, presumably derived from the islands, and it was considered likely that sampling these deposits might lead to significant knowledge of the history of the islands and their place in the tectonic development of the region.

A further objective was to sample and date three prominent sedimentary interfaces that can be traced over large distances in the seismic profiler records. One of these, approximately at mid-depth in the sediment, appeared to be the same reflector (called A' by Ewing et al., 1968) that corresponded to Early Tertiary, or possibly to a Late Cretaceous-Early Tertiary hiatus at other drilling sites in the Pacific.

OPERATIONS

The proposed site was approached from NNE along a line running near two R/V *Conrad* tracks (Figure 3). When the desired pattern of reflectors was observed on the profiler record, the course was reversed, the ship was slowed to about 6 knots, and the beacon was dropped underway. This course was maintained for a few miles, reversed again, and the streamers were retrieved by the time the ship had arrived back at the beacon.

The first attempt to touch down was made at 0320 hours on 13 Apr 71. Because of uncertainty about the depth at which bottom had been reached at Site 164, an extra precaution was taken to retain soft sediments in the core barrel on the first two attempts to core. A soft cloth sleeve was added to the regular plastic one in the belief that

¹Edward L. Winterer, Scripps Institution of Oceanography, La Jolla, California; John I. Ewing, Lamont-Doherty Geological Observatory of Columbia University, Palisades, New York; Robert G. Douglas, Case Western Reserve University, Cleveland, Ohio; Richard D. Jarrard, Scripps Institution of Oceanography, La Jolla, California; Yves Lancelot, Universite de Paris, Paris, France; Ralph M. Moberly, University of Hawaii, Honolulu, Hawaii; T. C. Moore, Jr., Oregon State University, Corvallis, Oregon; Peter H. Roth, Scripps Institution of Oceanography, La Jolla, California; Seymour O. Schlanger, University of California at Riverside, Riverside, California.



Figure 1. Graphic log showing lithology, age, and rate of accumulation of sediments at Site 165.



Figure 2a. Seismic profile recorded by Glomar Challenger approaching Site 165.

6.0-7.0-7.0-10 KTS

Figure 2b. Seismic profile recorded by Glomar Challenger leaving Site 165.

even if the upper sediments were unusually watery, some would be caught in the mesh of the cloth.

Even with this precaution no sediment was recovered in the first attempt to core although the bit was lowered to a depth 4 meters below the calculated depth based on PDR sounding corrected by Matthews' Tables. On the second try, the bit was lowered an additional 14 meters and a 5-meter section of core was recovered. Thus, the topmost sediment was apparently about 14 meters below the calculated depth.

A second punched core between 5 and 14 meters was taken, and, because the cloth sleeve had become detached from the core catcher and moved up, jamming the check valve, the core was not full length and was suspected of not properly representing the sediments of this interval. Therefore, a new hole number, 165A, was designated and the 5 to 14 meter interval was repeated in Core 1A.

Hole 165A was spot-cored to a depth of 242 meters where hard cherts were encountered. From that depth downward, hard and soft layers were interbedded and posed the usual problem of recovery. For this reason, a procedure was adopted that combined good progress in penetration with obtaining at least some sample of the section by drilling up to 28 meters, with substantial pump pressure, before retrieving the core barrel. During these drilled-cored intervals, the pump pressure was reduced to the minimum permissible for the last few meters so that some soft material might be retained. Even so, only rarely was a substantial amount of soft sediment recovered from the deeper part of the hole.

At least two thin layers of basalt were penetrated in the region between 424 and 470 meters. At the latter depth

massive basalt was encountered and was cored to a total depth of 490 meters with no indication of any more soft layers. The hole was abandoned at this depth.

Two passes over the site were made after the drill string was retrieved, but the beacon was barely detected on the first pass and could not be detected on the second. The passes were made at a speed of 8 knots; apparently this produces too much flow noise at the hydrophones. Having dropped the beacon initially while profiling, it was not deemed worthwhile to spend the additional time for a slow-speed pass to get more seismic data.

BIOSTRATIGRAPHIC SUMMARY

The section cored at Site 165 consists generally of early Tertiary nannofossil-radiolarian ooze with turbidite layers and Upper Cretaceous calcareous turbidites and volcanic sediments resting upon basalt. All cores described below are from Hole 165A.

The Oligocene oozes recovered (Cores 1 to 7) contain common nannoplankton, generally sparce foraminifera, and common, moderately well preserved radiolarians. Reworked Upper Cretaceous, Paleocene, and Eocene foraminifera and reworked Eocene Radiolaria occur throughout the Oligocene part of the section.

Cores 1 to 3 belong to the upper Oligocene and Cores 4 through 7 to the lower Oligocene, based on foraminifera, nannofossils, and radiolarians. Transported large miliolids indicative of an inner neritic environment occur in Cores 2 and 3, associated with large foraminifera (*Astrocyclina, Discocyclina*) and molluscan and echinoid fragments. Numerous small well-preserved benthonic foraminifera indicative of a lower bathyal environment occur in Cores 2





Figure 3. Tracks of Glomar Challenger and R. D. Conrad in the vicinity of Site 165. Bathymetric contours in uncorrected fathoms.

and 3. They are found in smaller numbers throughout the cored section. Core 3 also contains numerous ostracods. In Cores 4 to 7 Cretaceous heterohelicids are admixed with *Chiloguembelina* and small globigerinas in size-sorted assemblages. The skewed size distribution of the radiolarian assemblages in several cores also suggests that much of the "pelagic" sediment at this site has been strongly affected by bottom currents. Diatoms are very abundant in Core 1 and in Cores 6 and 7.

A reduced upper Eocene section was recovered in the lower part of Core 7 and uppermost part of Core 8. The Oligocene-Eocene boundary lies in Section 5 of Core 7, the upper to middle Eocene boundary is in Core 8 or 9. Cores 9 through 14 belong to the middle Eocene and contain abundant and well-preserved radiolarians and common, slightly etched and recrystallized nannoplankton. Planktonic foraminifera are missing from that interval.

Core 15 yielded a lower Eocene radiolarian assemblage. The boundary between the middle and lower Eocene lies between Cores 14 and 15. Core 16 recovered Upper Maastrichtian planktonic foraminifera and nannoplankton. Poorly preserved planktonic foraminifera in Cores 17 and 18 indicate an early Maastrichtian to late Campanian age. Cores 19 and 20 contain sparce planktonic foraminifera and nannoplankton indicating a middle to early Campanian age. Cores 21 and 25 recovered rare nannofossils indicative of the early Campanian, but Cores 22 to 24 lack nannoplankton completely. Rare and poorly preserved Upper Cretaceous radiolarians occur in Cores 15, 17, 18, 20, 21, 22, and 25.

Indications of winnowing, size sorting, reworking, and transporation are numerous throughout the cored section. Table 1 summarizes the data on reworked and transported benthonic foraminifera.

A plot of depth drilled versus age of the sediments (Figure 1) gives the following sediment accumulation rates: 10 m/m.y. for the Oligocene; 18 m/m.y. for the middle Eocene, and 9 m/m.y. for the Upper Cretaceous.

LITHOLOGIC SUMMARY

The section penetrated at this site can be divided into four lithologic units.

1) Unconsolidated nannofossil and foraminiferal chalk oozes and radiolarian oozes. These are represented by Cores 1 and 2, 1A through 13A, and part of 14A. This represents the interval between 0 and 240 meters.

2) Chert and limestone. The first chert occurred in the core catcher of Core 14A. Cores 15 through 17 had poor recovery. The rocks recovered were fragments in core catchers and a few centimeters of mixed sediment in Core 17A. The section between 240 and 290 meters is this second unit.

3) Volcanoclastic siltstones, mudstones, sandstones, and conglomerates interbedded with marly, laminated, micritic, nannofossil-bearing limestone, containing streaks and laminae of volcanic sand and silt. These were recovered in Cores 18A through 22A (290 to 424 m).

4) Basalt and volcanoclastic siltstone, mudstone, sandstone, and breccia were recovered in Cores 23A through 27A (424 to 490 m).

Unconsolidated Oozes

The upper 140 meters is characterized by distinct sedimentation units that range in thickness from centimeters to meters. At the base of each unit is a streak a few millimeters thick of dark fine to medium sand-size mineral grains. These streaks are made up of pyroxene, plagioclase, palagonite, zeolites (phillipsite?), light and dark brown vesicular glass shards, and very rare quartz grains. The zeolites are largely isolated rosettes formed by euhedrally terminating sheaves and clusters of crystals up to 120 microns long by 10 to 20 microns wide. Some of these crystal clusters are attached to substrates giving the appearance that the crystals grew into cavities of which the substrate fragments are the only remaining trace. Others are interlocking sheaves, radial in geometry, that originated from several centers of crystal growth. Pyroxenes are present both as angular fragments of individual crystals and as euhedral, doubly terminating crystals up to 0.4 mm long. Some of these show pleochroic colors suggestive of titanaugite. Some pyroxenes are represented by elongate, very pale green, non-pleochroic grains up to 0.5 mm in length that show very well-developed hacksaw terminations; a few crystals are entirely made up of a sheaf-like bundle of perfectly terminated crystal faces (Figure 4). Such hacksaw terminations are generally attributed to intrastratal solution effects (Pettijohn 1957, p. 674). Erickson et al. (1961) have described "spiny" pyroxene crystals from deep-sea cores of Pleistocene and Miocene age taken near the Bermuda Rise. The plagioclase fragments are angular, as are the rare quartz grains and the glass fragments.

Above this dark mineral streak, the sediments are generally white, gray, very pale brown, and very pale orange nannofossil and foraminiferal-nannofossil chalk oozes. An important component of these oozes is acicular to platy nannofossil-size calcite fragments. Manganese micronodules are locally abundant. Above the chalk oozes is a final upper layer of nannofossil-bearing to pure radiolarian ooze, moderate to pale brown or gray in color. The above description is generalized and represents an idealized sedimentary unit. In most of these cores the original bedding has been highly disturbed and the sediments have been mixed. In many cyclic units the chalk and radiolarian oozes are themselves interbedded without an intervening dark mineral layer. The radiolarian oozes are commonly burrowed and mottled. In general, within units that are thicker than one meter, the uppermost layers are pure radiolarian ooze. Of particular interest in this lithologic unit is the presence of coarse bioclastic debris of shallow-water origin and fragments of drusy calcite found in Cores 2A and 3A. Core Catcher 3A contained coarse sand to granule-size skeletal debris and both volcanic and limestone rock fragments. The skeletal material is made up of echinoid spine fragments, tests of large benthonic foraminifera, bryozoans, molluscs, and rare Halimeda. These fossils are worn and highly abraded and have a blank white chalky appearance. One of the large forams is partially coated by a coarse calcite cement. The limestones are very fine grained. Worn and abraded clumps of coarse translucent calcite aggregates are common; some of these show euhedrally terminating crystals typical of drusy cements. The volcanic

TABLE 1 Summary of Reworked and Transported Benthonic Foraminifera – Hole 165A

	Core	Age	Benthonic and Reworked Fossils	Paleobathymetry
		L. Miocene	Sparse benthic assemblages-	? bathyal
	1	Upper	all smaller foraminifers	-
	-	Oligocene	and M. Eocene pelagics	
	_2	(P.22)	Common to abundant ben- thics, ostracods numerous-	Shallow water M-U Eocene
	3	(P.21)	larger foraminiferas (Discocyclina and Astro-	bathyal
			Bryozoan and molluscan fragments-echinoid spines.	pelagic
			Reworked Maastrichtian, Paleocene, L., M., and U. Eocene pelagics-increasing amounts through 2 and 3.	Maastrichtian Paleocene
	4	Lower Oligocene (P.20)	Reworked Eocene-Oligocene pelagics; small chiloquembe- lina and Globigerina-size sorted. Rare benthic species, no	
100			ostracods.	
100)	a.		
	6	Oligocene/ Eocene	Rare benthic species. Rare pelagic species; size sorted, none $>125\mu$.	? bathyal
	8		Barren	
	9		Rare benthic species, mostly agglutinated types	
			No pelagic species.	
				
200	10			
			Essentially barren, rare speci-	
	11		foraminifera; mostly	
	12	Eocene	aggratimated types	
	13	(according to radiolar-		
	14	ians and nannofossils		
	15			
	16	Upper Maastrich- tian	Rare benthic species-	? bathyal
	17	L. Maas- trichtian/ U. Cam-	Sparse pelagic species- larger species missing.	Shallow water Campanian-
200		paman	luscan fragments larger	Maastrichtian
300	18	(Barren)	foraminifera ? <i>Pseudorbitoids</i> (chalky or recrystallized)	
			Rare pelagic species.	
	-		Barren	
	19	U. Cam- panian	Rare pelagic species, no benthic species	

TABLE 1 – Continued



rocks are subrounded to well-rounded granule size fragments of: (a) highly vesicular basalt showing weathered pyroxene (?) phenocrysts in an aphanitic brown groundmass, and (b) soft, easily crushed, light yellow green clay aggregates.

The presence of coarse-grained calcite cement fragments and the shallow-water bioclastic elements of reefal affinities indicates that an emergent limestone island contributed second cycle carbonate detritus to turbidite flows. The well-rounded and weathered volcanic rock fragments suggest that the paleogeography of this island included volcanic terranes. The large benthonic foraminifera are Asterocyclina and forms referred to Discocyclina (see section on biostratigraphy). Such forms are also present in Core 3A from this site. Reworked planktonic and benthonic small foraminifera are relatively abundant in cores from this lithologic unit including large miliolids characteristic of inner neritic depths. Species of these reworked forms are indicative of Upper Cretaceous, Paleocene, and middle and lower Eocene strata. It is evident that rocks and sediments representing a considerable stratigraphic section were contributing material to these turbidites of Oligocene age in the Line Islands area.

This occurrence of shallow-water turbidite debris is similar to one reported at Site 58 (Fischer, Heezen et al., 1971) on the north flank of the Caroline Ridge, where shallow-water skeletal debris and recrystallized limestone fragments of late Oligocene to Miocene age were found in early Pliocene to Miocene sediments, and at Site 76 (Hays et al., 1972) north of the Tuamotu Ridge, where similar



Figure 4. Pyroxene crystal (165A-1-3). Etched crystal of pyroxene from base of "turbidite" bed in the upper ooze sequence. Almost all of the pyroxene crystals in these basal volcanic-rich laminae show "hacksaw" terminations.

material of Paleocene to Pleistocene ages was found in a lower Pliocene to Pleistocene section.

Chert and Limestone

This lithologic unit is represented by fragments of rock recovered in four core catcher samples and 50 cm of mixed, watery sediment recovered in Core 17A. The top of the unit is marked by the first appearance of chert at this site; these highest chert beds give rise to a strong reflector on the profiler records. The base of the unit is less well defined and may be gradational down into the underlying unit that is rich in volcanoclastic debris and lacking in chert.

The chert fragments recovered are dense, conchoidally fractured, and moderate red brown to light brown in color. Chalcedony, opal, and both rhombic (dolomite ?) and irregular grains of carbonate were noted in thin section. Ghosts of radiolarians are also present. The limestones are present as: (a) laminated micritic marls; (b) white, very fine-grained limestone containing thin laminae of dark volcanic minerals; (c) nannofossil-bearing micritic limestone; and (d) coarse-grained fossiliferous, calcite-cemented limestone. Some of the fragments of this fourth type are made up largely of bioclastic skeletal debris of shallowwater origin (Figure 5). Echinoid, mollusc, and foraminiferal fragments form an intact framework of grains firmly cemented by coarse-grained mosaics of calcite. This cement is largely optically continuous overgrowths on echinoid spines and ossicles. The foraminifera include very worn and rounded fragments of large benthonic types tentatively identified as Pseudoorbitoides, tests of small planktonic foraminifera, and worn and broken tests of small thickwalled benthonic types. Porosity is virtually nil due to the pervasive calcite cement. The skeletal debris is moderately

well sorted. Volcanic material is present as subangular to rounded fragments of basalt showing relic intersertal and hyaloophitic textures; closely packed plagioclase laths are prominent in highly altered groundmasses that show traces of pyroxene, opaque minerals, and clay minerals. Angular fragments of pyroxene, plagioclase, and palagonite are present in trace amounts. The volcanic rock fragments are sand size ranging up to 0.5 mm in diameter. The bioclastic debris ranges from 0.1 to 1.0 mm in diameter. It appears that the volcanic fragments have been sorted along with the skeletal pieces. Other fragments of this fourth limestone type (Figures 6 and 7) are composed of very abraded and broken pieces of large benthonic foraminifera (Pseudoorbitoides?), bryozoans, small thick-walled foraminifera, echinoids, and mollusc shells in a micritic "mud" matrix. The individual fossil fragments are highly recrystallized. Volcanic material similar to that described above is present. In one piece of rock studied grading is evident. At one end of the specimen (4 cm in length) the coarse bioclastic debris, up to 1.5 mm in diameter, is closely packed and shows a parallel orientation. Towards the other end of the piece the bioclastic debris is much finer grained, the mud matrix is more abundant, and tests of planktonic foraminifers are abundant. These coarse-grained limestones are similar in faunal content and texture to limestones from the fore-reef and fore-reef transitional facies from many parts of the world (Henson, 1950; Forman and Schlanger, 1957; and Schlanger, 1964). Their presence in Core 16A indicates that reef conditions existed in the Line Islands region during early Maestrichtian time. On Guam (Schlanger, 1964) similar limestones formed on the flanks of a volcano that was at or near sea level; the volcanic material in the limestones from Core 16A is also similar in texture to the volcanics in the Miocene Maemong Limestone from Guam.



Figure 5. Echinoid biosparite of Cretaceous age (165A-16,CC). Echinoid fragments, volcanic rock fragments, and tests of planktonic foraminifera in a coarse-grained calcite mosaic.



Figure 6. Foraminiferal biomicrite of Cretaceous age (165A-16, CC). Base (?) of a graded rock fragment. Large foraminifera, broken and abraded, echinoid, molluscan, and bryozoan debris in a mud matrix.



Figure 7. Top (?) of graded rock fragment (165A-16, CC). A few centimeters from the rock shown in Figure 6. Bioclastic debris is finer grained and tests of planktonic foraminifera are common.

Volcanic Sediments and Limestone

The 16.5 meters of rock recovered in Cores 18A through 22A are of two basic types: (1) volcanoclastic mudstones, siltstones, sandstones, and conglomerates; and (2) nannofossil-bearing marls and micritic limestone. These two types are interbedded and each shows complex sedimentary structures; a series of close-up core photographs illustrate the characteristic sedimentary structures (Figures 8, 9, 10, 11, 12, and 13). In general, the carbonate-rich pieces of core tended to be separate from the volcanic-rich pieces, probably due to breakage and wearing down along bedding planes and contacts during drilling operations. However, enough pieces containing contacts between the two rock types were recovered to decipher the nature of the cyclic sedimentation characteristic of this lithologic unit. A typical cycle consists of a basal bed of marly and micritic limestone, gray, very pale brown, or grayish brown in color, showing disturbed laminations and well-developed burrow and bioturbation structures. These are distorted and locally partially flattened due to compaction. Overlying these carbonates, with relatively sharp contacts are currentlaminated, locally crossbedded and graded deposits of volcanic sediments, dark greenish gray, grayish brown, olive gray, and olive black in color. A thin section across such a contact shows the underlying limestone to be a dense micrite with only small ellipsoidal cavities up to 60 microns across breaking the monotony; these may represent former fossils now removed by diagenetic processes. The contact with the overlying volcanic lamina is sharp, although on a macroscopic scale small irregular channels exist at the contact, and blebs and streaks of volcanic sand are imbedded in the limestone within a few millimeters of the

contact. This indicates erosion and disturbance of the originally soupy carbonate as the volcanics were emplaced. Above the contact the sediment is a volcanic sandstone containing angular to subrounded pyroxene grains 70 to 400 microns in diameter, subrounded fragments of finegrained, plagioclase-rich basalt, brown palagonite, glass fragments, and clays. Irregular patches of calcite cement are common, as are zeolitic cements. At the top of this lamina is a thin, clay-rich film; this is overlain by a series of laminae that are admixtures of the micrite and volcanic grains and rock fragments-the micrite forming the matrix of the rock. Petrographic examination of typical sandstones in the volcanic sequences show them to be well sorted, medium to coarse grained and made up of altered to relatively fresh basalt grains, highly vesicular palagonite, pyroxene, brown glass, and plagioclase. These clastic elements are cemented by green brown montmorillonite; locally, sparry calcite is abundant as well as sheaves and clusters of zeolitic cement. Fossil debris in the form of whole and broken tests of small planktonic foraminifera is present.

In Core 20A a single bed of volcanic conglomerate 270 cm thick underlies laminated, dark greenish gray, coarsegrained volcanic sandstone at 130 cm in Section 1. It extends to 103 cm in Section 3, where a void separates it from underlying burrowed yellowish gray marly limestone. The conglomerate bed is crudely bedded; the average clast size at the base of the bed is approximately 6 mm and at the top approximately 2 mm, although clasts up to 2 cm in diameter occur throughout the bed. The clasts are angular to rounded and variegated shades of pale green, dark green, dark brown, reddish brown, black, and gray. The matrix is



Figure 8. Section 18-3, 128 to 149 cm. Turbidite sequences in volcanic sandstones and clay-rich siltstones. Crossbedded volcanic sandstones at the base of the section (143-149 cm) grade up into finely laminated, burrowed clay-rich silts and carbonate-rich blebs. Between 132 and 133 cm the base of an overlying turbidite sequence begins with crossbedded volcanic sandstones and siltstones.



Figure 9. Section 19-2, 58 to 75 cm. Hard, well-cemented volcanic sandstones and siltstones with well-developed current laminations.



Figure 10. Section 20-2, 128 to 144 cm. Volcanic conglomerate.



Figure 11. Section 20-3, 131 to 140 cm. Marly, micritic limestone, yellowish gray to light olive gray. Distortion of original lamination well displayed.



Figure 12. Section 21-2, 28 to 47 cm. At 45 cm is a sharp contact between dense micritic limestone and laminated volcanic sandstone. Upwards from this contact the laminae become thinner, fainter, and less volcanic in composition. Between 30 and 35 cm is another contact showing the relationship between the basal unit of burrowed limestone and the overlying turbidite of volcanic debris.



Figure 13. Section 21-2, 86 to 96 cm. The lower part of this piece is burrowed gray limestone. At 90 cm irregular laminae of volcanic sand predominate and above this the sediment is severely burrowed marly limestone. The isolated masses of volcanic sand between 90 and 91 cm represent cross sections of burrows. Evidently organisms survived the influx of volcanic turbidite sands and mixed these with the underlying marls.

clay-rich, very fine grained, and light olive gray in color. The clasts are vesicular glass, montmorillonite-rich aggregates, reworked volcanic siltstones and sandstones, and fine-grained and vesicular basalt; rare fragments of limestone are present.

These volcanic sediments and limestone represent a turbidite sequence in which the volcanic material was carried down by turbidity currents into a realm of pelagic sedimentation. The volcanics were probably derived from nearby volcanoclastic and hyaloclastic mounds that extended into shallow water. The carbonate beds represent periods of non-turbidite deposition during which burrowing organisms modified the sediment. However, the highly micritic nature of many of these limestones and marls suggests that much of the carbonate component may itself be of turbidite origin.

Basalt and Volcanoclastic Sediments

Cores 23A through 27A are considered to represent one major lithologic unit, because the first basalt encountered was at 425 meters in Section 1 of Core 23A. Sediments do occur between this uppermost basalt and the first massive basalts in Core 26A, so that one might consider two definable lithologic units, an upper basalt and volcanic sediment unit and a lower massive basalt unit. For the purposes of this summary, however, the section from 425 meters to the bottom of the hole at 490 meters is considered a single major lithologic unit.

The basalts in Core 23A were fragments and the stratigraphic relationships of the basalt to the overlying sediments is unknown. Likewise no definite contact was seen between the basalt fragments and the directly underlying rocks which were also recovered as fragments. These upper dark gray basalts are alkalic, fine grained, and porphyritic to glomeroporphyritic in texture. They contain plagioclase and brown hornblende phenocrysts up to 0.6 mm long and display an intersertal texture in thin section.

Vesicles rimmed with chlorite up to 1 mm in diameter but averaging about 0.25 mm are common. Montmorillonite pseudomorphs after olivine are present in some of the glomeroporphyritic masses. Section 2 of Core 23A contains a wide variety of volcanic mudstones, siltstones, sandstones, and breccias. These include reddish brown massive siltstone containing silicified radiolarian remains, brownish gray mudstones displaying sedimentary slump structures, grayish white and grayish olive green currentlaminated volcanic siltstone and sandstone, and coarsegrained volcanic breccias with clasts up to 8 cm long, some of which are fragments of resedimented siltstone. Core 24A contained only a few tens of centimeters of rock fragments including mudstones and well-laminated micritic, light gray and olive gray limestone. Small pieces of dark gray fine-grained vesicular basalt cut by thin calcite veins were also present. Core 25A contained only fragmental material, probably caved from above. In Core 26A massive alkalic basalt (hawaiite) was encountered at approximately 480 meters, and 7 meters were recovered. At the top of the basalt in Core 26A is a few centimeters of laminated, dark greenish gray volcanic siltstone and marly mudstone, the base of which is in contact with the underlying basalt. The

sediments were deformed by the basalt and small inclusions of these are present in the upper part of the basalt A thin section study of the contact between one of these inclusions and the basalt shows a zone 1 to 2 cm thick composed of black opaque glass containing phenocrysts up to 1.0 mm long of plagioclase and augite. The texture of the glass is vitrophyric, vesicular, and flow banded. The vesicles are filled with amygdules of calcite, chlorite, chalcedony, and montmorillonite. On one side of the glassy contact is clay-rich crystalline calcite, on the other side is vesicular basalt. The massive basalt in which the hole bottomed is aphanitic and vesicular with an intersertal texture. The augite crystals are seen in thin section to be surrounded by sheaves and irregular masses of albite and chlorite; the opaque minerals show a platy skeletal habit. The rock is dark gray when wet, light gray when dry. Thin, calcite-filled pyrite lines and veinlets cut the cores. Core 27 was entirely aphanitic alkali basalt.

The presence of two kinds of basalt and intervening sedimentary sections indicates that at least two separate flows were drilled at this site.

PHYSICAL PROPERTIES

Wet bulk densities from this site probably are, in general, fairly representative of in situ conditions, for many of the cores are undisturbed.

Density within the top 240 meters of mixed radiolarian ooze and nannofossil ooze turbidites varies from 1.25 to 1.5, depending largely on the proportions of the two biogenous components. Density minima at 160 meters and 230 meters are apparently caused by a predominance of Radiolaria. Both the densities and the gamma count of this top 240 meters are similar to that of the Marquesas Oceanic Formation farther east.

Below 280 meters the density increases to 1.7 to 1.8 and the gamma is erratic at 400 to 1000 because of a large volcanic component in the sediment. Core section weights are consistently too low in this zone.

Individual turbidite beds are often readily distinguishable on the GRAPE records as zones of uniform increase in wet bulk density from top to bottom, with sudden drops in density marking the bases of the turbidite beds. This difference in density between calcareous and siliceous oozes is also apparent as a correlation of density and porosity with sediment color. At Site 165, syringe samples from the white sediments tend to have porosities about 5 to 10% lower and densities about 5 to 10% higher than pale brown or light gray sediments.

The very high gamma counts of the top 10 meters are characteristic of Quaternary sediments and are presumably caused by the short-lived radionuclides. The substantial difference in gamma counts between Core 2 and Core 1A, both supposedly from the same depth below the sea floor, would appear to indicate that Core 1A is older than Quaternary, in agreement with paleontology.

CORRELATION BETWEEN STRATIGRAPHIC SECTION AND SEISMIC REFLECTION PROFILE

The seismic profiler record at Site 165 showed four subbottom reflectors: a distinct one, although not of high reflectivity, at 0.19 sec; a highly reflective one at 0.30 sec; a weak one at about 0.4 sec; and the deepest one, apparently basement, at 0.54 sec (Figure 2a). Profiler records made on nearby tracks by R/V *Robert D. Conrad* clearly show the same pattern of reflectors. A 3.5 kHz echo sounder record is also available from the *Conrad* 13 track (Figure 14) and shows interesting details of the stratification of the upper 70 to 80 meters. This part of the column is highly stratified and clearly has been eroded in a broad channel between the drilling site and the nearest seamounts. Erosion has removed a large part of the stratified sequence at the base of the small seamount 60 km northeast of the site (Figure 15). The topmost sediment is a layer of variable thickness and marked acoustical transparency that has been deposited since the erosion occurred.

The first core was recovered at a depth about 12 to 13 meters (drill string measurement) below the depth calculated for the sea floor by PDR. The sample was only 5 meters long and had a thin section of Quaternary at the top overlying lower Miocene. Hence, it seemed likely that the site area, as well as the region between it and the seamounts, had been eroded. The profiler record made running westward from the site (Figure 2b) clearly confirms that about 20 meters of section have been removed at the drilling site and considerably more in the channel east of the site, where Oligocene is probably exposed. The highlystratified sequence recorded on the 3.5 kHz sounder represents middle and upper Oligocene and some lower Miocene at the coring site. Toward the west, the Tertiary sediments of post-early Miocene age may be present, but, if so, their rate of accumulation must be very low compared with that of the older Tertiary sediments.

The erosion of this area could have been caused by turbidity currents carrying detritus from the slopes of the seamounts but might indicate a period of vigorous flow of bottom water between early Miocene time and the Quaternary.

The sediments beneath about the upper one quarter of the stratified zone recorded by the 3.5 kHz sounder have accumulated at a rather constant rate of 8 m/m.y. from the middle Eocene to middle/late Oligocene time. This interval corresponds to 0.02 to 0.30 sec subbottom reflection time in the seismic section and to most of the upper 240 meters of the stratigraphic column (Figure 16). The base of this interval is a prominent reflector that apparently correlates with middle Eocene chert layers causing the first significant break in the drilling record. The less prominent reflector at 0.19 sec below bottom may be correlated with some moderately thick (1-2 m) turbidite beds encountered in Cores 7 and 8. This correlation gives a reasonable sound velocity structure in the post-chert sediments-1.50 km/sec from sea floor to about 150 meters and 1.65 km/sec for the 150 to 242 meter interval. The top of the chert is such a pronounced lithologic change and causes such a break in the drilling graph that there is a strong tendency to correlate it with the 0.3 sec reflector. However, at this site and at several others, the cherty section is in or just above a hiatus, and the possibility that the hiatus, rather than the cherts, is the principal cause of the reflector must be considered. Unfortunately, sample recovery is so poor in

the cherty sections that the extent and position of the hiatus is very difficult to determine.

The next reflector below the cherts is at about 0.4 sec below bottom and probably is associated with a thick layer (at least 3 m) of cemented coarse breccia. A very distinct drilling break was observed between this layer and overlying volcanic siltstones and claystones.

There is some ambiguity with respect to the deepest reflector. First, in a region where the reflector is distinct almost everywhere, we managed to drill the hole in a place where, locally, the reflectivity is anomalously low (Figure 2b). Second, two or three thin basalt flows, one of them at least 1 meter thick, were encountered before a massive layer was entered at 480 meters.

In Figure 16, which shows the relationship of the stratigraphic section to the seismic record, the basement reflector is correlated with the top of the massive basalt. The thick layer should be more reflective than the thin flows for low frequency sound. In view of the local weakness of the basement reflector and of the possibility that basalt flows may be confusing the identification of the reflecting depth, the speed of sound listed for the layer above basement may be in error by a few percent. It is unlikely to be less than 1.8 km/sec or higher than 2.1 km/sec. The speed of sound in the basalt, 5.13 km/sec, was measured with the laboratory sound velocimeter on a cored sample.

CONCLUSIONS

The stratigraphic succession at Site 165 contains six units which can be used to help reconstruct the geologic history of this part of the Pacific Ocean. The units, from top to bottom, are:

1) An unsampled unit, probably mainly Quaternary and perhaps Pliocene and late Miocene in age, recognizable on 3.5 kHz reflection profiles near Site 165 (Figures 14 and 15) as a highly transparent, very unevenly and patchily distributed layer that fills shallow channels and rests unconformably on eroded older strata. This unit has a maximum thickness of about 0.04 sec (\sim 30 m), and in some places it appears to have been eroded partly or even entirely away.

2) A unit about 235 meters thick of soft radiolarian and nannofossil-foram ooze, including many turbidite layers. The unit is middle Eocene at its base and extends upward to at least the lowest part of the lower Miocene. The reflection profile taken by D/V *Glomar Challenger* on leaving Site 165 (Figures 2b and 17) shows that the site is located on a slope where the uppermost parts of the acoustically highly stratified unit have been eroded away. The beds that appear nearly to crop out at the site can be traced westward on the profile beneath an increasing thickness of more highly stratified material. An additional 0.04 sec (\sim 30 m) of thickness can be discerned in that direction and, if the rate of accumulation for the Oligocene and early Miocene persisted, the unit would extend upward to the Middle Miocene (\sim 15 m.y.).

The ooze unit, as seen on the reflection profile (Figures 2b and 17), can be divided into two subunits separated by a



Figure 14. 3.5 kHz record made by R.D. Conrad near Site 165. See Figure 3 for track.



Figure 15. 3.5 kHz record made by R. D. Conrad about 60 km northeast of Site 165.



Figure 16. Correlation of lithology, seismic stratigraphy, drilling rates, and sediment accumulation rates at Site 165.

prominent reflector about 0.19 sec (~140 m) below the sea floor at Site 165. This reflector would correspond roughly to the top of a series of very thick turbidities in Cores 8A and 9A, which extend from about the top of the Eocene into a middle Eocene. The rate of sediment accumulation (Figure 1) shows a change at just about this place in the column, from fast (~15 m/m.y.) in the thick turbidite section below to much slower (~5 m/m.y.) just above.

The two subunits thus defined have a different appearance and distribution on the reflection profile. The lower ("Eocene") unit (Unit 2B) stays more or less parallel to the underlying strong reflector at the top of the chert, whereas the upper unit (Unit 2A) shows considerable variation not only in thickness, but also in reflectivity. Near Site 165 the upper unit is acoustically well stratified internally, but farther west the stratification becomes somewhat obscure, and an additional very transparent unit (Unit No. 1?) makes its appearance at the top of the section. Irregular steps in the basement surface, possibly indicating faults, are mirrored by the reflector at the top of the chert as well as by the reflector between Units 2A and 2B. Whether most of Unit 2A is affected by this faulting is not clear in the records; at any rate, the present-day sea floor is much smoother than the main reflecting horizons within the sedimentary section, as is shown in Figure 17, between 1300 and 1800 hours. Whether this smoothing has been done during deposition of the turbidites of Unit 2A or by post-2A processes is not clear from available records.

On another reflection profile taken by Glomar Challenger during Leg 7 about 100 miles south of Site 165 (Kroenke et al., 1971, p. 1216, record 118), the thickness of Unit 2A is about 0.35 sec (~260 m), or 120 meters thicker than at Site 165. This may indicate that the source of the turbidites in Unit 2A is in a southeasterly direction, toward Kingman Reef and Palmyra Island. This source area is also suggested by the displaced Eocene shallow-water foraminifera found in Cores 2 and 3, in the upper Oligocene part of Unit 2A. These reefs are possible sources of shallow-water material of Tertiary age, since only planktonic Paleogene foraminifers have shown up in dredge hauls on guyots and bank tops near Sity165, for example on the guyot just east of Site 165 and on the guyot 225 km northeast of Site 165, during Leg 6 of 7-Tow cruise of R/V Washington (E.C. Allison, personal communication). The regional bathymetric chart (in pocket) shows a broad arch or ridge extending northwest from the Line Island chain from a point between Palmyra and Washington islands and enclosing a broad basin between this arch and the Line Island chain in the region west of Site 165. Turbidites that derive much of their sediments from seamounts, guyots, and reefs along the east side of this basin probably constitute about half the material in Unit 2A. Besides the displaced shallow-water materials, the turbidites contain reworked pelagic fossils, some of which are very well size-sorted. In fact, the great bulk of the turbidites contains mainly pelagic fossils, with only rare benthic forms from bathyal depths, suggesting that only occasionally did material from Kingman or Palmyra reach Site 165 and that most of the turbidite materials came from the other guyots in the vicinity. Active erosion and winnowing, concurrent with deposition, has been documented in some detail at Horizon Guyot at the northern end of the Line Island chain (Lonsdale et al., 1972), and it seems likely that the guyots

near Site 165 have been similarly swept by currents that carry away much of the biogenous sediment that is temporarily deposited there.

The other main component in Unit 2A is radiolarian (and nannofossil) ooze. Where graded bedding is clearly observable in the cores, the nannofossils are seen to occur chiefly in the lower and middle parts of the turbidite units, as if they had been introduced into the depositional site from somewhat shallower areas, whereas the radiolarians occur mainly in the upper parts of graded units, or between units, and commonly show mottling, as if burrowed by benthic animals. These features suggest that the radiolarian ooze may have been accumulating here as a pelagic deposit. The present-day depth at Site 165 (5053 m) is well below the calcium carbonate compensation depth, and the alternation of calcareous turbidites and pelagic radiolarian ooze in Unit 2A suggests that the site was also below the compensation depth during the Oligocene and early Miocene.

Unit 2B, below the prominent seismic reflector, is lithologically not much different from the overlying beds except for the very thick turbidites at the top of the unit and for the lack of calcareous foraminifers in the turbidites. On the other hand, the distribution of Unit 2B is different from 2A. The reflection profile taken by *Glomar Challenger* (Figure 2a) shows the thickness of 2B to be relatively more uniform than 2A, suggesting that pelagic sediments may make up a greater proportion of this unit than in 2A. The tendency for 2B to be uniform in thickness over both buried hills and valleys suggests that turbidites, except near the top of the unit (and perhaps only locally), may not be as numerous as in 2A. Information from the long (38 m) unsampled portion of 2B would be very helpful in resolving this possibility.

In the diagram of rate of sediment accumulation at Site 165 (Figure 1), the rates for Unit 2 could be interpreted as indicative of two components: (a) a pelagic (mainly radiolarian ooze) component which accumulated at a rate of about 4 meters per m.y. (this rate is typical for the pure radiolarian ooze at Sites 65 and 66 in the central Pacific basin), and (b) a turbidite component (mainly calcareous fossils from guyots and submarine plateaus). The combined average accumulation rate for both (a) and (b) for the



Figure 17. Interpretation of reflection profile taken from Glomar Challenger on leaving Site 165, showing correlation of major reflectors. Lithologic Unit 1 (an acoustically very transparent layer) is too thin to show at the scale of this profile. Unit 2 includes everything from the sea floor to the top of the chert. Units 4 and 5 are between the chert reflector and the basaltic basement.

whole of Unit 2 is close to 10 m/m.y., and the turbidites would therefore be inferred to contribute about half the thickness of the unit.

We can push this analysis still a little further by asking how often, on the average, turbidites were deposited at Site 165. Recognizable turbidite layers occur in unequal thicknesses in Unit 2, ranging from a centimeter or two to several meters, and an average is difficult to estimate. The range of possibilities would seem to lie between one and ten turbidite layers per meter. This implies about 250 to 2500 turbidites in the 25 m.y. represented by Unit 2, that is, one event every 10^4 to 10^5 years, on the average.

3) A chert and limestone unit, about 50 meters thick, of Late Maastrichtian to middle Eocene age. This unit was very sparsely sampled, and the fact that no Paleocene beds are represented may be due either to an unconformity or to gaps in the coring. The cherts at the top of this unit (Unit 3) give rise to a very strong reflection on the profiler records, but the base appears gradational, by loss of chert and addition of volcanogenic detritus, into the next lower unit. The top of the chert at Site 165 is at very nearly the same stratigraphic level as at numerous other sites in the Pacific and Atlantic, that is, in the middle Eocene. And here, as elsewhere, the rate of sediment accumulation appears to have been markedly slower during earliest Tertiary times than either earlier or later.

Within the uppermost part of the Cretaceous, in Unit 3, limestone turbidites with contemporaneous, large shallowwater foraminifers, bryozoans, and echinoid fragments belonging to a fore-reef facies attest to the presence of a Maastrichtian reef in the Line Island chain.

4) A volcanogenic turbidite unit (Unit 4) about 140 meters thick, ranging in age from Campanian to earliest Maastrichtian. This unit contains minor marls and micritic limestones, which may be partly of turbidite origin and partly of pelagic origin. Some of the turbidite beds are very coarse and thick, e.g., one graded bed is about 2.5 meters thick, with clasts 2 cm in diameter at the base. All the coarse clastic material is of volcanic origin: glass, mineral grains, and basaltic rock fragments—and some fragments are highly vesicular, suggesting a relatively shallow-water origin. The most likely source for the coarsest debris is the guyot whose summit is just 50 km east of Site 165 (see chart in pocket).

5) A unit about 50 meters thick (Unit 5), consisting of alternating turbidites and fine-grained vesicular porphyritic basalt flows. Two flows were sampled, the first at 425 meters being represented only by a few fragments of fine-grained basalt, and the second, at 451 meters, represented by fragments totaling about 0.5 meters in thickness. The sediments adjacent to the basalt in the cores are unaltered, but recovery was poor in these intervals. The only fossils in this unit are radiolarians of probable Campanian to Santonian age.

6) Slightly vesicular aphanitic spilitic basalt (Unit 6), into which the corer penetrated for about 7 meters. The basalt is overlain directly by baked volcanic siltstone, and the uppermost part of the basalt contains glassy-bordered fragments of siltstone. It is possible that more sediments lie beneath this deepest basalt, but it was not deemed appropriate to spend more time drilling at this site to check on this possibility. Units 5 and 6 are interpreted as recording the early history of the Line Island seamount chain and its adjacent sea floor in the vicinity of Site 165. The interbedded basalt and turbidites probably represent the final stages in the building of the local seamounts, some of which reached into fairly shallow water. Fragmented volcanic material lying loose on the summit and slopes of the volcanos was carried to deeper water by turbidity currents, while sea floor eruptions were still taking place, either on the lower flanks of the major seamount close to the site or from smaller independent vents in deep water.

The age of the oldest sediments, between basalt flows, at Site 165 is in the range from about 75 to 84 m.y., and the age of the oldest sediments (by straight-line extrapolation of the rate of accumulation curve, Figure 1) is 85 m.y. This age is consistent with dredge hauls from the Line Island guyots, the oldest of which contains planktonic foraminifera of Senonian (72-86m.y.) age. The oldest fossils dredged from the guyot just east of Site 165 are planktonic foraminifera of Paleogene age (E. C. Allison, personal communication). The age at Site 165 is considerably younger than the age of the sea floor obtained by simple westward extrapolation of the sea floor spreading rate between Sites 162 and 163. The youngest possible age using this method is about 95 m.y. (Sites 159, 78, 160, 161, and 70).

REFERENCES

- Erickson, D. B., Ewing, M., Wollin, G. and Heezen, B. C., 1961. Atlantic deep-sea cores. Bull. Geol. Soc. Am. 72, 193.
- Ewing, J., Ewing, M. Aitken, T. and Ludwig, W. J., 1968. North Pacific sediment layers measured by seismic profiling. *In* The Crust and Upper Mantle of the Pacific Area. Am. Geophys. Union. Geophys. Monograph 12, 147.
- Fischer, A. G., Heezen, B. C. et al., 1971. Initial Reports of the Deep Sea Drilling Project, Volume VI. Washington (U. S. Government Printing Office). 1327 p.
- Forman, J. J. and Schlanger, S. O., 1957. Tertiary reef and associated limestone facies from southern Louisiana and Guam. J. Geol. 65, 611.
- Hays, J. D. et al., 1972. Initial Reports of the Deep Sea Drilling Project, Volume IX. Washington (U. S. Government Printing Office). 1197 p.
- Henson, F. R. S., 1950. Cretaceous and Tertiary reef formations and associated sediments in the Middle East. Bull. Am. Assoc. Petrol. Geologists. 34, 215.
- Kroenke, L., Moberly, R., Jr., Winterer, E. L. and Heath, G. R., 1971. Lithologic interpretation of continuous reflection profiling. *In* Winterer, E. L., Riedel, W., R. et al., 1971. Initial Reports of the Deep Sea Drilling Project, Volume VII. Washington (U.S. Government Printing Office). 1161.
- Lonsdale, P., Normark, W. R. and Newman, W. A., 1972. Sedimentation and erosion on Horizon Guyot. Bull. Geol. Soc. Am. 83, 289.
- Pettijohn, F. J., 1957. Sedimentary Rocks. New York (Harper and Row). 718 p.
- Schlanger, S. O., 1964. Petrology of the limestones of Guam. U. S. Geol. Surv. Prof. Paper 403D. 52 p.
- van Andel, Tj. H., Heath, G. R., Bennett, R. H., Charleston,
 S., Gronan, D. S., Rodolfo, K. S., Yeats, R. S., Bukry,
 D., Dinkleman, M. and Kaneps, A., 1971. Deep Sea
 Drilling Project, Leg 16. Geotimes. 16 (6), 12.



APPENDIX A Core Inventory – Site 165

	Depti Sea (h Below Floor m)	Total (Depth ^a m)				
Core	Тор	Bottom	Тор	Bottom	Cored (m)	Recovered (m)	Lithology	Age
1	0	5	5053	5058	5	4.5	Nannofossil-foram ooze	Quaternary and Early
2	5	14	5058	5067	9	3	Nannofossil-foram ooze	Quaternary to Oligocene, mixed
1A	5	14	5058	5067	9	8	Foraminiferal nannofossil ooze	Late Oligocene
2A	14	24	5067	5077	10	9	Nannofossil ooze and radiolarian ooze	Late Oligocene
3A	24 33	33 71	5077 5086	5086 5124	9	8.5	Nannofossil ooze	Late Oligocene
4A	71	80	5124	5133	9	CC	Nannofossil ooze and radiolarian ooze	Late Oligocene
5A	80 89	89 127	5133 5142	5142 5180	9	6.2	Nannofossil ooze	Early Oligocene
6A	127	136	5180	5189	9	9	Nannofossil ooze and radiolarian ooze	Early Oligocene
7A	136	145	5189	5198	9	9	Nannofossil ooze and radiolarian ooze	Early Oligocene to Late Eocene
8A	145	154	5198	5207	9	9	Nannofossil ooze and radiolarian ooze	Late Eocene to Middle Eocene
9A	154 163	163 201	5207 5216	5216 5254	9	9	Nannofossil ooze and radiolarian ooze	Middle Eocene
10A	201	210	5254	5263	9	9	Nannofossil ooze and radiolarian ooze	Middle Eocene
11A	210	219	5263	5272	9	7.5	Nannofossil ooze and radiolarian ooze	Middle Eocene
12A	219	228	5272	5281	9	9	Nannofossil ooze and radiolarian ooze	Middle Eocene
13A	228	237	5281	5290	9	7	Nannofossil ooze and radiolarian ooze	Middle Eocene
14A	237	246	5290	5299	9	2.5	Radiolarian ooze and chert	Middle Eocene
15A	246	256	5299	5309	10	CC	Marl and chert	Early to Middle Eocene
16A	256	284	5309	5337	28	CC	Limestone	Late Maastrichtian
17A	284	290	5337	5343	6	0.75	Limestone and chert	Late to Early Maastrichtian
18A	290	321	5343	5374	31	4	Volcano clastic sandstone, siltstone and marly limestone	Early Maastrichtian to Campanian
19A	321	340	5374	5393	19	3	Volcanoclastic breccia, sandstone and siltstone	Middle to Late Campanian
20A	340	368	5393	5421	28	4	Volcanoclastic breccia and sandstone; marly limestone	Early Campanian
21A	368	396	5421	5449	28	3.5	Limestone and volcanoclastic sandstone	Early Campanian
22A	396	424	5449	5477	28	2	Volcanoclastic sandstone and siltstone	Late Cretaceous
23A	424	451	5477	5504	27	1.5	Vesicular basalt; volcanoclastic siltstone and breccia	
24A	451	460	5504	5513	9	1	Limestone on basalt	
25A	460	480	5513	5533	20	0.5	Basalt and siltstone (cavings?)	Middle to Early Campanian
26A	480	485	5533	5538	5	3.5	Siltstone over basalt	
27A	485	490	5538	5543	5	5	Basalt	
 	1.0		l		I			

^aMeasured from the derrick floor.

APPENDIX B Physical Properties – Site 165

			(GRAPE				Syr	inge		N ₂ (mass)			
	Section	Wet Bu	lk Density		Poro	sity					Radia	tion	Sonic V	Velocity
Core Section	Weight Wet Bulk Density (g/cc)	Total Range (g/cc)	Undisturbed (g/cc)	Assigned Grain Density (g/cc)	Total Range (%)	Undisturbed (%)	Interval Sampled (cm)	Wet Bulk Density (g/cc)	Grain Density (g/cc)	Porosity (%)	Total Count	Net	Interval Sampled (cm)	(km/sec)
1-1		1.05-1.25	1.05-1.25	2.6	85.6-98.3	85.6-98.3	50 53 56 59 62 64	1.14 1.21 1.26 1.25 1.50 1.04	2.47 2.04 2.21 2.08 2.78 1.12	87.8 81.4 80.2 78.9 73.1 77.6	1800	525	48 58 94 104 115	1.47 1.47 1.47 1.46 1.46
1-2 1-3		1.05-1.20 1.25	1.05-1.20 1.25	2.6 2.6	88.8-98.3 85.6	88.8-98.3 85.6	143	1.44	2.16	62.9		с. 25	58 141 17	1.47 1.48 1.48
													48 98	$1.50 \\ 1.47$
2-1		1.05-1.25	1.05-1.25	2.6	85.6-98.3	85.6-98.3					1800	525	48 82	$1.47 \\ 1.47$
2-2		1.05-1.25	1.05-1.25	2.6	85.6-98.3	85.6-98.3					1200		43	1.46
1A-1 1A-2		1.32 1.2-1.3	1.32 1.2-1.3	2.6 2.6	81.1 82.4-88.8	81.1 82.4-88.8					1300	0	48 132	1.47 1.48
1A-3		1.2-1.3	1.2-1.3	2.6	82.4-88.8	82.4-88.8	110	1.36	2.15	70.2			10 57 109 135	1.49 1.48 1.47 1.47
1A-4 1A-5 1A-6		1.2-1.3 1.25-1.35 1.15-1.25	1.15-1.25	2.6 2.6 2.6	82.4-88.8 79.3-85.6 85.6-92.0	85.6-92.0	$\begin{array}{c} 118\\110\end{array}$	1.47 1.29	2.40 2.07	67.4 75.1				ж 110
2A-1		1.24-1.38	1.24-1.33	2.6	77.4-86.2	80.5-86.2	57	1.27	2.03	75.7	1350	50	59	1.54
2A-2 2A-3		1.1-1.3	1.1-1.3	2.6	82.4-95.1	82.4-95.1	133	1.36	2.04	67.4			55 98 133	1.46 1.51 1.46
2A-4 2A-5 2A-6		1.2-1.3 1.15-1.25 1.25-1.30	1.2-1.3 1.15-1.25 1.25-1.30	2.6 2.6 2.6	82.4-88.8 85.6-92.0 82.4-85.6	82.4-88.8 85.6-92.0 82.4-85.6	79	1.29	2.39	80.4	- 8			T.
3A-1 3A-2 3A-3 3A-4 3A-5 3A-6	2 A	$\begin{array}{c} 1.15 - 1.30 \\ 1.25 - 1.35 \\ 1.25 - 1.30 \\ 1.20 - 1.33 \\ 1.25 - 1.35 \\ 1.25 \end{array}$	1.20-1.33	2.71 2.71 2.71 2.71 2.71 2.71 2.71	83.6-92.5 80.6-86.5 83.6-86.5 81.8-89.5 80.6-86.5 80.6-86.5 86.5	81.8-89.5					1350	25		
5A-1 5A-2		1.55 1.60-1.70	1.60-1.70	2.71 2.71	68.8 59.9-65.8	59.9-65.8	23 90 140	1.64 1.62 1.48	2.54 2.26 2.20	60 52 61	1325	0	65 96 121	1.37 1.51 1.50

SITE 165

				GRAPE				Syri	inge		Natural	Commo		
	Section	Wet	Bulk Density		Por	osity					Radia	tion	Sonic V	Velocity
Core Section	Weight Wet Bulk Density (g/cc)	Total Range (g/cc)	Undisturbed (g/cc)	Assigned Grain Density (g/cc)	Total Range (%)	Undisturbed (%)	Interval Sampled (cm)	Wet Bulk Density (g/cc)	Grain Density (g/cc)	Porosity (%)	Total Count	Net	Interval Sampled (cm)	(km/sec)
5A-3		1.50-1.65	1.50-1.65	2.71	62.8-71.7	62.8-71.7	30	1.41	2.20	67			46	1.49
5A-4		1.35-1.60	1.35-1.60	2.71	65.8-80.6	65.8-80.6	10	1.43	2.06	62			67 41	1.49
5A-5		1.50-1.65	1.50-1.65	2.71	62.8-71.7	62.8-71.7	30 85	1.38 1.48 1.57	2.00 2.36	64 54 60				
6A-1 6A-2		1.45 1.40-1.55	1.45 1.40-1.55	2.71 2.71	74.7 68.8-77.6	74.7 68.8-77.6					1350	75	20 62	1.51 1.50
6A-3		1.45-1.60	1.45-1.60	2.71	65.8-74.7	65.8-74.7							112 50 111	1.52 1.50 1.49
6A-4		1.45-1.55	1.45-1.55	2.71	68.8-74.7	68.8-74.7							29 102	1.49
6A-5		1.45-1.65	1.45-1.65	2.71	62.8-74.7	62.8-74.7							21 97	$1.51 \\ 1.50$
6A-6		1.40-1.55	1.40-1.55	2.71	68.8-77.6	68.8-77.6								
7A-1 7A-2		1.50-1.55	1.50-1.55	2.71	68.8-71.7 68.8-71.7	68.8-71.7 68.8-71.7					1300	0		
7A-3		1.50-1.55	1.50-1.55	2.71	68.8-71.7	68.8-71.7	50	1.53	2.25	58.7			56	1.50
7A-4		1.50-1.60	1.50-1.60	2.71	65.8-71.7	65.8-71.7	50	1.57	2.38	59.7			56 116	1.50
7A-5		1.55-1.60	1.55-1.60	2.71	65.8-68.8	65.8-68.8							62	1.53
7A-6		1.45-1.65	1.45-1.65	2.71	62.8-74.7	62.8-74.7	133	1.35	1.94	65.0			37 74	1.51 1.48
8A-1		1.30-1.55	1.30-1.55	2.65	67.6-83.0	67.6-83.0	8 98	1.11 1.36	1.32 2.05	72 67	1325	50	70 110	1.51 1.52
8A-2		1.30-1.55	1.30-1.55	2.65	67.6-83.0	67.6-83.0	134	1.25	1.79	71			(2)	1.51
8A-3		1.30-1.50	1.30-1.50	2.65	70.7-83.0	70.7-83.0	28 110	1.23	2.22	62			62 105	1.51
8A-4		1.50-1.55	1.50-1.55	2.65	67.6-70.7	67.6-70.7							139 19 76	1.48 1.48 1.50
8A-5		1.35-1.50	1.35-1.50	2.65	70.7-79.9	70.7-79.9	83	1.45	2.55	72			138 17 76	1.50 1.52 1.50 1.48
8A-6		1.35-1.40	1.35-1.40	2.65	76.8-79.9	76.8-79.9	97	1.41	2.39	72			22 74	1.51
9A-1 9A-2 9A-3 9A-4 9A-5		1.30-1.40 1.35-1.50 1.27-1.35 1.27-1.35 1.25-1.35	1.30-1.40 1.35-1.50 1.30-1.35	2.71 2.71 2.71 2.71 2.71 2.71	77.6-83.6 71.7-80.6 80.6-85.4 80.6-85.4 80.6-85.4	77.6-83.6 71.7-80.6 80.6 - 83.6	37 93	1.48 1.26	2.60 2.03	71.0 76.9	1350	100		

9A-6		1.27-1.45	1.27-1.45	2.71	74.7-85.4	74.7-85.4	132 104	1.42	2.26	67.8 68.4			128	1.53
10A-1	1.49	1.35-1.55	1.35-1.55	2.65	67.6-79.9	67.6-79.9	89	1.48	2.29	63.8	1300	50	37	1.53
10A-2	1.45	1.40-1.45	1.40-1.45	2.65	73.8-76.8	73.8-76.8							76 42 102	1.53 1.53 1.54
10A-3 10A-4	1.43 1.43	1.40-1.45 1.40-1.45	1.40-1.45 1.40-1.45	2.65 2.65	73.8-76.8 73.8-76.8	73.8-76.8 73.8-76.8	120 87	1.36 1.30	2.10 1.82	69.0 65.4			40	1.53
10A-5 10A-6	1.43 1.41	1.35 - 1.40 1.35 - 1.45	1.35-1.40 1.35-1.45	2.65 2.65	76.8-79.9 73.8-79.9	76.8-79.9 73.8-79.9	27	1.31	1.82	65.9	×.	, A.	110	1.54
11A-1 11A-2 11A-3 11A-4 11A-5	1.35 1.45 1.51 1.51	$1.32-1.40 \\ 1.30-1.40 \\ 1.32-1.50 \\ 1.45-1.50 \\ 1.50 $	1.50	2.65 2.65 2.65 2.65 2.65 2.65	76.8-81.7 76.8-83.0 70.7-81.7 70.7-73.8 70.7		36	1.49	2.48	68.2	1325	75		
11A-6		1.35-1.45	1.35-1.45	2.65	73.8-79.9									
12A-1 12A-2 12A-3 12A-4 12A-5 12A-6	1.49 1.43 1.37 1.33 1.35 1.41	$\begin{array}{c} 1.35 - 1.50 \\ 1.25 - 1.47 \\ 1.25 - 1.45 \\ 1.25 - 1.38 \\ 1.25 - 1.40 \\ 1.25 - 1.40 \end{array}$	$\begin{array}{c} 1.35 \hbox{-} 1.50 \\ 1.25 \hbox{-} 1.47 \\ 1.25 \hbox{-} 1.45 \\ 1.25 \hbox{-} 1.38 \\ 1.25 \hbox{-} 1.40 \\ 1.25 \hbox{-} 1.40 \end{array}$	2.3 2.3 2.3 2.3 2.3 2.3 2.3	62.6-74.4 65.0-82.2 66.6-82.2 72.1-82.2 70.5-82.2 70.5-82.2	62.6-74.4 65.0-82.2 66.6-82.2 72.1-82.2 70.5-82.2 70.5-82.2	41 102	1.47 1.22	2.36 1.78	65.2 73.7	1325	75		
13A-1		1.15-1.30	1.15-1.30	2.3	78.3-90.1	78.3-90.1	104	1.23	1.80	74.3				
13A-2 13A-3	1.29	1.25-1.47 1.25-1.30	1.25-1.47 1.25-1.30	2.3 2.3	65.0-82.2 78.3-82.2	65.0-82.2 78.3-82.2	137 34	1.41 1.34	2.06 1.88	63.6			71	1.50
13A-4	1.29	1.25	1.23	2.5	02.2	02.2	8		*** *				103	1.52
13A-5 18A-1 18A-2 18A-3	1.27	1.25-1.30 1.60-1.78 1.55-1.75 1.45-1.70	1.25-1.30 1.60-1.78 1.55-1.75 1.45-1.70	2.3 2.7 2.7 2.7	78.3-82.2 54.8-65.6 56.6-68.6 59.6-74.5	78.3-82.2 54.8-65.6 56.6-68.6 59.6-74.5					2000	750	147	1.86
19A-1 19A-2		1.55-1.85 1.60-1.77	1.55-1.85 1.60-1.77	2.7 2.7	50.7-68.6 55.4-65.6	50.7-68.6 55.4-65.6			ν		1900	650		
20A-1 20A-2 20A-3	1.62	1.80 1.60-1.70 1.70-2.00	1.80 1.60-1.70 1.70-2.00	2.71 2.71 2.71	53.9 59.9-65.8 42.1-59.9	53.9 59.9-65.8 42.1-59.9					2100	850		
21A-1 21A-2 21A-3 21A-CC	1.60	1.75-1.97 1.65-1.85 1.70-1.97	1.75-1.97 1.65-1.85 1.70-1.97	2.71 2.71 2.71	43.8-56.9 51.0-62.8 43.8-59.9	43.8-56.9 51.0-62.8 43.8-59.9					1725	425		2.60
														2.78 2.95
22A-3	1.51	1.60-1.65	1.60-1.65	2.7	62.6-65.6	62.6-65.6					2050	750		
23A-2	1.31	1.60-1.82	1.60-1.82	2.7	52.5-65.6	52.5-65.6					2325	1025		
26A		2 10 2 25	2 10 2 25								1825	525		
27A-1 27A-2 27A-3 27A-4		2.10-2.25 2.10-2.23 2.10-2.23 2.10-2.40	2.10-2.25 2.10-2.23 2.10-2.23 2.10-2.40								2			×

SITE 165

69

_





SITE 165

	ĹĔ	EG XVII	SITE 165 LAT. 8°10.7'N		LONG. 164°51.6'W	DEPTH	5053 M	SHEET 3 OF 4
	Ŧ	CORES		4.05		BIOSTRATIGRAPHY		V:2,53,0 PHYSICAL PROPERTIES*
200	DEP		LTHOLOGY	AGE	FORAMINIFERA	NANNOFOSSILS	RADIOLARIA	$\rho: \Omega, 1, 0$ 1, 2 1, 4 1, 6 1, 8 2, 0
300	_	18	VOLCANOCLÁSTIC SANDSTONE, SILTSTONE,	O LATE CAMPANIAN	Barren	Tetralithus trifidus	Unzoned	
1	_	19	breccia, graded bedding, cross- bedding.	WIDDLE 7	G. elevata	Broinsonia parca	U. Cretaceous	
	-		SANDSTORE, minor MARLY, LAMINATED LIMESTONE.				Barren	
350	-	20						
	-	21	LIMESTONE; micritic, interbedded	ARLY TO MIDDLE CAMPANIAN		Eiffellithus eximius	Unzoned U. Cretaceous	
400 -	-	22	VOLCANOCLASTIC SILTSTONE and SANDSTONE: graded bedding and cross-lamination.					
	_	23	BASALT; vesicular, fine-grained.			Barren	Unzoned U. Cretaceous	

	LE	EG XVII	SITE 165	LAT. 8°10.7'N		LONG. 164°51.6'W	DEPTH	5053 m		SHEET 4 OF 4
1	Ξ	CORES					BIOSTRATIGRAPHY		V: <u></u> 2.5	3.0 PHYSICAL PROPERTIES*
450	DEPI		LIT	HOLOGY	AGE	FORAMINIFERA	NANNOFOSSILS	RADIOLARIA	- Y : ● 	<u>400 500 600 700 800 900 1000 1100</u> 4 1.6 1.8 2.0
450	-	24	WUDSTONE over icular,	over BASALT; massive, , fine-grained.				Barren		
	-	25	Cavings fr	rom hole.			Eiffellithus eximius 	Unzoned U. Cretaceous		
-	-	26	SILTSTONE BASALT; ma T.D. 490 m	over basalt. ssive, vesicular.						
500 -	-									
	-									
-	-									
-	-									
	-								-	
-	-									
	-									



SITE 165 SMEAR SLIDE SUMMARY

Sit	165	Hol	le		Co	re 1	C	ored Ir	iterv	val:	to 5 meters	Sit	e 165	Ho	le A		Cor	re 1	Cored I	nterv	al:	5 to 14 meters
AGE	ZONE	FOSSIL 2	ARACT	PRES.	SECTION	METERS	LIT	HOLOGY	DEFORMATION	LITHO.SAMPLE	LITHOLOGIC DESCRIPTION	AGE	ZONE	FOSSIL 2	FOSS HARAC	LL TER .Sand	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
LY MIDGENE QUAT.	18 - N17 abdulus carinatus contum hines	n r f n f n	A C F F C R C C	G G P M M	1	0.5-			?	* *	<pre>0 to 150 cm: Nannofossil-foraminiferal ooze; very pale orange (10YR 8/2) to gravish orange (10YR 7/4), micritic. Clay, brown (5YR 4/2) and (5YR 3/2), radiolarian-bearing. These two lithologies alternate in thin bands in Section 1. Rare dolomite (?) rhombs and phillipsite in darker bands.</pre> 0 to 8 cm: Nannofossil ooze; very pale orange (10YR 8/2) to pinkish white (5YR 9/1), micritic. 8 to 100 cm: Clay, brown (10YR 6/2), radiolarian. Contains irregular spots and laminae of nannofossil ooze, very pale orange (10YR 8/2). 100 to 150 cm: As at 0 to 8 cm. 0 to 150 cm: Nannofossil ooze; light yellow brown (10YR 6/4)			f n f n r	R C C C	P M M M	1	0.5		? 	* * * *	 130 to 148 cm: <u>Nannofossil ooze</u>; very pale brown (10YR 7/4) to white (10YR 8/1). 148 to 150 cm: <u>Radiolarian ooze</u>; yellow brown (10YR 5/4). 0 to 128 cm: <u>Nannofossil ooze</u>; white (10YR 8/1) <u>Radiolarian ooze</u>; pale brown (10YR 7/4) <u>These 11chologies alternate</u>. 128 to 140 cm: <u>Base of turbidite with streak of dark</u> minerals, fragments of drusy calcite and bioclastic debris of shallow-water fossils. 140 to 150 cm: <u>Nannofossil ooze</u>.
EAR	Triquetrorh UTriquetrorh	f n r Hol	FCC	MM	3 C Cat	ore tcher			terv	* * *	and very pale crange (10YR 8/2). Bases of turbidite beds at 51, 109, 121, and 139 cm. These show up as fine-sand size streaks of mineral grains including pyroxene, horn- blende and palagonite. Phillipsite rosettes are common. Nannofossil-foraminiferal ooze, grayish orange (10YR 7/4), micritic.	LATE OLIGOCENE	P22 Reticulofenestra abisecta	f n n f	R A C	F M F	3					O to 150 cm: <u>Nannofossil ooze;</u> white (10YR 8/1). <u>Nannofossil-radiolarian ooze</u> O to 150 cm: <u>Nannofossil ooze</u> .
AGE	ZONE	FOSSIL R	OSSIL RACT ONNBY	PRES. B	SECTION	METERS	LIT	IOLOGY	DEFORMATION	LITHO.SAMPLE	LITHOLOGIC DESCRIPTION			1	R	F	5					O to 150 cm: <u>Nannofossil ooze</u> , radiolarian and foraminiferal content variable, light yellow brown (10YR 6/4) and white (10YR 8/3).
LATE OLIGOCENE	P.22(?)	f n f n r	R C R C A	P G P G G	1	0.5			?		 0 to 12 cm: Foraminiferal-nannofossil ooze; light gray (10YR 7/2), coarse-grained calcite spar fragments common. 12 to 56 cm: Foraminiferal-nannofossil ooze; yellowish brown (10YR 5/4), micritic. 56 to 114 cm: Clay; very dark grayish brown (10YR 3/2), radiolarian rich. 114 to 134 cm: Nannofossil ooze; pale yellowish brown (10YR 8/3). 134 to 150 cm: As at 56 to 114 cm. 0 to 150 cm: Nannofossil and Foraminiferal ooze; light yellowish brown (10YR 5/4), micritic. This 1ithology alternates with radiolarian ooze, very dark grayish brown (10YR 3/2), clayey. 			f	F A C	M M M	6	Core				O to 150 cm: As in section 5 As in section 5
MIXED QUATOLIGOCENE		f n r	R C A	P G G	Cat	ore				*	Fish teeth up to 1 cm long present. <u>Nannofossil-foraminiferal ooze</u> ; light gray (10YR 7/2), calcite spar fragments up to 1 mm long are common.	Ex	planato	ry n	otes	in C	Chapt	ter 1	<u>, , , , , , , , , , , , , , , , , , , </u>	<u>-</u>	1	

Site	165	Hole	A	С	ore 2		Cored I	nter	val:	14 to 24 meters	Sit	e 165	Hol	le A		Co	re 3	Cored 1	Inter	val.	: 24 to 30 meters
AGE	ZONE	FOSSIL POP	RACTE	SECTION	METERS	L	.ITHOLOGY	DEFORMATION	LITHO.SAMPLE	LITHOLOGIC DESCRIPTION	AGE	ZONE	FOSSIL 2	OSSI ARACT	PRES. BI	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
					0.5-		VOID		_							1	0.5-				0 to 136 cm: <u>Nannofossil-foraminiferal ooze</u> ; very pale brown (10YR 7/3).
		f n r	R N A N C N		1.0-					(10YR 6/4) to white (10YR 7/4)						-	1.0-			*	136 to 142 cm: As above plus streak of <u>mannofossil</u> - <u>foraminiferal ooze</u> , white (N9) with dark mineral grains.
					Ϊ.					O to 150 cm: <u>Nannofossil ooze</u> ; very pale brown (10YR 8/3). <u>Radiolarian ooze</u> present as disturbed streaks.			f	с	M		_			*	O to 150 cm: <u>Foraminiferal-nannofossil goze</u> , very pale brown (10YR 7/3)
		f n	RI	, 2 M		****		? •					n r	A C	M P	2	-				8 to 16 and 44 to 61 cm: <u>Nannofossil ooze</u> ; white (N9) with scattered dark grains (palagonite and pyroxene?) plus rosettes of zeolites.
				-	<u> </u>					0 to 10 cm: <u>Nannofossil-foraminiferal</u> ooze; 10 to 140 cm: <u>Radiolarian ooze;</u> moderate brown (10YR 4/4), grading downward to <u>radiolarian-bearing nannofossil ooze</u> ,	SOCENE	distentus papilio	f	C	м						0 to 150 cm: <u>Nannofossil ooze;</u> very pale brown (10YR 7/3). Locally foraminifera-bearing. Scattered dark mineral grains in disturbed layer.
ENE	eroensis apilio	f n r	C I A I C I	и <u>з</u> и						pale yellow brown (10VR 6/4) thence to <u>nannofossil</u> - foraminiferal ooze, white (10VR 8/2).	LATE OLIG	P21 enolithus			, ri	3	-				
ATE OLIGOC	P22 ithus cip dopyris pa			-						0 to 150 cm: <u>Nannofossil ooze;</u> white (10YR 8/2). This lithology mixed with <u>radiolarian ooze</u> , dark		Sph									Same as dominant lithology of Sect. 3.
	Spheno1 Dorca	f n r	C I A I C I	м <i>L</i> м	+					brown (lUYR 4/2)						4	-				
				+					*	O to 150 cm: As in section 4			f r	R C	P M	_				-	Same as dominant lithology of Sect. 3.
		r n	CA	M	5		·		*							5					
		Т	ĸ	-					*	0 to 150 cm: As in section 4			f	с	м	с	ore				Foraminiferal-nannofossil ooze; worn fragments of large
		f n	C A	м	5								r r	A C	M	Cat	tcher		-	*	calcite (shallow-water reefal debris - Eocene age).
						Ŧ		-			Sit	e 165	Ho1	еA		Cor	re 4	Cored I	nter	val:	71 to 80 meters
		f n r	F A C	M M M	Core Catche				*	<u>Nannofossil ooze</u> ; radiolarian and foraminifera-bearing	AGE	ZONE	FOSSIL 중 -	ARACT	PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	ITHO. SAMPLE	LITHOLOGIC DESCRIPTION
		f n r	F A C	M M M	Core Catche	-14 -14 r 14			*	<u>Nannofossil ooze</u> ; radiolarian and foraminifera-bearing	AGE	ZONE	FOSSIL 2	ARACT 	PRES. B	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION

Explanatory notes in Chapter 1

C M

CM

LATE

Core Catcher

~~~

Nannofossil and radiolarian ooze.

<sup>1</sup>S. distentus

76

| Site 165                                     | Ho                | ole A                            | Ą                 | Co      | re 5          |                            | Cored   | Inter                                 | val:         | 80 to 89 meters                                                                                                                                                                                                                                                                      | Site            | 165                                                | Hol         | e A                     |             | Core 6          | Cored Ir  | terval      | : 127 to 136 meters                                                                                                                                                                           |
|----------------------------------------------|-------------------|----------------------------------|-------------------|---------|---------------|----------------------------|---------|---------------------------------------|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|----------------------------------------------------|-------------|-------------------------|-------------|-----------------|-----------|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| AGE<br>ZONE                                  |                   | FOSS                             | SIL<br>CTER       | SECTION | METERS        | .                          | ITHOLOG | DEFORMATION                           | LITHO.SAMPLE | LITHOLOGIC DESCRIPTION                                                                                                                                                                                                                                                               | AGE             | ZONE                                               | FOSSIL 2.   | OSSIL<br>RACTE<br>ONNBY | PRES.       | METERS          | LITHOLOGY | DEFORMATION | LITHOLOGIC DESCRIPTION                                                                                                                                                                        |
|                                              |                   |                                  |                   | 1       | 0.5-          |                            | VOID    |                                       |              |                                                                                                                                                                                                                                                                                      |                 | H. reticulata                                      | n<br>f<br>r | C<br>R<br>A             | M<br>P<br>G | 1 0.5           |           | ,           | O to 150 cm: <u>Radiolarian-nannofossil ooze</u> ; white (10YR 8/2).                                                                                                                          |
|                                              | r                 |                                  | G                 | 2       | -             | ┯╫┾┾┾┾┾┾                   |         |                                       | *            | O to 150 cm: <u>Foraminiferal-nannofossil ooze</u> ; white<br>(10YR 8/8) to gray(N7), black specks and streaks due<br>to Mn(?) coatings on foraminifera and radiolarians.                                                                                                            |                 | -                                                  | n<br>f      | C<br>R                  | M           | 2               |           |             | O to 150 cm: <u>Foraminiferal-nannofossil ooze;</u> white (N9)<br>alternating with <u>radiolarian-nannofossil ooze;</u> very<br>pale brown (10YR 7/4).                                        |
| LY OLIGOCENE<br>P19/20<br>ithus predistentus | cyrtis annosa     | R                                | : М<br>: Р        | 3       | -             |                            |         |                                       | *            | 0 to 150 cm: <u>Radiolarian-nannofossil ooze;</u> white,<br>(10YR 8/1).<br>Lower part of section contains foraminifera and is<br>light gray (N7).                                                                                                                                    |                 |                                                    | r           | A<br>R                  | G<br>P      | 3               |           | *           | O to 150 cm: As in section 2                                                                                                                                                                  |
| EAR                                          | Theor             |                                  |                   | 4       | -             | <del>┦╷┦┎╡╶╡┍╡┍╡┍╡┍╡</del> |         |                                       | *            | O to 150 cm: <u>Nannofossil ooze</u> ; entire section consists<br>of interbedded sequences of radiolarian-rich and<br>foraminifera-rich nannofossil <u>oozes</u> . Colors range from<br>white (10YR 8/1) to light yellowish brown (10YR 6/4).<br>Mn nodule, 3 cm diameter at 104 cm. | EARLY OLIGOCENE | P18<br>ricsonia subdisticha<br>Theocvrtis tuberosa | n           | C N<br>R                | 1           | 4               |           |             | 0 to 150 cm: As in section 2                                                                                                                                                                  |
|                                              | r<br>r<br>f       | C C                              | : м<br>: м        | 5       | -             | ┯╃┥┥┥┥┥┥                   |         | + $+$ $+$ $+$ $+$ $+$ $+$ $+$ $+$ $+$ | *            | O to 150 cm: <u>Oozes;</u> well-bedded, alternating bands of<br>oozes with varying proportions of radiolarians,<br>foraminifera, nannofossils and diatoms.<br>Mn micronodules common.                                                                                                |                 |                                                    | r           | A I                     | G<br>M      | 5               |           |             | O to 150 cm: <u>Radiolarian-diatom-nannofossil ooze</u> ; pale<br>brown (10YR 7/4) at top grading down into <u>foraminiferal-</u><br><u>nannofossil</u> ooze, white (N9) at base of section.  |
| -<br>EVELA<br>EVELA<br>Explanat              | tuberosa<br>u kuo | f F<br>n (<br>n <i>f</i><br>otes | M<br>M<br>G<br>in | Ca      | Core<br>tcher |                            |         | $\overline{4}$                        | *            | Nannofossil ooze.                                                                                                                                                                                                                                                                    |                 |                                                    | т<br>n<br>f | C I<br>R                | м<br>Р      | 6               |           |             | 0 to 150 cm: <u>Foraminiferal-nannofossil ooze</u> ; white (N9),<br>micritic at top underlain by <u>radiolarian-nannofossil</u><br>ooze, very pale brown (10YR 774) with contact at<br>72 cm. |
|                                              |                   |                                  |                   |         |               |                            |         |                                       |              |                                                                                                                                                                                                                                                                                      |                 |                                                    | f           | B                       | M           | Core<br>Catcher |           | ,           | <u>Nannofossil ooze</u> .                                                                                                                                                                     |

| Site         | 165                                       | Hole                   | A               | Co      | re 7         | Cored In  | terv        | val:         | 136 to 145 meters                                                                                                                                                  | Site          | 165           | ł                    | Hole A                   |        | Cor       | re 8   | Cored In                                  | terva       | 1: 145 to 154 meters                                                                                                                                                                                                                                                                                                                                                                        |
|--------------|-------------------------------------------|------------------------|-----------------|---------|--------------|-----------|-------------|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|---------------|----------------------|--------------------------|--------|-----------|--------|-------------------------------------------|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| AGE          | ZONE                                      | FOS<br>CHARA<br>TISSOL | SIL<br>ACTER    | SECTION | METERS       | LITHOLOGY | DEFORMATION | LITHO.SAMPLE | LITHOLOGIC DESCRIPTION                                                                                                                                             | AGE           | ZONE          |                      | FOSS<br>CHARAC<br>TISSOJ | DRES.  | SECTION   | METERS | LITHOLOGY                                 | DEFORMATION | LITHOLOGIC DESCRIPTION                                                                                                                                                                                                                                                                                                                                                                      |
|              |                                           | r A                    | G<br>G<br>M     | 1       | 0.5          |           |             | *            | 0 to 150 cm: <u>Radiolarian-nannofossil ooze</u> ; very pale<br>brown (10YR 7/4).                                                                                  | INE           |               | bromia               | n C<br>r A               | MG     | 1         | 0.5    |                                           |             | <pre>6 to 18 cm: <u>Radiolarian ooze</u>; yellowish brown (10YR 5/4),<br/>micritic. Grades downward to <u>nannofossil ooze</u>, white (N9)<br/>through 18 to 106 cm.<br/>106-124 cm: <u>Nannofossil ooze</u>; very pale brown (10YR 6/4)<br/>burrowing(?) structures. At 124 cm streak of dark grains;<br/>i light and dark glass, palagmite, pyroxene.</pre>                               |
| ENE          | sticha<br>erosa                           | f F<br>n C             | R P<br>C M      | 2       |              |           | -           |              | O to 150 cm: As in section 1                                                                                                                                       | LATE EOCE     | i             | Inyrsocyrtis         | n C                      | М      | 2         |        |                                           |             | <pre>124 to 150 cm: <u>Nannofossil ooze</u>; white (N9) 0 to 25 cm: <u>Nannofossil ooze</u>; white (N9) 25 to 150 cm: <u>Radiolarian ooze</u>; very pale brown (10YR 7/4) to light yellowish brown (10YR 6/4). This <u>radiolarian</u> ooze is top of gradational sequence in which <u>Tithology</u> gradually changes through sections 3, 4, and 5 to nannofossil oozes, white (N9).</pre> |
| EARLY OLIGOC | Ericsonia subdi<br>Theocyrtis tub         | fF                     | ξ P             | 3       |              |           |             |              | O to 150 cm: As in section 1                                                                                                                                       |               | grandis       |                      | r A                      | G<br>M | 3         |        |                                           |             | <pre>From 25 cm in section 2 to 83 cm in section 6 is a * single "turbidite" unit. *</pre>                                                                                                                                                                                                                                                                                                  |
|              | _                                         | n C                    | с м             | 4       |              |           | -           | *            | O to 150 cm: As in section 1                                                                                                                                       |               | Chiasmolithus |                      | n C                      | м      | 4         |        | ት ሕ ሕ ሕ ሃ / / / / / / / / / / / / / / / / |             |                                                                                                                                                                                                                                                                                                                                                                                             |
| /            | sis                                       | f B<br>n C<br>r F      | 3<br>2 M<br>7 M | 5       |              |           | -           |              | O to 150 cm: <u>Radiolarian-nannofossil ooze</u> ; pale brown<br>(10YR 7/4), grading downward into <u>foraminiferal</u> -<br>nannofossil <u>ooze</u> ; white (N9). | MIDDLE EOCENE |               | Jaocyrtis goetnelana | n C                      | M      | 5         |        |                                           |             |                                                                                                                                                                                                                                                                                                                                                                                             |
| LATE EOCENE  | Discoaster barbadien<br>Theocyrtis bromia | n (                    | A G             | 6       |              |           |             | *            | 0 to 150 cm: <u>Nannofossil ooze</u> and radiolarian-<br><u>nannofossil ooze</u> .                                                                                 |               |               | Ĩ                    | n C                      | м      | 6         |        |                                           |             | * At 83 cm: Base of turbidite sequence marked by streak of<br>mineral grains including brown pyroxene, plagioclase,<br>quartz, light and dark glass, zeolites and gypsum<br>(very rare).                                                                                                                                                                                                    |
|              |                                           | n (<br>r /             | C M<br>A G      | C<br>Ca | ore<br>tcher |           |             | *            | Nannofossil ooze.                                                                                                                                                  |               |               |                      | n C<br>r A               | M<br>G | C.<br>Cat | ore    |                                           |             | Radiolarian-nannofossil ooze                                                                                                                                                                                                                                                                                                                                                                |

Explanatory notes in Chapter 1

| Site          | 165                                    | Ho1         | еA                        | (           | Core    | 9               | Cored I                                            | nter                                  | val:         | 154 to 163 meters                                                                                                                                                                                                         | Si            | :e 1 | 65                                     | Hole        | еA          | C             | ore 10 | Cored In  | terva       | 1: 20        | 1 to 210 meters                                                                                                                                                                                  |
|---------------|----------------------------------------|-------------|---------------------------|-------------|---------|-----------------|----------------------------------------------------|---------------------------------------|--------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|------|----------------------------------------|-------------|-------------|---------------|--------|-----------|-------------|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| AGE           | ZONE                                   | FOSSIL R    | OSSIL<br>RACTE<br>. ONNBY | PRES. 2     | SECTION | METERS          | LITHOLOGY                                          | DEFORMATION                           | LITHO.SAMPLE | LITHOLOGIC DESCRIPTION                                                                                                                                                                                                    | AGE           |      | ZONE                                   | FOSSIL PL   | ABUND.      | PRES. 2       | METERS | LITHOLOGY | DEFORMATION | LITHO.SAMPLE | LITHOLOGIC DESCRIPTION                                                                                                                                                                           |
|               |                                        | fnr         | R<br>C                    | P M         | 0.      |                 |                                                    | ?                                     |              | 0 to 150 cm: Nannofossil-radiolarian ooze, very pale<br>brown (10YR 7/4). Grades downward to nannofossil ooze,<br>white (10YR 8/2).                                                                                       |               |      |                                        | n           | С           | 1             | 0.5-   |           | ?           |              | <pre>0 to 20 cm: <u>Radiolarian ooze</u>; light gray (10YR 7/2) to<br/>light yellow brown (10YR 6/4).<br/>20 to 150 cm: <u>Radiolarian-foraminiferal nannofossil ooze</u>;<br/>white (N9).</pre> |
|               |                                        |             |                           | 2           | 2       |                 |                                                    | · · · · · · · · · · · · · · · · · · · | *            | 0 to 93 cm: <u>Nannofossil ooze</u> ; white (10YR 8/2).<br>At 93 cm: Dark mineral grain streak containing pyroxene,<br>plagioclase, dark and light glass.<br>93 to 150 cm: Nannofossil ooze: white (10YR 8/2) and         |               |      |                                        | r<br>n      | A<br>C      | а<br>м 2      |        |           |             | *            | Same as dominant lithology of Sect. 1.                                                                                                                                                           |
|               | ndis<br>sana                           | n           | C<br>C                    | M 3         | 3       |                 |                                                    | ?                                     |              | radiolarian ooze, very pale brown (10YR 7/4)<br>O to 49 cm: As in 93 to 150 cm of section 2.<br>At 49 cm: Dark mineral streak as at 93 cm in section 2.<br>50 to 150 cm: <u>Nannofossil</u> and <u>radiolarian ooze</u> . |               |      | tus                                    | n           | C<br>A      | M 3<br>G 3    |        |           |             |              | Same as dominant lithology of Sect. 1.                                                                                                                                                           |
| MIDDLE EOCENE | Chiasmolithus gra<br>Podocyrtis goethe | r           | A                         | G           | 1       | mulmin          |                                                    |                                       |              | O to 150 cm: As from 50 to 150 cm in Sect. 3.                                                                                                                                                                             | MIDDLE EOCENE |      | Chiasmolithus soli<br>Podocyrtis mitra | n           | с           | м 4           |        |           |             |              | Same as dominant lithology of Sect. 1.                                                                                                                                                           |
|               |                                        | f<br>n<br>n | R<br>C<br>C               | P<br>M<br>M |         | بيلينينيلينيلير |                                                    |                                       |              | 0 to 150 cm: As from 50 to 150 cm in Sect. 3.                                                                                                                                                                             |               |      |                                        |             |             |               |        |           |             |              | Same as dominant lithology of Sect. 1.                                                                                                                                                           |
|               | tus                                    | r           | A                         | G           | 5       |                 | Т, <, <, +, <, <, <, <, <, <, <, <, <, <, <, <, <, |                                       |              | 0 to 128 cm: As from 50 to 150 cm in Sect. 3.                                                                                                                                                                             |               |      |                                        | f<br>r      | C<br>A      | g 5           |        |           |             |              | Same as dominant lithology of Sect. 1.                                                                                                                                                           |
|               | Chiasmolithus sol                      | n<br>n<br>r | C<br>C<br>A               | M<br>G C    | Corr    | re              |                                                    |                                       | *            | At 128 cm: Dark mineral streak as at 93 cm in section 2.<br>128 to 150 cm: <u>Radiolarian ooze</u> , dark brown (10YR 4/3).<br><u>Nannofossil-radiolarian ooze</u> .                                                      |               |      |                                        | n<br>n<br>r | C<br>C<br>A | M 6<br>M G Ca | Core   |           |             | *            | Same as dominant lithology of Sect. l.                                                                                                                                                           |

Explanatory notes in Chapter 1

| Site      | 165              | Но          | le A                     | (        | Core 1        | 1                                           | Cored 1   | Inter                                 | rval:         | 210 to 219 meters                                                                    | Site       | 165                            | н        | ole          | Α           | Cor       | re 12       | Cored Int                                                                                                     | terval:                     | 219 to 228 meters                                                                                                                                                                                                                                                                         |
|-----------|------------------|-------------|--------------------------|----------|---------------|---------------------------------------------|-----------|---------------------------------------|---------------|--------------------------------------------------------------------------------------|------------|--------------------------------|----------|--------------|-------------|-----------|-------------|---------------------------------------------------------------------------------------------------------------|-----------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| AGE       | ZONE             | FOSSIL 2_   | OSSIL<br>ARACTE<br>ONNBY | PRES. N  | METERS        |                                             | LITHOLOGY | DEFORMATION                           | LITHO. SAMPLE | LITHOLOGIC DESCRIPTION                                                               | AGE        | ZONE                           | Enceri D | FOS:<br>HARA | SIL<br>CTER | SECTION   | METERS      | LITHOLOGY                                                                                                     | DEFORMATION<br>LITHO.SAMPLE | LITHOLOGIC DESCRIPTION                                                                                                                                                                                                                                                                    |
|           |                  | f           | CA                       | M<br>G   | 0.5           |                                             |           |                                       | *             | 39 to 150 cm: <u>Radiolarian-mannofossil ooze;</u> white (N9)<br>to gray (10YR 7/1). |            |                                | r        | C A          | M<br>G      | 1         | 0.5         |                                                                                                               | ? *                         | O to 150 cm: <u>Radiolarian-nannofossil ooze;</u> white (N9),<br>crumbly and chalky zones alternate with soft plastic<br>zones.                                                                                                                                                           |
|           | Podocvrtis mitra | 'n          | c                        | 2        | 2             |                                             |           |                                       | *             | O to 150 cm: As in section 1.                                                        |            |                                | r        | n c          | м           | 2         |             | +<`<+`+`<`<+`+`<`<+`<                                                                                         |                             | O to 150 cm: <u>Radiolarian-nannofossil ooze</u> ; white,<br>(10YR 8/1).<br><u>Radiolarian ooze</u> ; light yellow brown (10YR 6/4).<br>These two lithologies alternate in layers 10 to 30 cm<br>thick. Parts are chalky and crumbly and parts are soft<br>and plastic.                   |
| LE EOCENE | ithus solitus    | n           | C I                      | M 3      |               |                                             |           | <u> </u>                              | *             | O to 150 cm: As in section 1.                                                        | ENE        | ulgens<br>mula                 | n        | CA           | MG          | 3         |             |                                                                                                               |                             | 0 to 150 cm: As in section 2.                                                                                                                                                                                                                                                             |
| MIDD      | Chiasmol         | n           | с                        | M L      | ł             |                                             |           | 4 4 4 4 4 4 4 4                       |               | O to 150 cm: As in section 1.                                                        | WIDDLE EOC | Nannotetrina f<br>Podorvrtis a | n        | c            | м           | 4         |             | + + > > > + + > > > + + > > > + + > > > + + + > > + + + > > + + + > > + + + + + + + + + + + + + + + + + + + + |                             | O to 150 cm: As in section 2.                                                                                                                                                                                                                                                             |
|           | Podocvrtis ampla | n           | C                        | M 5      | 5             |                                             |           | 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 |               | O to 150 cm: As in section l.                                                        |            |                                | r        | C<br>A       | M<br>G      | 5         |             |                                                                                                               |                             | <ul> <li>0 to 114 cm: As in section 2.</li> <li>At 114 cm: Streak of dark minerals, distorted but sharp.<br/>Base of turbidite(?)</li> <li>115 to 150 cm: <u>Radiolarian ooze</u>; light yellow brown<br/>(107R 6/4), with streaks of <u>mannofossil ooze</u>,<br/>white (N9).</li> </ul> |
| Exp       | anator           | n<br>n<br>r | C<br>C<br>A              | M<br>G C | Core<br>atche | 1777 S. |           | <u>2, 2, 2; 3] E E E E</u>            |               | O to 50 cm: As in section 1.<br><u>Radiolarian ooze</u> .                            |            |                                | n        | c            | м           | 6         |             |                                                                                                               |                             | 0 to 127 cm: <u>Radiolarian-nannofossil ooze</u> ; white (10YR 8/1 to 8/2). 127 to 150 cm: <u>Radiolarian-nannofossil ooze</u> ; pale brown (10YR 8/3), soft, "sugary", crumbly.                                                                                                          |
| υλþ       | ana cor          | , 110       |                          | una      |               |                                             |           |                                       |               |                                                                                      |            |                                | ,        | A            | G           | Cc<br>Cat | ore<br>cher |                                                                                                               | -                           | <u>Radiolarian ooze</u> .                                                                                                                                                                                                                                                                 |

| Sit    | e 165                 | Ho1        | еA                       | C        | ore 1         | 3            | Cored In  | nterv                                 | /al: 2       | 228 to 237 meters                                                                                                                              | Si       | te       | 165               | Ho1           | еA                        | C       | Core 1        | 14      | Cored Ir  | iterv       | /al:          | 237 to 246 meters                                                                                                                                                                                      |
|--------|-----------------------|------------|--------------------------|----------|---------------|--------------|-----------|---------------------------------------|--------------|------------------------------------------------------------------------------------------------------------------------------------------------|----------|----------|-------------------|---------------|---------------------------|---------|---------------|---------|-----------|-------------|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| AGE    | ZONE                  | FOSSIL 2   | OSSIL<br>ARACTE<br>ONNBY | PRES. 20 | METERS        | l            | _ITHOLOGY | DEFORMATION                           | LITHO.SAMPLE | LITHOLOGIC DESCRIPTION                                                                                                                         | AGE      | AGE      | ZONE              | FOSSIL R      | OSSIL<br>ARACTE<br>. ONNO | SECTION | METERS        | MEIERS  | LITHOLOGY | DEFORMATION | LITHO.SAMPLE  | LITHOLOGIC DESCRIPTION                                                                                                                                                                                 |
|        |                       |            |                          | 1        | 0.5           | Hullin I     | VOID      |                                       |              | 63 to 150 cm: <u>Radiolarian-nannofossil ooze;</u> white (N9).<br>Radiolarian ooze: <u>light vellow brown (1008 674</u> ).                     |          |          |                   |               |                           | 1       | 0.5           | אואאא   |           |             |               | O to 150 cm: <u>Radiolarian ooze;</u> light olive gray (5Y 6/1).<br>Liner not cut because of very high water content.                                                                                  |
|        |                       | n<br>r     | C A                      | G        | 1.0           | איינואיניען  |           |                                       | *            | "sugary" and crumbly.<br>These lithologies alternate.<br>O to 150 cm: As in section 1.                                                         | ?        |          | ?                 |               |                           |         | 1.0           | 4141414 |           |             |               | O to 150 cm: As in section 1.                                                                                                                                                                          |
|        |                       | r          | C                        | 2<br>M   |               |              |           |                                       |              |                                                                                                                                                |          |          | as<br>cantha      |               |                           | 2       |               | httttt  |           |             |               |                                                                                                                                                                                                        |
| EOCENE | jigas<br>s triacantha | r          | A                        | G 3      |               | thipping the |           | ?                                     |              | O to 150 cm: <u>Radiolarian ooze;</u> light gray (2.5Y 7/2),<br>massive. Material has appearance of slightly crystallized<br>soft maple sugar. | MIDDLE   | EOCENE . | r. triac          | r             | AG                        | Ca      | Core<br>atche | 5.1.2.1 |           |             | *             | Radiolarian ooze; light olive gray (5Y 6/1), few small chert chips.                                                                                                                                    |
| DDLE   | c.g                   |            |                          |          |               | ÷            | ~~~~      |                                       |              |                                                                                                                                                | sit      | e 1      | 65                | Hole          | A                         | Co      | are 1         | 5       | Cored In  | erv         | a1·2          | A6 to 256 meters                                                                                                                                                                                       |
| IIW    | Thyrsocy              |            |                          | 4        |               |              |           | · · · · · · · · · · · · · · · · · · · |              | O to 150 cm: As in section 3.                                                                                                                  | AGE      |          | ZONE              | FOSSIL FOSSIL | DSSIL<br>RACTER           | SECTION | METERS        | L       | .ITHOLOGY | DEFORMATION | LITHO.SAMPLE  | LITHOLOGIC DESCRIPTION                                                                                                                                                                                 |
|        |                       |            |                          |          |               | 11111        |           | 1111                                  |              |                                                                                                                                                | EARLY TO | C. didas | B.<br>clinata     | r<br>n        | F P<br>R P                | (<br>Ca | Core<br>tcher |         |           |             |               | Marl; very pale orange (10YR 8/2), laminated, friable.<br><u>Chert</u> ; moderate brown (5YR 3/4), dense. Present as rock<br>fragments.                                                                |
|        |                       |            |                          |          |               | 1            |           |                                       |              | 0 to 150 cm: As in section 3.                                                                                                                  |          |          |                   |               |                           |         |               |         |           |             |               |                                                                                                                                                                                                        |
|        |                       |            |                          |          |               | =            |           |                                       |              |                                                                                                                                                | Sit      | e 16     | 55                | Hole          | A                         | Co      | ore 16        | 5       | Cored Int | erva        | 1:2           | 56 to 284 meters                                                                                                                                                                                       |
|        |                       | r          | A                        | G 5      |               | 212121212    |           | ?                                     |              | Padiolarian ooza                                                                                                                               | AGE      |          | ZONE              | FOSSIL        | ACTER                     | SECTION | METERS        | L       | ITHOLOGY  | DEFORMATION | LITHO. SAMPLE | LITHOLOGIC DESCRIPTION                                                                                                                                                                                 |
|        | lanator               | r<br>v not | A es in                  | M C      | Core<br>atche | 2.2.2        |           |                                       |              |                                                                                                                                                | L. MAES. | A. mayo- | rensis<br>M. mura | f<br>r<br>n   | R P<br>B<br>C P           | C<br>Ca | Core<br>tcher |         |           |             |               | Limestone; grayish yellow (5Y 8/4), well-cemented by<br>calcite spar and micrite, large forams ( <u>pseudorbitoides?</u> ),<br>echinoid debris and volcanic rock fragments. See<br>Lithologic Summary. |

Explanatory notes in Chapter 1

| Site 1                 | 65                | Hole A                          |                          | Core                   | 17            | Cored    | Inte | erva        | 11:2         | 84 to 290 meters                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Sit      | e 165      |       | Hole                 | A              | С        | ore 1  | 19                                     | Cored I      | nter                  | /al:         | 321 to 340 meters                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|------------------------|-------------------|---------------------------------|--------------------------|------------------------|---------------|----------|------|-------------|--------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|------------|-------|----------------------|----------------|----------|--------|----------------------------------------|--------------|-----------------------|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| AGE                    | ZONE              | FOSSI<br>CHARAC<br>HBRND.       | LER                      | SECT ION               | METERS        | LITHOLOG | SY . | DEFORMATION | LITHO.SAMPLE | LITHOLOGIC DESCRIPTION                                                                                                                                                                                                                                                                                                                                                                                                                                                    | AGE      | ZONE       | FUNE  | FO<br>CHAI<br>LOSSIL | ISSIL<br>RACTE | SECTION  | METERS |                                        | .ITHOLOGY    | DEFORMATION           | LITHO.SAMPLE | LITHOLOGIC DESCRIPTION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| LATE MAESTRICHTIAN     | M. mura           | r R<br>n F<br>f R<br>n C<br>r R | P<br>P<br>M<br>P         | 1<br>1<br>Cor<br>Catch | .5            |          |      |             |              | 105 to 150 cm: <u>Nannofossil ooze</u> ; radiolarian-bearing plus<br>chert fragments. Very disturbed. <u>Limestone</u> ; white, fine-grained, laminae of dark, fine-<br>sand size mineral grains.<br><u>Chert; moderate red brown (10R 4/0), dense.</u><br><u>All fragments.</u>                                                                                                                                                                                          |          |            |       | n                    | C I            | 1 2      | 0.5    |                                        |              |                       |              | <ul> <li>0 to 150 cm: Volcanoclastic sandstone, siltstone, and breccia, interbedded with nannofossil marly limestone, colors range from dark greenish gray (56 4/1) to olive gray (5Y 4/1) to very light gray (NB). Rocks are laminated and show graded bedding, slump structures and burrowings. Breccias composed of fragments of volcanoclastic sandstone. Sedimentation units are on order of few cm thick. Very rapid lithologic changes in vertical section.</li> <li>0-to 93 cm: As above.</li> </ul> |
| Site 10                | 55                | Hole A                          |                          | Core                   | 18            | Cored    | Inte | erva        | 1:2          | 90 to 321 meters                                                                                                                                                                                                                                                                                                                                                                                                                                                          |          |            | ar ca |                      |                |          |        |                                        | Server.      |                       |              | 93 to 150 cm: Volcanoclastic sandstone, dark greenish<br>gray (56 4/1), coarse-grained, friable, well-developed<br>horizontal laminations.                                                                                                                                                                                                                                                                                                                                                                   |
| AGE                    | ZONE              | FOSSI<br>CHARAC                 | TER .Sa                  | SECTION                | METERS        | LITHOLOG | Y    | FORMATION   | THO. SAMPLE  | LITHOLOGIC DESCRIPTION                                                                                                                                                                                                                                                                                                                                                                                                                                                    | L. CAMP. | G. elevata |       | f<br>n               | R              | P<br>M C | Core   | er (1                                  |              |                       |              | Same as bottom of Sect. 2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|                        |                   | A F                             |                          | +                      | -             |          | -    | 8           | 3            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |          |            |       |                      |                |          |        | 20                                     | Course de la |                       |              | 210 4. 20                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| IAN                    |                   | n c<br>r r<br>n c               | м <sup>]</sup><br>Р<br>М | 0<br>L<br>1            | .0            | VOID     |      |             |              | 70 to 122 cm: <u>Nannofossil limestone</u> ; light gray (10YR 7/2),<br>finely laminated, burrowed. 122 to 150 cm: <u>Sand</u> ; dark greenish gray (56 4/1), rich                                                                                                                                                                                                                                                                                                         | AGE      |            | ZUNE  | FC CHAI              | SSIL<br>RACTE  | SECTION  | WETED  |                                        | _ITHOLOGY    | DEFORMATION           | LITHO.SAMPLE | LITHOLOGIC DESCRIPTION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| NIAN-EARLY MAESTRICHTI | ralithus trifidus | n c                             | м                        | 2                      |               |          |      |             |              | <pre>1n glass, palagonite, pyroxene, calcite cement.<br/>0 to 150 cm: <u>Volcanoclastic sandstone, siltstone,</u><br/><u>mudstone, and marl limestone; complex section of</u><br/>turbidites, crossbedding, graded bedding, planar<br/>bedding all common. Sedimentation units up to 25 cm<br/>thick. Disturbed, burrowed laminae common. Marly<br/>limestone very pale brown (10VR 7/3) to grayish brown<br/>(10VR 4/2), clastics are dark greenish gray (56 4/1).</pre> |          |            |       |                      |                | 1        | 0.1    | 111111111111                           | VOID         | 福田の茶                  |              | 95 to 124 cm: <u>Volcanoclastic sandstone;</u> dark greenish<br>gray, (56Y 4/1), coarse-grained, laminated.<br>124 to 150 cm: <u>Volcanoclastic breccia</u> (see section 2).                                                                                                                                                                                                                                                                                                                                 |
| LATE CAMPA             | Tet               | n c<br>r r                      | M<br>P                   | 3                      |               |          |      |             |              | r.                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |          |            |       |                      |                | 2        | 2      | 22220000000000000000000000000000000000 |              | いると思いていたので、           |              | O to 150 cm: <u>Volcanoclastic breccia</u> ; slightly graded bed<br>starting at 124 cm in section 1, clasts are volcanic<br>glass, pumaceoux, volcanoclastic sandstones in variegated<br>colors, white, pale green, dark green, dark brown and<br>reddish brown. Clasts range from 0.5 mm to 2 cm.<br>Cement is dense, vitreoux, pale green, non-calcareous.                                                                                                                                                 |
| Explan                 | atory             | y notes i                       | in Chaj                  | Cor<br>Catch           | e<br>ner<br>1 |          |      |             |              | Sandstone; grayish olive green (5GY 3/2), very fine-grained<br>Tamïnated, containing pyroxene, dark glass with calcite<br>cement.                                                                                                                                                                                                                                                                                                                                         |          |            | Jarca |                      |                | 3        | 3      | State State                            |              | K D. C. KUNDON MANUAR |              | O to 120 cm: As in section 2.<br>120 to 150 cm: <u>Limestone marly;</u> yellowish gray (5Y 8/1)<br>to light olive gray (5Y 6/1), laminated, burrowed.                                                                                                                                                                                                                                                                                                                                                        |

 $\frac{\text{Limestone; yellowish gray (5Y 8/1), to light olive gray}}{(5Y 6/1), marly, laminated, burrowed.}$ 

SITE 165

Explanatory notes in Chapter 1

ele

Core Catcher

ET.

MPANT

| Sit        | e 165           | Но        | le A                      |          | Cor       | re 21       |   | Cored I  | nterv       | al:3         | 368 to 396 meters                                                                                                                                                                                                                                                                                                                               | Sit    | e 1  | 65          | Hole       | A        | Co      | ore 23       | Cored In                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | terv        | al:4         | 424 to 451 meters                                                                                                                                                                                                                                                                    |
|------------|-----------------|-----------|---------------------------|----------|-----------|-------------|---|----------|-------------|--------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|------|-------------|------------|----------|---------|--------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| AGE        | ZONE            | FOSSIL 2_ | OSSII<br>ARACT<br>. ONNGY | PRES. BI | SECTION   | METERS      | Ľ | ITHOLOGY | DEFORMATION | LITHO.SAMPLE | LITHOLOGIC DESCRIPTION                                                                                                                                                                                                                                                                                                                          | AGE    |      | ZONE        | FC CHAI    | ABUND.   | SECTION | METERS       | LITHOLOGY                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | DEFORMATION | LITHO.SAMPLE | LITHOLOGIC DESCRIPTION                                                                                                                                                                                                                                                               |
|            | imius           | n         | с                         | Р        | 1         | 0.5         |   | VOID     |             |              | 100 to 146 cm: <u>Limestone</u> ; light yellowish gray (5Y 8/1),<br>micritic, burrowed with laminae of volcanoclastic sand<br>and silt. 146 to 150 cm: <u>Volcanic sandstone</u> ; greenish black (5G 2/1).                                                                                                                                     |        |      |             |            |          | 1       | 0.5          | VOID                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |             |              | 134 to 150 cm: <u>Basalt</u> , dark gray (N3), vesicular, fine-<br>grained.                                                                                                                                                                                                          |
| CAMP.      | Eiffellithus ex | n         | с                         | Р        | 2         |             |   |          |             |              | 0 to 150 cm: <u>Limestone</u> ; light yellowish gray (5Y 8/1)<br><u>Volcanoclastic sandstone</u> ; olive gray (5Y 4/1) to greenish<br>black (5GY 2/1). These two lithologies are interbedded.<br>Sandstones are graded, 5 to 10 cm thick. Burrow structures<br>common. Very rapid alternation of lithologies indicates<br>turbidite deposition. |        |      |             |            |          | 2       |              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |             |              | 0 to 150 cm: <u>Volcanoclastic mudstome</u> , <u>siltstome</u> , <u>sandstome</u><br>and <u>breccia</u> , brownish gray (5YR 4/1), grayish olive<br>green (56Y 4/2). Siltstones are laminated. Breccia<br>clasts up to 8 cm in diameter are fragments of siltstone<br>and sandstone. |
|            |                 | n         | с                         | Ρ        | 3         |             |   |          |             |              | O to 150 cm: As in section 2.                                                                                                                                                                                                                                                                                                                   |        |      |             |            |          | Cat     | ore<br>tcher |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |             |              | <u>Siltstone</u> ; moderate reddish brown (10R 4/6), massive,<br>contains silicified radiolarian tests.                                                                                                                                                                              |
|            |                 | r         | R                         | Р        |           | -           |   |          |             |              |                                                                                                                                                                                                                                                                                                                                                 | Site   | e 1  | 65          | Hole       | А        | Со      | re 24        | Cored In                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | terv        | a]:4         | 451 to 460 meters                                                                                                                                                                                                                                                                    |
| CAMP.      |                 | n<br>r    | c<br>R                    | P<br>P   | Cc<br>Cat | ore<br>cher |   |          |             |              | Same as Sect. 2.                                                                                                                                                                                                                                                                                                                                | AGE    |      | ZONE        | FO<br>CHAF | ABUND.   | SECTION | METERS       | LITHOLOGY                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | DEFORMATION | LITHO.SAMPLE | LITHOLOGIC DESCRIPTION                                                                                                                                                                                                                                                               |
| Sit        | e 165           | Hol       | еA                        |          | Cor       | e 22        |   | Cored I  | nterv       | al: 3        | 196 to 424 meters                                                                                                                                                                                                                                                                                                                               |        | T    |             |            | -        |         |              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |             |              |                                                                                                                                                                                                                                                                                      |
| AGE        | ZONE            | FOSSIL 2  | OSSIL<br>RACT             | PRES. B  | SECTION   | METERS      |   | THOLOGY  | DEFORMATION | LITHO.SAMPLE | LITHOLOGIC DESCRIPTION                                                                                                                                                                                                                                                                                                                          |        |      |             |            |          | 1       | 0.5          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |             |              | Limestone: light gray (5Y 7/1) and olive gray (5Y 4/1),<br>laminated.<br><u>Basalt</u> ; dark gray (N3) to black (N1), vesicular with white<br>to light green fillings, thin calcite veinlets.<br>All material in core is in form of loose subrounded rock<br>fragments.             |
|            |                 |           |                           |          | 1         | 0.5         |   | VOID     |             |              |                                                                                                                                                                                                                                                                                                                                                 |        |      |             |            |          | Cat     | ore<br>tcher | A     T     F     A     A       A     T     F     A     Y       A     T     A     Y     Y       A     Y     A     Y     Y       A     Y     Y     Y     Y       A     Y     Y     Y     Y       A     Y     Y     Y     Y       A     Y     Y     Y     Y       A     Y     Y     Y     Y       A     Y     Y     Y     Y       A     Y     Y     Y     Y       A     Y     Y     Y     Y       A     Y     Y     Y     Y       A     Y     Y     Y     Y       A     Y     Y     Y     Y       A     Y     Y     Y     Y       A     Y     Y     Y     Y       A     Y     Y     Y     Y       A     Y     Y     Y     Y       A     Y     Y     Y     Y       A     Y     Y     Y     Y       A     Y     Y     Y     Y       Y     Y     Y     Y <td></td> <td></td> <td>Basalt</td> |             |              | Basalt                                                                                                                                                                                                                                                                               |
|            |                 |           |                           |          |           | 1.0-        |   |          |             |              | Mudstone, brownish gray (5YR 4/1), silty laminae.                                                                                                                                                                                                                                                                                               | Site   | o 16 | 5           | Hole       | ۵        | 60      | re 25        | Cored In                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | tow         | .1. /        | 160 to 490 metaus                                                                                                                                                                                                                                                                    |
|            |                 |           |                           | ł        | -         |             |   |          | 1           |              |                                                                                                                                                                                                                                                                                                                                                 |        | Г    |             | FO         | SSIL     | Т       |              | cored In                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Z           |              | Hoo to Hoo meters                                                                                                                                                                                                                                                                    |
| CRETACEOUS |                 |           |                           |          | 2         |             |   | VOID     |             |              |                                                                                                                                                                                                                                                                                                                                                 | AGE    |      | ZONE        | FOSSIL     | ABUND.   | SECTION | METERS       | LITHOLOGY                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | DEFORMATIO  | LITHO.SAMPL  | LITHOLOGIC DESCRIPTION                                                                                                                                                                                                                                                               |
| LATE       |                 |           |                           |          |           |             |   |          |             |              | Mudstone: olive gray (5Y 4/1), laminated.<br>                                                                                                                                                                                                                                                                                                   | IAN    |      | eximius     |            |          | 1       | 0.5          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |             |              | <u>Cavings</u> ; mudstone fragments and granules and chips of<br>various lithologies. Some contain nannofossils of<br>Eccene age.                                                                                                                                                    |
|            | 2               | r         | R                         | Р        | 3         |             |   |          |             |              | part shows cross-lamination.<br>136 to 150 cm: <u>Volcanoclastic sandstone</u> ; graded bed<br>ranging from silty at top to sand at bottom.                                                                                                                                                                                                     | CAMPAN |      | Eiffelithus | n          | FM       | с       | 1.0-         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |             |              |                                                                                                                                                                                                                                                                                      |
| ATE        | INCOU           | r         | R                         | Р        | C         | ore         |   |          |             |              | Volcanoclastic siltstone.                                                                                                                                                                                                                                                                                                                       |        |      |             | <u>'</u>   | <u> </u> | La      | ccner        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |             |              |                                                                                                                                                                                                                                                                                      |
|            |                 |           |                           |          | Lat       | .cner       |   | ·····    |             |              |                                                                                                                                                                                                                                                                                                                                                 | Exp    | an   | atory       | note       | s 1n 1   | napt    | er I         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |             |              |                                                                                                                                                                                                                                                                                      |

83

| 165  | Hol      | еA     |          | Co     | re 26 | Cored In  | terv     | al:4      | 80 to    | 485       | meters             |                                                                         |
|------|----------|--------|----------|--------|-------|-----------|----------|-----------|----------|-----------|--------------------|-------------------------------------------------------------------------|
|      | F<br>CHA | OSSI   | L<br>TER | N      | 10    |           | NOI      | IPLE      |          |           |                    |                                                                         |
| ZONE | FOSSIL   | ABUND. | PRES.    | SECTIO | METER | LITHOLOGY | DEFORMAT | LITHO.SAM |          |           |                    | LITHOLOGIC DESCRIPTION                                                  |
|      |          |        |          | 1      | 0.5   | VOID      |          |           | 120<br>d | to<br>ark | 141 cm:<br>greenis | Volcanoclastic siltstone and mudd<br>h gray (5GY 4/1), laminated. Lower |

Site 165 Hole A Core 27 Cored Interval: 485 to 490 meters FOSSIL CHARACTER DEFORMATION LITHO.SAMPLE SECTION METERS ZONE LITHOLOGY LITHOLOGIC DESCRIPTION FOSSIL AGE ABUND. PRES VOID 0.5-1 <u>Basalt</u>; dark gray (wet)(N3) light gray (dry)(N6), massive slightly vesicular. Some vesicles up to 1.5 cm in diameter filled with calcite(?), shot through with thin white calcite veinlets. 1.0-2 3 Basalt; as in sections 1, 2, and 3. Core Catcher

Explanatory notes in Chapter 1

Catcher

84

Site

AGE



































