8. SITE 255

The Shipboard Scientific Party[1]

SITE DATA

Locality: Broken Ridge

Position:
lat 31°07.87′S
long 93°43.72′E

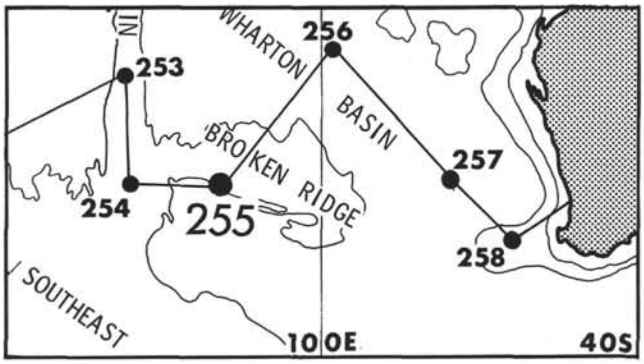
Dates Occupied: 11-12 October 1972

Water Depth: 1144 meters

Penetration: 108.5 meters

Number of Cores: 11

Oldest Datable Sediment Cored:
Depth (subbottom): 108.5 meters (Core 11)
Nature: Limestone
Age: Santonian



Principal Results: Basement was not reached at this site. Stratigraphy is as follows: 55 meters of lower Miocene to Recent nannoplankton foraminiferal ooze overlie 20 meters of mid Eocene, sandy, cherty gravel, and chalk, which in turn rest on dipping, gray fossiliferous limestone. The limestone is Santonian in age and contains chert bands.

BACKGROUND AND OBJECTIVES

Site 255 is located in 1144 meters of water atop Broken Ridge (Figure 1), near its southern edge. Broken Ridge is one of the particularly enigmatic shallow marine structures in the Indian Ocean. This structure strikes east-west for about 1000 km near the southern end of Ninetyeast Ridge and is about 500 km wide. It is not known whether Broken Ridge and the Ninetyeast Ridge are joined structurally (genetically) or topographically. Broken Ridge is marked by a very steep southern margin which has about 3 km of relief above the general level of the sea floor to the south. Just at the base of this southern scarp is the Ob Trench (Heezen and Tharp, 1965) which is from 0.5 to 1 km deeper than the sea floor, so that the total relief of this southern scarp is up to 4 km. In contrast to the steep southern scarp, Broken Ridge slopes gently northwards, with a gradient of about 0.006, to the abyssal depths of the south Wharton Basin some 500 km to the north.

Projecting along strike to the east of Broken Ridge, but separated by a deep-sea gap some 600 km wide, is the Naturaliste Plateau, a submerged extension or appendage of the Australian continent. This and other observations have led to speculations that Broken Ridge is a continental structure, although rock samples are lacking to confirm or deny this. The strongest evidence in support of a continental origin is the seismic refraction work of Francis and Raitt (1967) which shows a continental-type velocity structure and a crustal thickness of some 18 km. The Kerguelen Plateau is a structure similar to Broken Ridge which is located an equivalent distance south of the Southeast Branch of the Indian Ocean Ridge. This geometry has lead to suggestions that Kerguelen Plateau and Broken Ridge are the same original structure which was once joined but separated into two parts in the Eocene when Australia and Antarctica rifted. Kerguelen Island, on the Plateau, has late Tertiary granitic-like rocks (Watkins et al., 1974) which are no older than late Miocene and are probably differentiates.

The age and nature of the basement rock (continental-granitic vs. oceanic-basaltic) of Broken Ridge have several consequences for the breakup and dispersal of Gondwanaland. In particular, if the ridge is continental (and therefore probably Paleozoic or older), this eliminates the possibility that India lay against Antarctica unless it can be shown that Broken Ridge and the

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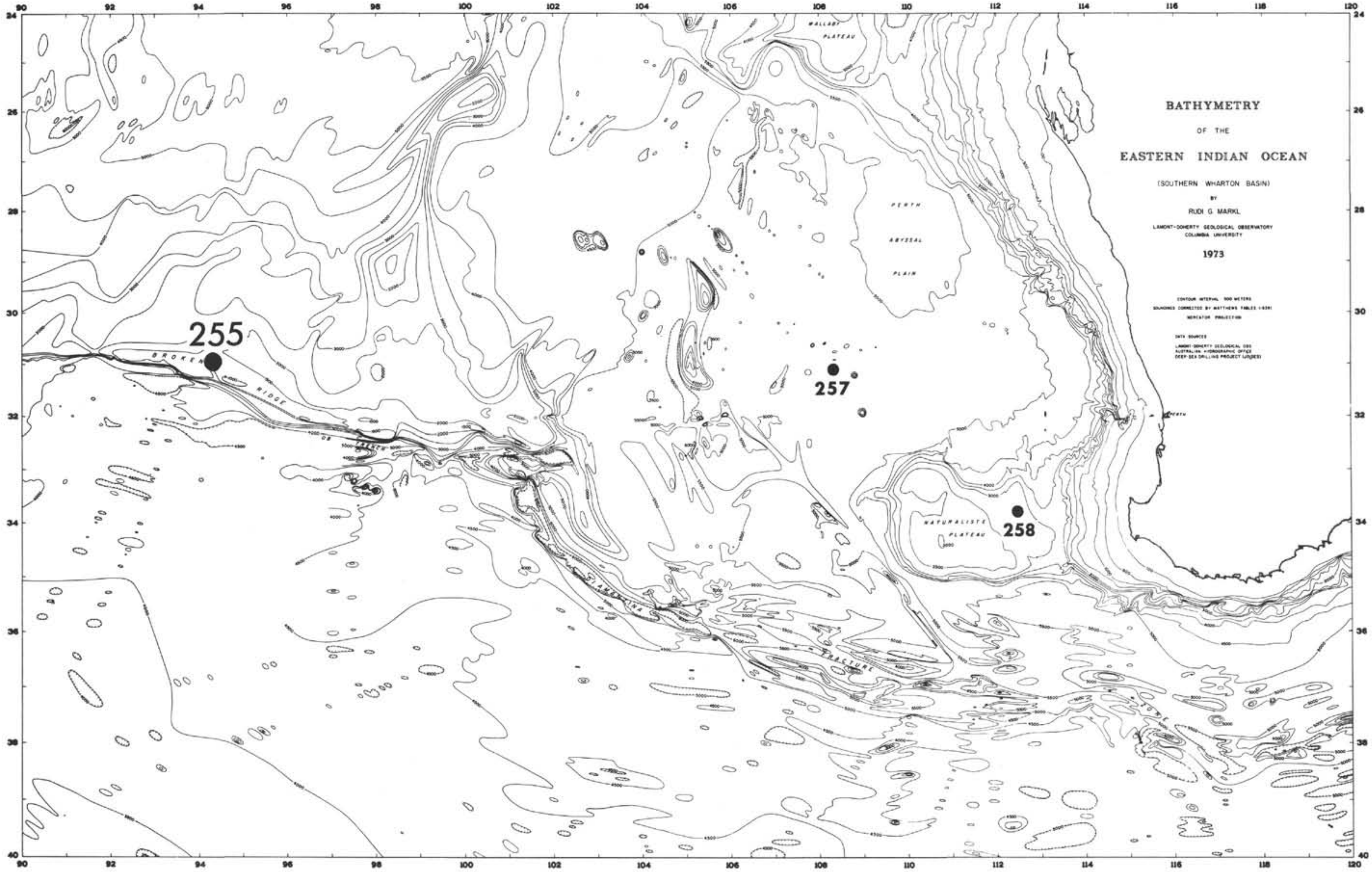

Figure 1. *Base chart showing locality of Site 255. (Chart compiled and contoured by R. Markl, Lamont-Doherty Geological Observatory.)*

Kerguelen Plateau have also "drifted" away from Antarctica. If Broken Ridge is oceanic then India can fit against Antarctica provided that Broken Ridge is no older than about 75 m.y. Further implications of an oceanic origin for Broken Ridge are that the structure cannot be younger than 45 m.y., the date that Australia-Antarctica rifted. If so, this would imply that the Kerguelen Plateau and Broken Ridge are separate structures with separate origins.

Available seismic profiles showed that the only place basement was likely to be within reach of the drill was very near the southern scarp of Broken Ridge. Away from this scarp to the north about 0.8 sec DT of sediments is seen above the deepest observed reflector, which is not obviously acoustic basement. Our seismic profiles (Figures 2 and 3) were taken approaching the site from the west, crossing the scarp heading southeast then crossing the scarp to the site heading northeast and, finally, heading northeast away from the site. The seismic structure atop the ridge shows a thin transparent layer above a strong subhorizontal reflector. The transparent layer shows evidence of reworking by currents. In several places either dune-like structures are seen or the transparent layer has been eroded to expose the underlying reflector (Figure 2). The profiles more normal to the scarp (Figures 2 and 3) show that near the site the transparent layer is about 0.1 sec DT thick. The intermediate reflector is in angular contact with a lower layer dipping northwards and subhorizontally truncated at about 0.1 sec DT subbottom (Figure 3). This dipping layer appears to lie conformably on basement, down at 0.3 sec DT near the site, also dipping northwards.

OPERATIONS

Glomar Challenger approached Site 255 from the southwest along a track parallel to and within a mile of an existing *Conrad*-11 track. The site was selected near the crest of Broken Ridge at a place where both the deep, dipping strata and the basement could be identified and were within reach of the drill. The beacon was dropped while underway at 5 knots in 1144 meters of water at 0042, 11 October. The first core was brought onboard at 0549. Vital statistics for the cores taken at Site 255 are given in Table 1.

The first cores cut consisted of foraminiferal ooze having the texture of silty sand. This resulted in very low recoveries and unstable hole conditions. Matters did not improve with the recovery of Cores 6 and 7 which consisted of "beach" sands and conglomerates. Core 8, cut at 70.5-80.0 meters subbottom, encountered the top of the dipping series and recovered one piece of chert. Drilling now became very hard and we proceeded with a certain amount of trepidation because of the unstable hole conditions and the fact that the bottom hole assembly was only partially buried (fortunately positioning and weather conditions were perfect). After cutting Core 9, which consisted of several pieces of limestone, the drill string was found to be stuck in the hole and it took about 10 min for it to be freed (1350-1400, 11 October). Core 9 showed an apparent dip in the limestones of 15°-20° and a drift survey was run to determine how much of this dip was true dip and how much might be due to drift of the hole as a result of the bit encountering resistant, dipping strata. The survey indicated the hole to be within 2° of vertical so the dip observed in the limestones can be considered true dip. While the survey was being run, we again became briefly stuck in the hole. To try to improve the hole conditions some mud was spotted before we continued.

Operations proceeded slowly, and uneventfully, until 2020 when we again became firmly and finally stuck in the hole. This occurred after Core 11 had been cut and the driller was gently reaming the hole prior to cutting Core 12. It is believed that the upper 70 meters of the hole, through the sandy oozes, caved in and trapped the pipe. All efforts to free the stuck pipe were in vain, and shortly before midnight the decision was made to shoot off the bottom hole assembly and abandon Hole 255. At 0430, 12 October the pipe was severed about 40 meters above the mudline and we commenced pulling the remainder of the pipe. The entire bottom hole assembly was left in the sea bed. The remainder of the pipe and the piccolo were aboard by 0750. We then took advantage of the near-perfect weather conditions to bring up the new bottom hole assembly from the hold before getting underway, at 1500, 12 October, for Site 256, in the Wharton Basin.

Further attempts to drill on Broken Ridge were abandoned because to drill in a comparable location on the crest of the ridge would clearly have been unwise, and we felt that to have drilled elsewhere would have involved drilling and coring through an inordinately thick section of sediment with concomitant expenditure of valuable time before adding significant new information on the origin and nature of Broken Ridge.

LITHOLOGY

Site 255 was cored almost continuously for 99 meters, down to a depth of 109 meters below the mudline. As a consequence of the friable nature of the uppermost sediments and the presence of cherts near the bottom of the hole, only 8 meters of core were recovered before the site had to be abandoned for technical reasons.

The sediments are divided into three units (Table 2). A considerable change in depositional environment, from deep water, pelagic facies to shallow water, littoral conditions occurs between Units 1 and 2, where there may be a disconformity. A major angular unconformity separates Units 2 and 3, the unit having been deposited in slightly deeper water than Unit 2, under shelf conditions.

Unit 1

The surficial unit, 55 meters thick, ranges from very pale yellowish-white nannoplankton foraminiferal ooze at the top, through pale orange and white to pale brown and yellowish-brown ooze of a similar nature at the base. The oozes are all sandy in texture, containing approximately two-thirds foraminifera and one-third coccoliths, with a trace of clay. The lowest core contains some glauconite, traces of zeolite, and ferruginous streaks and mottling.

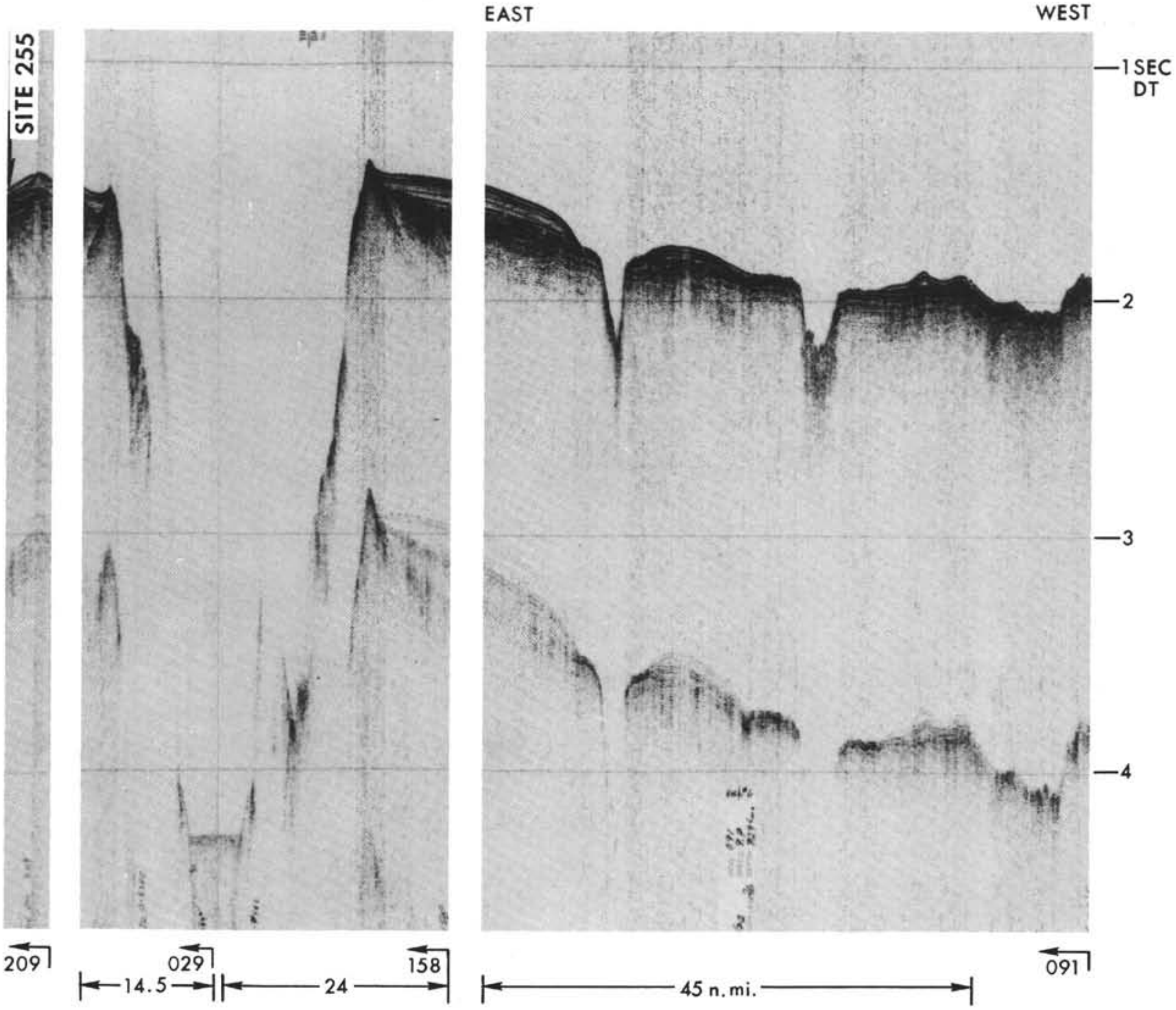

Figure 2. *Seismic reflection profile approaching Site 255, taken from D/V* Glomar Challenger.

Unit 2

Only core-catcher samples were retrieved from the two cores comprising this unit, so that the unit boundaries cannot be accurately fixed. The upper part consists of a coarse, probably reworked gravel of foraminifera, mollusc and chert fragments, with bryozoan encrustations. The lower part is an olive-yellow ironstained calcareous chalk, silt-sized in texture, with the composition approximately 50% carbonate, 30% chert, 16% clay, and 4% glauconite. At the base is a thin layer of light brownish-gray silty chalk with less iron staining but otherwise of a similar composition.

Unit 3

The lowest unit, below the angular unconformity, is a gray fossiliferous biomicritic limestone, overlain by, and containing at least four layers and bands of black chert, the thickest completely recovered layer being 18 cm and the thinnest 6 cm. The limestone bedding dips at angles of between 15° and 30° and has numerous thin (1-2 mm) calcite bands which widen into lenses containing mollusc fragments, including some silicified pelecypod plates. There are occasional layers of glauconite within crevices in the limestone.

The chert is black but altered to a white patina at the surface, where there are occasional clusters of minute pyrite crystals. It has a conchoidal fracture, and several such fractures are recemented by clear cristobalite. Bluish-white chalcedony is deposited in crevices, and the chert contains foraminifera and other microfossils. At several points a normal contact between chert and limestone is visible.

In thin section the biomicritic limestone exhibits a well-preserved microfauna of foraminifera and radiolarians dispersed within a fine micrite. Also present are disaggregated turbid calcite prisms up to 0.5 mm in size derived from macrofossils and a few much larger valves of thin-walled ?pelecypods and crinoid ossicles. Lamination is visible in thin section due to incipient layering of the fossil debris. Layers and pockets of sparite cement are sometimes associated with the macrofaunal fragments, and sparite partially fills foraminifera.

The carbonate fossil fragments show some recrystallization and, rarely, partial replacement by micro-

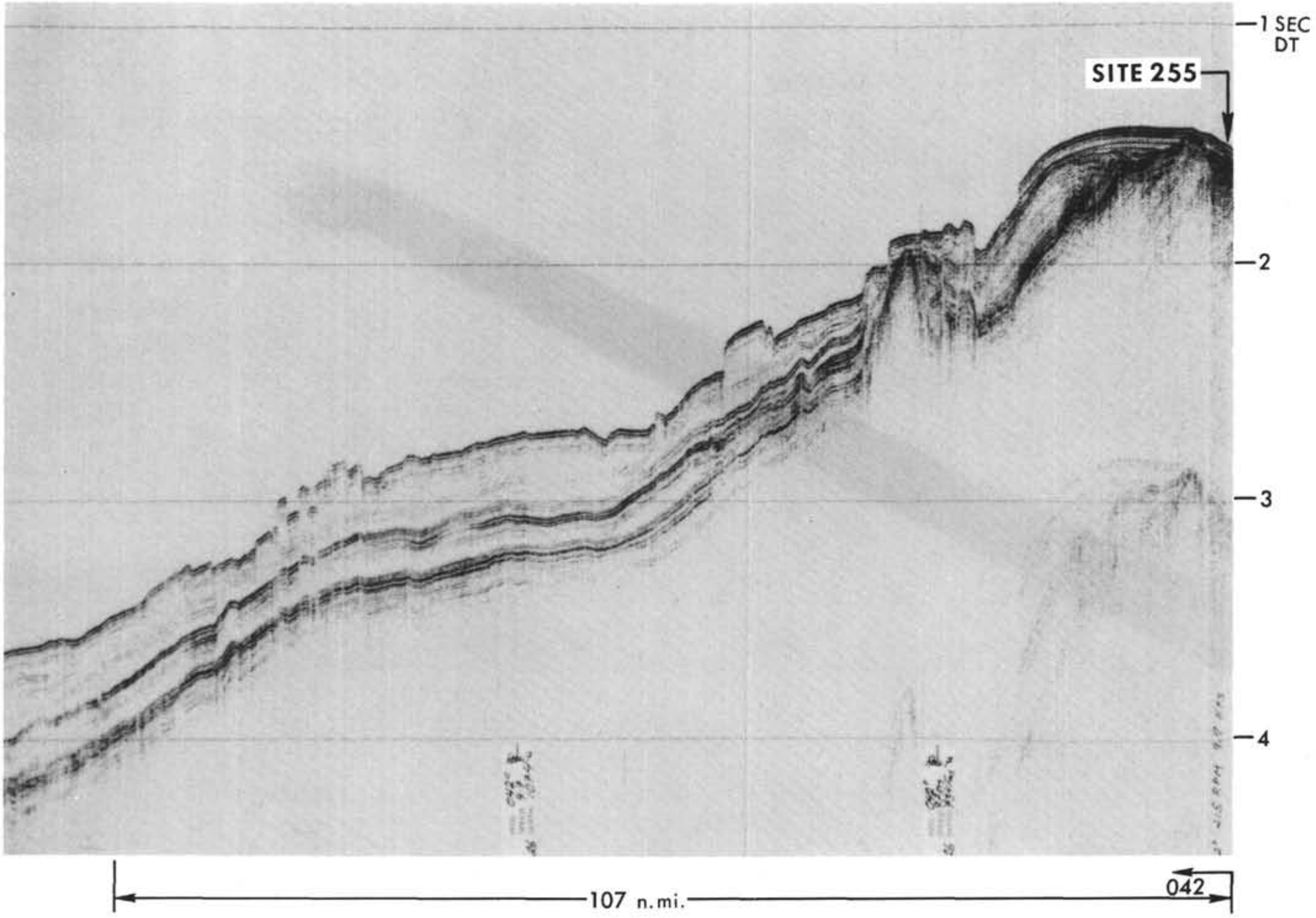

Figure 3. *Seismic reflection taken from D/V* Glomar Challenger *on leaving Site 255 and heading down the north flank of Broken Ridge.*

crystalline quartz. Pyrite granules, averaging some 5 mm, are relatively abundant (<1%) both in the matrix and partially filling foraminifera. Pellets of glauconite (0.1 mm) in trace amounts are common (ca 1%) and glauconite also replaces radiolarian tests. Organic fragments of brown collophane in trace proportions are widespread, but there are no obvious terrigenous components.

SHIPBOARD GEOCHEMICAL MEASUREMENTS

Only one sample of interstitial water was obtained at Site 255, reflecting the overall poor recovery. The sample was squeezed and analyzed for salinity, *p*H, and alkalinity with the standard techniques described in the report of Site 250. The data, obviously of little value, are given in Table 3.

PHYSICAL PROPERTIES

Acoustic velocities were measured on three limestone samples with a mean of 2.9 km/sec and on one chert sample with a mean of 5.7 km/sec.

No other physical properties were measured.

CORRELATION OF SEISMIC REFLECTION PROFILE WITH DRILLING RESULTS

At Site 255 an on-site seismic reflection profile was run using a SSQ41 sonobuoy and a 30-in^3 airgun (Figure 4). Prominent reflections are visible at 0.06, 0.075, 0.09, 0.145, 0.26, and 0.31 sec DT subbottom. The strongest reflections are at 0.06 and 0.09 sec DT and correspond to the base of the transparent layer and the top of the truncated beds seen in the seismic profile approaching the site (Figures 2 and 3).

Because very little undisturbed material was retrieved, acoustic velocity measurements and therefore impedance calculations could not be carried out. Assuming the lithologic contrasts represent significant impedance contrasts, we can make the following correlations. The contact between the ooze and gravel at 55 meters corresponds to the 0.06 sec DT reflection while the gravel-limestone contact at 75 meters corresponds to the 0.075 sec (or 0.09 sec) reflection. This gives an average velocity of 1.83 km/sec down to the ooze-gravel contact and of 2.0 km/sec down to the gravel-limestone contact.

The seismic profile leaving Site 255 gives insight as to the relevance of the drilling results to the structure of Broken Ridge (Figure 3). The ooze sequence unconformably overlies the truncated beds of the limestone unit and the lower part of the ooze section to the north. This lower truncated section of the ooze is presumably older sediments not found at Site 253. The limestone unit continues for 22 km northward from the site, which, when added to the section south of the site and correcting for the dip of 2.5° measured from the

TABLE 1
Cores Cut at Site 255

Core	Date (Oct. 1972)	Time	Depth from Drill Floor (m)	Depth Below Sea Floor (m)	Length		Recovery (%)
					Cored (m)	Recovered (m)	
1	11	0549	1154.0-1158.0	0-4.0	4.0	CC	0
2	11	0624	1158.0-1167.5	4.0-13.5	9.5	CC	0
Drilled			1167.5-1177.0	13.5-23.0			
3	11	0750	1177.0-1186.5	23.0-32.5	9.5	2.5	26
4	11	0830	1186.5-1196.0	32.5-42.0	9.5	2.0	21
5	11	0922	1196.0-1205.5	42.0-51.5	9.5	0.8	8
6	11	1010	1205.5-1215.0	51.5-61.0	9.5	CC	0
7	11	1111	1215.0-1224.5	61.0-70.5	9.5	CC	0
8	11	1244	1224.5-1234.0	70.5-80.0	9.5	CC	0
9	11	1420	1234.0-1243.5	80.0-89.5	9.5	0.5	5
10	11	1817	1243.5-1253.0	89.5-99.0	9.5	1.3	14
11	11	2020	1253.0-1262.5	99.0-108.5	9.5	0.8	8
Total					99.0	7.9	8

TABLE 2
Lithologic Summary, Site 255

Unit	Core	Depth Below Sea Floor (m)	Thickness (m)	Description
1	1-5[a]	0-55.0[a]	55	Pale yellowish-white to brown nannoplankton foraminiferal ooze, locally glauconitic at the base
2	6, 7	55.0[b]-75.0[b]	20	Probably reworked sandy cherty gravel, overlying yellow and gray silty calcareous chalk
3	8-11	75.0[b]-108.5	33.5	Gray fossiliferous biomicritic limestone with chert layers and bands

[a] Core 1 was totally devoid of sediment.

[b] Because of extremely poor recoveries, boundaries have been partly fixed by reference to drilling log. In view of the distinctive lithologies present, this procedure is probably quite reliable.

TABLE 3
Shipboard Geochemical Measurements, Site 255

Sample (Interval in cm)	Depth Below Sea Floor (m)	Lab Temp (°C)	pH, Flow-through	Alkalinity (meq/kg)	Salinity (°/oo)
5-1, 144-150	43.44-43.50	22.4	7.57	2.52	35.8

profile, gives a total thickness of about 1300 meters. The top of the limestone continues to be observed a short distance downslope where it ultimately plunges beneath the increasing thickness of soft oozes.

PALEONTOLOGY

Biostratigraphic Summary

Lithologically and biostratigraphically, three units[2] can be recognized at this site.

1) Unit 1: 55 meters of Miocene to Recent nannoplankton foraminiferal ooze. Reworked Oligocene planktonic foraminifera occur in the lower part of this unit. In addition, contamination through drilling operations in these unconsolidated sediments may account for some of the rather unusual assemblages found.

2) Unit 2: 20 meters of fine- to coarse-grained sandy cherty gravel with abundant bryozoan debris, at the base yellow and gray silty calcareous chalk. Sample 7, CC shows lower Eocene larger foraminifera (possibly reworked) above a middle Eocene nannoplankton assemblage and is therefore placed in the middle Eocene. Deposition of this unit took place in a shallow-water environment.

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[2] Boundaries have been fixed with reference to the drilling log since core recovery was so low.

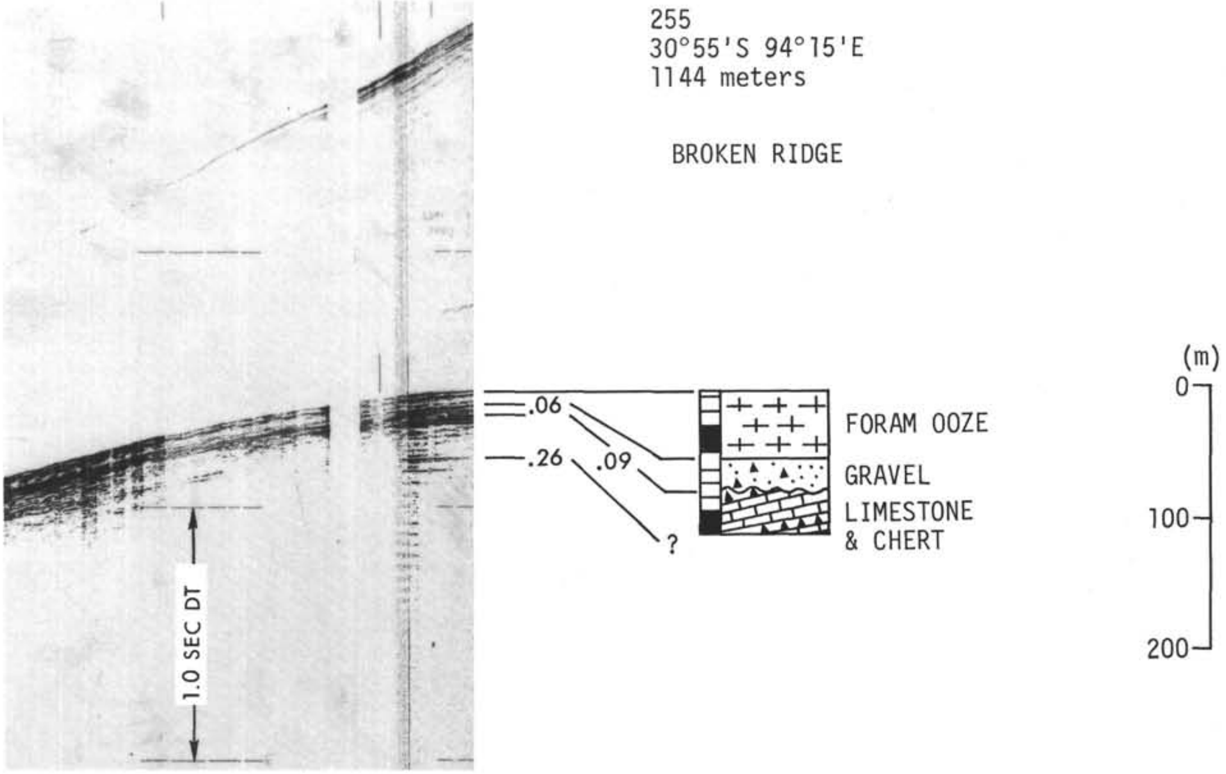


Figure 4. *Correlation of seismic reflection profile and drilling results.*

3) Unit 3: 33.5 meters of hard limestone and chert with planktonic and benthonic foraminifera as well as nannoplankton and radiolarians. This unit is placed in the Santonian. It has been deposited in medium water depths of not more than a few hundred meters. The calcareous assemblages indicate a cool to temperate paleoenvironment.

Foraminifera

Neogene (Unit 1): The foraminifera in the nannoplankton foraminiferal ooze are well preserved except in the lower Miocene, where many tests are damaged. The site is located at approximately the same latitude as Site 254, and its fauna is of the same temperate zone type. *Globorotalia inflata s.l.* is predominant in the Pliocene-Recent section. As at Site 254, the uppermost sample (taken at a depth of 4 m below bottom surface) contains *Globorotalia tosaensis* (besides *G. truncatulinoides*) and not typical Recent forms. Thus it was not possible to recognize Recent sediments. The Pleistocene/Recent boundary must be situated somewhere in the uppermost 4 meters of sediments.

The Pliocene/Quaternary boundary was determined by means of the *Globorotalia truncatulinoides: G. tosaensis* ratio. Also, several species, among them—*Globorotalia miozea conoidea, Globigerina nepenthes,* and *Sphaeroidinella seminulina*—became extinct at the end of the Pliocene. It was not possible to subdivide the Pliocene sediments.

In the Miocene sequence only upper, middle, and lower Miocene could be distinguished; zones were not separated. The upper part of the lower Miocene could not be recognized at all.

Paleogene (Unit 2): In Cores 6 and 7 only core-catcher material was recovered. Besides fragments of bryozoans and molluscs, some larger foraminifera of the genus *Asterocyclina* and, in Core 7, small nummulites (*Nummulites* cf. *irregularis* Deshayes) occur. The presence of the latter form indicates lower Eocene, but the partly broken tests of the larger foraminifera, as well as their occurrence in a coarse detrital sediment, are indications of reworking in the middle Eocene, as shown by the nannoplankton (see below). The presence of Miocene-Pliocene planktonic foraminifera, which were found in the core catcher of Core 6, is considered to be the result of contamination during drilling operations.

It should be pointed out that the presence of Eocene sediments on Broken Ridge has already been noted by Saito (in Ewing et al., 1969).

Upper Cretaceous (Unit 3): No isolated foraminifera could be extracted from the hard limestones and cherts encountered in Core 8 and below (75 m). Ten thin sections were made, and all showed rich assemblages of Upper Cretaceous planktonic foraminifera, a number of benthonic species, and, in the limestones only, fragments of *Inoceramus* showing the thick prismatic layer typical for the larger Upper Cretaceous representatives of this pelecypod group. The assemblage of planktonic foraminifera in these limestones consists mainly of abundant, small nonkeeled forms which cannot be identified specifically in nonoriented thin sections. Many of them are almost planispirally coiled and show up to seven chambers in the last whorl (probably *Globigerinelloides*). Very few sections of double-keeled *Globotruncana* were found, and the age of the drilled Upper Cretaceous can therefore, according to foraminifera alone, not be older than Turonian. The high preponderance of *Hedbergella* over *Globotruncana* raises problems of paleoecologic interpretation. A cool paleoenvironment during deposition of this sediment might be one way of explaining it. The great abundance of planktonic foraminifera, together with a variety of smaller benthonic foraminifera, suggest deposition in depths corresponding to the outer shelf or the uppermost slope.

Calcareous Nannoplankton

Stratigraphy: Few to common strongly overgrown nannofossils of Santonian (Cores 9 to 11), middle Eocene (Core 7), Miocene (Cores 3 to 5), Pliocene (Core 3), and Quaternary ages (Core 2) were found. The three poorly preserved Upper Cretaceous nannofossil assemblages are correlated with those of the Santonian on the Naturaliste Plateau (Site 258) and seem to be slightly older than the nannofossils of the Gingin Chalk (Santonian) in the Perth Basin. The assemblage in the core catcher of Core 7 consists of about 50% Santonian and 50% lower to middle Eocene species. As at Sites 251 and 258, a stratigraphic overlap of *Discoaster* sp. and *Gephyrocapsa* sp. (Sample 255-3-1, 35 cm) is observed, and again the foraminifera indicate an upper Pliocene age for this overlap.

Preservation: The extent of overgrowth of the nannofossils increases with the age of the sediment.

Paleoecology: The Santonian and the Miocene assemblages are characteristic of transitional environments.

SEDIMENTATION RATES

Due to the resedimentation processes in the Cenozoic part of the sequence, it is impossible to give any precise figures for the accumulation rates at Site 255. Assuming that there is a continuous sequence of lower Miocene-Recent between the sea floor and Sample 5, CC, the average rate would be approximately 2.4 m/m.y. for the Neogene. It may be considerably higher during certain time intervals if the sedimentation were discontinuous or began later in the Miocene. There is no proof so far for either of these possibilities, however.

For the Cretaceous part of the site, a minimum rate of approximately 6.7 m/m.y. can be given, since top and bottom of the drilled sequence both fall within the Santonian.

SUMMARY AND CONCLUSIONS

Summary of Results

Site 255 is located in 1144 meters of water atop Broken Ridge near its southern edge. Near the site seismic profiles show a 0.1 sec DT or thinner transparent layer unconformably overlying a north-dipping reflective sequence. The angular unconformity is subhorizontal and gives a very strong reflection. At about 0.3 sec DT acoustic basement is seen below the intermediate unit, also dipping north. At the site, 108.5 meters were drilled, coring 99 meters and recovering 7.9 meters. The oldest sediment was recovered from 108.5 meters and is biomicritic limestone of Santonian age.

The sediments at this site are divided into three units. Unit 1 was deposited in deep water whereas Unit 2 was deposited in shallow littoral conditions. There may be a disconformity between Units 1 and 2. A major angular unconformity separates Unit 2 from Unit 3, the latter unit being deposited in slightly deeper water than Unit 2; perhaps under shelf conditions. Unit 1 is 55 meters of Miocene to Recent yellowish white-to-brown nanno foram ooze. This ooze is sandy in texture and unconsolidated. Unit 2 is 20 meters thick and of Eocene to Miocene age. The upper part of this unit is a coarse gravel containing mollusc and chert fragments and bryozoans. The base of the unit is a yellow calcareous chalk. Unit 3 extends from 75 meters to at least 108.5 meters subbottom. It is a gray fossiliferous limestone with internal bedding dipping 15°-30° and four thin chert bands. Molluscs are seen along some bedding planes.

The mixed faunal assemblage of Unit 1 indicates transport and resedimentation of this unit. Reworked Oligocene forms are found at the base of the unit. This unit was deposited in deeper open-sea conditions. The gravels of Unit 2 contain Eocene floras and faunas at its base. The faunas of Units 1 and 2 suggest a shallow littoral environment in the Eocene followed by pelagic conditions in the Oligocene. Unit 3 can be placed in the Santonian. Planktonic and benthonic forms indicate deposition was in shallow, quiet waters of the outer shelf environment, with water depths no more than a few hundred meters. The fauna also suggest a cold-water environment for Unit 3. No reworked Paleocene fauna were found in the entire section. Because of low core recovery, sedimentation rates are hard to determine; they can be estimated as 2.4 m/m.y. for the ooze and a minimum of 6.7 m/m.y. for the Cretaceous limestone.

Preliminary Conclusions

The stratigraphy of this site indicates that this portion of the sea floor has been generally shallow throughout its existence and has been uplifted to sea level at least once and possibly twice. A period of uplift evidently occurred between the Cretaceous and Eocene to truncate the Cretaceous limestone section and produce the Eocene littoral gravels. However, the absence of reworked Paleocene fauna in the section may imply erosion and removal of the Paleocene section prior to the Eocene.

The seismic profiles approaching and leaving the site (Figures 2 and 3) show that the truncated limestone unit extends north-south for 28.5 km. Extrapolating from a 2.5° dip measured from the profile, this limestone section is about 1.3 km thick. The dip from the seismic profile (2.5°) is much less than that measured from the limestone cores (15°-30°). Possibly the limestone has a locally steeper dip near the southern edge of Broken Ridge. To the north it is conformably overlain by a dipping ooze section which is also truncated angularly near the site. The Eocene reflector can be traced north from the site until it dips conformably into the middle of the ooze section. Evidently, an Eocene uplift removed and truncated this Cretaceous to Eocene ooze section below the reflector, besides truncating the Cretaceous limestone. A Paleocene unconformity may mark the contact between the dipping ooze and limestone sections to the north, as is explained above.

REFERENCES

Ewing, M., Eittreim, S., Truchan, M., and Ewing, J., 1969. Sediment distribution in the Indian Ocean: Deep-Sea Res., v. 16, p. 231-248.

Francis, T. J. G. and Raitt, R. W., 1967. Seismic refraction measurements in the southern Indian Ocean: J. Geophys. Res., v. 72, p. 3015-3041.

Heezen, B. C. and Tharp, M., 1965. Physiographic diagram of the Indian Ocean: New York (Geol. Soc. Am.).

Watkins, N. D., Gunn, B. M., Nougier, J., and Baksi, A. K., 1974. Kerguelen: continental fragment or oceanic island? Geol. Soc. Am. Bull., v. 85, p. 201-212.

APPENDIX A
Grain-Size Determinations for Site 255

Core, Section, Top of Interval (cm)	Subbottom Depth (m)	Sand (%)	Silt (%)	Clay (%)	Classification
3-1, 90	23.9	66.5	22.3	11.2	Silty sand
4-1, 97	33.5	59.1	29.4	11.5	Silty sand
5-1, 90	42.9	54.8	36.4	8.9	Silty sand

APPENDIX B
Carbon-Carbonate Determinations for Site 255

Core, Section, Top of Interval (cm)	Sub bottom Depth (m)	Total Carbon (%)	Organic Carbon (%)	$CaCO_3$ (%)
3-1, 88	23.88	11.5	0.1	95
4-1, 88	33.38	11.6	0.1	96
5-1, 88	42.88	10.9	0.1	90

APPENDIX C
X-Ray Analyses for Site 255

Core	Cored Interval Below Sea Floor (m)	Sample Depth Below Sea Floor (m)	Diff.	Amor.	Calc.	Quar.	Phil.	Anal.	U–2[a]
Bulk Sample									
5	42.0-51.5	43.3	54.6	29.0	100.0	–	–	–	T
2-20μ Fraction									
5	42.0-51.5	43.3	80.2	69.0	–	29.8	62.2	8.0	A
<2μ Fraction									
5	42.0-51.5	43.3	96.5	94.6	–	100.0	–	–	M

[a] Peaks at 2.787Å, 2.689Å, and 1.836Å among others. Its peaks closely match those of wilkeite (JCPDS 6-454) and less closely those of apatite. A = abundant; M = major; T = trace.

Site 255 Hole Core 1 Cored Interval: 0.0-4.0 m

AGE	ZONE		FOSSIL CHARACTER				SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
	FORAMS	NANNOS	FORAMS	DISSOL. EFFECTS	NANNOS	SILICEOUS FOSS., ETC.						
QUATERNARY	N22-N23	NN19	AG	0	CGO		Core Catcher					Small recovery consumed totally in Paleo Lab.

Explanatory notes in chapter 2

Site 255 Hole Core 2 Cored Interval: 4.0-13.5 m

AGE	ZONE		FOSSIL CHARACTER				SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
	FORAMS	NANNOS	FORAMS	DISSOL. EFFECTS	NANNOS	SILICEOUS FOSS., ETC.						
QUATERNARY	N22-N23	NN19	AG	0	CGO		Core Catcher				*	2.5Y 8/2 RECOVERY: Core catcher only. Very pale yellowish white NANNOPLANKTON FORAMINIFERAL OOZE. TEXTURE: Approximately 65% sand, 35% silt and clay (Smear Slide) COMPOSITION: 70% forams, 30% nannos, trace clay

Explanatory notes in chapter 2

Site 255 Hole Core 3 Cored Interval: 23.0-32.5 m

AGE	ZONE		FOSSIL CHARACTER				SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
	FORAMS	NANNOS	FORAMS	DISSOL. EFFECTS	NANNOS	SILICEOUS FOSS., ETC.						
PLIOCENE		?			CGO	FP	1	0.5 1.0			CC GZ * KE HO	10YR 8/2 2.5Y 8/2 Very pale orange and white NANNOPLANKTON FORAMINIFERAL OOZE. TEXTURE: Sand 66% Silt 22% Clay 11% COMPOSITION: 67% foraminifera and foraminiferal fragments 33% nannoplankton (coccoliths) Tr detrital clay Total Carbon: 11.5% Organic Carbon: 0.1% Calcium Carbonate: 95% CONSOLIDATION: Soupy.
UPPER MIOCENE		NN14			CGO		2				*	
	N19	NN12	AG	0	CMO		Core Catcher				*	2.5Y 8/2

Explanatory notes in chapter 2

Site 255 Hole Core 4 Cored Interval: 32.5-42.0 m

AGE	ZONE		FOSSIL CHARACTER				SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
	FORAMS	NANNOS	FORAMS	DISSOL. EFFECTS	NANNOS	SILICEOUS FOSS., ETC.						
MIDDLE MIOCENE		NN5			CMO	FP	1	0.5 1.0			CC GZ KE * HO	2.5Y 7.5/2 Very pale brown and pale brown NANNOPLANKTON FORAMINIFERAL OOZE. TEXTURE: Sand 59% Silt 29% Clay 12% COMPOSITION: 72% forams 28% coccoliths Tr detrital clay Total Carbon: 11.6% Organic Carbon: 0.1% Calcium Carbonate: 96% CONSOLIDATION: Soupy.
					CMO	FP	2				*	2.5Y 8/2 slight deformed mottling 10YR 8/3
	N18/N19		AG	0	CMO		Core Catcher				*	10YR 7/3 & 10YR 8/4

Explanatory notes in chapter 2

Site 255 Hole Core 5 Cored Interval: 42.0-51.5 m

AGE	ZONE		FOSSIL CHARACTER				SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
	FORAMS	NANNOS	FORAMS	DISSOL. EFFECTS	NANNOS	SILICEOUS FOSS., ETC.						
LOWER MIOCENE		NN1-NN3			CMO	FP	1	0.5 1.0			CC GZ KE *XM *HO	10YR 5/3 few deformed 10YR 5/2 streaks Yellowish brown NANNOPLANKTON FORAMINIFERAL OOZE, slightly mottled in places. TEXTURE: Sand 55% Silt 36% Clay 9% COMPOSITION: 70% foraminifera 28% coccoliths 2% glauconite and ferruginous amorphous aggregates Tr zeolite Total Carbon: 10.9% Organic Carbon: 0.1% Calcium Carbonate: 90% CONSOLIDATION: Soupy.
			AG/M	0		RP	Core Catcher				*	10YR 5/4 w/few N1 specks; sandy

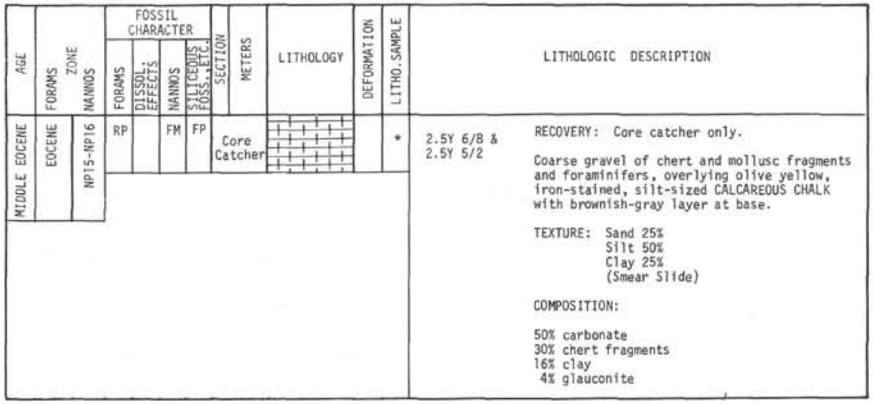
Explanatory notes in chapter 2

Site 255 Hole Core 6 Cored Interval: 51.5-61.0 m

AGE	ZONE		FOSSIL CHARACTER				SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE	LITHOLOGIC DESCRIPTION
	FORAMS	NANNOS	FORAMS	DISSOL. EFFECTS	NANNOS	SILICEOUS FOSS., ETC.						
MIOCENE			RP	1-2		FP	Core Catcher					RECOVERY: Core catcher only Drilling debris composed of foraminifera admixed with coarse mollusc shell fragments and flint (chert) fragments.

Explanatory notes in chapter 2

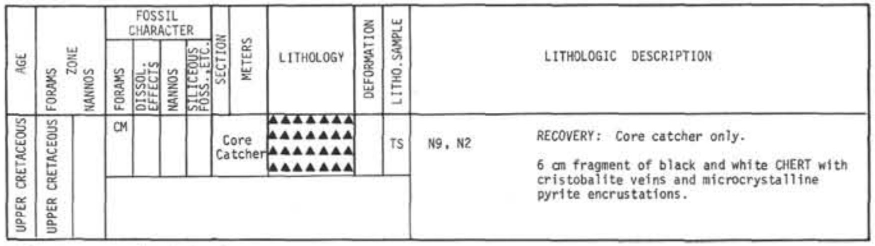
Site 255 Hole Core 7 Cored Interval: 61.0-70.5 m



AGE	FORAMS ZONE	NANNOS ZONE	FORAMS	DISSOL. EFFECTS	NANNOS	SILICEOUS FOSS., ETC.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
			FOSSIL CHARACTER										
MIDDLE EOCENE	EOCENE	NP15-NP16	RP		FM	FP	Core Catcher				*	2.5Y 6/8 & 2.5Y 5/2	RECOVERY: Core catcher only. Coarse gravel of chert and mollusc fragments and foraminifers, overlying olive yellow, iron-stained, silt-sized CALCAREOUS CHALK with brownish-gray layer at base. TEXTURE: Sand 25% Silt 50% Clay 25% (Smear Slide) COMPOSITION: 50% carbonate 30% chert fragments 16% clay 4% glauconite

Explanatory notes in chapter 2

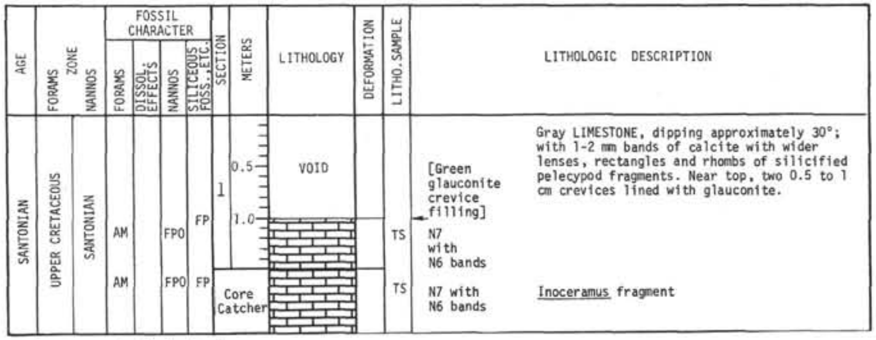
Site 255 Hole Core 8 Cored Interval: 70.5-80.0 m



AGE	FORAMS ZONE	NANNOS ZONE	FORAMS	DISSOL. EFFECTS	NANNOS	SILICEOUS FOSS., ETC.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
			FOSSIL CHARACTER										
UPPER CRETACEOUS	UPPER CRETACEOUS		CM				Core Catcher				TS	N9, N2	RECOVERY: Core catcher only. 6 cm fragment of black and white CHERT with cristobalite veins and microcrystalline pyrite encrustations.

Explanatory notes in chapter 2

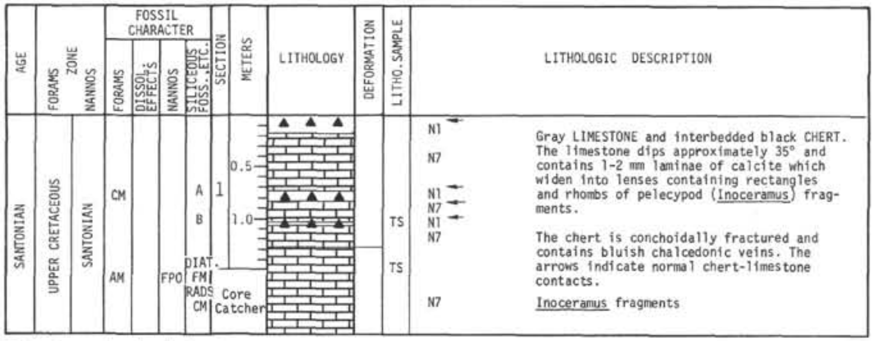
Site 255 Hole Core 9 Cored Interval: 80.0-89.5 m



AGE	FORAMS ZONE	NANNOS ZONE	FORAMS	DISSOL. EFFECTS	NANNOS	SILICEOUS FOSS., ETC.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
			FOSSIL CHARACTER										
SANTONIAN	UPPER CRETACEOUS	SANTONIAN					1	0.5	VOID			[Green glauconite crevice filling]	Gray LIMESTONE, dipping approximately 30°; with 1-2 mm bands of calcite with wider lenses, rectangles and rhombs of silicified pelecypod fragments. Near top, two 0.5 to 1 cm crevices lined with glauconite.
			AM		FPO	FP		1.0			TS	N7 with N6 bands	
			AM		FPO	FP	Core Catcher				TS	N7 with N6 bands	*Inoceramus* fragment

Explanatory notes in chapter 2

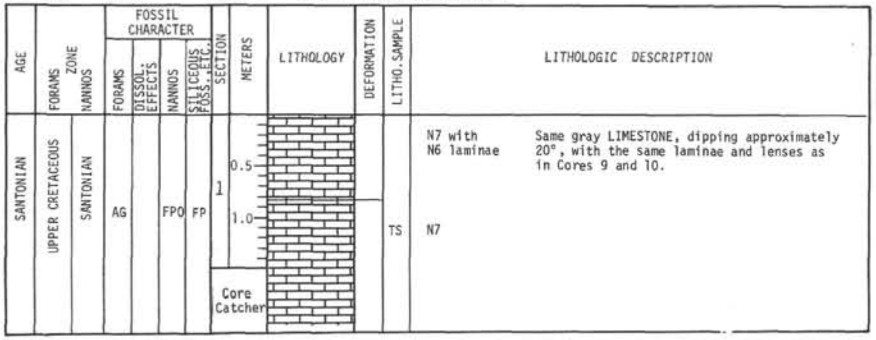
Site 255 Hole Core 10 Cored Interval: 89.5-99.0 m



AGE	FORAMS ZONE	NANNOS ZONE	FORAMS	DISSOL. EFFECTS	NANNOS	SILICEOUS FOSS., ETC.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
			FOSSIL CHARACTER										
SANTONIAN	UPPER CRETACEOUS	SANTONIAN	CM			A	1	0.5				N1 ← N7 N1 ← N7 ← N1 ←	Gray LIMESTONE and interbedded black CHERT. The limestone dips approximately 35° and contains 1-2 mm laminae of calcite which widen into lenses containing rectangles and rhombs of pelecypod (*Inoceramus*) fragments.
						B		1.0			TS	N7	The chert is conchoidally fractured and contains bluish chalcedonic veins. The arrows indicate normal chert-limestone contacts.
			AM		FPO	DIAT. FM RADS CM	Core Catcher				TS	N7	*Inoceramus* fragments

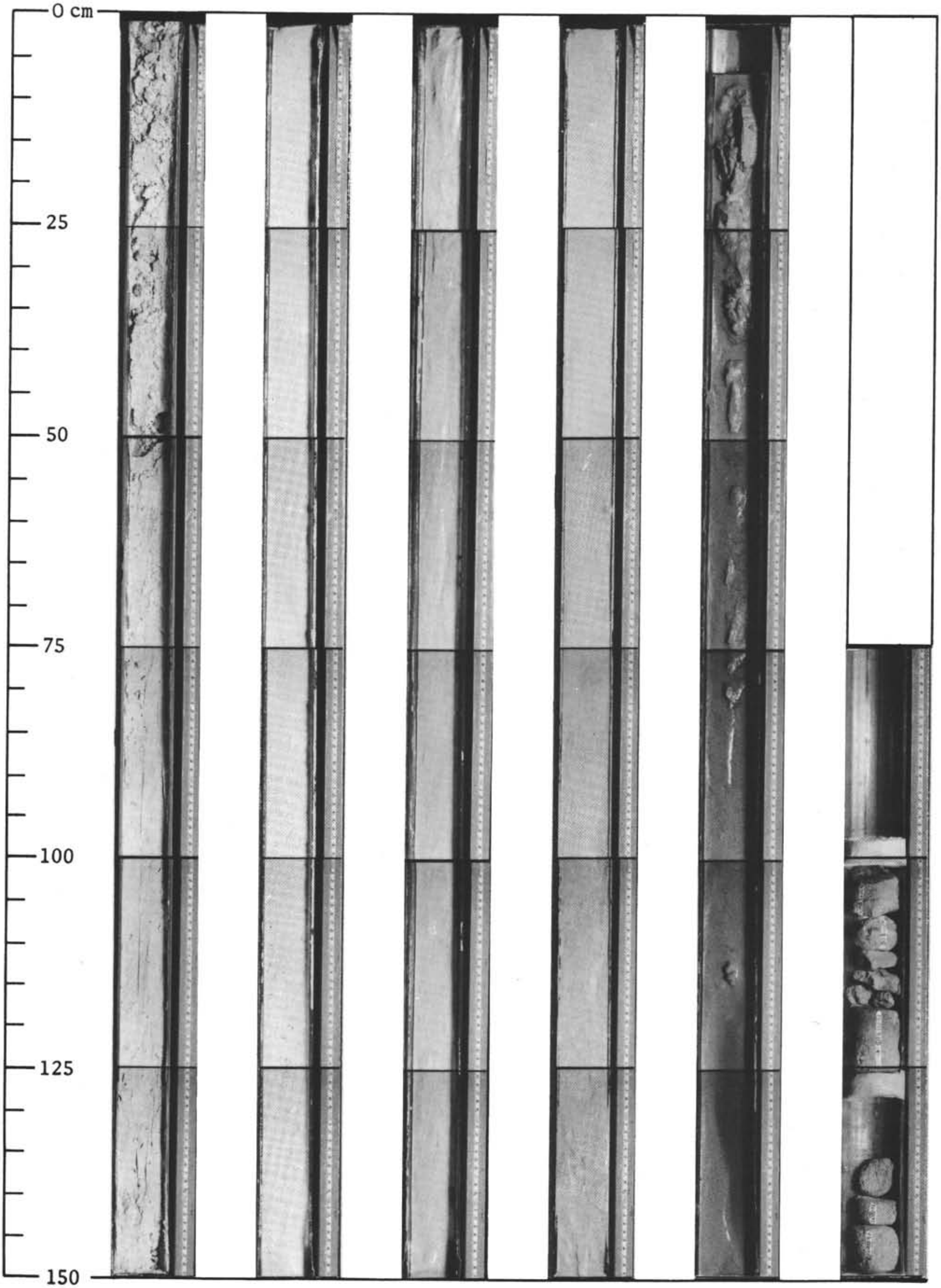
Explanatory notes in chapter 2

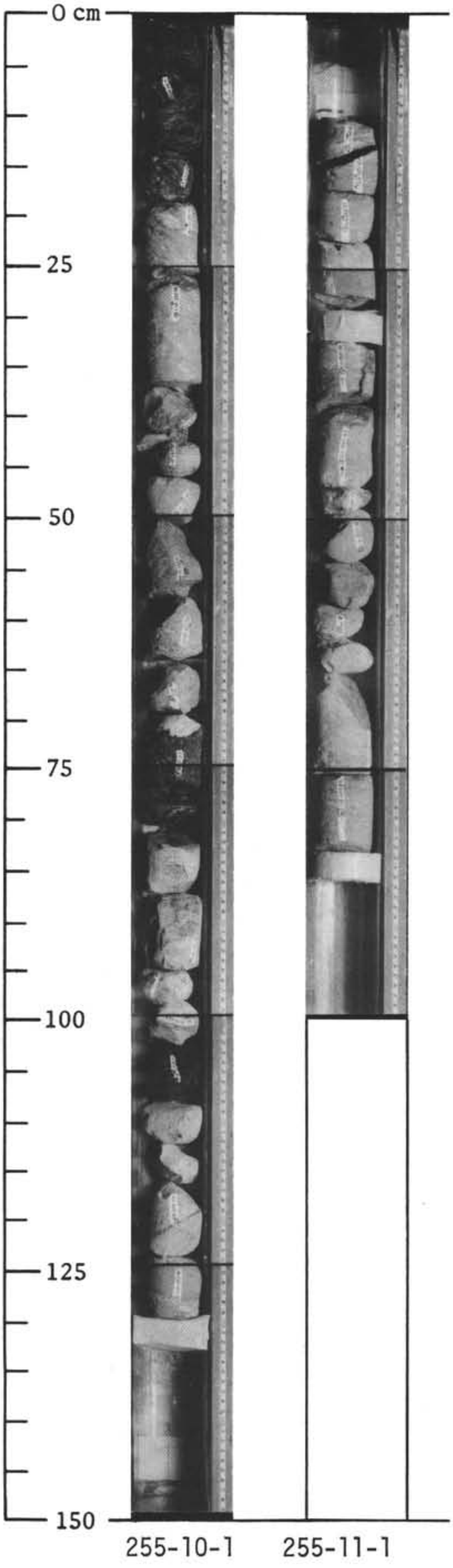
Site 255 Hole Core 11 Cored Interval: 99.0-108.5 m



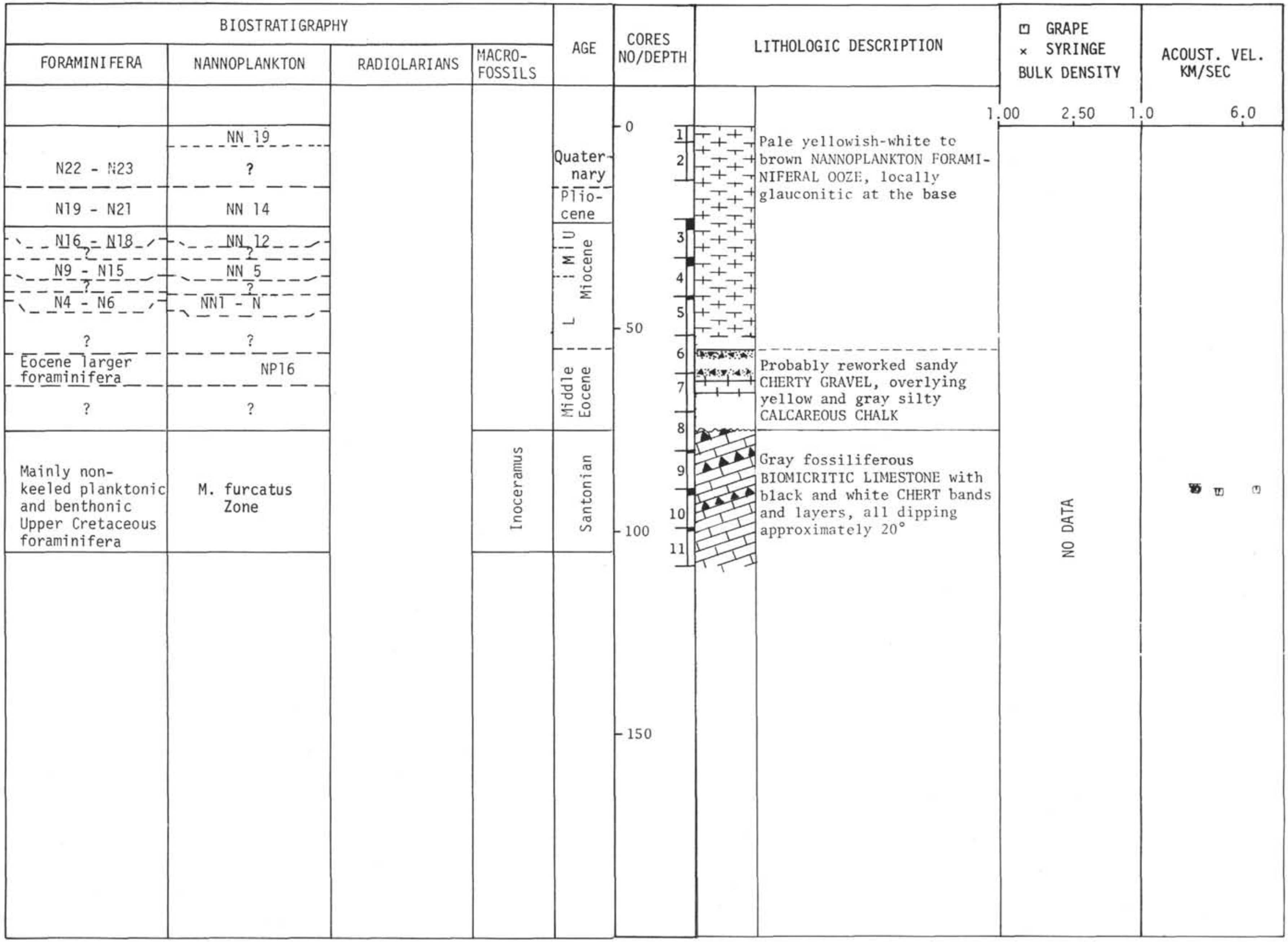
AGE	FORAMS ZONE	NANNOS ZONE	FORAMS	DISSOL. EFFECTS	NANNOS	SILICEOUS FOSS., ETC.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO. SAMPLE		LITHOLOGIC DESCRIPTION
			FOSSIL CHARACTER										
SANTONIAN	UPPER CRETACEOUS	SANTONIAN	AG		FPO	FP	1	0.5 1.0				N7 with N6 laminae	Same gray LIMESTONE, dipping approximately 20°, with the same laminae and lenses as in Cores 9 and 10.
											TS	N7	
							Core Catcher						

Explanatory notes in chapter 2


0 cm
25
50
75
100
125
150
255-3-1
255-3-2
255-4-1
255-4-2
255-5-1
255-9-1


0 cm
25
50
75
100
125
150
255-10-1
255-11-1

SUMMARY OF DRILLING RESULTS: SITE 255/0 - 200 m



Pale yellowish-white to brown NANNOPLANKTON FORAMINIFERAL OOZE, locally glauconitic at the base

Probably reworked sandy CHERTY GRAVEL, overlying yellow and gray silty CALCAREOUS CHALK

Gray fossiliferous BIOMICRITIC LIMESTONE with black and white CHERT bands and layers, all dipping approximately 20°