Reports

Investigation of Horizon Beta

Abstract. *Horizon beta is a subbottom reflector in the North Atlantic deep ocean sediments that extends over a large portion of the North America basin. Cores from an outcrop of beta contained shallow-water Aptian-Albian sediments and deep-water Cenomanian sediments. A core near an outcrop of a deeper horizon, horizon B, contained shallow-water Lower Cretaceous (Barremian-Hauterivian) sediments. These cores can be interpreted to support extensive subsidence of the eastern portion of the basin in early Cretaceous time. It is equally likely that the shallow-water deposits are a result of sediments slumping into an already deep basin. A reconciliation of these interpretations depends upon the JOIDES project.*

Seismic reflection profiling has indicated three major subbottom stratigraphic horizons within the unconsolidated and semiconsolidated sediments in the North America basin (*1*). These horizons, designated A, β, and B, in order of increasing depth beneath the sea floor, are acoustically identified by distinct changes in the reflective properties of the sedimentary deposits that overlie the oceanic basement surface (layer 2) (*1, 2*).

Horizon A, the shallowest of these, is identified as the top of a smooth and highly stratified zone usually about 300 to 500 m beneath the sea floor (*2–4*). It extends over most of the North America basin (*5*) and appears to be continuous, at least to the flank (base) of the mid-Atlantic ridge (*2*). Several cores of Maestrichtian turbidite have been obtained from an outcrop of horizon A located northeast of San Salvador (*1*). Both the deepwater turbidites in these cores and the stratified nature of reflectors immediately beneath the horizon indicate that it represents the surface of a fossil abyssal plain that covered most of the North America basin at the end of the Mesozoic era (*1, 6*).

The deepest of the horizons, B, is identified as a reflecting surface that is too smooth, both regionally and locally, to be regarded as true basement, but reflecting horizons beneath B have not yet been recorded in the Lamont seismic reflection data. This horizon is best observed near the continents and is thought to result from a cover of terrigenous sediment that acoustically masks the usually rough basement surface beneath. One core, taken from near the apparent stratigraphic level of horizon B, recovered semiconsolidated Lower Cretaceous (Barremian-Hauterivian) sediments containing wholly shallow-water fauna overlying siliceous sandstone.

Horizon β has been discussed (*1*) with respect to horizon A and other problems relating to sediment distribution in the North Atlantic. It is defined as the top of a stratified zone in the North America basin that is similar to horizon A and stratigraphically about midway between horizons A and B. The stratified zone beneath β extends downward to horizon B in some continental margin areas. In the more central portions of the basin where B is not observed, the stratification beneath β is less pronounced. In the western North Atlantic, the reflectivities of both A and β seem to decrease to the east of the continent.

The areal extent of horizon β has not been fully established. Its western limit is obscured by the great thickness of sediment on the continental rise. It has been traced northward at least as far as the Sohm abyssal plain and eastward to the central Bermuda rise where it appears to die out as a reflector, but whether this is the result of regional discontinuity of the reflector or a change in its acoustical properties is not clear. If the latter is the case, then it is possible that sediments of an equivalent age may continue east of the central Bermuda rise area and possibly to the mid-Atlantic ridge.

Horizon β has been followed southwestward to the base of the Bahama escarpment, but it is often hidden by, or indistinguishable from, horizon A in much of the area north of the Puerto Rico trench. However, Cretaceous (Cenomanian) deposits dredged from outcrops on the north wall of the trench (*7*) are of the same age as most of the cores taken in the horizon β outcrop area north of San Salvador, and they confirm the continuity of the reflector in the trench area.

The regional relief of horizon β is small relative to that of the modern sea floor. The highest point recorded is slightly less than 7.0 seconds in reflection time below the sea surface and occurs in the outcrop area northeast of San Salvador; the lowest points, slightly deeper than 8.0 seconds total reflection time, occur beneath the Blake-Bahama outer ridge. The regional dip of the horizon is generally toward the continent and may steepen beneath the continental rise in response to isostatic adjustments in the mantle caused by the great thickness of sediments on the continental rise.

Although β is regionally smooth, its local relief is greater than that of younger horizon A. Its conformity to the normal basement surface is moderate, and to horizon B, very high. The mutual conformity and the continuity of reflectors immediately beneath horizon β suggest the type of stratification attributed to pelagic deposition, such as that in the Pacific equatorial region, rather than the stratification of abyssal plains. It is then possible that at least some of the conformity of horizon β to deeper horizons is a consequence of more quiescent (pelagic) deposition than that of horizon A. However, the apparent local and regional stratification of any horizon depends upon the resolution of the seismic technique.

It is clear that much of the deposition that preceded horizon β has filled in the regional roughness of the basement surface, leaving a fairly smooth depositional surface that is interpreted as horizon B near the continents and is represented by more transparent sediments east of the termination of B in areas of normal basement surface. It is not clear whether the transparent sediment is a seaward continuation of horizon B or whether it is contemporaneous with the stratified section immediately beneath horizon β.

For convenience the term "horizon" will hereafter be used to refer to all the sediment between the horizon itself and the next deeper stratigraphic level. Horizon β is observed to crop out northeast of San Salvador within the same area as

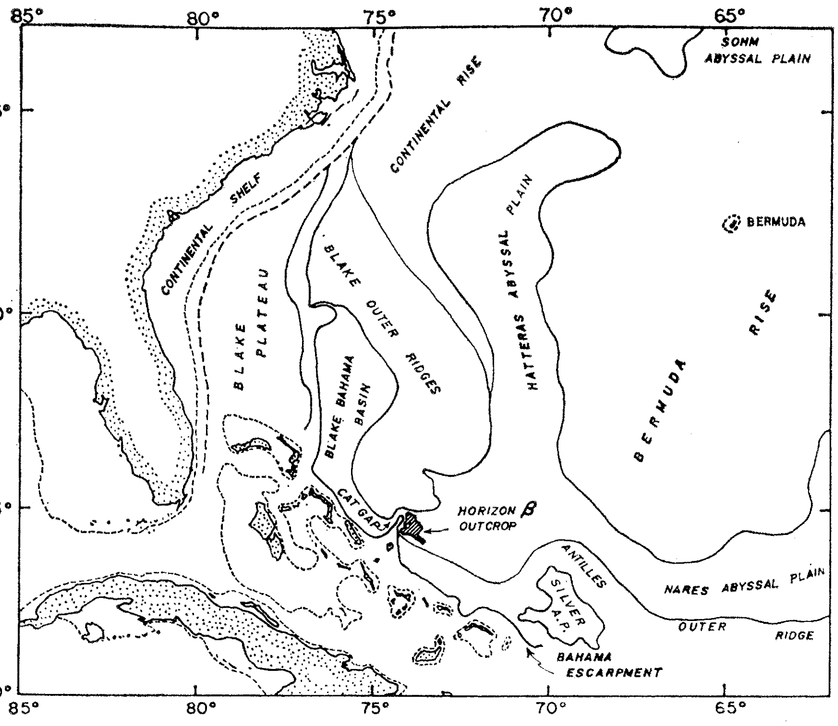

Fig. 1. Location of horizon β outcrop.

an outcrop of horizon A discussed earlier (*1*). Seismic coverage of the β outcrop includes about 3000 km of ship's track and 50 crossings of the outcrop boundary. Location of the outcrop is shown in Fig. 1; bathymetry of the outcrop area in Fig. 2. The outcrop is indicated by stippling, and the hachured part of the figure shows the area where the oldest section of these sediments appears to be exposed on the sea floor. Sediments between horizons A and β are exposed, surrounding the β outcrop over most of the area east of 74°40′W longitude in the figure. This outcrop is considerably larger than previously reported (*1*). It covers about 3500 km^2 of sea floor and may continue southeast of the mapped area along the base of the Bahama escarpment.

Two seismic reflection profiles made in the horizon β outcrop area are shown in Fig. 3. The ship's tracks, along which the profiles were made, are also shown in Fig. 2. They are dashed where data are missing. The north-south dogleg on the extreme western end of profile *a-a′* extends from the southern end of Blake-Bahama outer ridge into the Hatteras abyssal plain. The outcrop of both horizon A and horizon β occurs at mile 24 on profile *a-a′* near the point where Cat Gap channel opens onto the abyssal plain. The effects of erosion or nondeposition by currents through Cat Gap are seen in the shallow channels on the outcrop surface and, more obviously, by the presence of the outcrop itself. The relation of these currents to physiography of the area and to exposure of horizon A have been discussed (*1*). Horizon β remains exposed to about mile 44, where it dips gently beneath a cover of younger transparent sediment that usually separates horizon A from β. The densely stratified layers that define horizon A are clearly exposed on the sea floor in all of the area east of about mile 48.

On profile *b-b′*, horizon β crops out near mile 133. Detailed surveying has

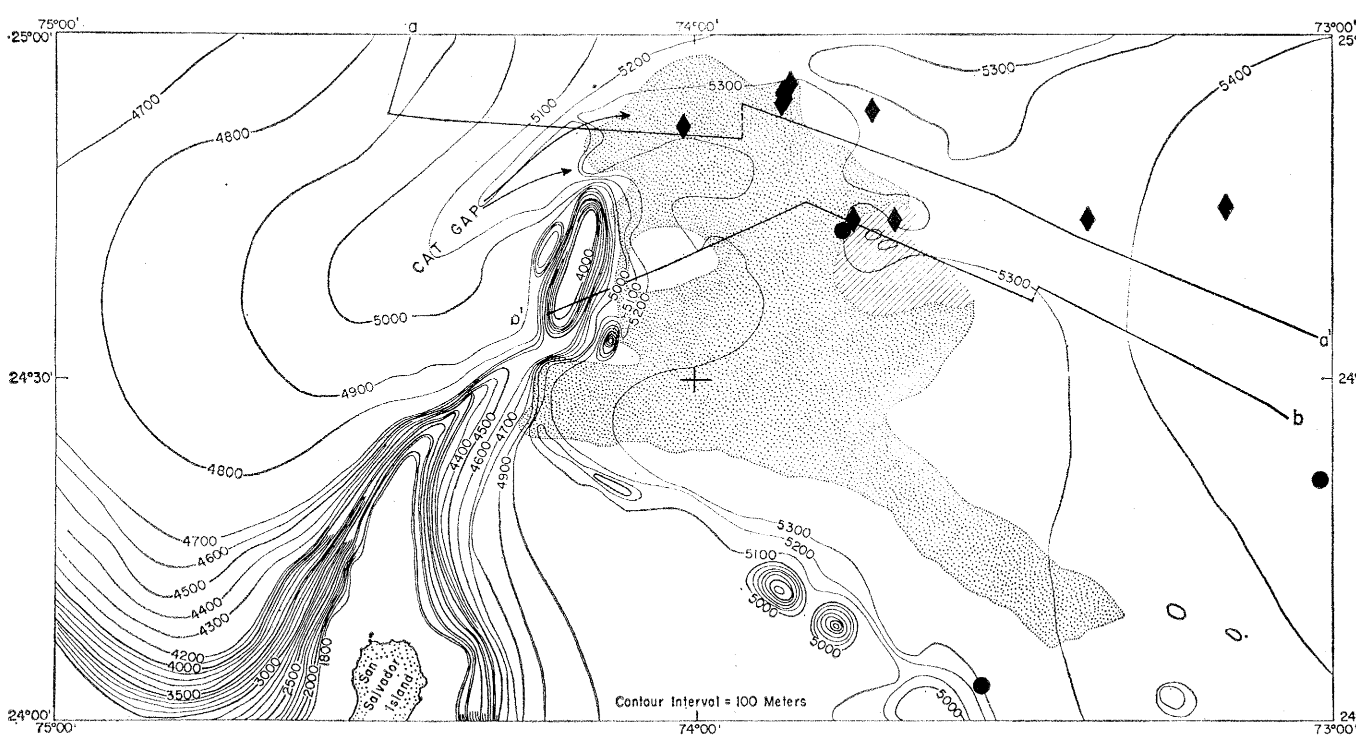

Fig. 2. Bathymetry of horizon β outcrop area. Outcrop of β is stippled, and the oldest outcropped sediments are indicated by hachures. (Solid diamonds) Cretaceous cores; (solid circles) Miocene cores. Profiles along tracks *a-a′* and *b-b′* are shown in Fig. 3.

shown that the horizon remains exposed over most of the area west of mile 133 to mile 165. The oldest exposed sediments are indicated by the hachured area in Fig. 2 and appear to crop out as a result of local uplift associated with two partially buried seamounts near mile 138. These peaks are also evident as small closed contours in Fig. 2. Horizon B is the deepest reflector observed on these profiles and may crop out on the exposed surfaces of these features.

There is an intermediate horizon located about halfway between β and B at the beginning of record *a-a'* that ends near mile 62. This same horizon is evident in record *b-b'* from miles 141 to 164. On close examination, it appears that various reflecting members of the stratified zone beneath the intermediate horizon merge and become continuous with the surface of horizon B. Good examples of this apparent continuity are evident on miles 44 to 48 on profile *a-a'*. We might conclude then that while horizon B is too densely stratified for reflections from individual layers to be resolved in most areas, this stratification becomes evident in the outcrop area where the separation between reflectors has been increased by layers of transparent sediment. An alternative possibility is that these reflectors represent a thickening of the lower portion of the stratified zone beneath horizon β. Sediment beneath the intermediate horizon thickens near the base of the submarine ridge that extends northward from San Salvador, probably in response to subsidence of the ridge itself.

Horizons A, β, and B are stronger and better developed reflectors in the vicinity of the outcrop area than they are in most other regions of the North America basin. They also attain their highest elevations here. These facts suggest that a major source of sediments near the outcrop has contributed significantly to the local development of the horizons and perhaps even to their basin-wide extent. The similarity of A and B to horizons in other ocean areas has been discussed (*8*).

Distribution of sediment above horizon B in the outcrop area is roughly indicated in the isopach map in Fig. 4. Those areas indicated as being free of sediment probably have a sedimentary cover that is too thin to be resolved by our usual profiling method. A contour map of horizon B in the same area is provided by Fig. 5. Both figures were prepared by assuming that compressional wave velocity in the sediment above horizon β was 1.76 km/sec and below β, 3.40 km/sec. The latter velocity is based on a wide-angle sonobuoy reflection profile in the outcrop area and is tentatively confirmed by velocity determinations elsewhere in the North America basin (*9, 10*). The intermediate stratified zone tentatively identified as part of horizon B is included as a portion of the β section since its reflective nature is more consistent with the reflective nature of unconsolidated or semiconsolidated sediments than it is with that of higher velocity materials, such as horizon B or basement.

A core containing mid-Cretaceous (Cenomanian) turbidite was obtained from the approximate stratigraphic level of horizon β on cruise 22 of R.V. *Vema* (*1*). Later work on cruise 10 of R.V. *Conrad* and *Vema* cruise 24 obtained six additional Cretaceous cores from the same general outcrop area, but seaward of the V22 core. Lithology and paleontology of the cores from the outcrop are given in Table 1; core locations are also indicated in Fig. 2 and on the seismic reflection profiles in Fig. 3. All the β cores were taken near the top of the horizon.

The *Conrad* cores have been discussed by Habib (*11*). The oldest portions of these consist of dark, indurated, carbonaceous lutites that lack calcareous fossils. Palynological investigations indicate that three of the *Conrad* cores (RC10-281 to RC10-283) are Cenomanian in age and that core RC10-284 is probably Aptian-Albian in age. The composition of these cores has led Habib to conclude that the sediments must have been deposited fairly close to their source. However, the presence of deepwater (probably greater than 1000 m) Cenomanian benthonic foraminifers such as *Eponides* sp., *Gyroidi-*

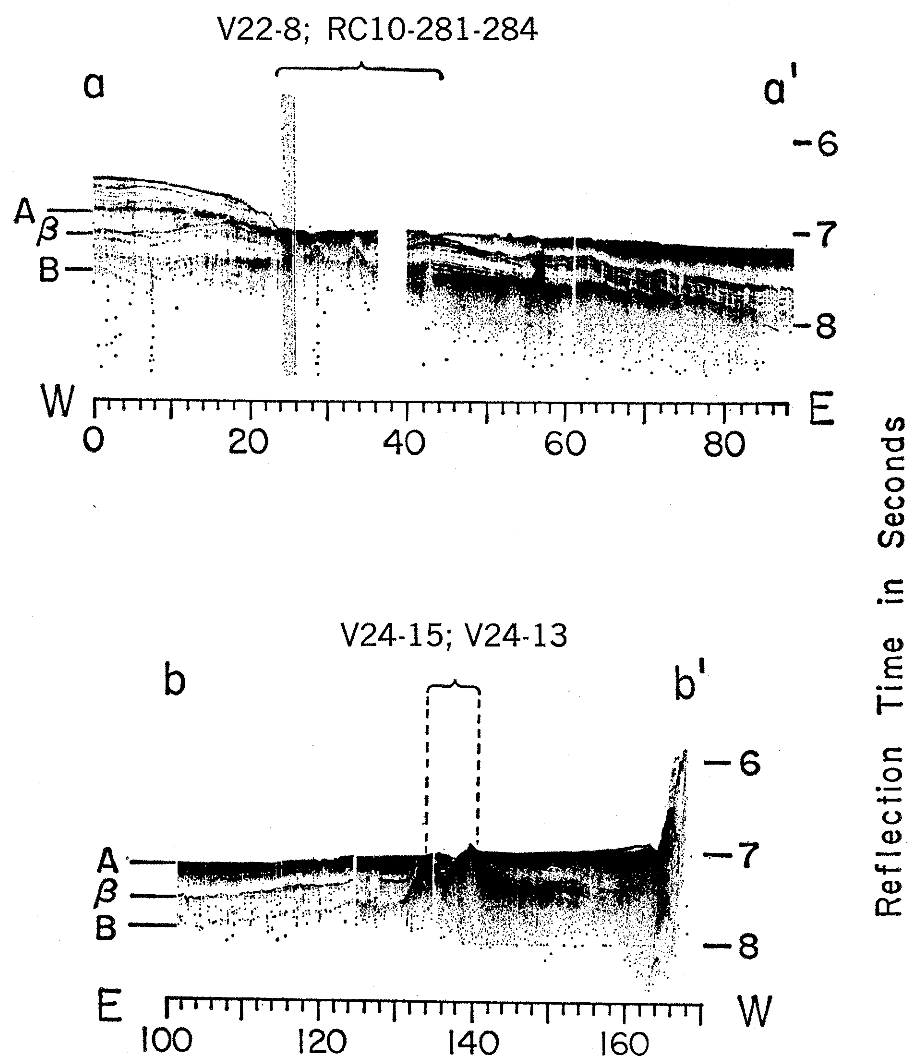

Fig. 3. Seismic reflection profiles in horizon β outcrop area. Profile tracks are indicated in Fig. 1. Vertical exaggeration is approximately 25:1. Approximate locations of Cretaceous cores are indicated. Scale in nautical miles; 1 nautical mile = 1.83 km; 1 second reflection time, 760 m water depth.

noides globosa (Hagenow), *Osangularia* sp., *Quadrimorphina allomorphinoides* (Reuss), and *Spiroplectammina* sp. in cores V22-8 and V24-15 indicates a deepwater depositional environment during Middle Cretaceous time in the outcrop area.

The Aptian-Albian core RC10-284, on the other hand, either must have been deposited very rapidly in deep water in order to preclude contamination with typical pelagic fauna or it must represent a shallow-water depositional environment. The latter possibility requires at least 1000 m of subsidence of the depositional environment during Cenomanian time. Another possibility is that the submarine ridge north of San Salvador was once at or near the sea surface and was periodically breached and eroded during Cretaceous time as a result of subsidence. The redeposition of lagoonal sediments supported by the ridge into the surrounding basin of some 1000 m or more in depth could account for the presence both of the shallow-water Aptian-Albian sediments and the presence of shallow- and deepwater Cenomanian facies. This must be followed by enough subsidence in Cenomanian to Maestrichtian time to account for the Upper Cretaceous red clays cored from horizon A that identify the depth of the outcrop area as being nearly equal to its present depth at the end of the Cenozoic era (*1*). The fact that the cores RC10-283 and RC10-284 span nearly 25 $\times$ 10^6 years, yet were cored from nearly identical geographic and stratigraphic locations, indicates very slow or variable rates of deposition. Such variability is evident in other cores near the β outcrop where Miocene deposits are found closely overlying Upper Cretaceous (Maestrichtian) sediments (*1*). More recently core V24-15 contained an Oligocene-Cretaceous (Cenomanian) disconformity. These cores suggest that the Cenomanian-Aptian hiatus in deposition could be real and that the factors responsible for erosion or nondeposition in the outcrop area may have been in effect since early Cretaceous time, but it is difficult to imagine how these factors could have remained constant throughout several thousand meters of subsidence.

The oldest core taken in the horizon β outcrop area, core V24-13, contained shallow-water marl of lowermost Cretaceous (Barremian-Hauterivian, 118 to 124 $\times$ 10^6 years) age overlying a chalcedonic volcanic arenite lacking fossils. The core was located on the flank of a complex of partially buried seamounts evident between miles 131 and 143 on profile section *b-b′*. The sediments in core V24-13 are some of the oldest yet recovered from the deep basins of the world's oceans, and are therefore worth some detailed discussion.

The Lower Cretaceous benthonic assemblage illustrated in Fig. 6 occurs in the white marl at the base of the core.

Table 1. Location and description of 12 pre-Quaternary deep-sea sediment cores raised from the horizon β outcrop area.

Lithology	Fauna and flora	Disconformity (depth in core)	Age
Core No. V22–10; location, 24°43′N, 73°46′W; water depth, 5130 m; length, 900 cm			
Dark yellowish-brown to moderate yellowish-brown sandy lutite overlying white calcarenite	*Globorotalia cibaoensis* Bermudez *Globorotalia margaritae* Bolli and Bermudez *Globigerina nepenthes* Todd *Sphaeroidinellopsis seminulina* (Schwager)	168 cm Recent-Pleistocene/ Pliocene	Pliocene
Core No. V21–243; location, 24°21′N, 73°01′W; water depth, 2564 m; length, 426 cm			
Pale brown lutite overlying interbedded layers of pale greenish-yellow biogeneous sand and pale olive lutite	*Globorotalia mayer* Cushman and Ellisor *Globorotalia peripheron底onda* Blow and Banner *Sphaeroidinellopsis seminulina* (Schwager)	278 cm Recent-Pleistocene/ Lower Miocene	Lower Miocene
Core No. V22–10; location, 24°43′N, 73°46′W; water depth, 5130 m; length 900 cm			
Dark yellowish-brown lutite overlying pale olive calcareous gravels	*Praeorbulina curva* Blow *Globigerinoides bisphericus* Todd *Globoquadrina altispira* (Cushman and Jarvis) *Globorotalia peripheroronda* Blow and Banner	73 cm Recent-Pleistocene/ Lower Miocene	Lower Miocene
Core No. V22–12; location, 24°45′N, 73°10′W; water depth, 5244 m; length, 366 cm			
Pale brown to dusty yellow silty lutite overlying olive-gray lutite, dark yellowish-brown lutite, and quartzose and calcareous silt	*Globotruncana citae* Bolli *Globotruncana elevata* (Brotzen) *Globotruncana gagnebini* Tirev *Rugoglobigerina rugosa* (Plummer) *Schackoina multispinata* (Cushman and Wickenden)	255 cm Recent-Pleistocene/ Cretaceous	Maestrichtian
Core No. V22–16; location, 24°44′N, 73°23′W; water depth, 5187 m; length, 400 cm			
Pale to moderate yellowish-brown and gray lutite overlying interbedded layers of reddish-brown lutite and yellowish-gray to light gray sand	*Globotruncana citae* Bolli *Globotruncana elevata* (Brotzen) *Globotruncana gagnebini* Tirev *Rugoglobigerina rugosa* (Plummer) *Schackoina multispinata* (Cushman and Wickenden)	60 cm Recent-Pleistocene/ Cretaceous	Maestrichtian
Core No. V22–8; location, 24°52′N, 74°01′W; water depth, 5329 m; length, 487 cm			
Medium olive gray to dark gray lutite and silty lutite overlying interbedded carbonate sands and gravels, light green olive-gray lutite, and dark greenish-gray to medium dark gray lutite	*Praeglobotruncana stephani* (Gandolfi) *Globinigerinelloides bentonensis* (Morrow) *Rotalipora cushmani* (Morrow) *Rotalipora greenhornensis* (Morrow)	93 cm Recent-Pleistocene/ Cretaceous	Cenomanian

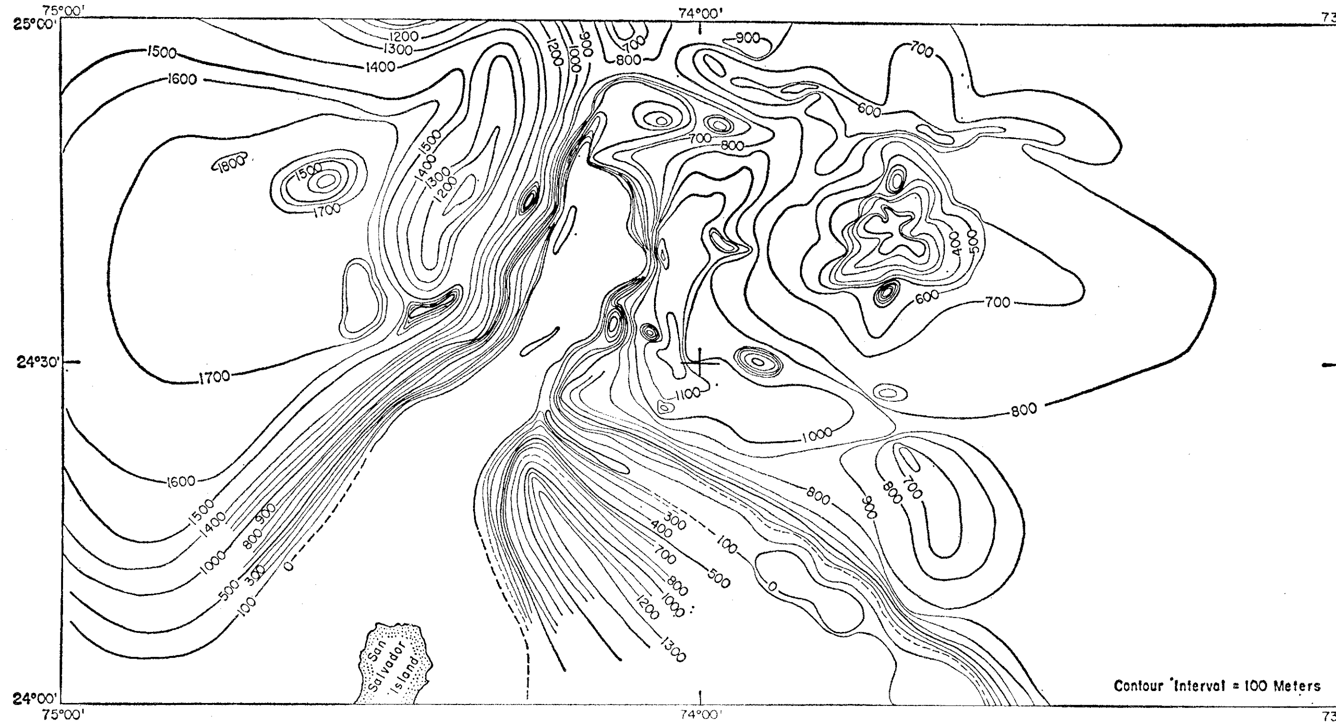

Fig. 4. Isopach map of sediment thickness above horizon B.

(Table 1—continued)

Lithology	Fauna and flora	Disconformity (depth in core)	Age
Core No. V24–15; location, 24°44'N, 73°45'W; water depth, 5305 m; length, 627 cm			
Yellowish-gray lutite overlying gray lutite interlayered with white calcilutite and light brown clay	Oligocene: *Chiloguembelina cubensis* (Palmer) *Cassigerinella chipolensis* (Cushman & Ponton) *Globorotalia postcretacea* (Myatiluk) *Pseudohastigerina micra* (Cole) *Globigerina ouachitaensis* (Howe & Wallace) Cenomanian: *Praeglobotruncana delrioensis* (Plummer) *Globigerinelloides bentonensis* (Morrow) *Schackoina cenomana* (Schacko)	318 and 79 cm Recent-Pleistocene/ Oligocene/Cretaceous	Oligocene Cenomanian
Core No. RC10–281; location, 24°53.5'N, 73°52'W; water depth, 5240 m, length, 32 cm			
A basal structurally deformed unit of blackish and greenish indurated clays, overlain by three graded beds of medium gray foraminiferal and reef-derived calcarenites, the middle unit containing greenish and blackish clay pebbles similar to above; capped by 18 cm of soft pale brown lutite	Palynomorphs	183 cm Recent-Pleistocene/ Cretaceous	Cenomanian
Core No. RC10–282; location, 24°54.2'N, 73°51.5'W; water depth, 5302 m; length, 485 cm			
Well mottled and indistinctly layered homogeneous, dark greenish-gray clay overlain by light olive-gray clay intercalated with indistinct to well-defined layers of black, sulfide-rich clay	Palynomorphs	84 cm Recent-Pleistocene/ Cretaceous	Cenomanian
Core No. RC10–283; location, 24°54.6'N, 73°51.3'W; water depth, 5305 m; length, 533 cm			
Black to dark greenish-gray, semi-indurated, laminated lutites overlain by very pale orange to pale yellowish-brown, fine-grained foraminiferal sand	Palynomorphs	133 cm Recent-Pleistocene/ Cretaceous	Cenomanian
Core No. 10–284; location, 24°55.7'N, 73°51'W; water depth, 5314 m; length, 454 cm			
Dusky yellowish-brown, extremely well compacted and homogeneous clay overlain by light brown to very pale orange, foraminiferal calcilutite	Palynomorphs	175 cm Recent-Pleistocene/ Cretaceous	Aptian?-Albian
Core No. V24–13; location, 24°44'N, 73°41'W; water depth, 5323 m; length, 139 cm			
Pale yellowish-brown and light brown clay. White to pale olive marl encrusted around a cobble of quartzose sandstone at the bottom	Rhyncholites, *Phyllocrinus* sp. *Patellina* sp. *Spirillina neocomiana* (Moullade) *Trocholina infragranulata* Noth *Guttulina* sp.	110 cm Recent-Pleistocene/ Cretaceous	Barremian-Hauterivian

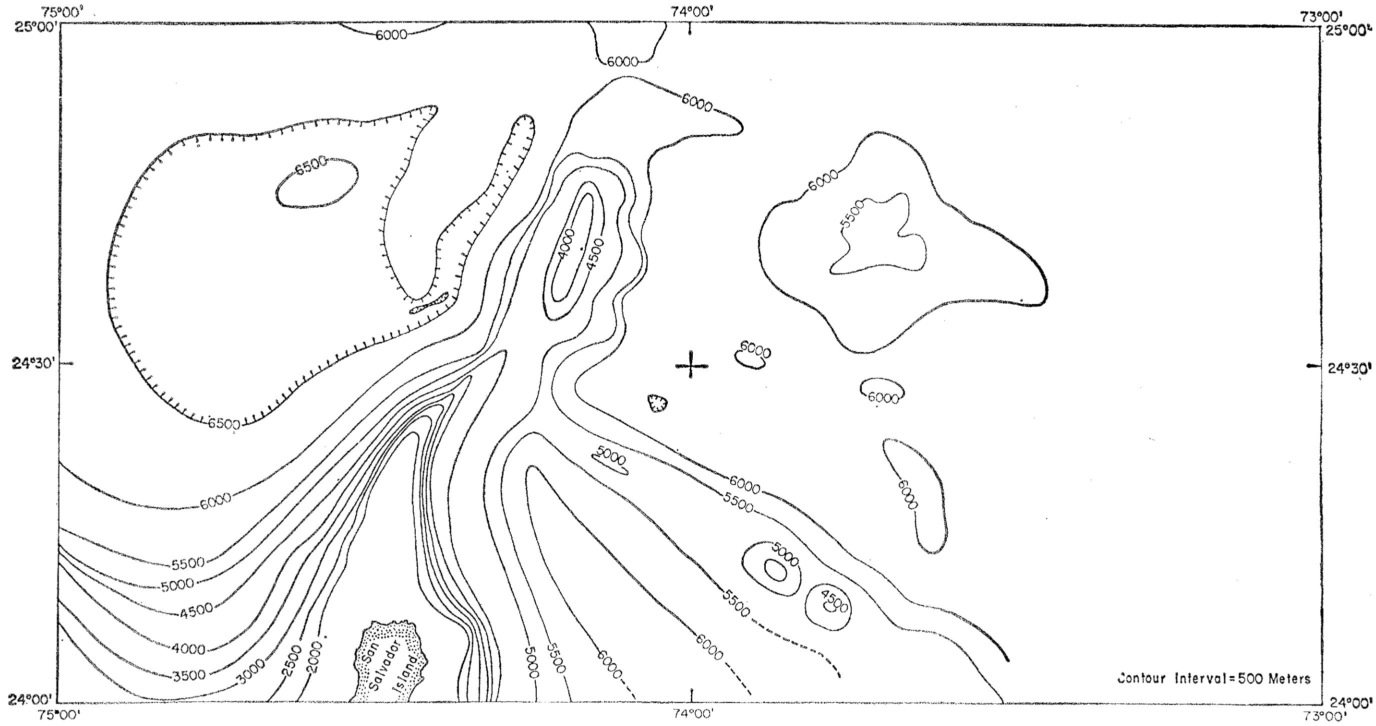

Fig. 5. Bathymetry of horizon B.

This assemblage consists of pelecypod fragments, juvenile brachiopods, ammonite beaks (Rhyncholites), crinoids, and benthonic foraminifers. The lower Barremian–upper Hauterivian age is based on the joint occurrence of benthonic foraminifers, *Trocholina infragranulata* North and *Spirillina neocomiana* Moullade, and Rhyncholites. *Trocholina infragranulata* was originally described from the Hauterivian section of Austria and has since been reported from Valanginian through Aptian sediments of northwest Germany, Austria, Switzerland, Yugoslavia, France, and Trinidad (*12*). *Spirillina neocomiana* was originally described from Lower Cretaceous of southern France. It is reported to range, in the Barremian type section of France, from the upper Hauterivian to the lower part of the lower Barremian (*13*).

Most of the occurrences of Rhyncholites reported thus far have been from rocks of Mesozoic age in France, southern Germany, Mallorca, southern Poland, and the southern part of the European U.S.S.R. This is the first reported occurrences of Mesozoic Rhyncholites from the Western Hemisphere. Three specimens from core V24-13 are morphologically very similar to the specimen described by Sigal (*14*) as *Akidocheilus* cf. *ambiguus* Till, from the type Barremian section of France. Guillaume and Sigal (*13*), in their discussion of the stratotype Barremian, reported the occurrence of Rhyncholites in the uppermost part of Hauterivian with some reservation for their extended range above and below. Crinoids of the genus *Phyllocrinus* (*15*) range from the Jurassic to the Lower Cretaceous.

Trocholina infragranulata is commonly found in the Toco formation of Trinidad and is believed to be a species closely associated with a coral reef community (*12*). The presence of this species and the absence of planktonic as well as other deepwater species seems to indicate a shallow-water origin of the Lower Cretaceous sediment.

It is felt that the sandstone portion of the core probably represents horizon B, since the distinct change in facies from a soft marl to an arenite is consistent with the seismic picture of the acoustically transparent sediments beneath horizon β, overlying a strongly reflecting, acoustically opaque horizon B. The great difference in facies of these materials also suggests an equally great separation in their ages, but for the moment we can only say that the sandstone is at least Barremian-Hauterivian in age.

If these older cores represent the regional depositional environment of their respective horizons, we must conclude that an area of sea floor, extending some 1000 km east of the present continental margin, was once a shallow sea that has subsided some 5000 m, most of this during Cretaceous time. We cannot suggest when this subsidence might have begun, but if the intermediate horizon between B and β actually represents a thickened upper section of horizon B then there is evidence of local subsidence of about 2 km that probably preceded the deposition of Barremian-Hauterivian sediments and could conceivably have extended back into the later Jurassic time.

There is no clear evidence of major regional subsidence in the seismic reflection data in the North America basin, certainly nothing approaching 4000 to 5000 m; but there is good evidence of late Mesozoic subsidence of the continental margin in drilling logs in Florida and the Bahamas (*16*, *17*) and from cores and dredge hauls on the Blake-Bahama escarpment (*18*). The maximum amount of subsidence indicated by these data agrees roughly with the depth of horizon β in the outcrop area. Except for some westward dip attributed to differential crustal loading by continental rise sediments, horizons A and β appear to be regionally horizontal near the continent. These same horizons are flat and undisturbed near the base of the Blake-Bahama escarpment and do not suggest differential subsidence or shearing in that area. Assuming then that horizons A, β, and even B were deposited as nearly horizontal layers, it would appear that the southwestern portion of the North America basin, its adjacent continental margin, and part of Florida subsided rather uniformly relative to the continent. This subsidence would have occurred for the most part during the Cretaceous period but probably continued into the Cenozoic in the continental margin areas, possibly due to crustal loading. We might try to extend this line of reasoning to other ocean areas. Two major reflecting horizons analogous to A and B cover extensive areas of the eastern and southern Atlantic, the Caribbean, and the Pacific. It has been postulated that these are stratigraphically related to horizons A and B in the northwest Atlantic (*8*). If so, then those reflectors, analogous to horizon B in other oceans could represent broad areas that were once covered by shallow seas.

While the ages of all the cores are consistent with the apparent stratigraphic positions of the cored horizons in the seismic data, it is important to bear in mind that there are very few pre-Maestrichtian cores and that the identification of their depositional environments depends upon an imperfect knowledge of the ecology of benthonic fauna at the end of the Mesozoic era. Equally important is the fact that the outcrop has always been very close to shallow-water sediment sources, the closest of which is the island structure of San Salvador. It is possible and even likely that the shallow-water sediments have slumped or have been periodically eroded from the island area and rapidly redeposited in the deep vicinity of the outcrop. This process would not require any large or continuous subsidence of the ocean basin and it would be compatible with the evidence that suggests variable rates of deposition in the outcrop area since early Cretaceous time. The presence of shallow-water Miocene gravels on the outcrop surface is compelling evidence for the occurrence of this type of deposition in the post-Mesozoic era (*1*). The thesis of a stable ocean basin necessitates some other interpretation of the evidence for subsidence of the continental margin, possibly that the margin subsided independently of the basin floor. If so, then there must be a very narrow shear zone at the base of the Bahama escarpment. Such a zone is suggested by a magnetic high near the Blake escarpment (*19*), but is not evident from present seismicity (*20*).

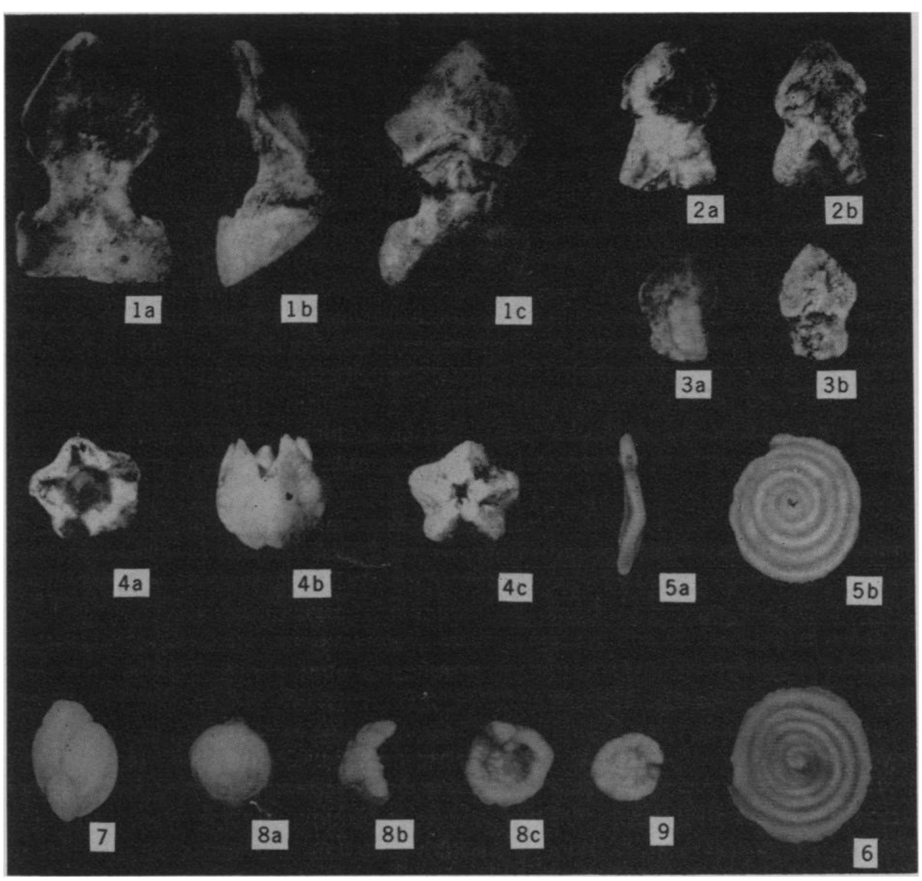

Fig. 6. Diagnostic fauna of the Hauterivian-Barremian age of core V24-13: *1* to *3*, *Akidocheilus* cf. *ambiguus* Till; *4*, *Phyllocrinus* sp.; *5* and *6*, *Spirillina neocomiana* Moullade; *7*, *Guttulina* sp.; *8* and *9*, *Trocholina infragranulata* Noth (*1* to *4*, × 6; *5* to *9*, × 40).

It is clear that a thorough discussion of the implications of the cores from horizons β and B requires many more extrapolations and tenuous assumptions than we have presented here. We do not favor any of the tentative explanations of the data, and it seems unlikely that convenient answers to these problems will be provided with conventional coring techniques. The JOIDES program (*21*), on the other hand, should be able to determine not only the ages and depositional environments of the various reflecting horizons but also the continuity of their sedimentary parameters in the more remote areas of the ocean. When these facts are at hand, we will have a better picture of the structural and stratigraphic history of the North America basin and its counterpart east of the mid-Atlantic ridge.

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