

A STUDY OF THE FORAMINIFERA CONTAINED IN CORES FROM THE BARTLETT DEEP.

JOSEPH A. CUSHMAN.

ABSTRACT. Three cores taken in the Bartlett Deep show very decided changes during the time represented by their deposition. The foraminiferal content varies greatly and shows periods of absence of pelagic foraminifera due possibly to a change in the position of warm tropical currents during the periods of accumulation of polar ice. These periods alternate with others of great abundance of pelagic forms. The occurrence of shallow water forms at great depths may also be accounted for by radical changes in sea level.

THE methods by which submarine cores may be taken from the ocean bottom have been developed until at present cores ten to twelve feet in length may be obtained. A study of such cores from a series of stations across the Atlantic has revealed very interesting glacial and interglacial periods. A similar study of cores from off our Atlantic coast has shown similar changes in the foraminiferal faunas. The three cores which formed the basis for this particular study came from great depths. They were taken from the vicinity of the Bartlett Deep between Cuba and Jamaica, a region of known gravity anomalies, and also interesting as being in a tropical region that might be supposed to be relatively free from radical changes during glacial periods. The results of these studies are very interesting, and the facts as revealed by the foraminifera will be given in later pages so that those who are more familiar with the geologic import of what is shown may have them to interpret in terms of geologic history as it affects the time interval represented by these cores.

LOCATION AND DESCRIPTION OF CORES.

The small map (Text Fig. 1) given here will show in general the position of the three cores obtained by Dr. C. S. Piggot with the apparatus designed by him. The three cores are designated as P.135, P.136, and P.137 (Text Figs. 1, 5-9). It was at once evident from a preliminary examination of the cores that they represented changing conditions as shown by differences in color, in relative coarseness of the material, and that in each core was an outstanding zone which proved to be a very

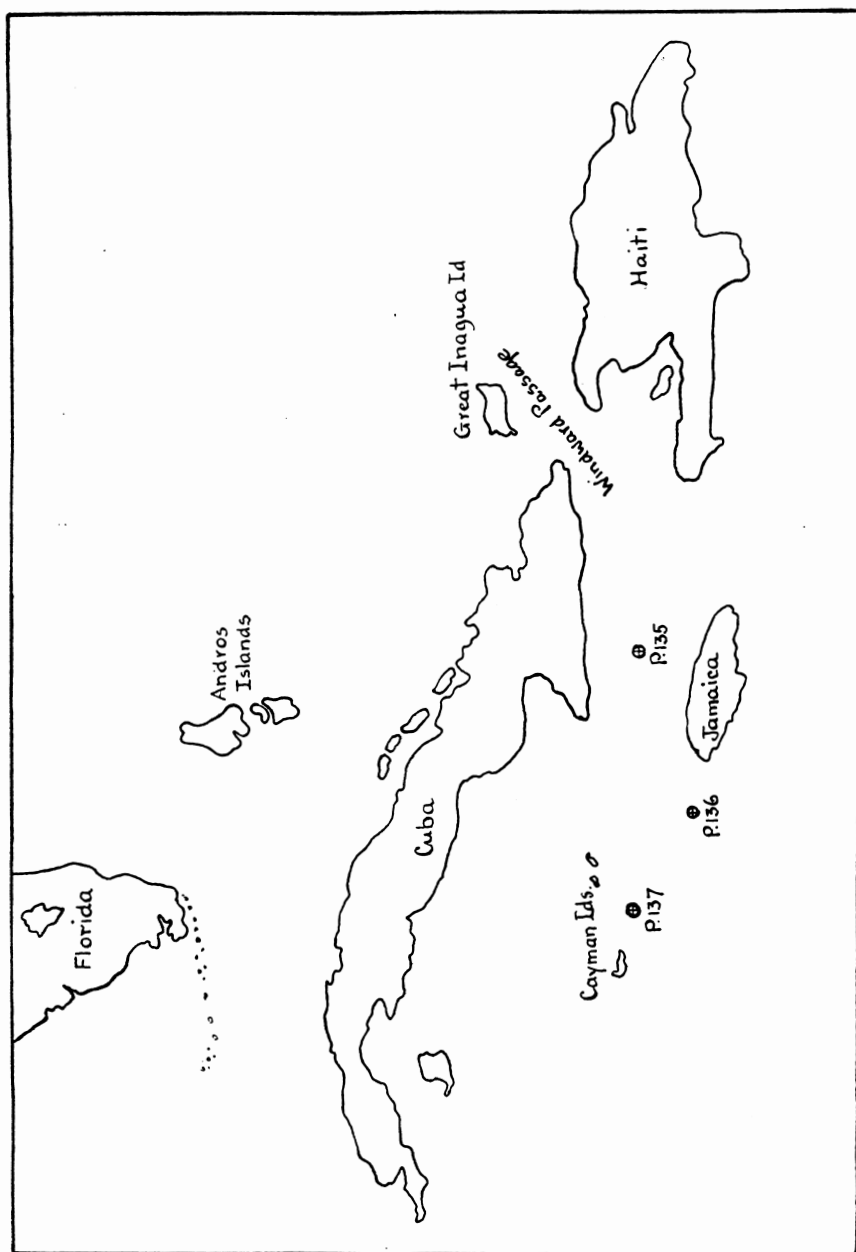


Fig. 1. Map showing location of the three cores.

pure *Globigerina*-ooze. If this zone were the same in each core, it was suggested at once that it might be used in the correlation of these three cores though it occurred, as might be expected, at different levels. These cores are from deep water, and two of them are from greater depths than any that had been obtained up to that time. The data for these follows:

No.	N. Latitude	W. Longitude	Depth in Fathoms	Length of Core in Inches
P.135	19° 18'	76° 49'	2680	44
P.136	18° 38'	79° 12'	2540	76
P.137	19° 14'	80° 20'	2675	75

The position of the abundant *Globigerina*-ooze will be shown on the charts, giving the relative abundance of the pelagic species.

METHOD OF SAMPLING AND PREPARATION OF SAMPLES FOR STUDY.

Before any samples were taken from the cores, a close study of the evidence of changes in color and relative coarseness of the material was made. Samples were then taken to include so far as possible all the very evident differences shown, and, in the case of the evident *Globigerina*-ooze zone, samples were taken immediately above and below the limits of this zone. The samples all broke down very rapidly in water, and were carefully washed through sieves of silk bolting cloth. The samples taken were so far as possible of approximately the same initial size. The washing immediately showed a great difference in the amount of residue left after washing. The *Globigerina*-ooze zone gave approximately the same bulk of washed material as that of the original sample.

The washed and dried samples were carefully picked by assistants in the laboratory, counting the actual number of specimens of the different species, and mounting a series for later checking. In the case of the very rich samples, a mechanical separation was made by the use of a sample splitter, so that the resulting portion examined would be a fair sample of the whole amount. The material was then spread on a black tray ruled into squares by white lines, the material on several squares counted, and the numbers of each species estimated for the reduced sample. Using only adult specimens to avoid possibility of errors in identification, the results obtained are believed to be reasonably accurate and dependable.

My thanks are due to Eleanor J. Crosby, Anna L. Dorsey, and Patricia G. Edwards for their laborious and painstaking work in picking out and mounting the foraminifera from these many samples, to Miss Dorsey for her work in preparing the charts and tables and the illustrations, and to Alice E. Cushman for typing the manuscript and the charts.

CONDITIONS AND TIME INTERVAL REPRESENTED BY THE CORES.

Enough is now known about the distribution on the ocean surface of the pelagic species and of the depths at which benthic species occur in the region where the cores were taken, so that at least generalized ideas as to the conditions obtaining during the period represented by the deposition of the cores may be given. It has already been stated by Murray that Pteropod ooze is largely dissolved at depths of more than 1,000 fathoms, and that *Globigerina*-ooze likewise largely disappears at from 2,000 to 2,500 fathoms. It was at once apparent that these cores did not carry out the conditions supposed to occur at these depths, as an extremely pure and beautifully preserved *Globigerina*-ooze occurred in all three of the cores, and well preserved Pteropods were found also in some of the samples. This immediately raised the question as to whether the particular samples were actually deposited at the depth where they were found, or if changes in depth had been rapid during the time subsequent to their deposition. This will be discussed after the data are presented. In one sample from core P.135 (Text Fig. 5), a large number of relatively shallow water, bottom-living species occur, and this must have a definite significance.

If these core samples were deposited in the ocean at approximately the depth from which they were recovered, the time interval represented by the entire cores must be relatively long. If the figures given by Schott of the rate of deposition of *Globigerina*-ooze, a rate of 0.53 to 2.13 centimeters in 1,000 years be at all accurate, and much of the material would be included in his minimum group, the time interval would be relatively great. In the longest core, this would represent approximately 90,000 years if his mean rate is taken, and possibly much longer or even several times this amount if all were included in his minimum group.

Distribution of Species in Core P.135	TOP	100-110 mm	170-180 mm	240-250 mm	375-380 mm	510-520 mm	630-640 mm	650-670 mm	760-770 mm	860-870 mm	960-970 mm	1050-1060 mm
<i>Candina nitida</i>												
<i>Globigerina inflata</i>												
<i>Globigerina conglomerala</i>												
<i>Globigerina aquilasteralis</i>												
<i>Globigerinoides conglobata</i>												
<i>Globigerinoides rubra</i>												
<i>Globigerinoides sacculifera</i>												
<i>Globorotalia menardi</i>												
<i>Globorotalia tumida</i>												
<i>Globorotalia truncatulinoides</i>												
<i>Orbulina universa</i>												
<i>Pulliatina obliquiloculata</i>												
<i>Sphaeroidinella dehiscens</i>												
<i>Alibonella sp.</i>												
<i>Ammobaculites clavata</i>												
<i>Ammobaculites lessoni</i>												
<i>Ammobaculites sp.</i>												
<i>Buccella sp.</i>												
<i>Buccella quadrate</i>												
<i>Buccella subglobosa</i>												
<i>Cassidulinia laevigata</i>												
<i>Cassidulinia bradyi</i>												
<i>Chilostoma sp.</i>												
<i>Chilostoma pseudounguiculata</i>												
<i>Commensalites involvens</i>												
<i>Dentalina sp.</i>												
<i>Eggerella propinqua</i>												
<i>Eubuccella sp.</i>												
<i>Elphidium sp.</i>												
<i>Elphidium umbonata</i>												
<i>Globigerina digitata</i>												
<i>Globorotalia acuta</i>												
<i>Globorotalia hirsuta</i>												
<i>Gomosiphia charoides</i>												
<i>Hastigerina pelagica</i>												
<i>Lagena A.</i>												
<i>Lagena B.</i>												
<i>Lagena C.</i>												
<i>Lagena hexagona</i>												
<i>Laticarinina paupercula</i>												
<i>Nonion pompilioides</i>												
<i>Pulliatina quinqueloba</i>												
<i>Pulliatina sphaeroides</i>												
<i>Pulvinulina A.</i>												
<i>Pyrgo muricina</i>												
<i>Pyrgosella sp.</i>												
<i>Pyrgosella socorata</i>												
<i>Quinqueloculina A.</i>												
<i>Quinqueloculina B.</i>												
<i>Robertina sp.</i>												
<i>Stimulidina stimuloides</i>												
<i>Stimulidina sp.</i>												
<i>Siphonina advena</i>												
<i>Siphonodossaria sp.</i>												
<i>Spirillina sp.</i>												
<i>Triloculina trilocarinata</i>												
<i>Virgulina sp.</i>												
<i>Virgulina bradyi</i>												
<i>Rehderella spines</i>												
<i>Gomocaris sp.</i>												
<i>Ostracoda</i>												
<i>Otoliths</i>												
<i>Pteropods</i>												

Fig. 2.

Globorotalia occurred usually in such small numbers that they were not included in the general pelagic group, although known to be pelagic.

The relative abundance of the pelagic species is given in the series of charts showing the departure from the norm as represented by the top sample (at the left in the charts) which is taken to represent present day deposition in that area. In core P.137 (Text Figs. 9 and 10), it will be seen that there are two wide swings at the maximum of occurrence of *Globigerinoides rubra* and *G. sacculifera*, two species abundant today in the warm waters of the Gulf Stream. In core P.136 (Text Figs. 6, 7, 8), there are four distinct increases in abundance of these two species confirmed by many others. The truncated ends of the charts show to what limits the lines of relative abundance would extend to make a point if room were available to show the maximum occurrence of those species.

One of the interesting things is the opposite swing in the relative abundance of *Globorotalia menardii* compared with those of most of the other pelagic species. This is shown particularly in the charts of core P.136 (Text Figs. 6, 7, 8) where, during the time of greatest development of most of the pelagic species, *G. menardii* is at its minimum. Similar relations of this species and the other pelagic ones were found by Schott in his work on the *Meteor* expedition material.

The swings in the pelagic species in core P.135 (Text Fig. 5) are relatively small, and indicate somewhat different conditions of deposition for this particular area. They indicate that the warm current which carried the mass of pelagic foraminifera was far less active over this area than over the others represented by cores P.136 (Text Figs. 6, 7, 8) and P.137 (Text Figs. 9 and 10).

The pelagic species which gave the most significant data are as follows:

Candeina nitida d'Orbigny
Globigerina inflata d'Orbigny
Globigerina conglomerata Schwager
Globigerinella aequilateralis (H. B. Brady)
Globigerinoides conglobata (H. B. Brady)
Globigerinoides rubra (d'Orbigny)
Globigerinoides sacculifera (H. B. Brady)
Globorotalia menardii (d'Orbigny)
Globorotalia tumida (H. B. Brady)

Globorotalia truncatulinoides (d'Orbigny)*Orbulina universa* d'Orbigny*Pulleniatina obliquiloculata* (Parker and Jones)*Sphaeroidinella dehiscens* (Parker and Jones)

A study of bottom samples under the present Gulf Stream shows that the distribution of most of these warm water pelagic species on the ocean bottom is almost entirely due to the position of warm surface currents. Therefore the great abundance, the relative scarcity or even absence of some of these species in certain parts of the cores may be taken to mean that warm ocean currents were present or absent at the various times of deposition. On this basis, it would seem that in core P.137 (Text Figs. 9 and 10) there are two periods of great abundance of the pelagic forms, far greater than at the present time, and may be due to warm surface waters and the presence of warm currents from the Atlantic during the period in which they were deposited, while the absence or scarcity of these species would seem to indicate the opposite conditions, either that the surface waters were colder or that the warm currents were excluded from this area by land barriers which caused them to change their courses. Likewise in core P.136 (Text Figs. 6, 7, 8), there are four periods of maximum development of the warm water pelagic foraminifera. In core P.135 (Text Fig. 5), which is the shortest of the three, there seems to have been far less evidence of rapid change, and the area during the time of deposition of this shorter core was largely outside the influence of warm surface currents. In this case, however, some very peculiar data are available from the bottom living species.

No description of the pelagic species seems necessary. Photographs are given so that they may be checked by anyone interested in the identification of the species.

DATA FROM THE BENTHIC FORAMINIFERA.

Although of relatively small numbers, the benthic foraminifera are of interest from the fact that most of them are not known to occur at such depths as those from which they were recovered in these cores. This is more marked in core P.135 (Text Fig. 5) than in the other two. The number of species is far greater than in the other two cores, even though this core was only slightly more than half as long as the other two. A very large number of the benthic foraminifera, nearly all in fact, occurred in one of the samples from this core, and

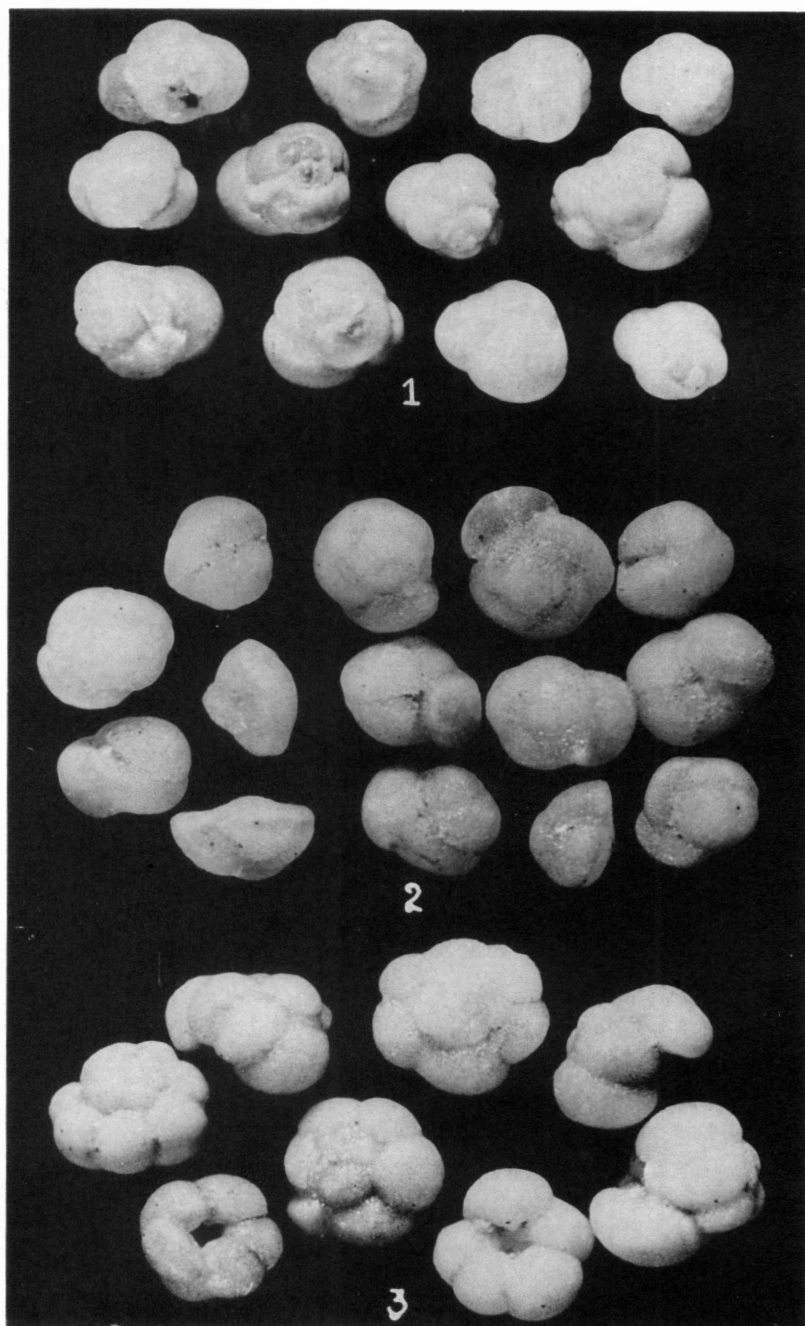


FIG. 1. *Candeina nitida* d'Orbigny
FIG. 2. *Globigerina inflata* d'Orbigny
FIG. 3. *Globigerina conglomerata* Schwager

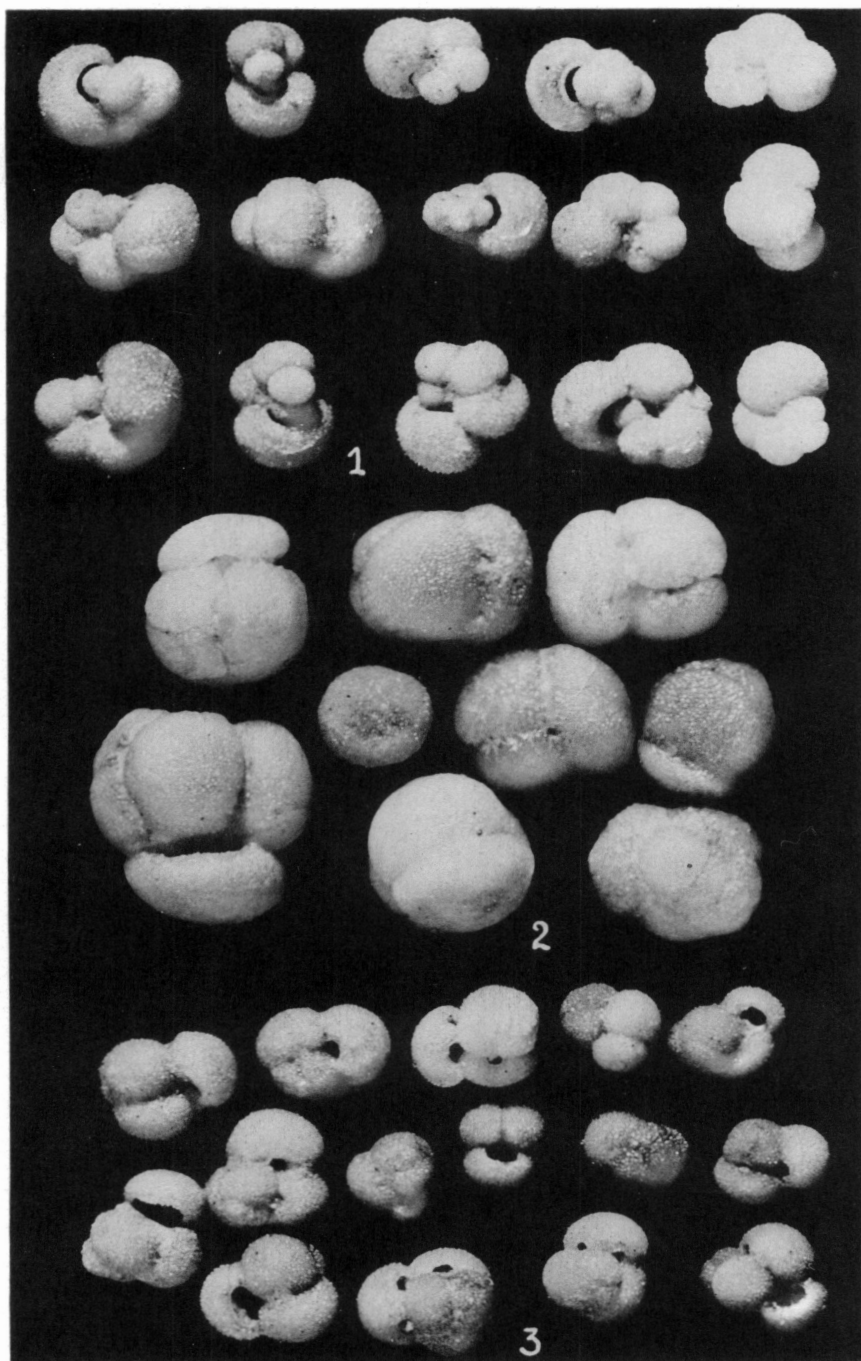


FIG. 1. *Globigerinella aequilateralis* (H. B. Brady)
 FIG. 2. *Globigerinoides conglobata* (H. B. Brady)
 FIG. 3. *Globigerinoides rubra* (d'Orbigny)

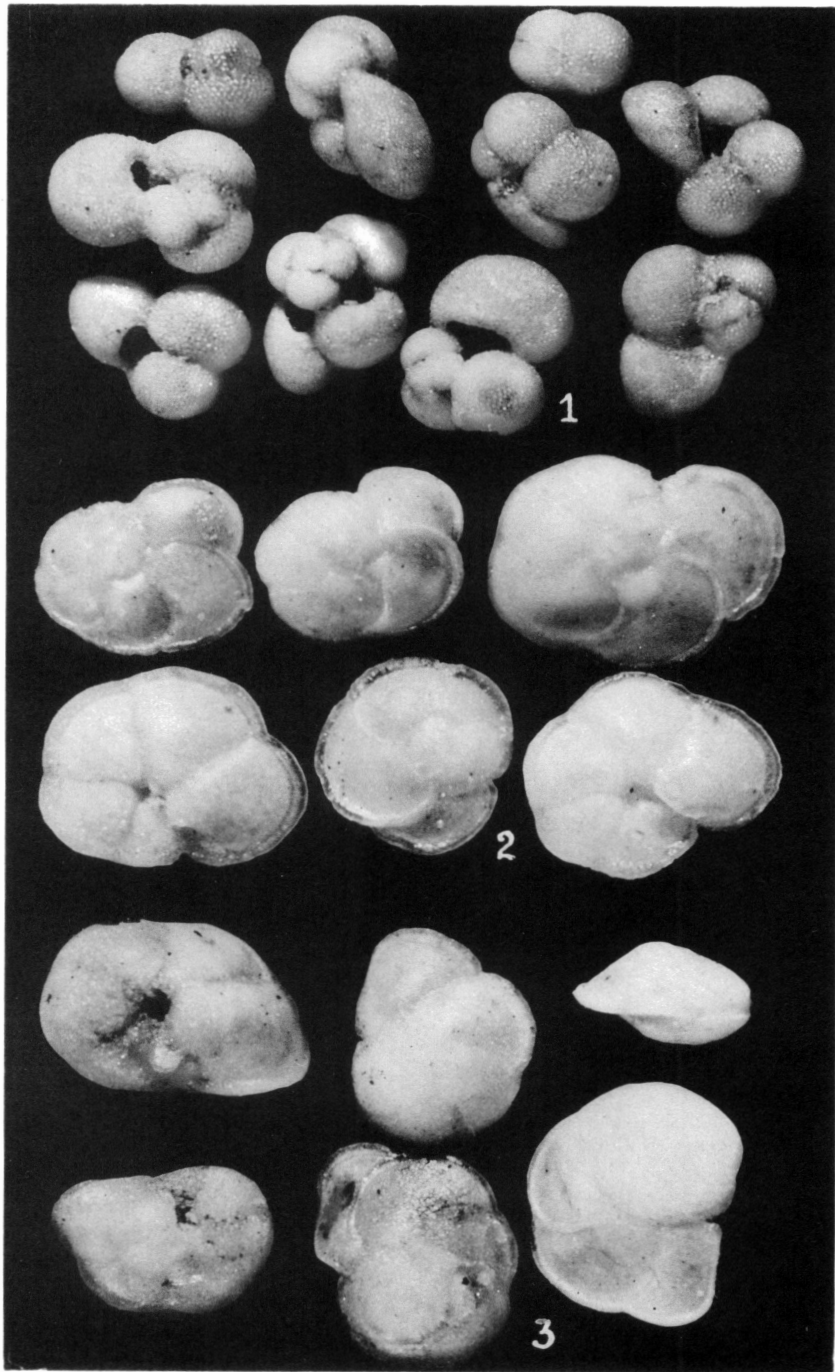


FIG. 1. *Globigerinoides sacculifera* (H. B. Brady)
FIG. 2. *Globorotalia menardii* (d'Orbigny)
FIG. 3. *Globorotalia tumida* (H. B. Brady)

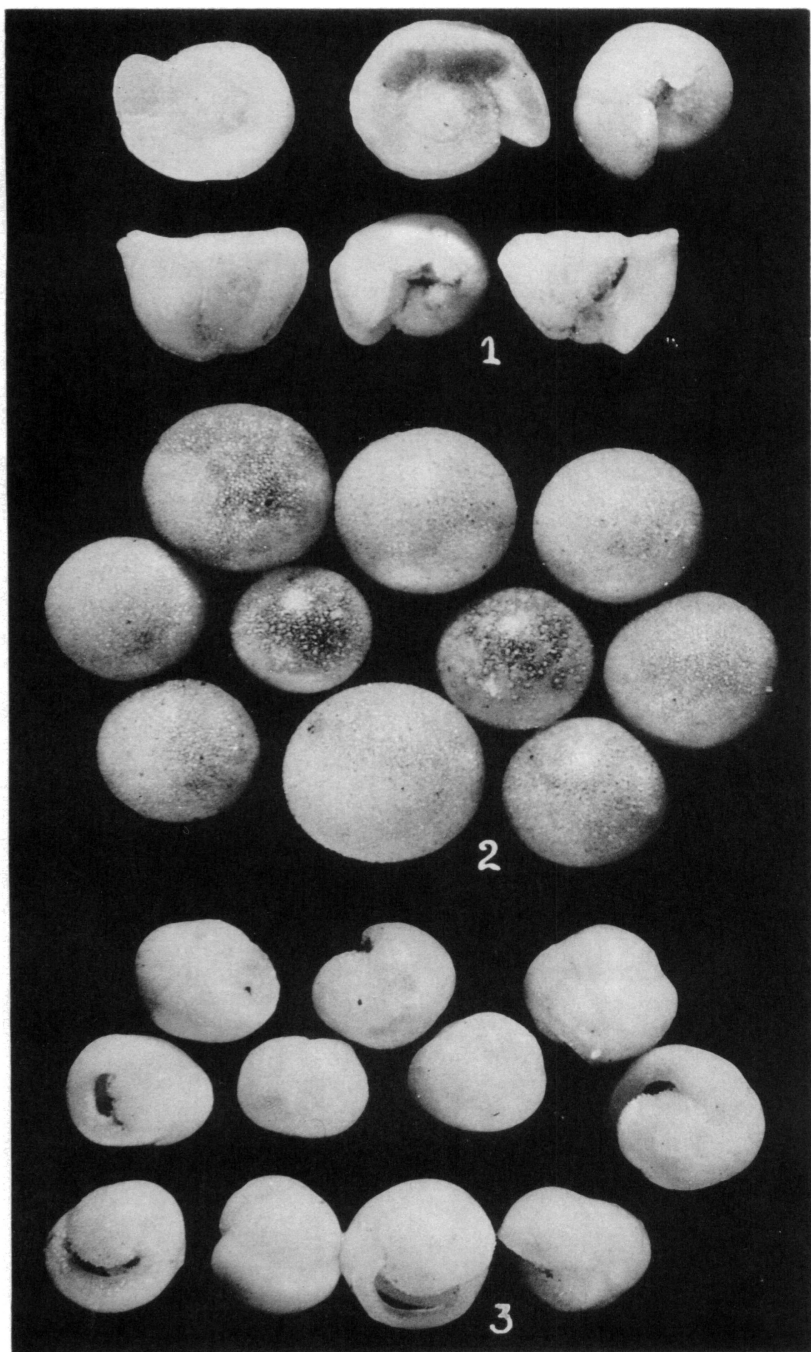


FIG. 1. *Globorotalia truncatulinoides* (d'Orbigny)
FIG. 2. *Orbulina universa* d'Orbigny
FIG. 3. *Pulleniatina obliquiloculata* (Parker and Jones)

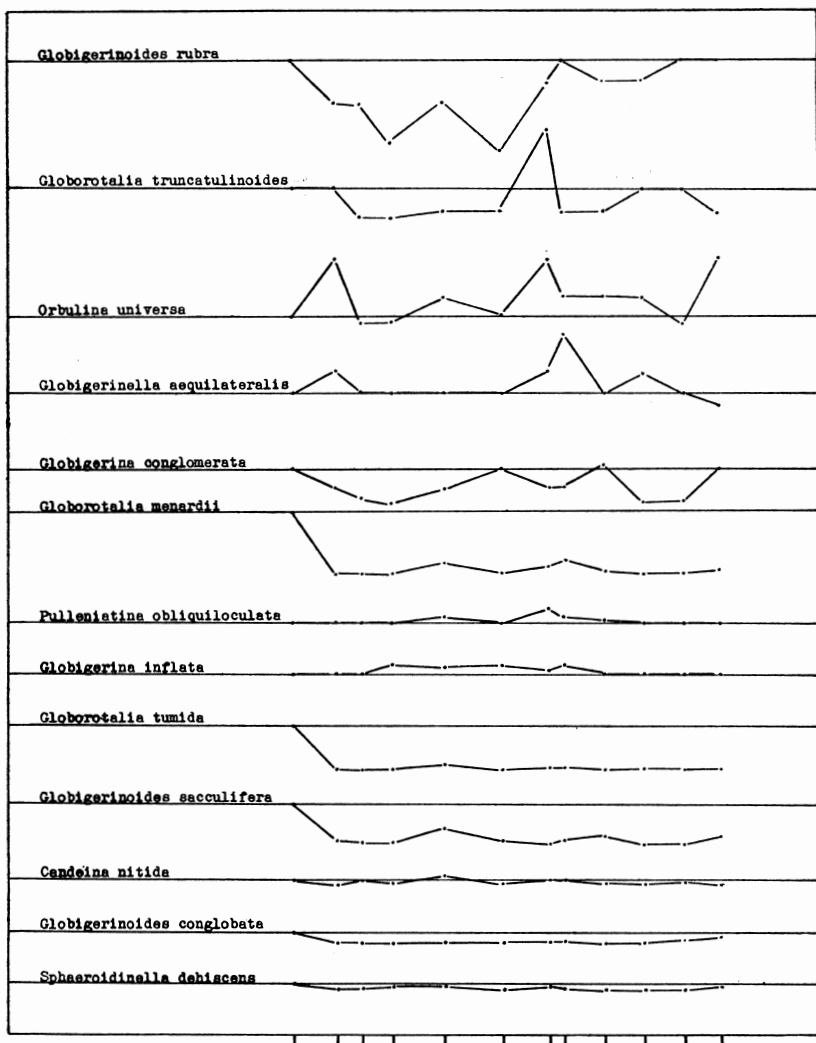


Fig. 5.

many were not found elsewhere. A discussion of this particular part of the core will be given later. As a basis for discussion, the depth range in the general area is given for a number of the benthic species based largely on records from the dredgings of the *Albatross* in these and adjacent regions.

AMPHISTEGINA LESSONII d'Orbigny.

(Pl. 5, Fig. 2.)

This is essentially a species of shallow water of coral reefs. It is abundant in the West Indies at depths ranging from 1 to

37 fathoms, and found more rarely down to depths of 60 fathoms. Specimens may be carried into deeper waters by currents, and there are records for it as rare from four deep stations in 222, 417, 463, and 1169 fathoms. The species occurred only in core P.135 (Text Fig. 5), and there, is limited to two adjacent samples.

BOLIVINITA QUADRILATERA (Schwager).

(Pl. 5, Figs. 5-7.)

There are very few records for this species in the area. It has been recorded as rare in 60 and 896 fathoms.

CASSIDULINA SUBGLOBOSA H. B. Brady.

(Pl. 5, Figs. 9-11.)

The records for this general area give a range in depth from 20 to 880 fathoms with the greatest numbers at stations between 79 and 463 fathoms.

CASSIDULINA LAEVIGATA d'Orbigny.

This is a very rare species in the region, and has a colder water habitat than the preceding. It occurred only in core P.135 (Text Fig. 5).

CASSIDULINOIDES BRADYI (Norman).

(Pl. 5, Fig. 14.)

This is rare in the core samples, occurring only in core P.135 (Text Fig. 5). It is a colder water form and not recorded in dredgings from this general region.

CHILOSTOMELLA OVOIDEA Reuss.

(Pl. 5, Fig. 15.)

The only present occurrences in areas adjacent to this are from 167, 382 and 896 fathoms. Its occurrence in the core samples is limited to core P.135 (Text Fig. 5), and all but one of the specimens occurred in the zone already noted as having so many benthic species. There are many records from higher latitudes.

CIBICIDES PSEUDOUNGERIANUS (Cushman).

(Pl. 5, Figs. 16-19.)

This species ranges downward to 2,000 fathoms or more, but is most common at depths of less than 1,000 fathoms. It occurred in all three cores.

CORNUSPIRA INVOLVENS (Reuss).

(Pl. 5, Figs. 12, 13.)

This is especially a shallow water form in this region. Its occurrence in some numbers in the sample from core P.135 (Text Fig. 5) is therefore significant.

EGGERELLA PROPINQUA (H. B. Brady).

(Pl. 5, Fig. 23.)

This is a widely distributed species in fairly deep waters of the Atlantic.

PYRGO MURRHINA (Schwager).

(Pl. 6, Figs. 6-8.)

This is a deep water species ranging in depth to 2,500 fathoms.

SIGMOILINA SIGMOIDEA (H. B. Brady).

(Pl. 6, Figs. 6-8.)

This is a species of fairly deep water and widely distributed.

SIPHONINA ADVENA Cushman.

Most of the records available are from waters of medium depth.

TRILOCULINA TRICARINATA d'Orbigny.

Depth records for this species are incomplete, but it is mostly a species of warm waters.

VIRGULINA BRADYI Cushman.

Most of the records for this species are from fairly deep water and in higher latitudes.

OCURRENCE OF REMAINS OTHER THAN FORAMINIFERA.

The charts (Text Figs. 2, 3, 4) include the occurrences of Pteropods, Ostracods, Echinoderm spines, Otoliths and spicules of Gorgonids. The records for the Pteropods as already noted is of decided significance if the theory is correct that these disappear by solution in waters over 1,000 fathoms in depth. These occur particularly in core P.135 (Text Fig. 5). The occurrence of spicules of a Gorgonid in the sample from P.135 (Text Fig. 5) is of especial significance, as these animals are largely confined to relatively shallow water.

SUMMARY.

The data presented in the accompanying charts and plates seem to show certain definite facts, the explanation of which will depend on what is known of the past history of the region from which the cores were taken.

In the three charts showing the distribution of the species, the pelagic ones of the first thirteen spaces are indicated by solid black if present, and by a white space if absent. The other six diagrams showing the relative abundance will give that information. In the benthic species, however, an attempt has been made to show the relative abundance. Where the square is solid black, it occurred with ten or more specimens. With one-half of the square black, from five to ten specimens were found, and where less than five the number is represented by the number of dots in the square.

CORE P.135.

(Text Fig. 5.)

This core is the shortest of the three, being but 44 inches in length, but came from the greatest depth at 2,680 fathoms. The variation in relative abundance of pelagic foraminifera, when compared with the other two cores, is very slight, yet there are indications of the development of a more definite *Globigerina*-ooze in the core. The most significant facts obtained from a study of this core may be derived from the fauna of the samples at 63-64 cm. and 66-67 cm., especially the former. In this sample, there are over thirty species of benthic foraminifera, a number of which occur nowhere else in the three cores as sampled. More striking than the large number of species is the fact that some of these, such as *Amphistegina lessonii* and others are known to occur normally only in comparatively shallow water. Another significant fact is the occurrence of gorgonid spicules also in this sample. It becomes evident that the contained remains of organisms could not have originated at any such depth as that from which they were recovered. While this locality is rather far removed from land at the present time, it is clearly indicated that the fauna which it contains originated in much shallower water. The depth of water in the Windward Passage between Cuba and Haiti is not very great, even at the present time, and during periods of accumulation of polar ice caps may have been considerably less

than today. Anyone who has gone through this passage by daylight must have noted the many signs of elevated terraces and of the change in height of the land that is now Cape Maisi. It may have been possible for currents sweeping through this passage at some past time, when it was even more shallow than it is today, to have carried into the area where this core was obtained enough material to have accounted for this peculiar fauna. The same solution might apply to the area between Jamaica and Cape Tiburon, the southwestern tip of Haiti. The depth of water between the two islands today is much shallower than the area to the north of Jamaica where this core was obtained. If this intermediate area was shallower at that time, it might have carried normally the fauna now found in the greater depth of water indicated by the core sample, and the remains now found might have been carried to their present position by strong currents across this comparatively shallow water. If more data were available as to the time of the sinking which produced the Bartlett Deep, it would make it easier to account for the discrepancy of a comparatively shallow water fauna now found at such great depths in this one particular sample in the core.

CORE P. 136.
(Text Figs. 6, 7, 8.)

This core is slightly the longest of the three, and its location is directly west of Jamaica. This and the following core lie in the present path of the Gulf Stream, and are areas of deposition of pelagic foraminifera. It is interesting, therefore, to find in this core evidences of four greatly increased periods of deposition of pelagic foraminifera with intermediate periods of much lessened accumulation of these same species. These were not only less by comparison with the four periods of greater abundance in the past, but actually much less than at the present day, if the top sample of the core is taken as normal for what is being deposited at present. It would therefore seem that one or two things must have occurred. The surface waters over this area from which the core was taken were perhaps much warmer than today at four periods during the deposition of the material in the core, with three intermediate periods of colder surface water between. The other alternative might be that the progress of the warm currents from the open

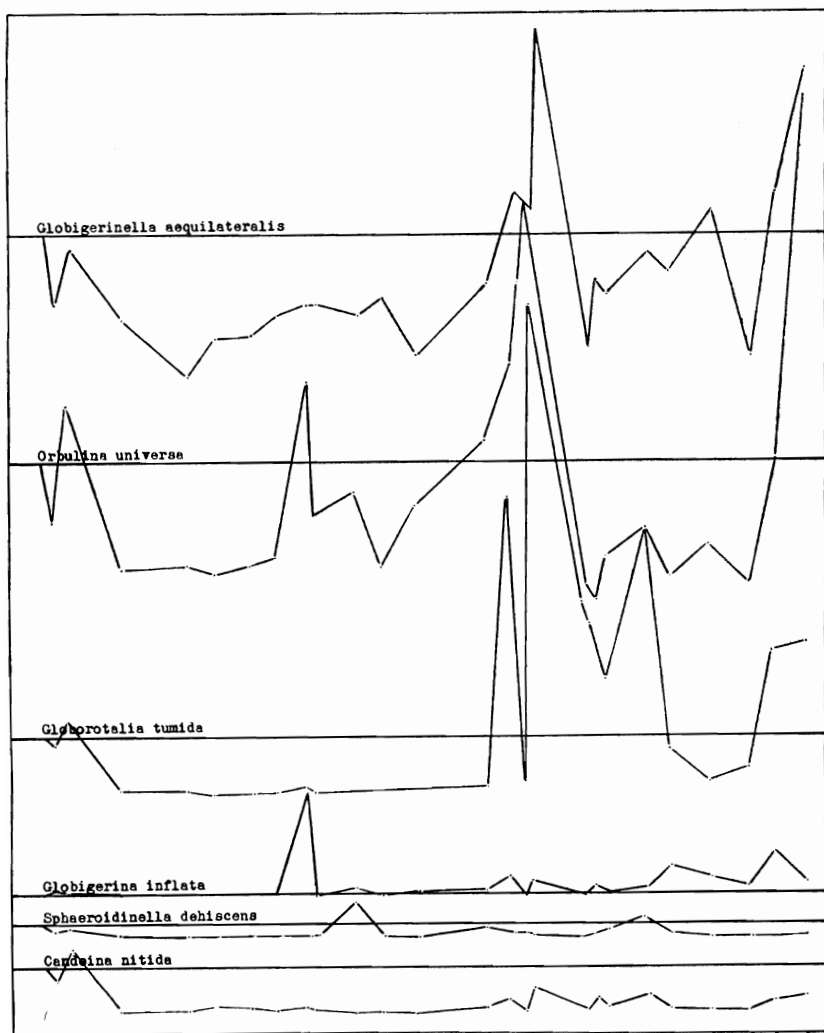


Fig. 6.

Atlantic may have been barred from this region by a lowering of the ocean level sufficient to cause the openings through the Windward and Leeward Islands to become shallow enough to form an actual barrier. These channels today are not deep, and it is conceivable that some such barrier to the entrance of warm currents to this area may have existed in the past. The benthic foraminifera do not show as definite significance

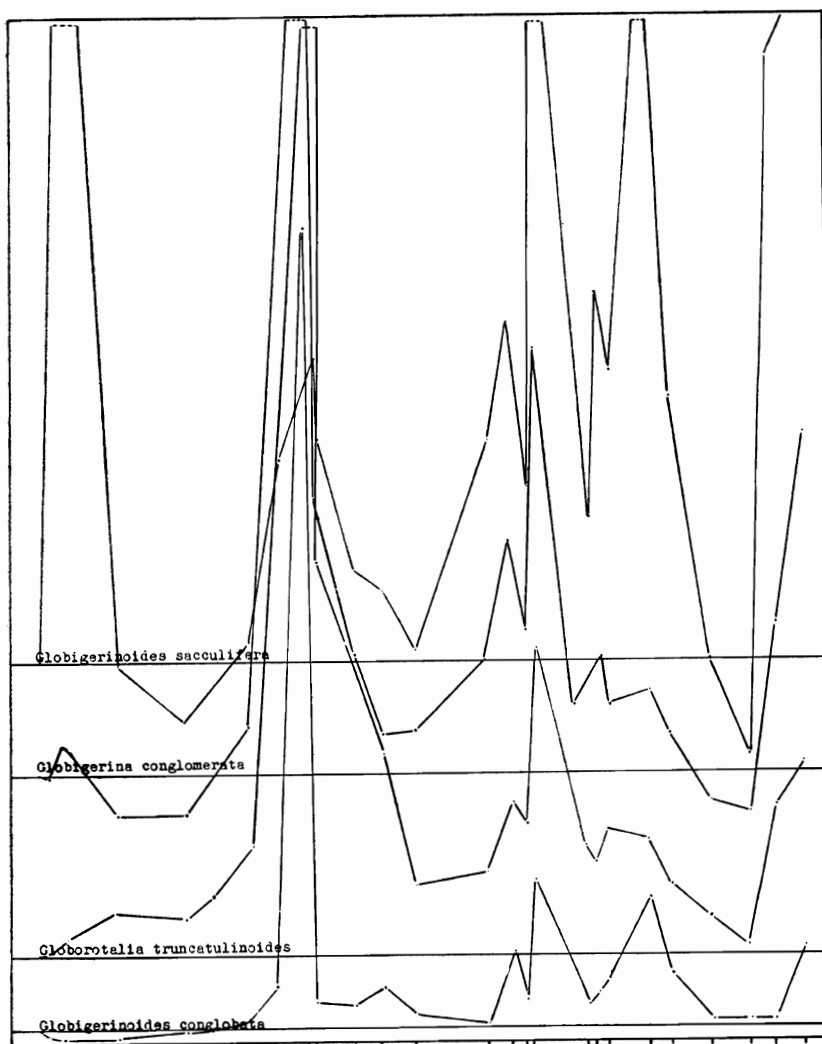


Fig. 7.

as in the previous core. As already mentioned, the great scarcity of *Globorotalia menardii* (d'Orbigny) during the period of great abundance of *Globigerinoides rubra* (d'Orbigny) and *G. sacculifera* (H. B. Brady) is puzzling. All these species are today characteristic of deposits of the Gulf Stream. However, the same relationship has been noted by Schott in the Atlantic cores of the area between Africa and South

Relative Abundance of Pelagic Species in Core P.136

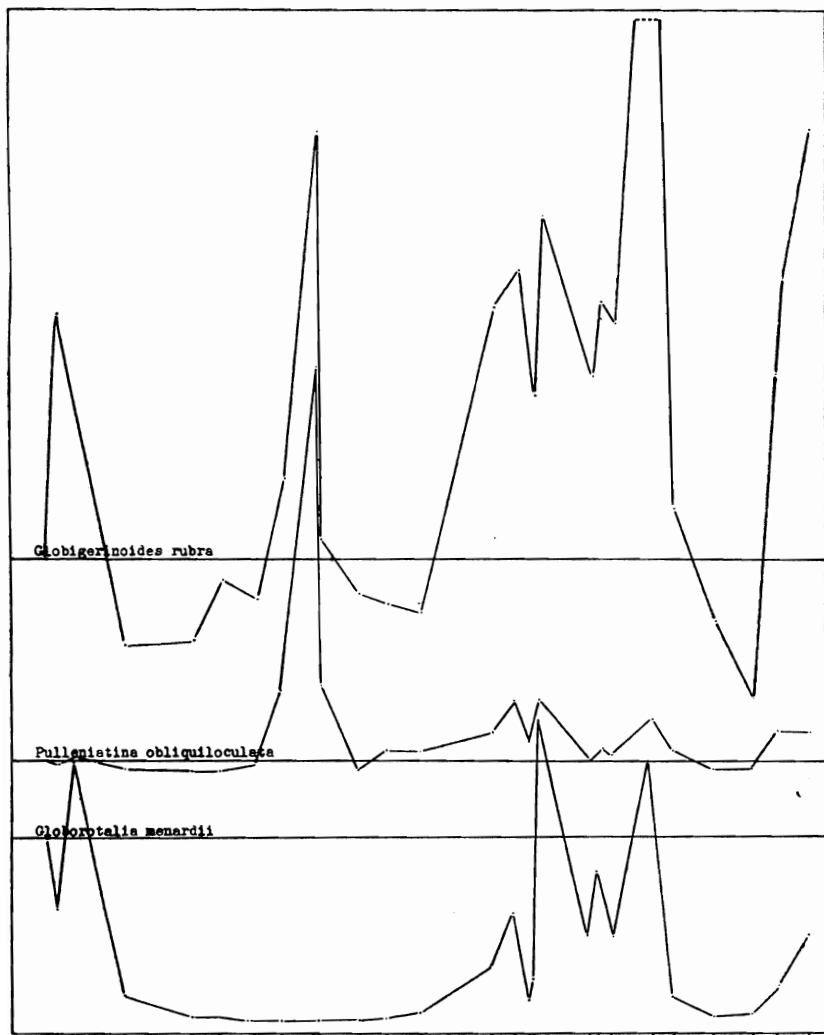
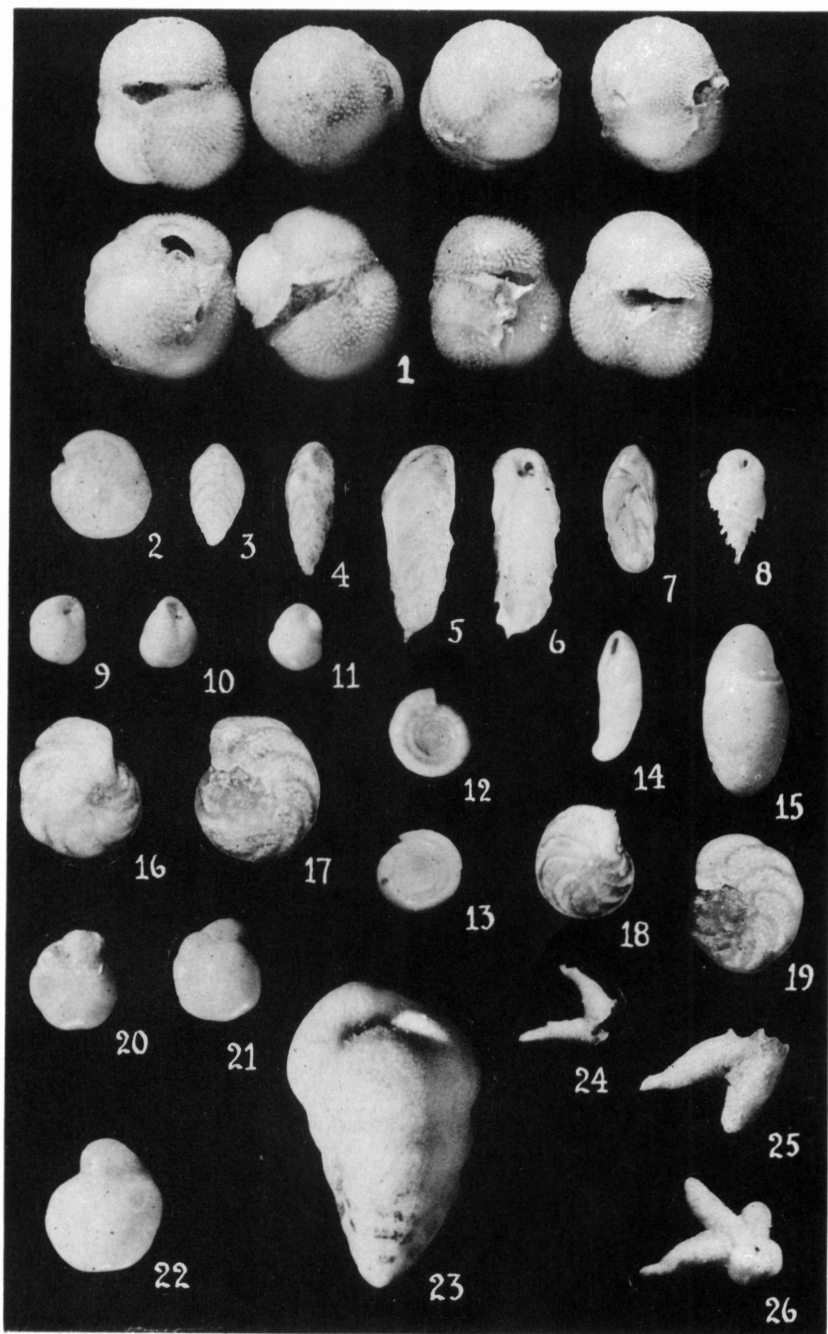


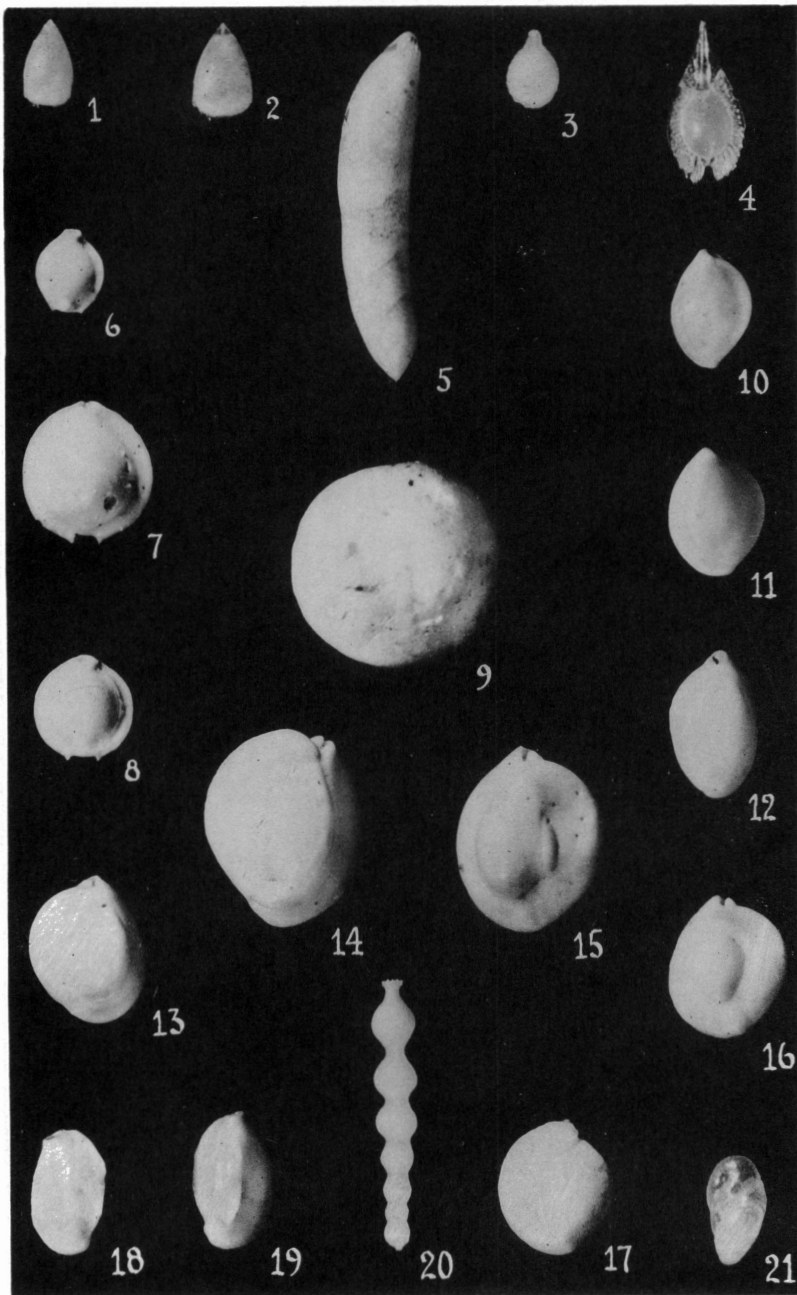
Fig. 8.

America. The exact significance of this coincident abundance and scarcity of these species is not yet clear.

At least the pelagic foraminifera of the samples from this core indicate great changes in surface water conditions during the time of the deposition with four periods warmer than at present, and three intermediate ones probably cooler than now existing in that region.



- | | |
|---|--|
| 1. <i>Sphaeroidinella dchiscens</i>
(Parker and Jones) | 12, 13. <i>Cornuspira involvens</i> (Reuss). |
| 2. <i>Amphistegina lessonii</i> d'Orbigny. | 14. <i>Cassidulinoides bradyi</i> (Norman). |
| 3. <i>Bolivina</i> sp. | 15. <i>Chilostomella ovoidea</i> Reuss. |
| 4. <i>Bolivina</i> sp. | 16-19. <i>Cibicides pseudoungerianus</i>
(Cushman). |
| 5-7. <i>Bolivinita quadrata</i> (Schwager). | 20-22. <i>Eponides umbonata</i> (Reuss). |
| 8. <i>Bulimina</i> sp. | 23. <i>Eggerella propinqua</i> (H. B. Brady). |
| 9-11. <i>Cassidulina subglobosa</i> H. B. Brady. | 24-26. <i>Globigerina digitata</i> H. B. Brady. |



- 1-4. *Lagena* sp.
 5. *Dentalina* sp.
 6-8. *Pyrgo murrhina* (Schwager).
 9. *Pyrgoella* sp.
 10-12. *Sigmoilina sigmoidea* (H. B. Brady)

- 13-17. *Quinqueloculina* sp.A.
 18, 19. *Quinqueloculina* sp.B.
 20. *Siphonodosaria* sp.
 21. *Robertina* sp.

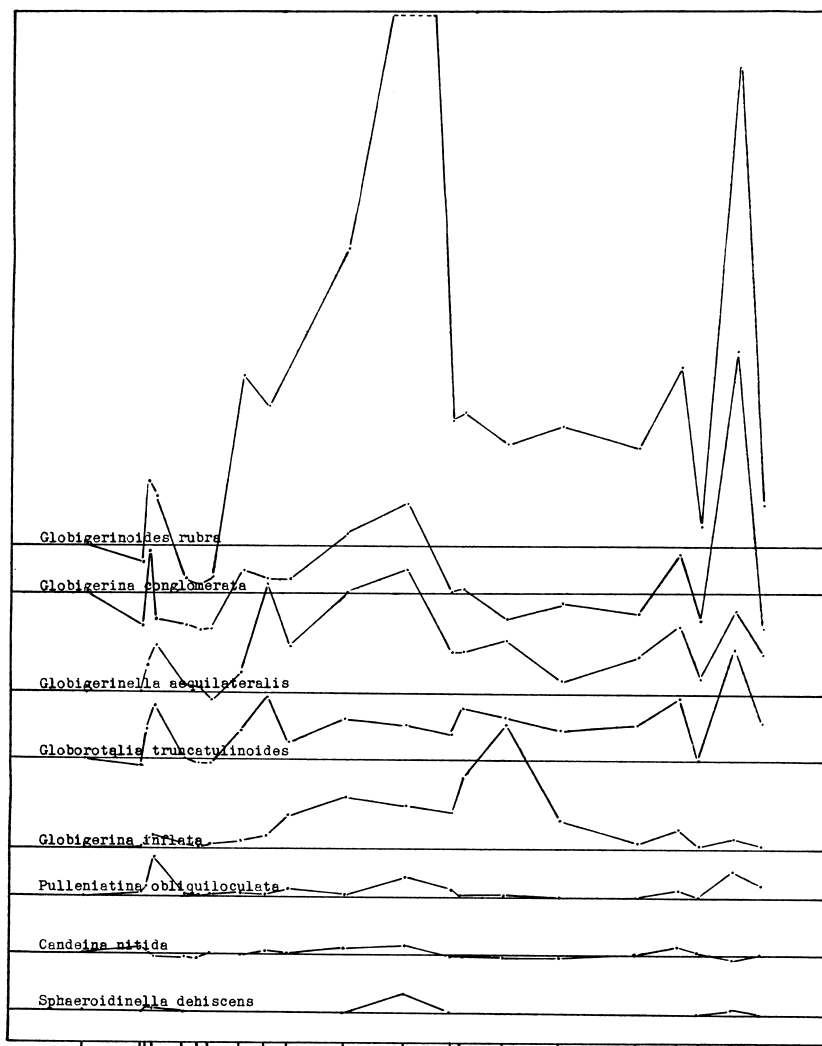


Fig. 9.

CORE P. 137.
(Text Figs. 9 and 10.)

This core is practically of the same length as the preceding, and came from water over 100 fathoms deeper. There were two periods during its deposition when there was a great increase in the number of pelagic foraminifera being deposited. There were lesser periods of increase also, not as well marked, and between, as in the previous core. The relationship between

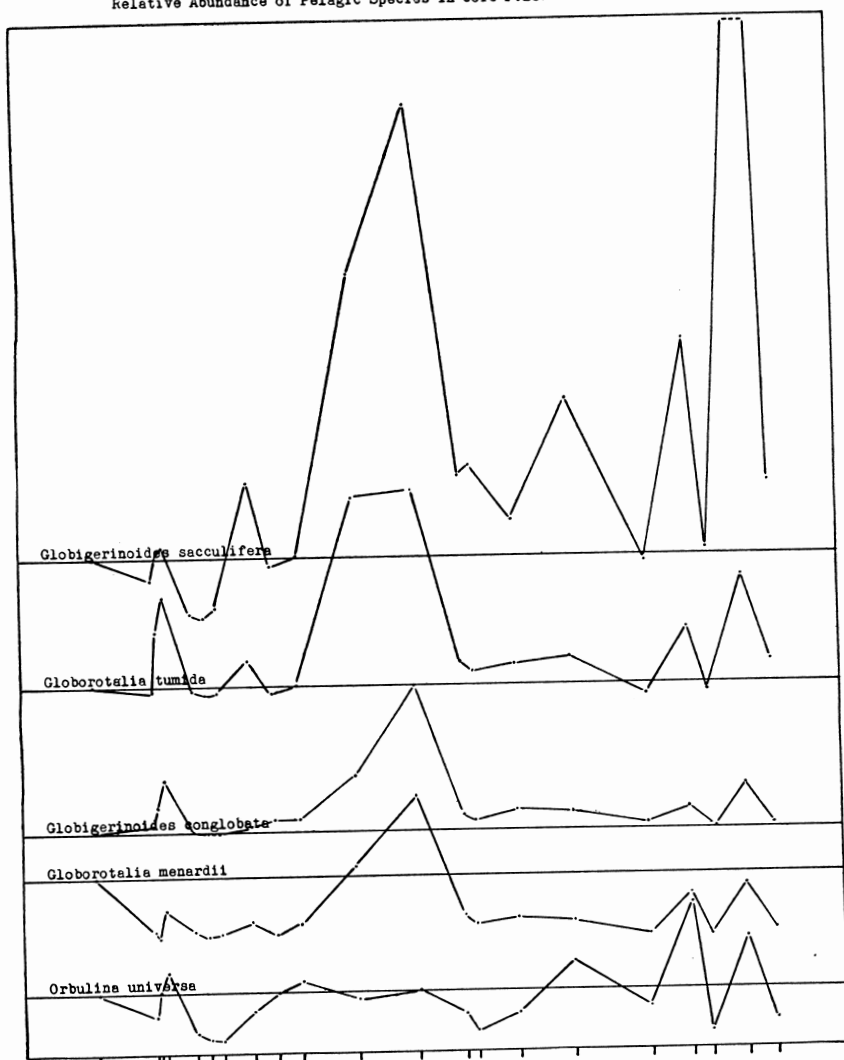


Fig. 10.

Globorotalia menardii and *Globigerinoides rubra* and *G. sacculifera* is not distinctly marked as in core P. 136. (Text Figs. 6, 7, 8.)

SUMMARY.

The data derived from a study of the foraminifera of these three cores show that in this region there have been, in the time corresponding to that of the period of deposition of the

cores, very decided changes. These include rhythmic swings of either colder and warmer surface water temperatures or of alternating periods of presence or absence of warm currents such as our present Gulf Stream. These are evidently due to recurring climatic changes, perhaps coincident with a distinct change of sea level during this period of time. The time of deposition of the longest cores according to published data may be from 90,000 to 200,000 years or even more. If this is at all in accord with the actual time, the swings shown in core P. 136 (Text Figs. 6, 7, 8), in particular, may be coincident with known glacial and interglacial periods. There is added evidence that the actual depths of the ocean in these areas may have changed appreciably during the interval of deposition, and that changes of depth of intermediate areas between present land masses may also have taken place.

The possibility should not be overlooked that if the ingress of warm waters into this area may have been blocked during the accumulation of polar ice caps and consequent lowering of ocean level, the cold fresh water pouring into the area may have greatly changed the surface conditions during these periods. Such conditions might conceivably have been unfavorable for the persistence of normally warm water pelagic species. The possibility of slumping during earthquakes, or at other times, of the sides of the basin must be considered. However, to have carried down shallow water foraminifera in this way slumping should have also carried with them many other things which were not found with them.

Altogether the evidence presented by the charts, while in greatly condensed form, may have a significant bearing on the interpretation of the changes that have taken place in this region.

CUSHMAN LABORATORY,
SHARON, MASS.