CONTRIBUTIONS
FROM THE
CUSHMAN FOUNDATION
FOR
FORAMINIFERAL RESEARCH

Volume XV (1964)

Editor
ROBERT M. KLEINPELL

1964

CUSHMAN FOUNDATION FOR FORAMINIFERAL RESEARCH, INC.

1964

PATRONS

MRS. JOSEPH A. CUSHMAN, Sharon, Massachusetts
ARTHUR N. DUSENBURY, JR., 19 Sherman Ave., White Plains, New York
WALDO L. SCHMITT, U. S. National Museum, Washington, D.C.
SUN OIL COMPANY, Dallas, Texas

FELLOWS

HAROLD V. ANDERSEN, Louisiana State University, Baton Rouge, Louisiana
HARRY W. ANISGARD, Humble Oil & Refg. Co., New Orleans, Louisiana
ORVILLE L. BANDY, Univ. Southern California, Los Angeles, California
C. LOTHROP BARTLETT, 842 East Drive, Beaumont, Texas
R. STANLEY BECK, 621 Truxtun, Bakersfield, California
LERÔY E. BECKER, R. D. 1, Spencer, Indiana
NOEL BROWN, JR., Humble Oil & Refg. Co., Houston, Texas
JAMES BUSH, 11 T Research Inst., Chicago, Illinois
RICHARD CIFELLI, U. S. National Museum, Washington, D.C.
DANA K. CLARK, 112 Cherry St., Seattle, Washington
W. STORRS COLE, Cornell University, Ithaca, New York
G. ARTHUR COOPER, U. S. National Museum, Washington, D.C.
RAYMOND C. DOUGLASS, U. S. National Museum, Washington, D.C.
RONALD ECHOLS, Univ. Southern California, Los Angeles, California
M. A. FURRER, Dominion Oil Co., Port-of-Spain, Trinidad
J. B. GARRETT, JR., Pan American Petroleum Corp., Houston, Texas
GEOLOGISCH-PALAONTOLOGISCHES INST., Univ. Kiel, Kiel, Germany
JOSEPH J. GRAHAM, Stanford University, Stanford, California
GEORGE L. HARRINGTON, 850 Webster St., Palo Alto, California
HOLLIS D. HEDBERG, 118 Liberty Place, Princeton, New Jersey
LLOYD G. HENBEST, U. S. Geological Survey, Washington, D.C.
HUMBLE OIL and REFINING CO., Houston, Texas
MRS. F. H. KIERSTEAD, Smith College, Northampton, Massachusetts
ROBERT M. KLEINPELL, 5959 Margarido Drive, Oakland, California
H. G. KUGLER, Natural History Museum, Basel, Switzerland
A. R. LOEBLICH, JR., c/o California Research Corp., La Habra, California
DONALD H. LOKKE, East Texas State College, Commerce, Texas
DORIS L. LOW, U. S. Geological Survey, Washington, D.C.
DONALD A. MYERS, Federal Center, Denver, Colorado
ENRICO F. DINAPOLI, Via G. A. Guttani 14, Rome, Italy
KATHERINE V. W. PALMER, Paleontological Research Institution, Ithaca, New York
FRANCES L. PARKER, Scripps Institution of Oceanography, La Jolla, California
SETEMBRINO PETRI, University of Sao Paulo, Brazil
FRED B PHLEGER, Scripps Institution of Oceanography, La Jolla, California
MORTON POLUGAR, Standard Oil Co. of California, Oildale, California
C. M. QUIGLEY, 5303 Brae Burn Drive, Bellaire, Texas

K. Norman Sachs, U. S. National Museum, Washington, D.C.
F. Marion Setzer, 536 College St., Bellaire, Texas
Leo W. Stach, 255 Beaconsfield Parade, Victoria, Australia
Charles R. Stelck, University of Alberta, Edmonton, Canada
Hans E. Thalmann, P. O. Box 4407, Stanford, California
M. Ruth Todd, U. S. Geological Survey, Washington, D.C.
Donald F. Toomey, Pan American Petroleum Corp., Tulsa, Oklahoma
Universitat Graz, Geologisch-Palaeontologisches Institut, Graz, Austria
James A. Waters, 308 Shadywood Lane, Seagoville, Texas
R. T. D. Wickenden, Geological Survey of Canada, Calgary, Canada
Virgil Winkler, c/o Creole Petroleum Corp., Caracas, Venezuela
A. E. Wirz, 1 D Ardmore Park, Singapore, Malaya
Gordon A. Young, c/o Mene Grande Oil Co., Caracas, Venezuela

INDEX TO VOLUME XV, 1964

CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
VOLUME XV, PART 1, JANUARY, 1964

275. DISTRIBUTION OF FORAMINIFERA OFF THE SOUTHERN ATLANTIC COAST OF THE UNITED STATES

JAMES A. WILCOXON
University of Southern California, Los Angeles, California[1]

ABSTRACT

The Foraminifera from 98 stations — intertidal zone to a depth of 1000 fms. — between Cape Hatteras and the Florida Straits were studied. The Gulf Stream apparently restricts the benthonic specimens to the continental shelf and upper slope, since few are found deeper. The deeper benthonic specimens may have been displaced from shallower water; planktonic specimens are common. The number of species increases with depth to the outer shelf, with arenaceous forms most common from 15-52 m. Porcelaneous forms are most abundant nearshore. Hyaline species are the dominant ones on the shelf. There are four faunal depth zones: 0.1 m., 1-15 m., 15-61 m., and 61-192 m. No species were believed to be selective of any particular sediment type. Tropical planktonic species have been carried north by the Gulf Stream. Some planktonic species show stratification with depth of the sea floor.

INTRODUCTION

General Statement

This study was undertaken to determine the distribution of Foraminifera off the southern Atlantic coast of the United States between Cape Hatteras and the Florida Straits, and extending from near the beaches to beyond the axis of the Gulf Stream (text fig. 1).

Ecologic conditions were related to faunal distribution and particular attention was paid to sediment type to establish what effect, if any, it has upon the foraminiferal distribution. The area of investigation, from Cape Hatteras to the Florida Straits, is a coastal band more than 700 km. in length.

The original program of investigation stemmed from (1) the interest of the United States Fish and Wildlife Service in the biological and chemical conditions in the offshore waters from Cape Hatteras to the Florida Straits; (2) interest of the South Atlantic Section, Atlantic States Marine Fisheries Commission for the same reasons; (3) the interest of the United States Navy Hydrographic Office in the physical oceanography of the same region; and (4) the interest of the Office of Naval Research in the deep scattering layer and related subjects.

During the period January, 1953, to December, 1954, the Fish and Wildlife Service M/V *Theodore N. Gill* completed nine cruises over an established station pattern of 80 regular stations and nine special stations. The regular stations were 32 km. apart on east-west lines and 65 km. apart on north-south lines. Between some of the east-west lines single stations were occupied.

[1] Now with Standard Oil Co. of California, La Habra, California.

Previous Work

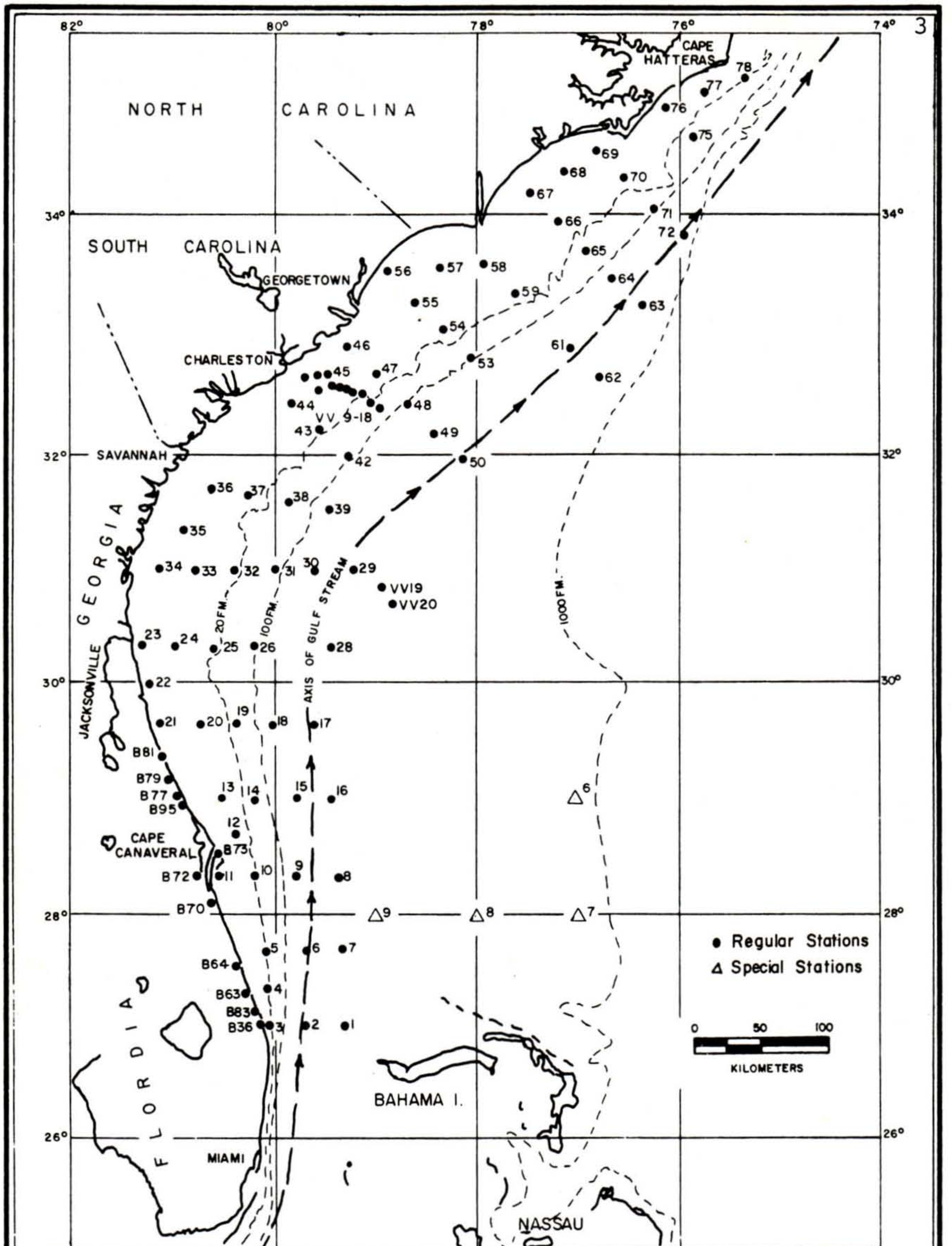
Very little work has been done with the Foraminifera from the southeast coastal area of the United States. In 1920 Cushman undertook to describe the Foraminifera of the Atlantic Ocean with particular reference to the area adjacent to the coast of the United States and the Caribbean Sea. This work was primarily descriptive. Norton (1930) contributed an important study concerned with ecologic trends in the region of southern Florida and the West Indies. He divided his stations into bathymetric zones based upon depth and temperature. Papers emphasizing foraminiferal ecology along the northeastern coast of the United States have been written by Parker (1948), Phleger (1952) and Parker (1952). The abundant species of the continental shelf reported by these authors agree favorably with the distribution south of Cape Hatteras. Moore (1957) demonstrated the ecologic significance of Recent Foraminifera in the northern Florida Keys on the basis of family analysis. He distinguished between the assemblages of families in different parts of the reef tract. More recently Bé (1959, 1960) completed a study of the ecology of planktonic Foraminifera in the western North Atlantic in which he analyzed the bathymetric and seasonal distribution of the various species.

Acknowledgments

The author wishes to express appreciation to Dr. O. L. Bandy of the University of Southern California for suggesting this study and for his constructive criticisms and helpful assistance in the laboratory; to Drs. K. O. Emery of Woods Hole, Massachusetts, and R. O. Stone, also of the University of Southern California, for their helpful suggestions and critical review of the manuscript; and to Dr. Donn Gorsline of the University of Southern California for making available sediment data and additional samples and also for his helpful suggestions. In addition, acknowledgment is made to the Allan Hancock Foundation of the University of Southern California for use of laboratory facilities and its library.

Method of Study

In addition to the bottom samples taken at each of the regular stations, 12 samples collected by Mr. R. D. Terry from the intertidal zone along the beaches of Florida were analyzed. An additional 12 samples from the continental shelf along a traverse off South Carolina were also used. All of the samples were first



STATION LOCATIONS,
SOUTH ATLANTIC COAST OF THE UNITED STATES

TEXT FIGURE 1

weighed to obtain their dry weight and those that required it were washed on a 250-mesh screen (0.61 mm.). In a few instances the samples were also placed in an ultrasonic cleaner to remove material adhering to the tests of the Foraminifera. After cleaning, the Foraminifera were concentrated by the flotation method employing perchlorethylene, a solution of greater density (1.58) than that of the foraminiferal tests. Following the separation of the tests from the sediment residue, the concentrates were placed in vials and recorded. Residues were saved for later observation because in a few samples complete separation was not achieved.

Each sample was split a sufficient number of times to produce a representative fraction that could easily be accommodated on a counting slide. Relative frequencies of the foraminiferal species were obtained by identifying and counting at least 300 specimens. In some instances more than 300 were counted and in some, such as some of the beach samples, fewer than 100 specimens comprised the total fauna.

OCEANOGRAPHY

Currents

The coastal area of the southeastern United States is dominated by the Gulf Stream. Inshore of the north flowing Gulf Stream during most of the year, secondary counter currents are present which are believed to have a general counterclockwise motion of very low velocity (Bumpus and Wehe, 1949). After emerging from the Straits of Florida, the Gulf Stream flows along the outer continental shelf to approximately 32° N. latitude, where it bends towards the northeast and leaves the shelf in the vicinity of Cape Hatteras to flow into deep water. As the stream flows away from the continent, warm tropical water is introduced into the colder northern water of the North Atlantic. Here the stream acts as a barrier to prevent the warm water of the Sargasso Sea from flowing over the colder water mass to the north. During the winter months the surface temperatures in the stream are much higher than those of the water to either side. This same effect can be seen in the summer months, but to a lesser degree. Bottom temperatures in winter and summer present very different pictures and are discussed in the section covering temperature.

Where the Gulf Stream flows along the continental slope velocities of 150 cm./sec. have been recorded (Stommel, 1958). Current velocities of such magnitude, though considerably less at depth, must exert a significant influence upon the transportation of planktonic organisms. Further, a high velocity current such as the Gulf Stream which impinges on the outer continental shelf must surely be a restricting factor of the productivity of benthonic organisms.

Temperature

The more pronounced seasonal variations in surface temperature occur over the shelf while the isotherms in the deep water remain nearly constant throughout the year (Anderson *et al.*, 1956). Over the shelf the surface temperature ranges perhaps as much as 7°C. in the winter but only 2 to 3°C. in the summer. Beyond the shelf and into the Gulf Stream a sharp increase of approximately 5°C. is common. During the summer months temperatures in excess of 28°C. are not unusual. Patterns of bottom temperatures are a function both of the depth and proximity of the Gulf Stream (text figs. 2 and 3). Average summer bottom temperatures range from 8°C. in 400 to 700 meters of water to greater than 27°C. over the shelf. During the winter months temperatures near the bottom range from less than 5°C. in the deeper water to greater than 25°C. over the shelf.

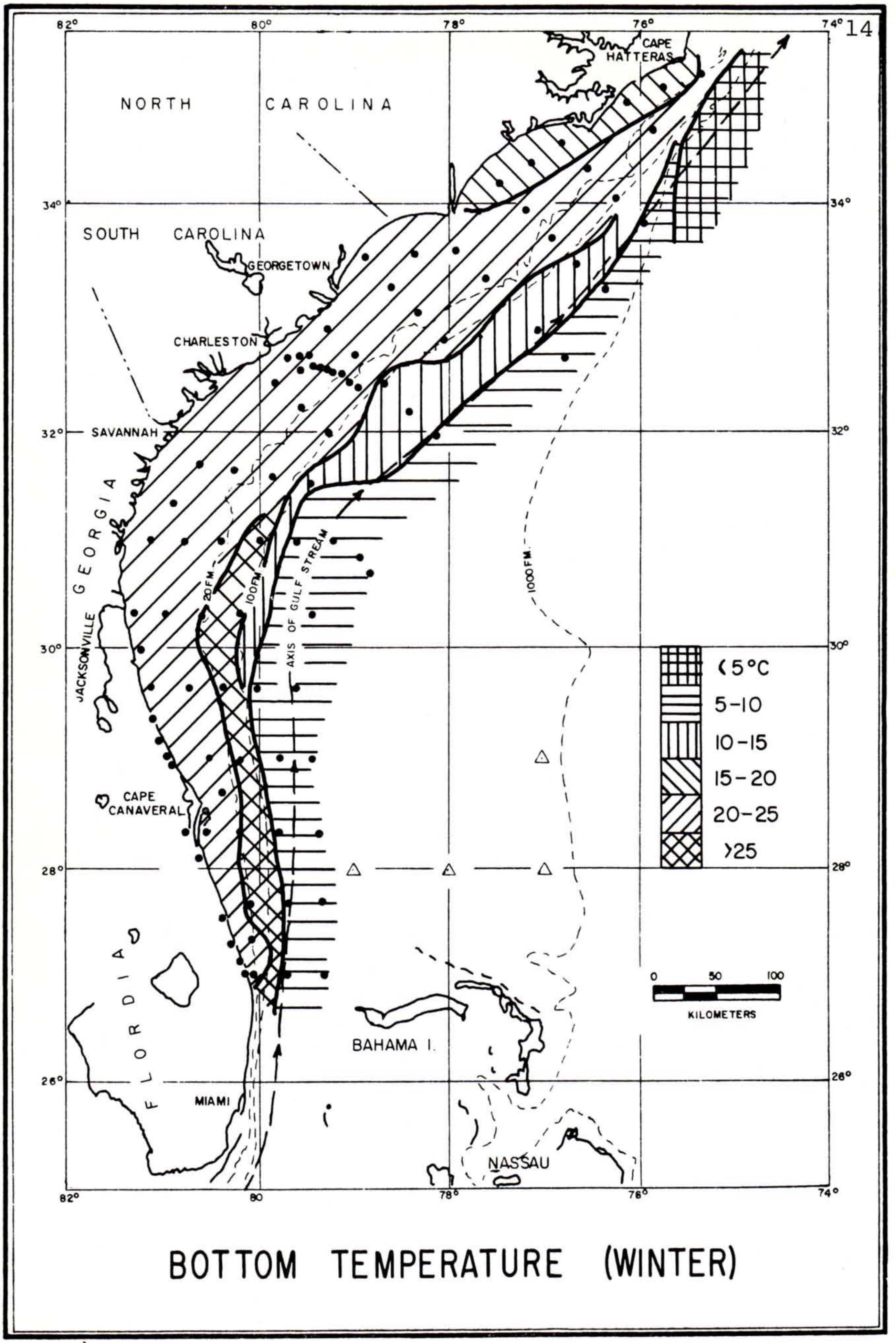
Salinity

Along coasts where there is considerable stream runoff, a nearshore wedge of less saline water penetrates the more normal marine water. Along the southern Atlantic coast of the United States stream runoff is negligible except locally along the coast of Georgia and the Carolinas. As mentioned above, the Gulf Stream is a high-salinity current transporting dense tropical water into the area.

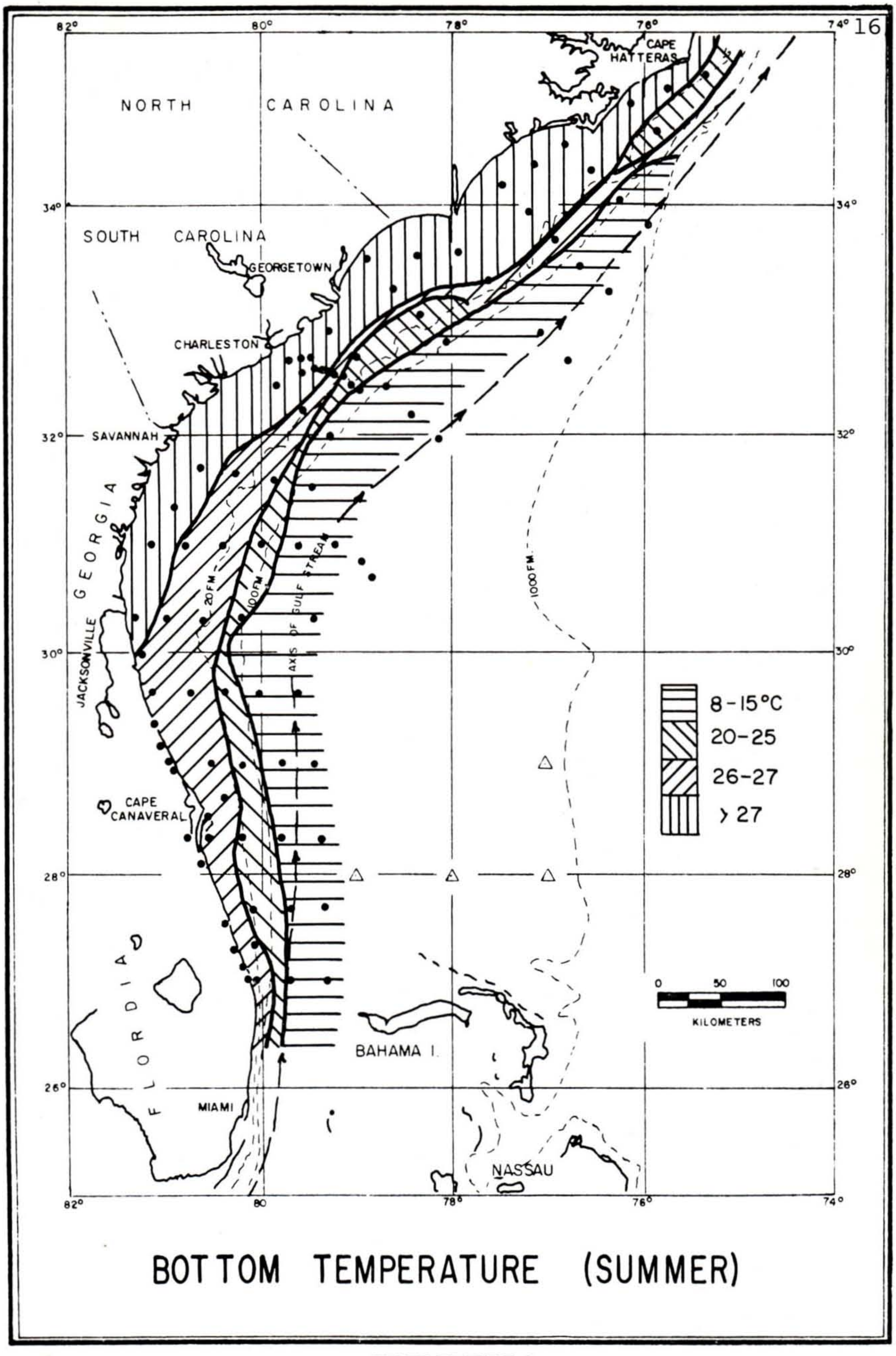
Data from Gorsline's report (1960) indicate that seasonal variations in salinity are slight. In the winter the bottom salinity varies more than in the summer because of an increase in surface runoff from the land (text figs. 4 and 5). Where rivers debouch into the ocean, bottom salinities of less than 30 parts per thousand are common. Surface salinity ranges from 2 parts per thousand above normal marine salinity (34 o/oo) in the summer to 3 parts per thousand below normal in the winter. These variations occur only over the shelf for the changes in the Gulf Stream from season to season are very slight. Within the Gulf Stream there is a variation in salinity with depth. Between depths of approximately 50 and 200 meters there is an increase in salinity followed by a decrease at greater depths. This condition is not seasonal but apparently is continuous throughout the year.

Sediments

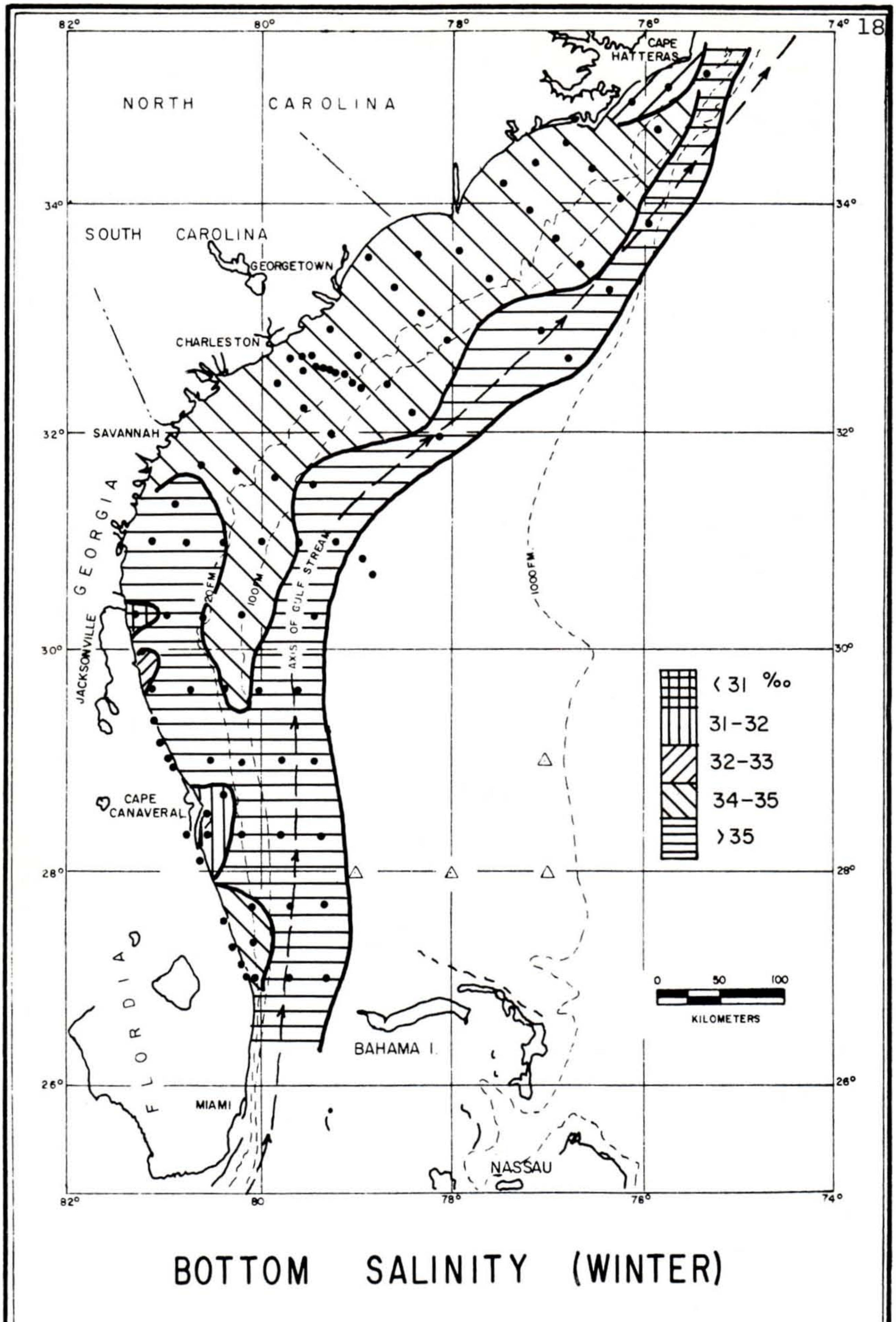
Throughout the area the sediments exhibit a simple pattern of textural types. It is evident (text fig. 6) that the dominant factor in the distribution of sediments is the Gulf Stream. According to Gorsline (1960), carbonate sediments are important constituents of the bottom material. He pointed out that the boundary of the high carbonate sediment essentially lies along the boundary of the north-flowing stream. Seaward of this approximate boundary the sediments are dominantly composed of foraminiferal tests. On the inland side the sediments are combinations of quartz sands and shell fragment sands. Along the outer edge of the shelf where the bottom is swept by the Gulf Stream the sediments are primarily gravelly-sands and sandy-gravels. Apparently the finer material



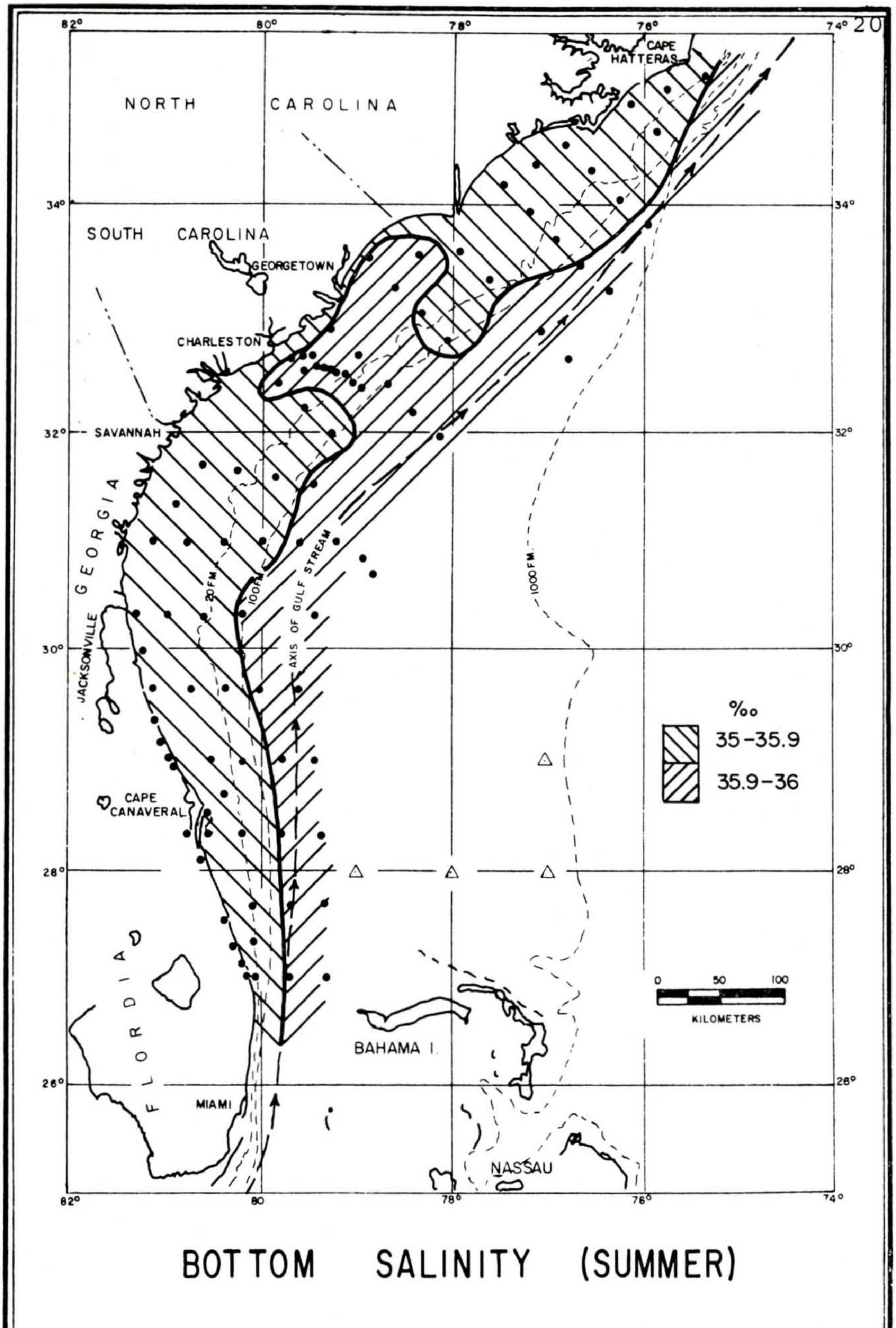
TEXT FIGURE 2



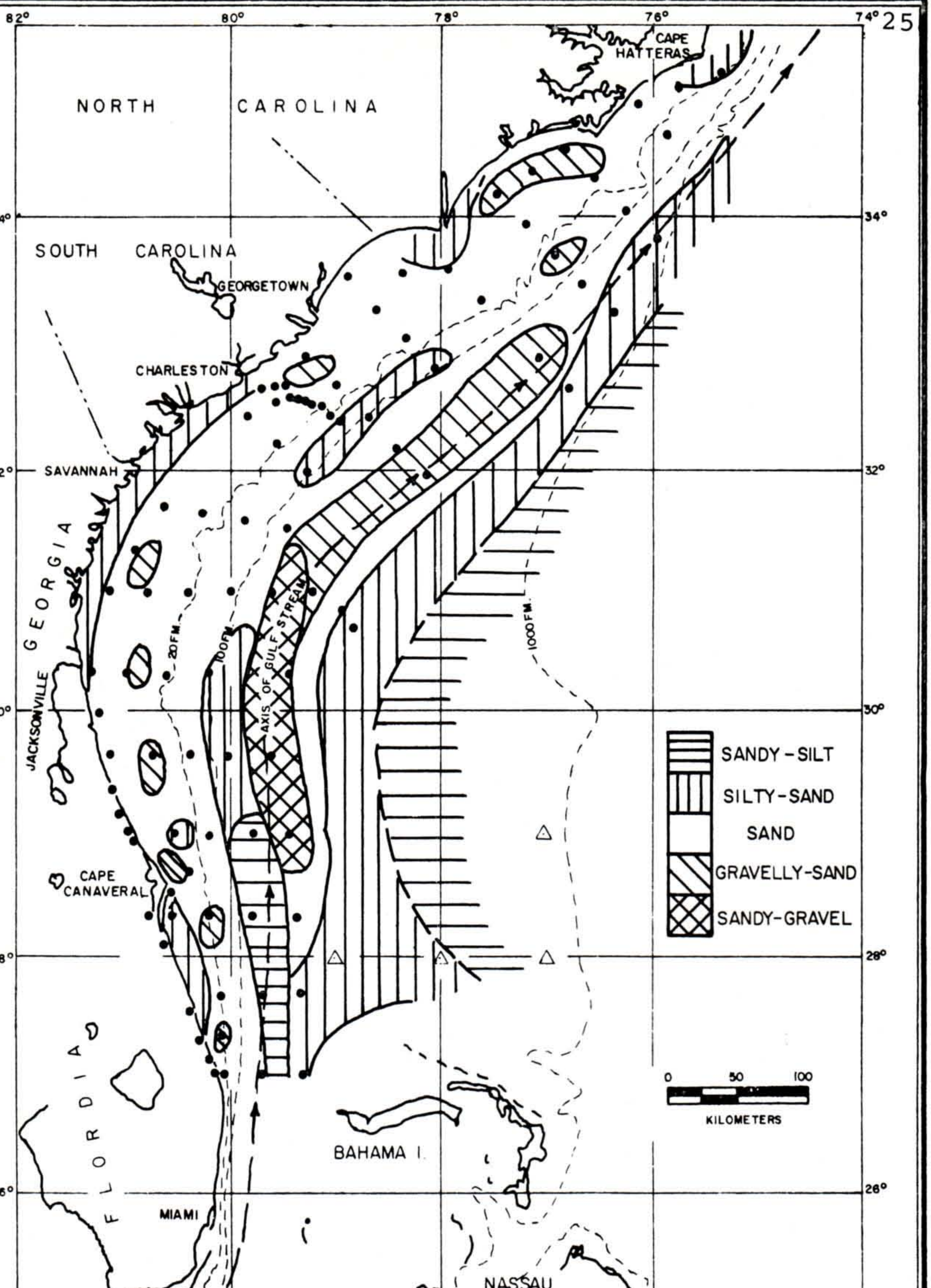
TEXT FIGURE 3



TEXT FIGURE 4



TEXT FIGURE 5



PATTERN OF SEDIMENT TEXTURAL TYPES

(AFTER GORSLINE, 1960)

TEXT FIGURE 6

is carried to the north and deposited in much deeper water farther seaward. Immediately north of the Florida Straits a linear zone of sandy-silt is present which is probably a shadow effect resulting in the deposition of fine material behind the relatively shallow sill of the straits.

Bathymetry

The continental shelf south of Cape Hatteras to Cape Canaveral, Florida, extends from the shore to the shelf break, which lies parallel to the coast, about 100 km. seaward. South of Cape Canaveral the shelf narrows and almost disappears at the Straits of Florida. The approximate break in the continental shelf is between 70 and 100 meters where another shelf, the Blake Plateau, is present. This plateau is divided into two parts, the northern part extending from Cape Hatteras to 29° N. and the southern or main part from 29° N. to approximately 26° N. in the region of the Bahamas.

The continental shelf has an extremely low gradient (less than 1:1000) and is a relatively smooth plain with no major topographic irregularities. However, at the base of the continental slope along the inner margin of the Blake Plateau the surface changes from smooth to rough, with hills 20 to 37 meters high and up to 2½ km. wide (Heezen *et al.*, 1959). These hills, which appear to be fault controlled, are directly under the Gulf Stream.

As shown in Table II, the stations are arranged according to increasing depth regardless of geographic position. The bathymetric range includes samples from the intertidal zone along some Florida beaches to samples collected in water as deep as 1100 meters. The table shows the relative percentage abundance of each species at each station.

FAUNAL ANALYSIS

Foraminiferal Number

The foraminiferal number was originally defined by Schott in 1935 as the total number of specimens of Foraminifera, benthonic and planktonic, contained in one gram of dry sediment.

The foraminiferal number increases with depth and distance from shore to the edge of the continental shelf and considerably beyond (text fig. 7). There is, however, a rather sharp break between the benthonic and planktonic forms just beyond the outer portion of the shelf. The great increase in foraminiferal number beyond the shelf break is wholly due to the presence of planktonic forms in the sediments.

It is believed that the sharp decline in benthonic forms on the upper part of the slope is the result of the high velocity Gulf Stream that is present there. Apparently the current produces environmental conditions that are too rigorous for the benthonic Foraminifera to live successfully. Many of the planktonic forms that constitute the bulk of the sediments along the course of the Gulf Stream have undoubtedly been transported into the area by the stream.

Glauconite, an indication of slow sedimentation, is abundant at stations 42, 48, and 53, off the coast of South Carolina. At these stations there is a very high number of benthonic Foraminifera per gram of sediment.

Species Number

The number of species occurring in a sample is defined as the species number. Distribution patterns of species abundance are useful in recognizing ecologic trends. It can be assumed that in areas of high species occurrence the conditions for species propagation are most desirable.

There is a general increase in number of species with distance from shore to the outer edge of the continental shelf and for a short distance beyond (text fig. 8). Along the inner edge of the Blake Plateau the number decreases to 10 or less because of the smaller number of planktonic species which constitute the bulk of the sediments beyond the shelf area. Off the coast of North and South Carolina occur areas of highest species number (30). Whether this is due primarily to the added nutrients brought in by the rivers or to the action of the Gulf Stream is not known, but it is likely that the river discharge is the influencing factor. A small area of high species number also occurs off the St. Johns River of Florida.

Benthonic Foraminifera

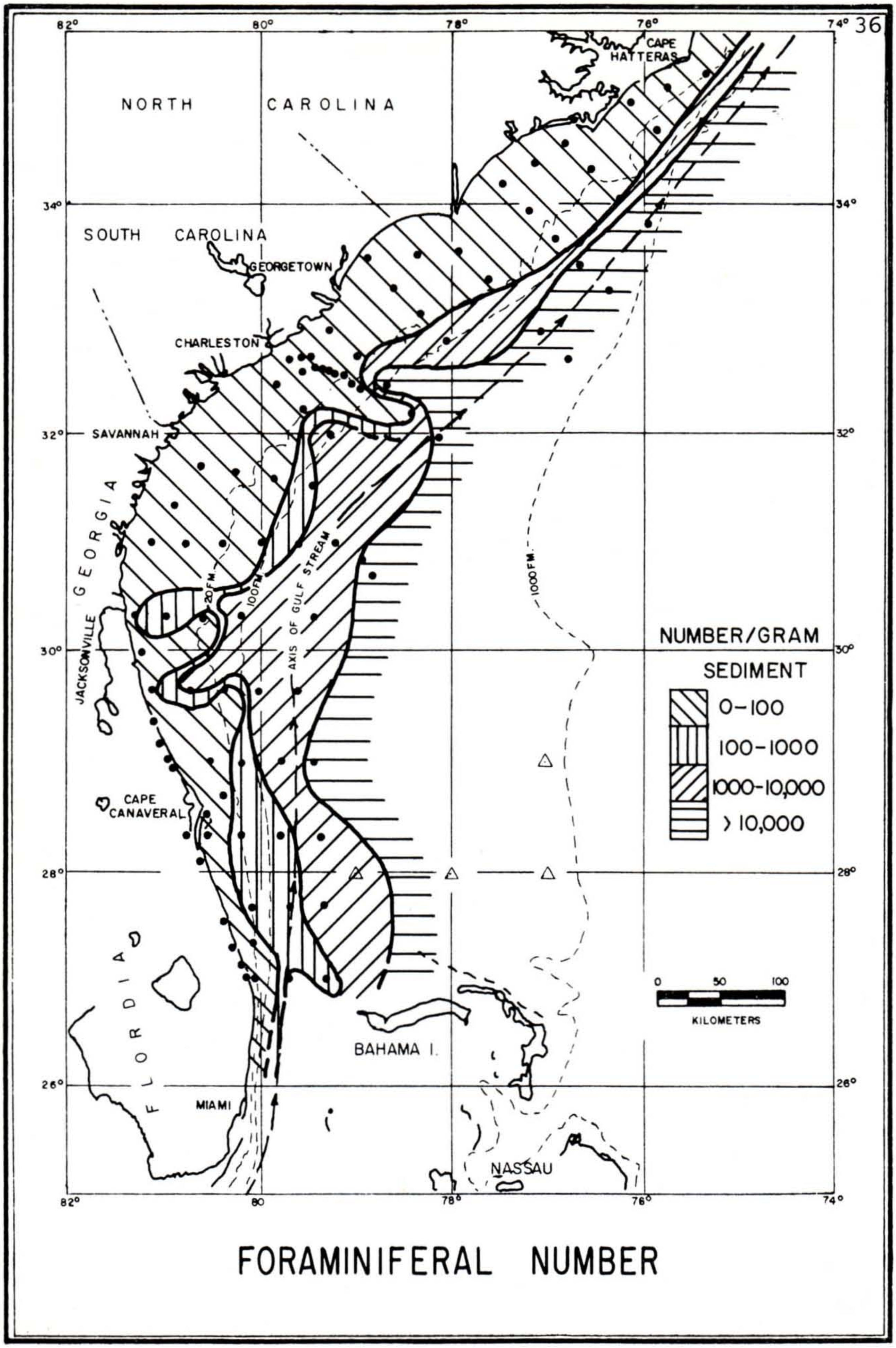
Arenaceous Species

The greatest abundance of arenaceous species occurs off the coast of Georgia and the northern coast of Florida at depths between 15 and 52 meters and in patches scattered along the coast (text fig. 9). In places the arenaceous species comprise as much as 30 to 40 per cent of the total benthonic fauna. At one station (25) they constitute 47 per cent of the entire fauna.

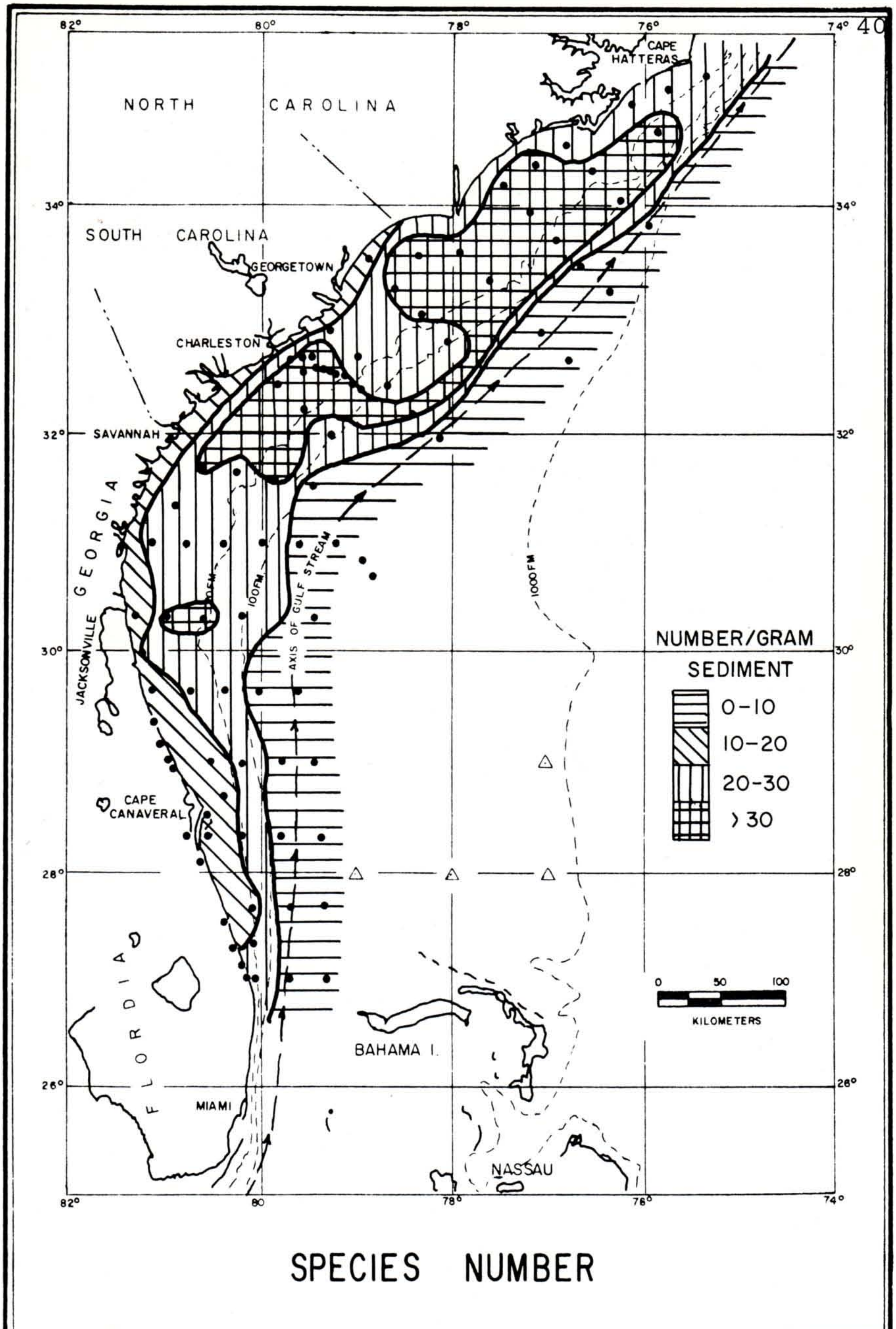
The most important arenaceous species, those which contribute the most towards the high percentages, in order of importance are:

Textularia secasensis
Miliammina fusca
Trochammina pacifica

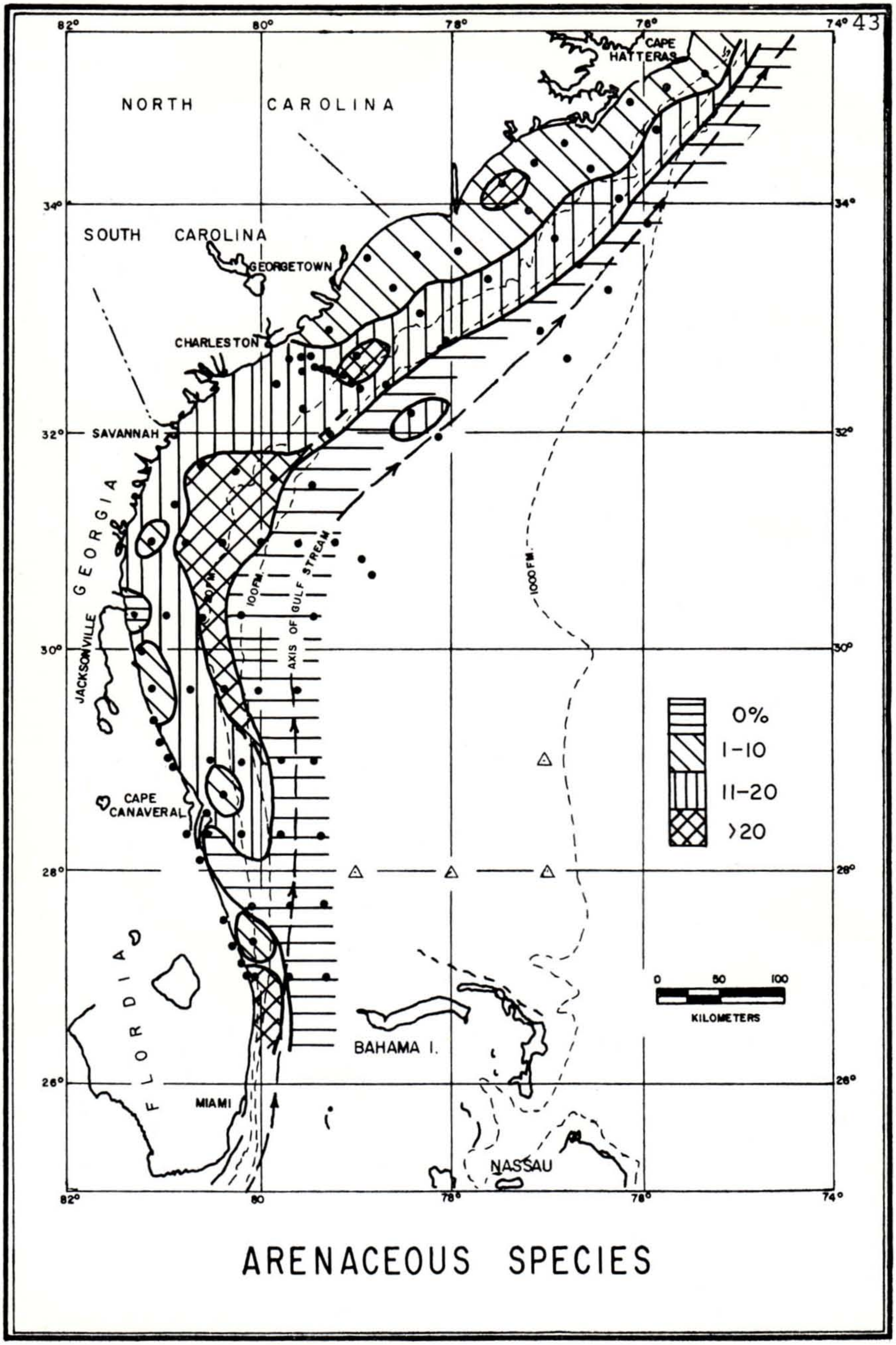
Textularia secasensis is not only the most widely occurring, highly abundant arenaceous species, but is also the most abundant of all other species in the entire area of study. *Miliammina fusca* occurs in this area in all depth zones except the littoral zone. Its most concentrated occurrences are from depths of 20 to 33 meters. *Trochammina pacifica,* the least abundant of the three major arenaceous species, shows highest concentrations from depths between 15 and 20 meters.



TEXT FIGURE 7



TEXT FIGURE 8



TEXT FIGURE 9

Other species contributing to the high percentages of arenaceous forms are:

Textularia candeiana
Textularia conica
Bigererina irregularis
Trochammina advena
Spiroplectammina floridana

Areas of very low concentrations (excluding zero percentages beyond the continental shelf) adjoin the coast of North and South Carolina and occur in smaller patches elsewhere along the entire coast.

Porcelaneous Species

The highest percentage occurrences of porcelaneous species are found in small patches scattered near shore along the coast at depths between 15 and 26 meters (text fig. 10). One exception was noted. At station 49 off the coast of South Carolina at a depth of 332 meters the porcelaneous species comprised 26 per cent of the entire benthonic fauna. At this station values higher than those of surrounding stations were also noted for the arenaceous species. Apparently these anomalous values are due to the displacement down slope of shallow-water forms.

Wide areas along the entire coast are covered by 11 to 20 per cent porcelaneous species. Many of these forms occur in the littoral zone and comprise a significant percentage of the Beach Fauna. This is to be expected as they are best suited to withstand the very strenuous conditions found in such a zone.

The most important porcelaneous species are:

Quinqueloculina lamarckiana
Quinqueloculina seminulum
Quinqueloculina akneriana
Quinqueloculina dutemplei
Sigmoilina subpoeyana

With the exception of *Quinqueloculina lamarckiana,* none of the above-mentioned species occurs in significant quantities deeper than 60 meters. Less abundant but important are the following:

Quinqueloculina compta
Quinqueloculina bicostata
Quinqueloculina bosciana

An important porcelaneous species that serves as a depth indicator is *Pyrgo subsphaerica.* This species is characteristic of the Outer Shelf Fauna from depths between 60 and 180 meters.

Hyaline Species

The most abundant foraminiferal test type is the hyaline. At most of the stations on the continental shelf between 60 and 90 per cent of the species have hyaline tests (text fig. 11). Further, there is a much greater variety of genera and species belonging to this group.

Several species far outweigh all other hyaline forms in abundance, each of which is widely distributed on the continental shelf. Following are the most important:

Hanzawaia concentrica
Cibicides mollis
Nonionella atlantica
Planulina exorna
Elphidium discoidale
Bolivina paula
Cassidulina subglobosa
Angulogerina angulosa

The following species occur in lower percentages but have a wide geographic distribution:

Reussella spinulosa atlantica
Guttulina australis
Discorbis floridanus
Rotorbinella lomaensis

Faunal Zonation

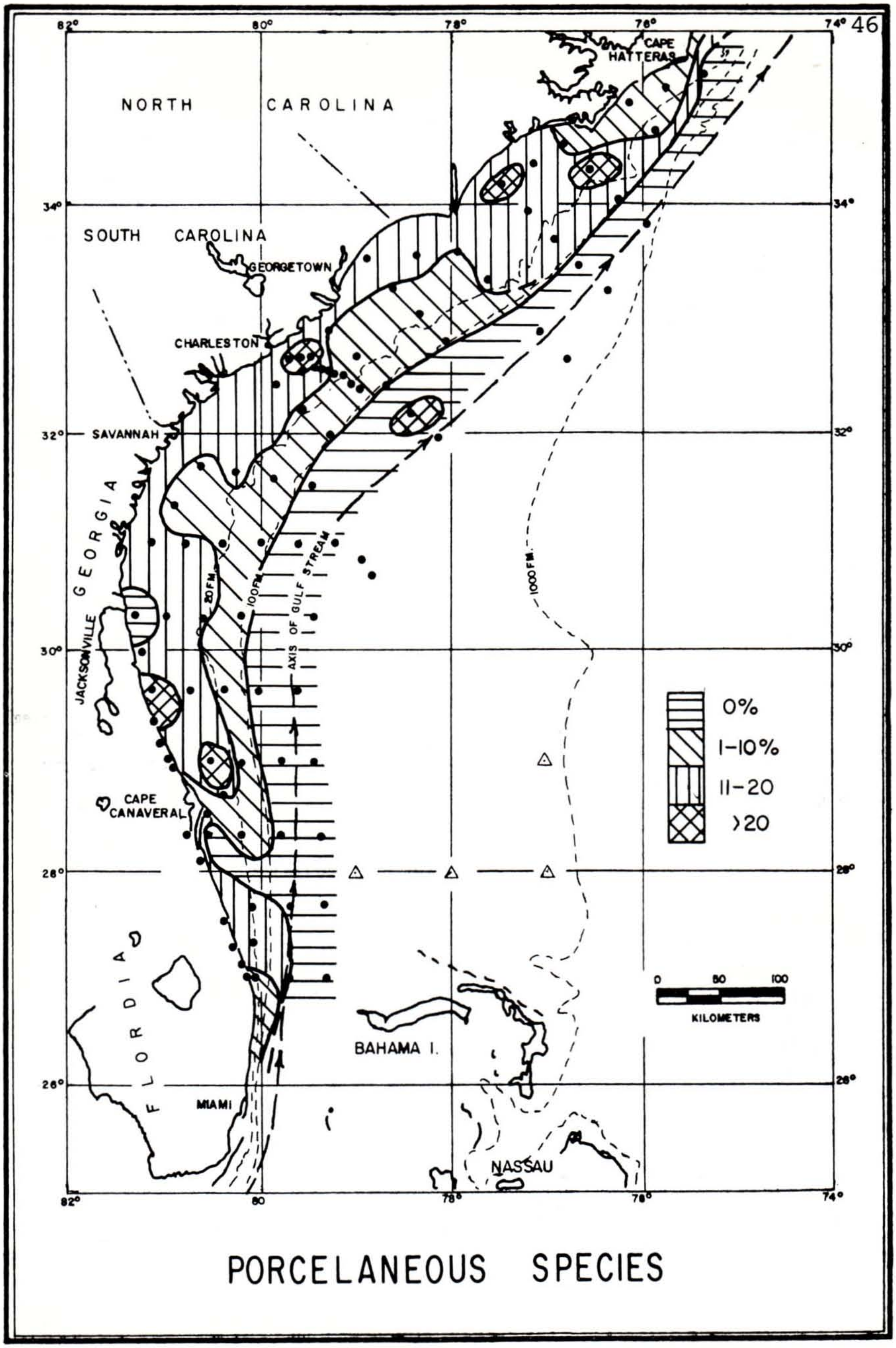
Faunal zonation in increasing depth of water and distance from shore was detected by comparing the cumulative percentages of the benthonic Foraminifera along various offshore profiles. Frequency data are presented in graph form in text figure 12 together with some of the major ecologic factors thought to be significant in controlling the distribution of Foraminifera, such as depth of water, salinity, temperature, and sediment median diameter. On the basis of dominant species 4 faunal zones were distinguished. These zones occur in water between depths of less than one meter (in the intertidal area along the beach) and 180 meters.

Because depth of water is not the only factor that exerts control in species distribution, faunas within the various depth zones may differ slightly from one region to another. Lateral changes of faunas within the same depth zones are to be expected for a large region such as the one covered in this investigation, and such a change can be seen in faunal zone 4 (*see* text fig. 13).

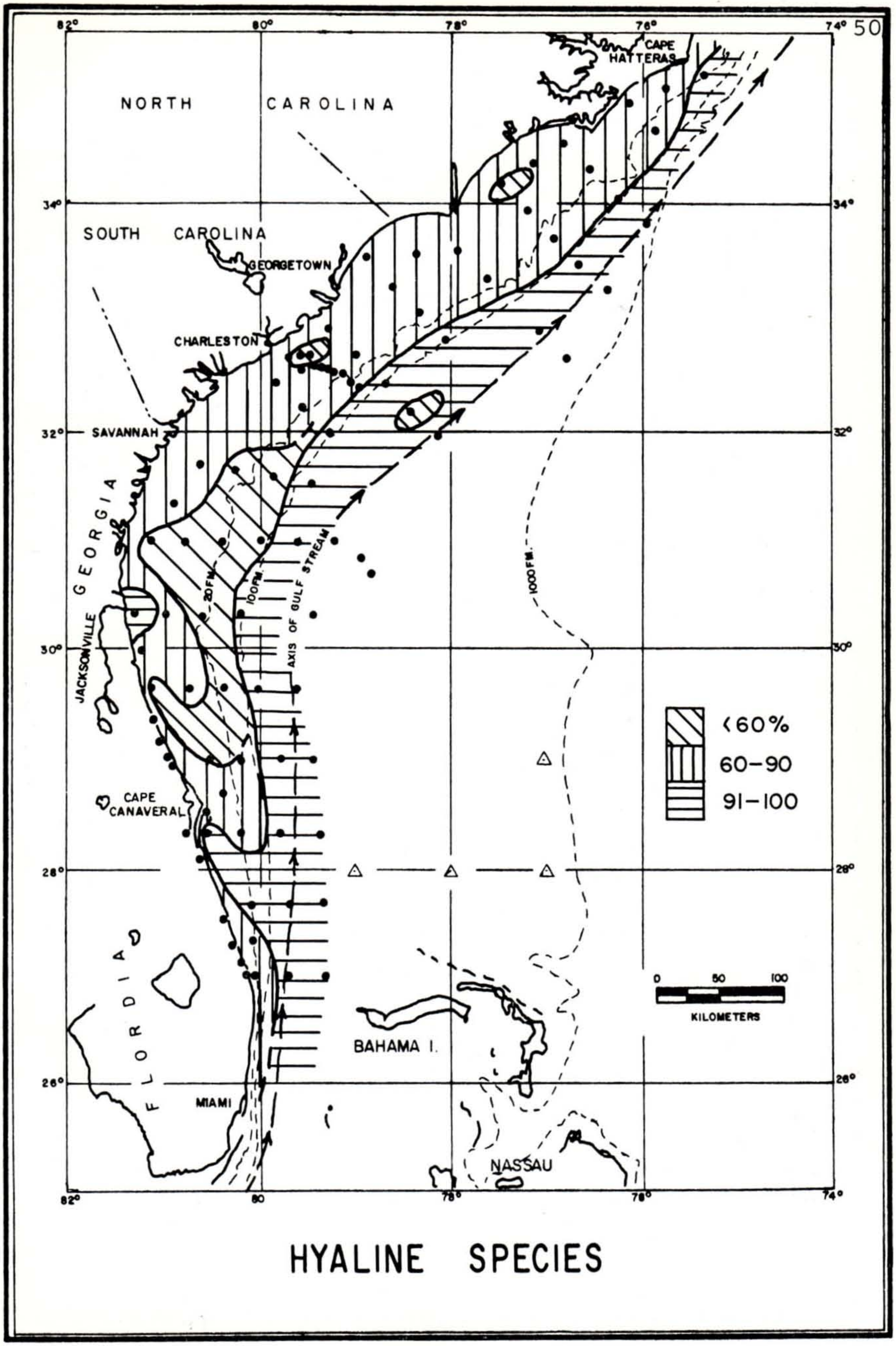
Beach Fauna
(0-1 meter)

Eleven samples obtained along the beaches of Florida were found to be predominantly composed of only 5 genera: *Elphidium, Quinqueloculina, Nonionella, Hanzawaia,* and *Ammonia.* The genera *Elphidium* and *Quinqueloculina* are represented by a number of species, most of which are common and abundant. Of the two, *Elphidium* is much more abundant, with *E. rugulosum* and *E. incertum mexicanum* most consistently abundant. Of all species identified in the Beach Fauna, *E. rugulosum* is the most abundant followed by *Ammonia tepida.*

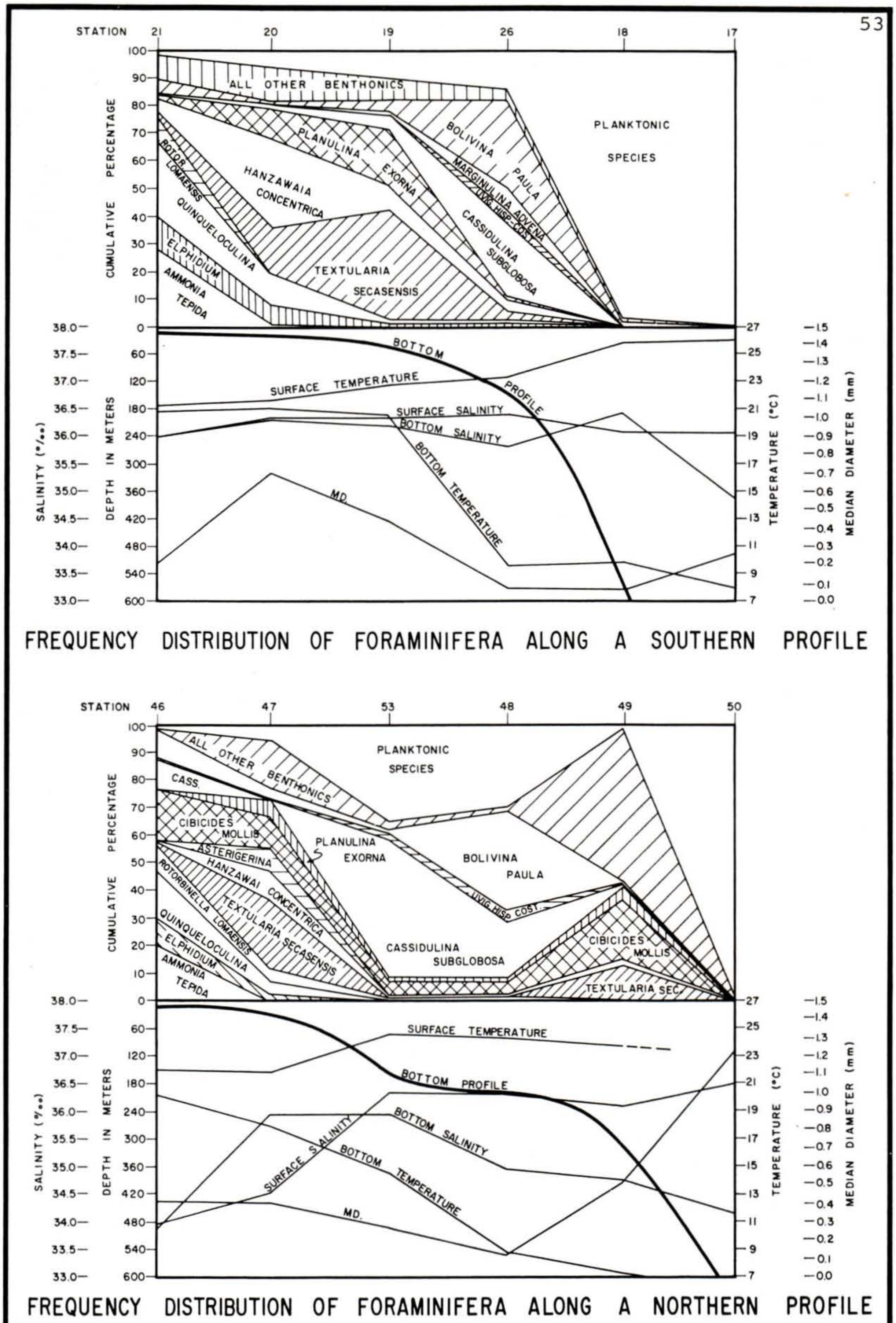
Hanzawaia concentrica, one index species of the Middle Shelf Fauna, occurs consistently with values from 2 to 11 per cent. This distribution, along with the abundant presence of *Nonionella atlantica,* another Middle Shelf index form, leads to the speculation that their presence is due to sorting by wave action, just as inorganic sediments are sorted. However, it was noted that the individual tests were in good condition rather than broken and rounded as might be expected from specimens caught in the turbulence of the surf zone.



TEXT FIGURE 10

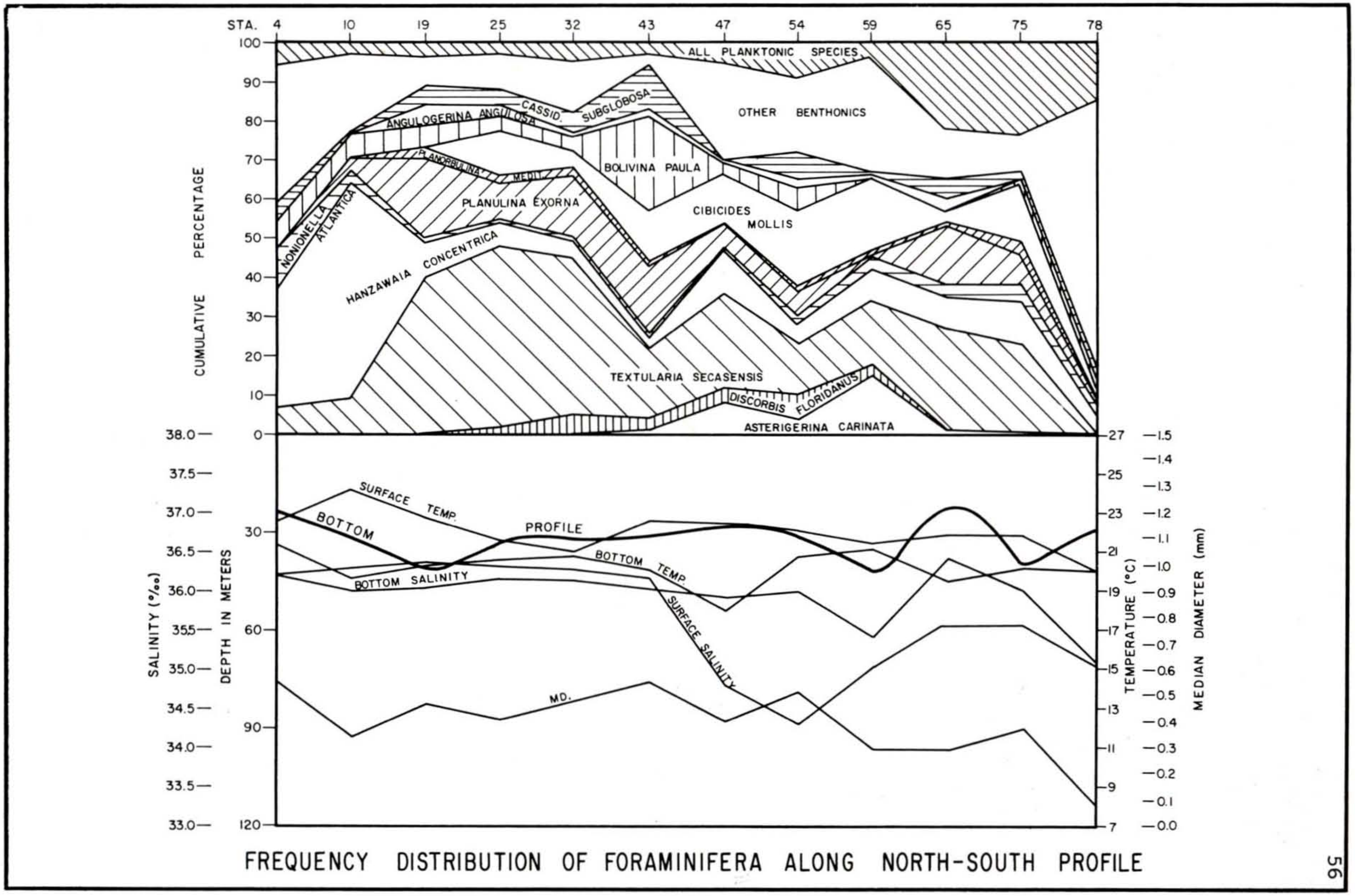


TEXT FIGURE 11



TEXT FIGURE 12

Cumulative percentages of dominant species along two offshore profiles compared with significant ecologic factors. (*See* text fig. 1 for position of stations.)



TEXT FIGURE 13

Cumulative percentages of dominant species of Middle Shelf Fauna showing lateral changes along a north-south profile compared with significant ecologic factors. (*See* text fig. 1 for position of stations.)

Inner Shelf Fauna
(1-15 meters)

Species of *Elphidium* and *Quinqueloculina*, having their highest percentage occurrences in water shoaler than 15 meters, are the most characteristic members of this fauna (Table I). Of the genus *Elphidium*, *E. rugulosum*, *E. incertum mexicanum*, and *E. discoidale* are the most abundant. Of the genus *Quinqueloculina*, *Q. lamarckiana*, *Q. akneriana*, and *Q. compta* are most representative, although they extend into deeper water.

TABLE I. Diagnostic species of the offshore faunal zones.

Inner Shelf Fauna (1-15 meters)	
Ammonia tepida	(0-15 meters)
Elphidium incertum mexicanum	(0-15 meters)
Elphidium rugulosum	(0-18 meters)
Elphidium discoidale	(0-31 meters)
Articulina mucronata	(9-15 meters)
Rotorbinella lomaensis	(9-25 meters)
Quinqueloculina akneriana	(9-15 meters)
Quinqueloculina compta	(9-31 meters)
Quinqueloculina lamarckiana	(9-31 meters)
Middle Shelf Fauna (15-61) meters)	
Asterigerina carinata	(15-31 meters)
Discorbis floridanus	(18-31 meters)
Textularia secasensis	(15-61 meters)
Hanzawaia concentrica	(15-61 meters)
Nonionella atlantica	(25-61 meters)
Planulina exorna	(26-61 meters)
Planorbulina mediterranensis	(31-61 meters)
Cibicides mollis	(14-183+ meters)
Eponides antillarum	(31-61 meters)
Outer Shelf-Upper Continental Slope Fauna (61-183 meters)	
Bolivina paula	(9-183+ meters)
Reussella atlantica	(31-150 meters)
Planulina ariminensis	(61-183+ meters)
Cassidulina subglobosa	(61-183+ meters)
Pyrgo subsphaerica	(183+ meters)
Cassidulina laevigata	(61-183+ meters)
Marginulina planata	(61-183 meters)
Uvigerina hispidocostata	(150+ meters)

A single species which is everywhere characteristic of shallow brackish water and which is highly abundant locally is *Ammonia tepida*. At station 69 off the coast of North Carolina it comprises as much as 83 per cent of the fauna. *Articulina mucronata* and *Rotorbinella lomaensis* have their greatest development in this zone but also occur at lower frequency in deeper water on the continental shelf.

Middle Shelf Fauna
(15-61 meters)

Faunal boundaries of this zone are defined by species which are more arbitrarily selected than those of the other zones because they have a wider range in shoaler as well as deeper water. Those species that are statistically more abundant than all others in this fauna include *Asterigerina carinata*, *Textularia secasensis*, *Cibicides mollis*, *Nonionella atlantica*, and *Discorbis floridanus*. Other species consistently present but in fewer number are *Planulina exorna*, *Planorbulina mediterranensis*, and *Eponides antillarum*. *Peneroplis proteus* appears consistently at stations between 15 and 35 meters. Another species, *Angulogerina angulosa*, occurs frequently in this faunal zone but is not particularly diagnostic of this depth range, for it also occurs, sometimes abundantly, in the faunal zones both above and below this zone.

Some of the characteristic Inner Shelf species of *Elphidium* and *Quinqueloculina* occur in relatively high frequencies in the Middle Shelf Fauna as well. Several species of *Quinqueloculina* occur almost wholly within this depth range and include *Q. seminulum*, *Q. bosciana*, *Q. bradyana*, and *Q. agglutinans*. *Q. dutemplei* occurs at numerous stations in low frequencies in this depth range. *Elphidium advena* also occurs at numerous stations within this zone and rarely in the Beach Fauna, but always with very low frequencies. As shown in the faunal list of Table II, many other benthonic species occur in this faunal zone but are not necessarily characteristic.

Outer Shelf-Upper Continental Slope Fauna
(61-183 meters)

Dominant species of this fauna are: *Bolivina paula*, *Reussella atlantica*, *Cassidulina subglobosa*, *Pyrgo subsphaerica*, and *Uvigerina hispidocostata*. *Cassidulina subglobosa* and *Bolivina paula* have a wide distribution both geographically and bathymetrically, but occur in more significant abundance below 61 meters. Less abundant, but certainly characteristic of this zone, are *Planulina ariminensis*, *Cassidulina laevigata*, and *Marginulina advena*. A few other species of *Uvigerina* occur but are very rare, although the species present appear to be deep-water indices.

Some other species from this zone have occurrences in deeper water but are generally restricted to shallower depths. High-percentage occurrences indicated in Table II for depths greater than 183 meters are misleading because of the scarcity of benthonic specimens contained in the samples. Therefore, a few individuals transported down the continental slope may be reported as having a high-percentage occurrence.

Some of the species of this zone have been reported in other areas as occurring in much deeper water. As mentioned earlier, this lack of occurrence in deeper water is undoubtedly the result of the rigorous conditions of the impinging Gulf Stream. Normally, a well-developed faunal zonation can be traced into the greater depths. The scarcity of the fauna below the upper continental slope can be seen by examining Table II. The area included under Continental Slope-Blake Plateau in Table II has only an insignificant amount of benthonic Foraminifera. Very high percentages of planktonic Foraminifera are present here.

Planktonic Foraminifera

The planktonic Foraminifera have been analyzed separately and the planktonic foraminiferal number (text fig. 14) is based upon the number of planktonic individuals occurring in one gram of sediment. A complete list of the species identified in this study will be found in Table II.

Samples from planktonic tows were not available in conjunction with the present study; therefore, the discussion is based upon the distribution of the tests occurring in the sediment samples. Although for most species there is no distinct zonation, a general depth stratification was noted. The most widely occurring species, *Globigerinoides ruber,* is abundant at depths as shallow as 15 meters. Likewise, *Globigerina bulloides* and *Globigerinoides sacculifer* are abundant at depths around 15 meters. *Globigerina bulloides* shows a distinct decrease in abundance seaward while *Globigerinoides sacculifer* shows an increase. *Globigerina eggeri* begins to make a significant appearance between 20 and 25 meters and its frequency increases constantly seaward. *Globigerina dutertrei* and *Globorotalia menardii* become common in the sediments at a depth of about 30 meters. *Hastigerina aequilateralis, Orbulina universa, Globigerinoides conglobatus, Globorotalia truncatulinoides,* and *Pulleniatina obliquiloculata* occur in steady abundance at about 46 meters depth. Significant occurrences of *Globorotalia puncticulata, Sphaeroidinella dehiscens,* and *Globorotalia tumida* do not appear in less than 150 meters of water. An insignificant number of *Globigerina pachyderma,* a cold tolerant species, occurs in the area. An abundance of immature planktonic forms occurs throughout the area, but owing to their small size and the several morphological variations they may resemble, they were analyzed only as immature forms and listed accordingly.

There is a marked increase in the concentration of planktonic foraminiferal tests in sediments beyond the edge of the continental shelf (text fig. 14). Because of the effect of the swift Gulf Stream, a number of species common to the warm tropic regions have been transported far to the north of their natural habitat. Bé (1959) reported that the greatest foraminiferal concentration in the western North Atlantic occurred in the region of relatively strong currents and steep temperature and salinity gradients of the Gulf Stream. Many of the species reported are warm-tolerant species of the tropic regions not common to the North Atlantic, but obviously transported there. Likewise, the cold-tolerant species common to the northern regions are more or less confined because of the barrier presented by the Gulf Stream.

Relationship of Faunas to Sediment Distribution

There is no conclusive evidence that any species show an affinity for any particular sediment type. Rather, the evidence indicates that here, as elsewhere, the Foraminifera in general prefer to inhabit areas where fine-grained sediments predominate.

There are relatively small patches of gravelly-sand parallel to the shore along the coast. It was suggested by Gorsline (1960) that these patches may represent the former position of the strand line during periods of lower sea level of the Pleistocene Epoch. If this were the case, fossil faunas might be anticipated; however, only at one station were the Foraminifera in such a state of preservation as to indicate the possibility of their representing a relict fauna.

CONCLUSIONS

Off the southern Atlantic coast of the United States the high velocity Gulf Stream is primarily responsible for restricting the distribution of benthonic Foraminifera to the continental self and the extreme upper continental slope. It is believed that the conditions, deeper on the sea floor, as a result of the currents, are too rigorous to permit the successful proliferation of benthonic Foraminifera.

The foraminiferal number increases with depth and distance from shore to the edge of the continental shelf and considerably beyond. Beyond the shelf break it is primarily based on the planktonic forms in the sediments.

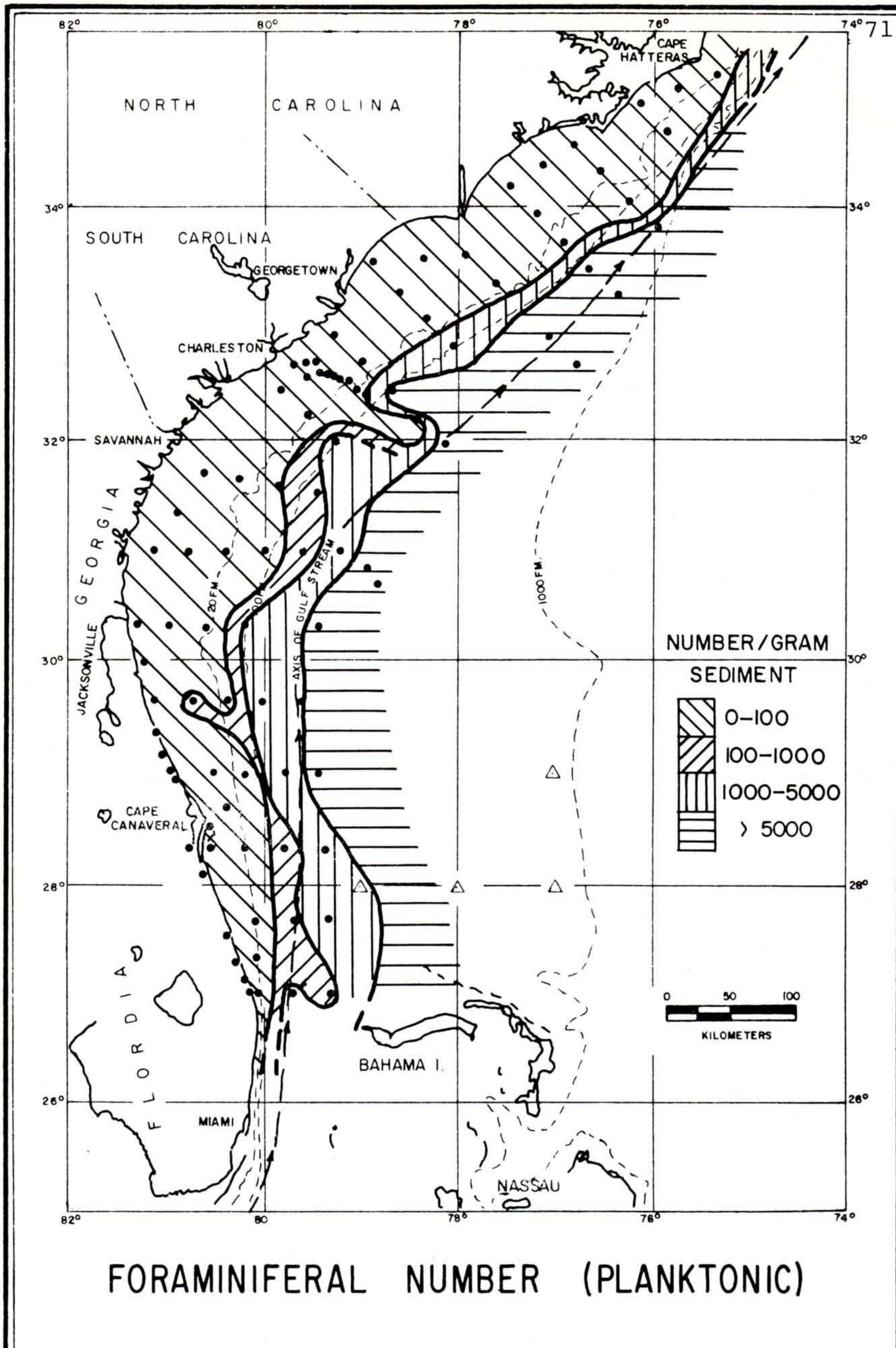
There is a general increase in number of species with distance from shore to the outer edge of the continental shelf.

Arenaceous species occur in greatest abundances off the coast of northern Florida and Georgia at depths between 15 and 52 meters. The areas where the highest percentages occur are in areas where the substrate is sandy or gravelly-sand. Areas of lowest concentrations of arenaceous species occur off the coasts of North and South Carolina and in small patches elsewhere along the coast. An arenaceous species, *Textularia secasensis,* is the most abundant, widely-occurring of all species in the region of study.

Porcelaneous species are most abundant in shallow water near shore. The most important porcelaneous species are *Quinqueloculina lamarckiana, Q. seminulum, Q. akneriana, Q. dutemplei,* and *Sigmoilina subpoeyana.*

At most stations on the continental shelf from 60 to 90 per cent of the Foraminifera have hyaline tests.

On the basis of dominant species four faunal zones could be distinguished. These zones with characteristic fauna occur between depths of less than 1 meter and 192 meters. They are as follows:



TEXT FIGURE 14

Beach Fauna	0-1 meter
Inner Shelf Fauna	1-15 meters
Middle Shelf Fauna	15-61 meters
Outer Shelf-Upper Continental Slope Fauna	61-192 meters

Of all species identified in the Beach Fauna, *Elphidium rugulosum* and *Ammonia tepida* are the most abundant. It is concluded that most of the Foraminifera in the intertidal area, the Beach Fauna, are not indigenous to that area but are present as a result of wave action.

The more characteristic members of the Inner Shelf Fauna are various species of *Elphidium* and *Quinqueloculina*.

There is a greater variety and abundance of species within the bathymetric range characterized by the Middle Shelf Fauna.

Not enough samples were available from the outer shelf to define faunal zonation. By combining the stations from the outer shelf and the upper continental slope, a general faunal zone was defined. Clearly, forms characterizing this area are those normally occurring in water as deep or even deeper than this zone.

Occurrences deeper than 192 meters are considered to be the result of down-slope movement rather than indigenous because of the extreme scarcity of benthonic specimens per sample.

There is a marked increase in planktonic Foraminifera beyond the outer continental shelf. As a result of the high velocity of the Gulf Stream a number of planktonic species common to the warm tropic regions have been transported far to the north of their natural habitat. Only a generalized depth stratification of planktonic Foraminifera is indicated. *Globigerinoides ruber*, *Globigerinoides sacculifer*, and *Globigerina bulloides* occur significantly below 15 meters. *Globigerina eggeri* begins to occur significantly between 20 and 25 meters and increases constantly seaward. *Globigerina dutertrei* and *Globorotalia menardii* become common at a depth of about 30 meters. Significant occurrences of *Globorotalia puncticulata*, *Sphaeroidinella dehiscens*, and *Globorotalia tumida* do not appear above 150 meters.

There is no conclusive evidence that any species show a preference for particular sediment type. Instead, Foraminifera in general show an affinity for the fine-grained sediments indicating that particle size is of more importance ecologically than lithology.

Linear patches of gravelly-sand along the coast may represent the position of the strand line during the Pleistocene Epoch when the sea level was lower. This is not supported, however, by evidence of fossil Foraminifera occurring in these patches.

FAUNAL REFERENCES

Following is an alphabetized reference list of all of the foraminiferal species included in this report:

Planktonic Species

Candeina nitida D'ORBIGNY, 1839, *in* DE LA SAGRA, Hist. Phys. Pol. Nat. Cuba, Foraminifères, p. 108, v. 8, pl. 2, figs. 27-28.

Globigerina bulloides D'ORBIGNY, 1826, Ann. Sci. Nat., ser. 1, v. 7, p. 277.

Globigerina dutertrei D'ORBIGNY, 1839, *in* DE LA SAGRA, Hist. Phys. Pol. Nat. Cuba, Foraminifères, p. 84, pl. 8, fig. 4.

Globigerina eggeri RHUMBLER, 1901, *in* Brandt, Nordisches Plankton, Ser. 1, no. 14, p. 19-20, fig. 20.

Globigerina inflata D'ORBIGNY, 1839, *in* Barker-Webb and Berthelot, Hist. Nat. Îles Canaries, Foraminifères, v. 2, pt. 2, Zool., p. 134, pl. 2, figs. 7-9.

Globigerina pachyderma (Ehrenberg) = *Aristerospira pachyderma* EHRENBERG, 1861, K. Akad. Wiss, Berlin, Monatsber., p. 276, 277, 303.

Globigerinita incrusta AKERS, 1955, Jour. Paleontology, v. 29, no. 4, p. 655, pl. 65, fig. 2.

Globigerinoides conglobatus (Brady) = *Globigerina conglobata* BRADY, 1879, Quart. Jour. Micr. Sci., new ser., v. 19, p. 286.

Globigerinoides ruber (d'Orbigny) = *Globigerina rubra* D'ORBIGNY, 1839, *in* DE LA SAGRA, Hist. Phys. Pol. Nat. Cuba, Foraminifères, p. 82-83, v. 8, pl. 4, figs. 12-14.

Globigerinoides sacculifer (Brady) = *Globigerina sacculifera* BRADY, 1877, Geol. Mag., n.s., dec. 2, v. 4, no. 12, p. 535.

Globorotalia menardii (d'Orbigny) = *Globigerina menardii* D'ORBIGNY, 1826, Ann. Sci. Nat., sér. 1, v. 7, p. 273; Modèles, no. 10.

Globorotalia puncticulata (d'Orbigny) = *Globigerina puncticulata* D'ORBIGNY, 1832, *in* Deshayes, Encyclopédie méthodique, v. 2, pt. 2, p. 170.

Globorotalia truncatulinoides (d'Orbigny) = *Rotalina truncatulinoides* D'ORBIGNY, 1839, *in* BARKER-WEBB and BERTHELOT, Hist. Nat. Îles Canaries, v. 2, pt. 2, p. 132, pl. 2, figs. 25-27.

Globorotalia tumida (Brady) = *Pulvinulina menardii* (d'Orbigny) var. *tumida* BRADY, 1877, Geol. Mag., n.s., dec. 2, v. 4, p. 535.

Hastigerina aequilateralis (Brady) = *Globigerina aequilateralis* BRADY, 1879, Quart. Jour. Micr. Sci., n.s., v. 19, p. 285.

Orbulina universa D'ORBIGNY, 1939, *in* DE LA SAGRA, Hist. Phys. Pol. Nat. Cuba, Foraminifères, p. 3, v. 8, pl. 1, fig. 1.

Pulleniatina obliquiloculata (Parker and Jones) = *Pullenia sphaeroides* var. *obliquiloculata* PARKER and JONES, 1865, Roy. Soc. London, Philos. Trans., v. 155, p. 365, 368, pl. 19, fig. 4.

Sphaeroidina bulloides D'ORBIGNY, 1826, Ann. Sci. Nat., sér. 1, v. 7, p. 267, no. 1; Modèles, no. 65.

Sphaeroidinella dehiscens (Parker and Jones) = *Sphaeroidina dehiscens* PARKER and JONES, 1865, Roy. Soc. London, Philos. Trans., v. 155, p. 369, pl. 19, figs. 5a-c.

Benthonic Species

Ammonia tepida (Cushman) = *Rotalia beccarii* (Linné) var. *tepida* CUSHMAN, 1926, Carnegie Inst. Washington, Pub. no. 344, p. 79.

Angulogerina angulosa (Williamson) = *Uvigerina angulosa* WILLIAMSON, 1858, Recent Foraminifera Gt. Britain, Ray Soc., p. 67, pl. 5, fig. 140.

Articulina mucronata (d'Orbigny) = *Vertebralina mucronata* D'ORBIGNY, 1839, *in* DE LA SAGRA, Hist. Phys. Pol. Nat. Cuba, Foraminifères, p. 52, v. 8, pl. 7, figs. 16-19.

Asterigerina carinata D'ORBIGNY, 1839, *in* DE LA SAGRA, Hist. Phys. Pol. Nat. Cuba, Foraminifères, p. 118, v. 8, pl. 5, fig. 25, pl. 6, figs. 1-2.

Bigenerina irregularis PHLEGER and PARKER, 1951, Geol. Soc. America, Mem. 46, pt. 2, p. 4, pl. 1, figs. 16-21.

Bolivina doniezi CUSHMAN and WICKENDEN, 1929, U. S. Natl. Mus. Proc. no. 2780, v. 75, art. 9, p. 9, pl. 4, fig. 3a-b.

Bolivina paula Cushman and Cahill, *in* CUSHMAN and PONTON, 1932, Florida Geol. Surv., Bull. no. 9, p. 84, pl. 12, fig. 6.

Bolivina pulchella (d'Orbigny) = *Sagrina pulchella* D'ORBIGNY, 1839, *in* DE LA SAGRA, Hist. Phys. Pol. Nat. Cuba, Foraminifères, p. 150, v. 8, pl. 1, figs. 23-24.

Bolivina striatula CUSHMAN, 1922, Carnegie Inst. Washington, Pub. 311, p. 27, pl. 3, fig. 10.

Bolivina subaenariensis CUSHMAN, 1922, U. S. Natl. Mus. Bull. no. 104, pt. 3, p. 46, pl. 7, fig. 6.

Buccella hannai (Phleger and Parker), emend. ANDERSEN, 1952, Washington Acad. Sci., Jour., v. 42, no. 5, p. 144.

Bulimina gibba FORNASINI, 1902, Mem. Sci. Nat., ser. 5, tomo 9, p. 378, pl. 10, figs. 32, 34.

Bulimina marginata D'ORBIGNY, 1826, Ann. Sci. Nat., ser. 1, v. 7, p. 269, no. 4, pl. 12, figs. 10-12.

Cancris sagra (d'Orbigny) = *Rotalina* (*Rotalina*) *sagra* D'ORBIGNY, 1839, *in* DE LA SAGRA, Hist. Phys. Pol. Nat. Cuba, Foraminifères, p. 77, v. 8, pl. 5, figs. 13-15.

Cassidulina crassa D'ORBIGNY, 1839, Voy. l'Amérique Mérid. Foraminifères, tome 5, pt. 5, p. 56, pl. 7, figs. 18-20.

Cassidulina laevigata D'ORBIGNY, 1826, Ann. Sci. Nat., sér. 1, v. 7, p. 282, no. 1, pl. 15, figs. 4-5.

Cassidulina laevigata carinata Silvestri = *C. laevigata* var. *carinata* SILVESTRI, 1896, Foraminiferi pliocenici della Provincia di Siena, Pt. I, Accad. Pont. Nuovi Lincei, Mem. v. 12, p. 104, pl. 2, fig. 10a-c.

Cassidulina subglobosa BRADY, 1881, Quart. Jour. Micr. Sci., new ser., v. 21, p. 60.

Cibicides io (Cushman) = *Cibicides pseudoungeriana* var. *io* CUSHMAN, 1931, U. S. Natl. Mus. Bull. no. 104, pt. 8, p. 125, pl. 23, fig. 1.

Cibicides mollis PHLEGER and PARKER, 1951, Geol. Soc. America, Mem. 46, pt. 2, p. 30, pl. 16, figs. 7-9.

Cibicides pseudoungerianus (Cushman) = *Truncatulina pseudoungeriana* CUSHMAN, 1922, U. S. Geol. Surv. Prof. Pap. no. 129-E, p. 97, pl. 20, fig. 9.

Conorbina orbicularis (Terquem) = *Rosalina orbicularis* TERQUEM, 1876, Essai sur le classement des animaux que vivent sur la plage et dans les environs de Dunkerque; deuxième fascicule Soc. Dunkerquoise, Mém. v. 20, p. 166, pl. 9, fig. 4a-b.

Discorbis floridanus CUSHMAN, 1922, Carnegie Inst. Washington Pub. 311, p. 39, pl. 5, figs. 11-12.

Discorbis floridensis CUSHMAN, 1931, U. S. Natl. Mus. Bull. 104, pt. 8, p. 17, pl. 3, figs. 3-5.

Elphidium advena (Cushman) = *Polystomella advena* CUSHMAN, 1922, Carnegie Inst. Washington, Pub. no. 311, p. 56, pl. 9, figs. 11-12.

Elphidium articulatum (d'Orbigny) = *Polystomella articulata* D'ORBIGNY, 1839, Voy. Amér. Mérid., Foraminifères, v. 5, pt. 5, p. 30, pl. 3, figs. 1-10.

Elphidium discoidale (d'Orbigny) = *Polystomella discoidalis* D'ORBIGNY, 1839, *in* DE LA SAGRA, Hist. Phys. Pol. Nat. Cuba, Foraminifères, p. 56, pl. 6, figs. 23-24.

Elphidium gunteri galvestonense Kornfeld = *E. gunteri* Cole var. *galvestonensis* KORNFELD, 1931, Stanford Univ. Dept. Geol. Contr., v. 1, p. 87, pl. 15, figs. 1-3.

Elphidium incertum mexicanum Kornfeld = *E. incertum* (Williamson) var. *mexicanum* KORNFELD, 1931, Stanford Univ. Dept. Geol. Contr., v. 1, p. 89, pl. 16, figs. 1-2.

Elphidium rugulosum CUSHMAN and WICKENDEN, 1929, U. S. Natl. Mus. Proc. 2780, v. 75, art. 9, p. 7, pl. 3, fig. 8.

Elphidium subarcticum CUSHMAN, 1944, Cushman Lab. Foram. Research, Special Pub. no. 12, p. 27, pl. 3, figs. 34-35.

Eponides antillarum (d'Orbigny) = *Rotalina antillarum* D'ORBIGNY, 1839, in DE LA SAGRA, Hist. Phys. Pol. Nat. Cuba, Foraminifères, p. 75, pl. 5, figs. 4-6.

Eponides repandus (Fichtel and Moll) = *Nautilus repandus* FICHTEL and MOLL, 1798, Testacea microscopica, p. 35, pl. 3, figs. a-d.

Fissurina marginata (Montagu) = *Vermiculum marginatum* MONTAGU, 1803, Testacea Brittanica, p. 524, pl. 1, fig. 7.

Guttulina australis (d'Orbigny) = *Globulina australis* D'ORBIGNY, 1839, Voy. Amér. Mérid. Foraminifères, v. 5, pt. 5, p. 60, pl. 1, figs. 1-4.

Hanzawaia concentrica (Cushman) = *Cibicides concentrica* CUSHMAN, 1918, U. S. Geol. Survey Bull. 676, p. 64, pl. 21, fig. 3.

Marginulina advena (Cushman) = *Vaginulina advena* CUSHMAN, 1923, U. S. Natl. Mus. Bull. 104, pt. 4, p. 134, pl. 39, figs. 1-4.

Miliammina fusca (Brady) = *Quinqueloculina fusca* BRADY, 1870, Ann. Mag. Nat. Hist., London, ser. 4, v. 6, p. 286, pl. 11, figs. 2-3.

Nonion nicobarensis CUSHMAN, 1936, Contr. Cushman Lab. Foram. Research, v. 12, pt. 3, p. 67, pl. 12, fig. 9.

Nonionella atlantica CUSHMAN, 1947, Contr. Cushman Lab. Foram. Research, v. 23, pt. 4, p. 10, pl. 20, figs. 4-5.

Nonionella grateloupi (d'Orbigny) = *Nonionina grateloupi* D'ORBIGNY, 1839, *in* DE LA SAGRA, Hist. Phys. Pol. Nat. Cuba, Foraminifères, p. 46, v. 8, pl. 6, figs. 6-7.

Peneroplis pertusus (Forskal) = *Nautilus pertusus* FORSKAL, 1775, Descriptiones animalium, p. 125.

Planorbulina mediterranensis D'ORBIGNY, 1826, Ann. Sci. Nat., v. 7, p. 280, no. 2, pl. 14, figs. 1-3.

Planulina ariminensis D'ORBIGNY, 1826, Ann. Sci. Nat., v. 7, p. 280, pl. 14, figs. 1-3.

Planulina exorna PHLEGER and PARKER, 1951, Geol. Soc. America, Mem. no. 46, pt. 2, p. 32, pl. 18, figs. 5-7, 8a-b.

Pullenia bulloides (d'Orbigny) = *Nonionina bulloides* D'ORBIGNY, 1826, Ann. Sci. Nat., sér. 1, v. 7, p. 293.

Pyrgo comata (Brady) = *Biloculina comata* BRADY, 1881, Quart. Jour. Micr. Sci., v. 21, p. 45, pl. 3, fig. 9.

Pyrgo denticulata (Brady) = *Biloculina ringens* (Lamarck) var. *denticulata* BRADY, 1884, Rept. *Challenger* Expedition, Zool., pt. 22, v. 9, p. 143, pl. 3, figs. 4-5.

Pyrgo subsphaerica (d'Orbigny) = *Biloculina subsphaerica* D'ORBIGNY, 1839, *in* DE LA SAGRA, Hist. Phys. Pol. Nat. Cuba, Foraminifères, p. 162, v. 8, pl. 8, figs. 25-27.

Quinqueloculina agglutinans D'ORBIGNY, 1839, *in* DE LA SAGRA, Hist. Phys. Pol. Nat. Cuba, Foraminifères, p. 195, pl. 12, figs. 11-13.

Quinqueloculina akneriana D'ORBIGNY, 1846, Foram. Fossiles Vienne, p. 290, pl. 18, figs. 16-20.

Quinqueloculina bicostata D'ORBIGNY, 1839, *in* DE LA SAGRA, Hist. Phys. Pol. Nat. Cuba, Foraminifères, p. 195, v. 8, pl. 12, figs. 8-10.

Quinqueloculina bradyana CUSHMAN, 1917, U. S. Natl. Mus. Bull. no. 71, pt. 6, p. 52, pl. 18, fig. 2.

Quinqueloculina compta CUSHMAN, 1947, Cushman Lab. Foram. Research, Contr., v. 23, pt. 4, p. 87, pl. 19, fig. 2.

Quinqueloculina dutemplei D'ORBIGNY, 1846, Foram. Fossiles Vienne, p. 294, pl. 19, figs. 10-12.

Quinqueloculina lamarckiana D'ORBIGNY, 1839, *in* DE LA SAGRA, Hist. Phys. Pol. Nat. Cuba, Foraminifères, p. 189, pl. 11, figs. 14-15.

Quinqueloculina poeyana D'ORBIGNY, 1839, *in* DE LA SAGRA, Hist. Phys. Pol. Nat. Cuba, Foraminifères, p. 191, pl. 11, figs. 25-27.

Quinqueloculina seminulum (Linné) = *Serpula seminulum* LINNÉ, 1758, Systema natural, Ed. 10, tomus 1, p. 786, pl. 2, figs. 1a-c.

Rectobolivina advena (Cushman) = *Siphogenerina advena* CUSHMAN, 1922, Carnegie Inst. Washington Pub. 311, p. 35, pl. 5, fig. 2.

Reussella spinulosa atlantica Cushman = *R. spinulosa* (Reuss) var. *atlantica* CUSHMAN, 1947, Cushman Lab. Foram. Research Contr., v. 23, pt. 4, p. 91, pl. 20, figs. 6, 7.

Robulus occidentalis (Cushman) = *Cristellaria occidentalis* CUSHMAN, 1923, U. S. Natl. Mus. Bull. no. 104, pt. 6, p. 102, pl. 25, fig. 2, pl. 26, figs. 1-2.

Rosalina parkerae (Natland) = *Discorbis parkeri* NATLAND, 1950, Geol. Soc. America, Mem. 43, pt. 4, p. 27, pl. 6, figs. 11a-c.

Rotorbinella lomaensis (Bandy) = *Rotalia lomaensis* BANDY, 1953, Jour. Paleontology, v. 27, no. 2, p. 179, pl. 22, fig. 6.

Sigmoilina subpoeyana (Cushman) = *Quinqueloculina subpoeyana* CUSHMAN, 1922, Pub. 311, Carnegie Inst. Washington, v. 17, p. 66; 1923, U. S. Natl. Mus. Bull. 104, pt. 6, p. 31, pl. 5, fig. 3.

Spiroloculina depressa D'ORBIGNY, 1826, Ann. Sci. Nat., sér. 1, tome 7, p. 298; Modelès, no. 92.

Spiroplectammina floridana (Cushman) = *Textularia floridana* CUSHMAN, 1922, Pub. 311, Carnegie Inst. Washington, v. 17, p. 24, pl. 1, fig. 7.

Textularia candeiana D'ORBIGNY, 1839, *in* DE LA SAGRA, Hist. Phys. Pol. Nat. Cuba, Foraminifères, p. 143, v. 8, pl. 1, figs. 19, 20.

Textularia conica D'ORBIGNY, 1839, *in* DE LA SAGRA, Hist. Phys. Pol. Nat. Cuba, Foraminifères, p. 143, v. 8, pl. 1, figs. 25-27.

Textularia secasensis LALICKER and MCCULLOCH, 1940, Allan Hancock, Pacific Exped., v. 6, no. 2, p. 141, pl. 16, fig. 24.

Trifarina bradyi CUSHMAN, 1923, U. S. Natl. Mus. Bull. no. 104, pt. 4, p. 99, pl. 22, figs. 3a-b, 4a-b, 5-8, 9a-b.

Triloculina linneiana D'ORBIGNY, 1839, *in* DE LA SAGRA, Hist. Phys. Pol. Nat. Cuba, Foraminifères, p. 172, v. 8, pl. 9, figs. 11-13.

Triloculina trigonula (Lamarck) = *Miliolites trigonula* LAMARCK, 1804, Paris Mus. Nat. Hist., Ann., v. 5, p. 351; 1807, *idem.*, v. 9, pl. 17, fig. 4.

Trochammina advena CUSHMAN, 1922, Pub. 311, Carnegie Inst. Washington, v. 17, p. 20, pl. 1, figs. 2-4.

Trochammina pacifica CUSHMAN, 1925, Cushman Lab. Foram. Research, Contr., v. 1, p. 39, pl. 6, fig. 3.

Uvigerina auberiana D'ORBIGNY, 1839, *in* DE LA SAGRA, Hist. Phys. Pol. Nat. Cuba, Foraminifères, p. 106, v. 8, pl. 2, figs. 23-24.

Uvigerina hispidocostata CUSHMAN and TODD, 1945, Cushman Lab. Foram. Research, Special Pub. no. 15, p. 51, pl. 7, figs. 27, 31.

Uvigerina parvula CUSHMAN and THOMAS, 1929, Jour. Paleontology, v. 3, p. 178, pl. 23, figs. 3-4.

Uvigerina peregrina CUSHMAN, 1923, U. S. Natl. Mus., Bull. 104, pt. 4, p. 166, pl. 42, figs. 7-10.

BIBLIOGRAPHY

ANDERSON, W. A., GEHRINGER, J. W., and COHEN, E., 1956, Physical oceanographic, biological and chemical data—South Atlantic coast of the United States: U. S. Fish and Wildlife Service Special Sci. Rept., No. 178.

BÉ, A. W. H., 1959, Ecology of Recent planktonic Foraminifera: Micropaleontology, v. 5, p. 77-100.

———, 1960, Ecology of Recent planktonic Foraminifera: Micropaleontology, v. 6, pp. 373-392.

BUMPUS, D. F., and WEHE, T. J., 1949, The hydrography of the western Atlantic: Woods Hole Oceanographic Institution Tech. Rept. no. 16.

CUSHMAN, J. A., 1920, The Foraminifera of the Atlantic Ocean: U. S. Natl. Mus. Bull. 104, pts. 2. 3, and 4.

GORSLINE, D. S., 1960, Physical and chemical data for bottom sediments, South Atlantic Coast of the United States: U. S. Fish and Wildlife Service Special Sci. Rept., no. 366, pp. 1-84.

HEEZEN, B. C., THARP, M., and EWING, M., 1959, The floors of the oceans, Part I, The North Atlantic: Geol. Soc. America, 122 pp.

MOORE, W. E., 1957, Ecology of Recent Foraminifera in northern Florida Keyes: Bull. Am. Assoc. Petroleum Geologists, v. 41, pp. 727-741.

NORTON, R. D., 1930, Ecologic relations of some Foraminifera: Scripps Inst. Oceanography Bull., Tech. ser., v. 2, pp. 331-388.

PARKER, F. L., 1948, Foraminifera of the Continental Shelf from the Gulf of Maine to Maryland: Bull. Mus. Comp. Zoology, v. 100, no. 2, pp. 214-241.

———, 1952, Foraminiferal distribution in the Long Island Sound-Buzzards Bay area: Bull. Mus. Comp. Zoology, v. 106, no. 10, pp. 427-473.

PHLEGER, F. B, 1952, Foraminifera ecology off Portsmouth, New Hampshire: Bull. Mus. Comp. Zoology, v. 106, no. 8, pp. 315-390.

SCHOTT, W., 1935, Die Foraminiferen in den aquatorealen teil des Atlantischen Ozeans: Deutsche Sudpolar Exped., 11, Heft. 6, pp. 411-616.

STOMMEL, H., 1958, The Gulf Stream—A physical and dynamical description: Berkeley and Los Angeles: California Univ. Press, 203 pp.

CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
VOLUME XV, PART 1, JANUARY, 1964

276. LOCATION OF THE PLIOCENE-PLEISTOCENE BOUNDARY

D. GRAHAM JENKINS
New Zealand Geological Survey, Lower Hutt, New Zealand

ABSTRACT

This paper presents the results of an examination of the planktonic faunas of some Pliocene-Pleistocene rocks from New Zealand, Italy and California. This study was undertaken because recently a "Pliocene-Pleistocene boundary" marked by the extinction of discoasters, by the first appearance of **Globorotalia truncatulinoides** (d'Orbigny) in abundance and by a change in the coiling ratio in populations of **Globorotalia menardii** was recognized in deep-sea sediments from the Atlantic, Indian and Pacific Oceans. This faunal break cannot be recognized in rock samples from the type Pliocene and Pleistocene in Italy, or in a Pleistocene section from California, U.S.A. With extra information regarding the ranges of the other planktonic foraminifera in the deep-sea sediments, it will be possible to locate accurately this faunal break in New Zealand rocks.

INTRODUCTION

The recent contribution by Ericson, Ewing and Wollin (1963) describing the Pliocene-Pleistocene boundary in eight deep-sea cores from the Atlantic and Indian Oceans was followed up by a discussion of this faunal break in Pacific deep-sea cores by Riedel, Bramlette and Parker (1963). This work has prompted me to check the evidence for this faunal break in rock samples of this age from New Zealand, Italy and California.

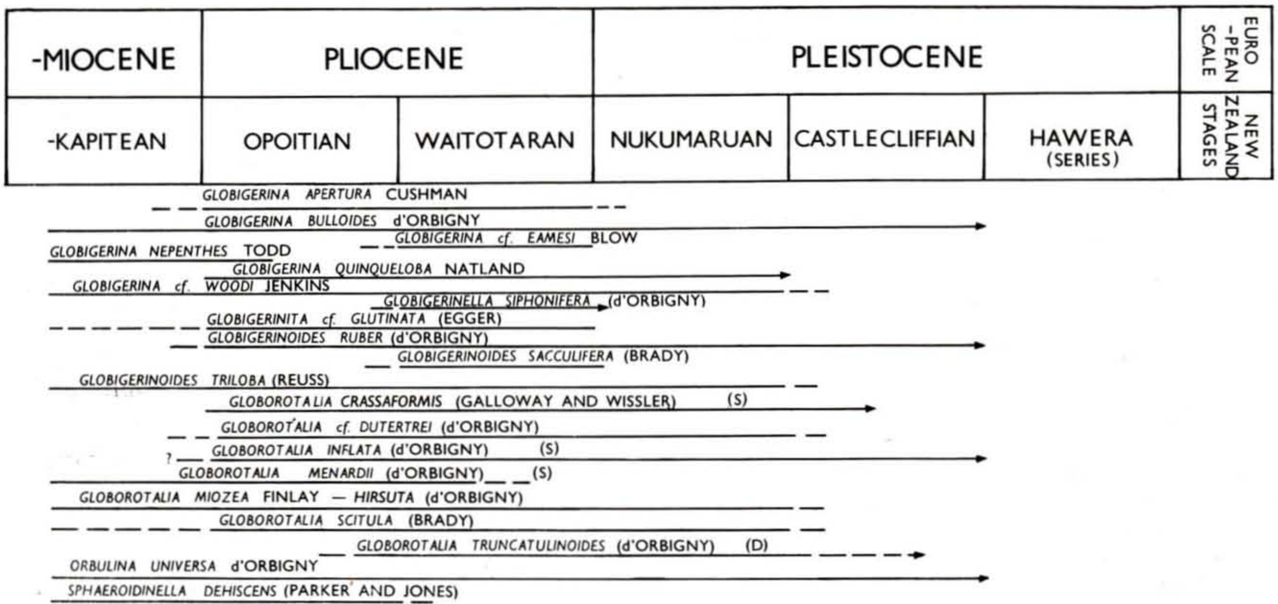
Acknowledgements.—The writer wishes to thank Dr. Maria Bianca Cita, Istituto di Geologia, Universita di Milano, Italy, for providing the type Calabrian samples for examination. Also the following New Zealand Geological Survey staff: Dr. C. A. Fleming who collected the Castell 'Arquato samples, Mr. A. R. Edwards for examining some of the samples for discoasters, and Mr. G. H. Scott and Dr. Fleming for reading the original manuscript and making valuable comments.

FAUNAL ANALYSIS

A number of New Zealand samples from the east coast of North Island containing good planktonic foraminiferal faunas yielded the following results which are compared with the results obtained by Ericson *et al.* from the deep-sea sediments:

Pliocene-Pleistocene Boundary Ericson et al. (1963)	Comparative results from New Zealand rocks
1. Extinction of all discoasters.	1. Discoaster spp. occur with *Globorotalia truncatulinoides* in two samples (F8179, F6039) examined, but were rare.
2. Change in the coiling direction of members of the *Globorotalia menardii* complex from 95% dextral coiling below the boundary to 95% sinistral coiling above it and at all higher levels in the Pleistocene.	2. *G. menardii* is present in the Pliocene rocks and in sample F5971 containing *Globorotalia inflata* and *Globigerina nepenthes,* the specimens have a sinistral coiling dominance.
3. Appearance of *Globorotalia truncatulinoides* in abundance above the boundary.	3. *G. truncatulinoides* occurs for the first time in rocks which in New Zealand have been equated with the Pliocene (text fig. 1).
4. Extinction of *Globigerinoides sacculifer fistulosus.*	4. *G. sacculifer fistulosus* has not been recorded in New Zealand rocks. It is possible that this subspecies was restricted to the warmer waters in the Pliocene seas, the nearest record to New Zealand is by Belford (1962) from the Upper Miocene-Pliocene rocks of New Guinea.
5. Reduction of the *Globorotalia menardii* complex to a single fairly uniform race above the boundary.	5 & 6. *Globorotalia menardii* is rare in the Pliocene rocks and appears to be absent in the Pleistocene rocks. Again this species was probably restricted to the warmer waters of the Pliocene-Pleistocene time.
6. Increase in the average diameter of the tests of *G. menardii* and reduction in their number with respect to the total assemblage of foraminifera above the boundary.	

To check the validity of the Pliocene-Pleistocene boundary suggested by Ericson *et al.*, some rock samples from the type area of the Pliocene of Italy have been examined. Three samples from the Upper Pliocene of Castell 'Arquato (see Barbieri, 1958) have yielded a planktonic foraminiferal fauna composed of *Orbulina universa, Globigerinoides sacculifer sacculifer, Globigerinoides* cf. *G. conglobatus, Globigerinoides trilobus, Globigerina bulloides, Globigerina apertura, Globigerina quinqueloba, Globorotalia* cf. *G. hirsuta, Globorotalia scitula* and *Globorotalia inflata.* These samples



TEXT FIGURE 1

Tentative range chart of planktonic Foraminifera from New Zealand rocks: arrows indicate species recorded in Recent sediments off the coast of New Zealand (Vella, 1957). The coiling dominance in four *Globorotalia* spp. is shown (S = sinistral; D = dextral.)

did not contain specimens of *Globorotalia menardii, Globigerinoides sacculifer fistulosus* or *Discoaster* spp. These essential species must be present in rock samples in order that the 'Pliocene-Pleistocene boundary' of Ericson *et al.* can be located. The question therefore arises as to whether these Castell 'Arquato rocks are to be positioned above or below their boundary.

Three samples have been examined from clay beds of the lower, middle and upper parts of the type Calabrian section from Bovetto, Italy. The Calabrian has been designated the type section of the Lower Pleistocene by King and Oakley (1950).

All three samples were found to be rich in planktonic foraminifera, containing the following species: *Globigerina bulloides, Globigerina quinqueloba, Globigerinella siphonifera, Globigerinita* cf. *G. glutinata, Globigerinoides ruber, Globigerinoides sacculifer, Globigerinoides trilobus, Globorotalia* cf. *G. crassaformis, Globorotalia inflata, Globorotalia scitula* and *Orbulina universa.*

Globorotalia truncatulinoides has been recorded from the Pliocene-Pleistocene rocks of Italy (AGIP, 1957) and a single specimen was found in the sample from the middle part of the Calabrian section. A single specimen of *Globigerinoides sacculifer fistulosus* was also obtained from this sample. No specimens of *Globorotalia menardii* or *Discoaster* spp. were found in these samples. Therefore it is not possible to say whether the Calabrian lies above or below the Pliocene-Pleistocene boundary of Ericson *et al.*

Three samples from the Lomita Quarry, California, the same three samples described by Galloway and Wissler (1927) have also been examined. These two authors regarded these samples as being of early Pleistocene age and Valentine (1961) has recently supported this view. The planktonic foraminifera from these samples consist mainly of the following species, *Globigerina bulloides, Globigerina* cf. *G. apertura, Globigerina pachyderma, Globigerina dutertrei, Globigerinella siphonifera, Globigerinoides ruber, Orbulina universa, Globorotalia crassaformis, Globorotalia inflata* and *Globorotalia* cf. *G. scitula.* One specimen of *Discoaster* sp. was obtained from the 'Lower Bed' sample but no specimens of *Globorotalia menardii* or *Globorotalia truncatulinoides* have been found. Probably the presence of the cold water species *Globigerina pachyderma* precludes the possibility of *Globorotalia menardii* and *Globorotalia truncatulinoides* being present in these samples. Again it is not possible to position the Lomita rocks in relation to the Pliocene-Pleistocene boundary of Ericson *et al.*

DISCUSSION

A pointer to the difficulty of correlating Pliocene-Pleistocene sequences with this faunal break is provided by the data from Core V16-66 described by Ericson *et al.* This core lacked the species *Globorotalia menardii, Globigerina nepenthes* and *Globigerinoides sacculifer fistulosus,* probably because of its high latitude position.

Ericson *et al.* state that *Globorotalia truncatulinoides* appears "in abundance" above the faunal break which suggests that specimens may have been recorded from below this break. This will make it difficult to place the boundary unless "in abundance" is more accurately defined. Possibly too much reliability as a world-wide marker could be attached to the level at which *G. truncatulinoides* makes its appearance "in abundance." It is doubtful if this horizon would be contemporaneous in all deposits. A far more reliable marker would be the initial appearance of *G. truncatulinoides* (s.s.) especially if its immediate ancestor could be accurately identified.

There is also the problem of the southern and northern limits of *G. truncatulinoides* at the base of the Pleistocene. The southernmost record of Pleistocene specimens is in Core V16-66 (lat. 42° 39′ S.) in the Indian Ocean and the northernmost is from the Atlantic Ocean in Core 296 (lat. 42° 27′ N.) recorded by Phleger, Parker and Peirson (1953).

In New Zealand it would appear that the warm water *Globorotalia menardii* was forced out of the area with the onset of the Pleistocene and that *Globorotalia truncatulinoides* may also have migrated towards the equator sometime afterwards.

CONCLUSION

The work of Reidel *et al.* on the Pacific deep-sea cores has confirmed the presence of the faunal break originally described by Ericson *et al.*, but in the Pacific sediments this "Pliocene-Pleistocene boundary" does not appear to be as well defined as that recorded in the Atlantic and Indian Oceans.

With extra information available regarding the ranges of the other Pliocene-Pleistocene planktonic foraminifera in the deep-sea cores described, it will then be possible to position fairly accurately in New Zealand rocks the faunal break described by Ericson *et al.* The question as to whether it is the Pliocene-Pleistocene boundary remains to be proved in the type areas of these rocks in Italy, or at least in equivalent deeper-water facies as near as possible to these type areas.

BIBLIOGRAPHY

AGIP MINERARIA, 1957, Foraminiferi padani (Terziario e Quaternario); Atlante i conografico e distribuzione stratigrafica: 52 pls. Milano. (*fide* Frances L. Parker)

BARBIERI, F., 1958, La serie Pliocenica di Castell 'Arquato: Colloquio Int. Micropal. in Italia, University Milan pub., pp. 23-33.

BELFORD, D. J., 1962, Miocene and Pliocene planktonic Foraminifera, Papua-New Guinea: Bur. Min. Res., Geology, Geophysics, Australia, Bull. 62-1, pp. 1-52.

ERICSON, D. B., EWING, MAURICE, and WOLLIN, GOESTA 1963, Pliocene-Pleistocene boundary in deep-sea sediments: Science, vol. 139, No. 3556, pp. 727-737.

GALLOWAY, J. J., and WISSLER, S. G., 1927, Pleistocene Foraminifera from the Lomita Quarry, Palos Verdes Hills, California: Jour. Paleontology, vol. 1, pp. 35-87.

KING, W. B. R., and OAKLEY, K. P., 1950, Report of the Temporary Commission on the Pliocene-Pleistocene Boundary, appointed 26 August, 1948: Int. Geol. Cong. Rep. 18th Session Gt. Brit., pt. 1, pp. 213-214.

PHLEGER, F. B, PARKER, F. L., and PEIRSON, J. F., 1953, North Atlantic Foraminifera: Swedish Deep-sea Exped., Repts., vol. 7, fasc. 1, pp. 3-122, pls. 1-12.

RIEDEL, W. R., BRAMLETTE, M. N., and PARKER, F. L., 1963, "Pliocene-Pleistocene" boundary in deep-sea sediments: Science, vol. 140, pp. 1238-1240.

VALENTINE, J. W., 1961, Paleoecologic molluscan geography of the Californian Pleistocene: Univ. Calif. pub., Geol. Sci., vol. 34, no. 7, pp. 309-442.

VELLA, PAUL, 1957, Studies in New Zealand Foraminifera: N. Z. Geol. Survey, Pal. Bull. No. 28, pp. 1-64, pls. 1-9.

CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
VOLUME XV, PART 1, JANUARY, 1964

277. PRELIMINARY ACCOUNT OF THE TYPE AQUITANIAN-BURDIGALIAN PLANKTONIC FORAMINIFERA

D. GRAHAM JENKINS
N. Z. Geological Survey, Lower Hutt, New Zealand

ABSTRACT

The ranges of 22 species of planktonic foraminifera from the type Aquitanian-Burdigalian have been worked out. It is suggested that the initial appearances of the **Globigerinoides bisphericus** Todd - **Orbulina universa** d'Orbigny lineage must occur in post-Burdigalian rocks.

INTRODUCTION

The planktonic foraminifera in eight samples from the type area of the Aquitanian-Burdigalian rocks of southwestern France have been examined. The various species recovered from the samples are listed in Table 1. Seven of the samples came from near Soucats and the other (No. 5) came from near Leognan (*see* Sample Localities).

PREVIOUS WORK

Kaasschieter (*in* Drooger *et al.*, 1955) recorded two planktonic foraminiferal species from the type Aquitanian-Burdigalian: *Globigerina bulloides* d'Orbigny and *Globigerinoides trilocularis* (d'Orbigny). Drooger (1956) working on the same rocks recorded *Globigerinoides trilobus, Globigerina bulloides* and *Globigerina globularis,* and he concluded that "it is a rather neutral fauna."

DISCUSSION OF THE PLANKTONIC FAUNA

As can be seen from Table 1, 22 species have been recovered from the 8 samples examined. Some of these faunas were obtained by floating off the rather delicate tests before the samples were washed.

Drooger (1956) stated that *Orbulina universa* d'Orbigny made its first appearance in the Tortonian and showed *Orbulina suturalis* starting in the upper Helvetian. These occurrences were based on work on the type Helvetian and Tortonian.

Blow (1957), on the other hand, stated that *Orbulina* started in the upper Aquitanian of Sicily "as defined by the concurrence of *Miogypsina irregularis* and *Miogypsinoides complanata.*" This statement has since been repeated by Blow (1959), by Banner and Blow (1959) and by Blow and Banner (*in* Eames *et al.* 1962).

It is inconceivable that *Orbulina universa* could have existed in the area of the Aquitaine basin during the deposition of the Aquitanian and Burdigalian rocks because of the large number of species of planktonic foraminifera that are present in these rocks. It follows that *O. universa* must have made its initial appearance in post-Burdigalian time. This is in accord with the results of Cita and Elter (1960, *in* Cita and Premoli Silva) obtained from the Miocene sequence of Collina di Torino.

The uppermost sample examined (No. 8), of Helvetian (?) age, contains well-developed *Globigerinoides trilobus trilobus* (Reuss). This means that this sample is below the level of the first appearance of *Globigerinoides bisphericus* Todd.

The lowest sample (No. 1) in the sequence yielded a very poor planktonic fauna, but the other samples contained sufficient numbers of specimens of the species which also occur in Trinidad to make a broad correlation with the zone *Globorotalia kugleri* to *Globigerinatella insueta - Globigerinoides trilobus* subzone.

CONCLUSION

The excellent work of Sourdillon (1960) shows clearly that the Oligocene-Miocene rocks of southwestern France contain the necessary number of species of planktonic foraminifera for correlations with other world Tertiary marine rocks. It is hoped shortly to illustrate the species of planktonic foraminifera obtained from the type Aquitanian-Burdigalian.

ACKNOWLEDGEMENTS

The writer wishes to acknowledge the cooperation of Mademoiselle O. Sourdillon, Compagnie Française des Pétroles, Bordeaux, who provided the rock samples. Dr. C. A. Fleming, of the New Zealand Geological Survey read the manuscript and made useful suggestions.

SAMPLE LOCALITIES

Aquitanian

Sampling on the south side of the Soucats stream.

Moulin de Bernachon (Near Soucats)

From bottom to top:

1 - GV 180a: Blue-grey marls, first stratum above the level of the water.	Lower Aquitanian
2 - GV 182a: Sandy marls, situated 2 metres above GV 180a.	Lower Aquitanian
3 - GV 183a: Same place as above: indurated levels situated about 1 metre higher up.	Lower Aquitanian

Lariey (near Soucats)

4 - GV 184b: Crag (Falun), clay, yellowish, rich in Gastropods, Lamellibranches etc.	Upper Aquitanian

TABLE 1

Range chart of the planktonic foraminiferal species obtained from the type Aquitanian-Burdigalian and from a Helvetian (?) sample from southwestern France.

	Aquitanian					Burdigalian		Helvetian (?)
	Lower		Upper			Lower	Upper	
Planktonic Foraminifera — Samples	1	2	3	4	5	6	7	8
Globigerina woodi Jenkins	x	x	x	x	x	x	x	x
Globorotalia continuosa Blow	?x		x	?x		x	x	x
Globigerina angustiumbiliculata Bolli	x	x	x	x	x	x	x	x
Globigerina sp.	x							
Globigerina praebulloides Blow		x	?x	x	x	x	x	x
Globigerina juvenilis Bolli			x	x	x	x	x	x
Globorotalia aff. *G. mayeri* Cushman and Ellisor		x	x	x		x	x	x
Globigerina cf. *G. bradyi* Wiesner		x	x				x	x
Globigerinoides cf. *G. primordius* Blow and Banner			x					
Globorotalia sp.			x	x				
Globoquadrina dehiscens Chapman, Parr and Collins			x			x	x	x
Catapsydrax sp. 1			x					
Globigerinoides trilobus (Reuss) *s.l.*			?x	?x	x	x	x	x
Globorotaloides ? sp.				x		x	x	x
Cassigerinella chipolensis (Cushman and Ponton)				x				
Catapsydrax sp. 2					x		x	
Globigerinoides apertasuturalis Jenkins						x	x	x
Globigerinoides sp.						x		
Globorotalia cf. *G. obesa* Bolli						x	x	x
Sphaeroidinella? sp.							x	x
Globoquadrina cf. *G. larmeui* Akers							x	x
Globigerina cf. *G. foliata* Bolli							x	

Burdigalian

Le Coquillat (near Leognan)

5 - GT 125: Reddish-brown sand. — Lower Burdigalian

Pont Pourquey (near Soucats)

6 - GT 136a: Base of the little cliff at the level of the water: crags (faluns), and sands. — Upper Burdigalian

7 - GT 183b: 4 metres above GT 136a, high on the cliff. — Upper Burdigalian

Helvetian

Ferme de la Sime (near Soucats)

8 - GT 130: Sample taken 500 metres downstream from the farm La Sime. — Helvetian (?)

REFERENCES

Banner, F. T., and Blow, W. H., 1959, The classification and stratigraphical distribution of the Globigerinaceae: Palaeontology, vol. 2, pt. 1, pp. 1-27.

Blow, W. H., 1957, Transatlantic correlation of Miocene sediments: Micropaleontology, vol. 3, no. 1, pp. 77-79.

———, 1959, Age, correlation and biostratigraphy of the upper Tocuyo (San Lorenzo) and Pozon formations, Eastern Falcon, Venezuela: Bull. Am. Paleontology, vol. 39, no. 175, pp. 59-251.

Cita, M. B., and Premoli Silva, I., 1960, Pelagic foraminifera from the type Langhian: Int. Geol. Cong. Repts. XXI Sess., Pt. XXII, Proc. Internat. Paleont. Union, pp. 39-50.

Drooger, C. W., 1956, Transatlantic correlation of the Oligo-Miocene by means of foraminifera: Micropaleontology, vol. 2, no. 2, pp. 183-192.

———, Kaasschieter, J. P. H., and Key, A. J., 1955, The microfauna of the Aquitanian-Burdigalian of southwestern France: K. Nederlandse Akad. Wetensch. Afd. Natuurk., Verh., ser. 1, vol. 21, pp. 1-136.

Eames, F. E., Banner, F. T., Blow, W. H., and Clarke, W. J., 1962, Fundamentals of mid-Tertiary stratigraphical correlation: Cambridge Univ. Press, England, 163 pp.

Sourdillon, O., 1960: Étude micropaléontologique du Tertiaire du Forage de Frouas (Landes): Rev. de Micropaléontologie, vol. 3, no. 2, pp. 81-94.

CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
VOLUME XV, PART 1, JANUARY, 1964

278. STABILITY OF FORAMINIFERAL NOMENCLATURE

ALFRED R. LOEBLICH, JR. and HELEN TAPPAN
California Research Corporation, La Habra, California and University of California, Los Angeles

ABSTRACT

Nomenclatural stability can be best achieved through close adherence to the international rules, whereas recent suggestions of a return to individual preference or previous usage as the major criterion will have chaotic results. Unnecessarily proposed generic and specific taxa could be avoided by following the stipulations of the International Code of Nomenclature.

Two recent articles published by the Cushman Foundation have indicated a basic disregard for the International Code of Zoological Nomenclature which cannot be ignored.

The past dozen years of work on the *Treatise on Invertebrate Paleontology* have imbued the present writers with a profound respect for the original proponents of the International Code of Zoological Nomenclature, and a high regard for the many who have since brought it to its present status. Most nomenclatural problems can be avoided by adherence to the rules and those which have arisen can usually be readily solved by reference to this Code. Yet taxonomic and nomenclatural arguments still result from failure of some authors to comply. The International Code must be followed explicitly regardless of personal preference in order to prevent nomenclatural chaos. The preamble of this Code clearly states its purpose "to promote stability and universality in the scientific names of animals, and to ensure that each name is unique and distinct . . . . ," adding that "priority is the basic principle of zoological nomenclature," and that "when stability of nomenclature is threatened in an individual case, the strict application of the code may under specified conditions be suspended by the International Commission on Zoological Nomenclature."

Nowhere do the rules allow for disregard of priority or homonymy as a matter of personal preference. The machinery for suspending these rules is also clearly outlined when such is truly advisable: submission of a formal petition to the Commission, its publication in the Bulletin of Zoological Nomenclature for comment by the profession, and its subsequent approval or rejection by the Commission, whose decision then becomes binding upon all later workers. Obviously, every genus proposed within the animal kingdom cannot be thus reviewed in detail, nor is there such intention because the law of priority and law of homonymy are regarded as generally sufficient, with the Code spelling out the necessary procedure to be followed under various types of unusual cases.

Very few conscientious workers at present fail to follow these specified rules and procedure, except rarely by error or inadvertance, hence it is disturbing to see serious proposals in scientific literature that workers determine as a matter of personal preference which name they use for an organism, regardless of priority or of the Code of Nomenclature.

In a recent discussion of foraminiferal nomenclature Todd (1963, p. 109) commented that "during a period of well over one hundred years (counting from d'Orbigny's Tableau méthodique de la classe des Céphalopodes, 1826) little stability of nomenclature has been achieved through strict application of the Rules of Zoological Nomenclature," hence she urged "that we let usage itself serve as a primary consideration over the principle of priority." We contend that what stability has been achieved has been due solely to the strict application of the rules. Although some 118 foraminiferal generic names had been proposed before publication of d'Orbigny's Tableau méthodique, only 14 of these were used as valid names by d'Orbigny. Meanwhile 50 new generic names were proposed by d'Orbigny (a few vernacular ones being invalid) and in some of his "new" genera he included as many as 10 earlier generic names as synonyms! If a similar degree of individualism were now allowed, the 2500 foraminiferal generic names that had been proposed by 1962 (for some 34,000 nominal species) would have proliferated astronomically. "Usage itself" cannot be a primary consideration, for comparison of the classifications or of the various genera recognized in two or three major publications of the past few years (even in those on related faunas) will show how great a variation in usage may still occur under "strict application of the rules," merely by the recognition of different criteria for taxonomic separation. Usage can never become stable, as long as knowledge of the group increases, but a strict application of priority and other stipulations of the Code of Nomenclature will result in the fewest changes and greatest possible degree of stability. With the increased complexity of nomenclature resulting from the past century of work it is more than ever imperative that the Code of Nomenclature be followed explicitly. Two recent examples of suggested disregard of this Code are discussed below.

Fursenkoina Loeblich and Tappan, 1961 vs. *Virgulina* d'Orbigny, 1826 (*non* Bory de St. Vincent, 1823)

Todd (1963, p. 110-111) objected to the recent proposal of the generic name *Fursenkoina* for *Virgulina* d'Orbigny, 1826, a junior homonym of *Virgulina* Bory de St. Vincent, 1823, stating that "in view of the long-continued and undisputed usage of the name

Virgulina for the foraminifer, it would have been more reasonable to continue the infinitesimal risk of confusion between the foraminifer and the worm than to introduce more confusion by having a new name. Here stability has been overthrown for the sake of eliminating a homonym. In the interest of stability, the generic name *Fursenkoina* should be rejected and the use of the generic name *Virgulina* continued."

The Code of Zoological Nomenclature (Art. 53) states unequivocally that "Any name that is a junior homonym of an available name must be rejected and replaced." No exceptions are allowed. Todd regarded the possibility of confusion of a worm and a foraminifer unlikely, yet one of the half dozen Linnaean species of foraminifers was described as a worm (*Serpula seminulum* = *Quinqueloculina*) and a dozen later species of foraminifers were originally described as *Serpula*. Even the recent publication by Henbest (1963) noted still another foraminiferal genus originally so referred. Hence "confusion" of tubicolous worms and foraminifers has taken place for the more than 200 years of zoological binomial nomenclature! Actually, although *Virgulina* Bory de St. Vincent, 1823 (p. 356), was originally regarded and later recorded by Neave (1940, p. 643) as a "worm," it is in reality a flagellate protistan, the first species subsequently assigned by Bory de St. Vincent being *Cercaria pleuronectes* Mueller, 1773, and *C. cyclidium* Mueller, 1773.

Virgulina Bory de St. Vincent is thus a prior synonym of *Phacus* Nitzsch, 1827. A petition to conserve the generic name *Phacus* of Dujardin, 1841 (*non* Nitzsch, 1827), is at present under consideration by the International Botanical Commission (Silva, 1960, p. 18, 19) with altered description and type species (*Euglena longicauda* Ehrenberg) as opposed to the colorless flagellate *Cercaria pleuronectes* (type of *Phacus* Nitzsch, 1827, and one of the two originally included species in *Virgulina* Bory de St. Vincent, 1823). Hence, the continued use of *Virgulina* as a foraminifer would undoubtedly lead to confusion, the above-mentioned unicellular flagellates being claimed as Flagellata by the protozoologists, as well as considered unicellular algae by the botanists.

The "long-continued and undisputed usage of the name *Virgulina*" is also less impressive, when one notes the relatively small number of species there included and the percentage of these which over the past decade have been transferred to other foraminiferal genera (*Bolivina, Cassidella, Francesita, Stainforthia, Virgulinella*).

If stability is truly desired, other than that automatically required under the Zoological Code, a documented petition should have been submitted by Todd to the International Commission requesting suppression of the earlier name and conservation of the later homonym, the petition published in the *Bulletin of Zoological Nomenclature,* with a detailed justification for such requested suspension of the rules, rather than the suggestion made that the individuals' preference or previous usage "serve as a primary consideration." Without such a petition and subsequent ruling by the Commission, *Virgulina* d'Orbigny cannot be validly used, and *Fursenkoina* must be regarded as the correct name for this genus.

Serpulopsis Girty, 1911 vs. *Minammodytes* Henbest, 1963

Henbest (1958, p. 128; 1960, p. B386) noted that *Serpulopsis* Girty, 1911, was later regarded by its author as a foraminifer rather than belonging to the tubicolid annelids as originally described. The type species of *Serpulopsis* (*Serpula insita* White, 1878) originally reported from Indiana, was identified by Girty as extremely abundant in the Pennsylvanian Wewoka Formation of Oklahoma, and Girty's figured specimens (USNM 120571) on which he based the generic description were later refigured by Henbest (1963, pl. 1, figs. 7, 8). Although recognizing *Serpulopsis* as a valid genus in 1958 and 1960, Henbest (1963, p. 27) stated that the original specimens of White were apparently lost and as the type-locality was given only in rather general terms, the species was unrecognizable. He then proposed a new generic and specific name, and placed the prior valid generic name *Serpulopsis* in its synonymy! There is no suggestion, however, that *Minammodytes* is proposed for an organism biologically distinct from that on which Girty based his original description of the genus *Serpulopsis*.

It would have been far simpler to have designated a neotype for *Serpulopsis insita,* if this were required for stability, yet even the International Code states that neotypes are only required in "exceptional circumstances," when a "neotype is essential for solving a complex zoological problem," When there is no doubt that the specimens used for a new species and genus are identical with those used in description of a prior valid generic name, the later name is an obvious junior synonym. There is no valid reason for assuming the type species of *Serpulopsis* to be misidentified, the Code of Nomenclature Art. 67(j), 70, stipulating that "It is to be assumed than an author correctly identifies the nominal species that he . . . . refers to a new genus when he establishes it." However (Art. 70(a)) if Henbest regards this as a misidentified type species, the Code states explicitly that "he is to refer the case to the Commission to designate as the type species whichever species will in its judgment best serve stability and uniformity of nomenclature either (i)) the nominal species actually involved . . . . or (ii) if the identity of that species is doubtful, a species chosen in conformity with the usage of the generic name prevailing at the time the misidentification is discovered; or (iii) the species named by the designator, regardless of the misidentification." No provision for renaming both the previous genus and its type species is given under the Code. Hence *Minammodytes* Henbest, 1963, is a junior synonym of *Serpulopsis* Girty, 1911, and *Minammodytes girtyi* Henbest, 1963, a junior synonym of *Serpulopsis insita* (White) Girty.

Henbest's morphological and petrological studies of *Serpulopsis* formed an interesting and valuable contribution to the knowledge of this and other Paleozoic foraminifers, hence it is doubly regrettable that this careful and detailed morphologic work be accompanied by poor taxonomic practice.

Classification Preference

In the above-mentioned publication, Henbest (1963, p. 23) objected to our recent foraminiferal reclassification (Loeblich and Tappan, 1961a) on the grounds that "extensive and numerous changes are presented *ex cathedra* without reasons and without any hint that some of these cases may be problematic or that some cases should be submitted to the profession through the International Commission. . . ." The basis for our re-classification obviously lies in the definition of the various suprageneric taxa, and all taxonomic changes, which are fully documented as to reference and date, are made solely on the basis of priority, as is required under Articles 35-39 of the International Code. Obviously the classification outline and synonymy could only be given in brief (if 85 pages is so regarded) whereas the *Treatise* which it outlined consists of nearly 1000 printed pages of a much smaller type face, hence perhaps more fully documents our reasons. Where we recognized the presence of problematic cases these were fully documented and published in detail elsewhere (Loeblich and Tappan, 1961b-f; 1962a-d; 1963a-c) and we formally presented petitions, comments or counter-proposals to the Commission for the stabilization of nomenclature in the cases of *Quinqueloculina, Ammodiscus, Endothyra* and *Chapmanina.* Unfortunately, Henbest did not specify the problematic cases to which he objected, but if such still exist he could likewise present these to the Commission for a solution. Incidentally, the most recent Code (December, 1961) which suggests reference of certain problematic cases to the Commission (e. g. Art. 23b, and 40a) appeared nearly a year after publication of our reclassification, whereas the Code then in force followed strict priority alone.

Any published taxonomic, morphologic, petrographic, chemical or even ecologic study must be accepted on faith, unless one wishes to personally re-examine each case, recollect each set of samples and perform again each experiment, but certainly if a later worker has reason to doubt the validity of any published work, he is obligated to so re-examine it. Any worker may determine which, if any, classification he prefers to use for any group of organisms, provided that the Code of Nomenclature is followed in so doing. No apology is needed for a decision to follow one classification in preference to another, but it would seem more scientific to identify the objectionable problematic cases rather than to consider their possible presence a blanket indictment of another worker's publication.

In the *Treatise,* we have attempted to allocate every generic name validly proposed for a foraminifer and to cite these names, authors, original publication and type species in the synonymies, so that future taxonomic changes in this order should be reduced to a minimum. For this purpose, type species have been designated for all foraminiferal generic names (for which these were lacking) validly proposed prior to 1930 (names proposed since that date have no validity without simultaneous definite type fixation), and in every instance these have been done so as to avoid supplanting names currently in use (e. g. *Discolithus;* see Loeblich and Tappan, 1963a). In our preparation of the *Treatise,* numerous recent brief nomenclatural articles on the foraminifers were prepared as a matter of necessity, certainly not one of choice, for it is far more interesting and rewarding to study the organisms themselves than to solve the legalistic dilemmas that have arisen from careless taxonomic practice.

After some dozen of years of labor on foraminiferal genera, their morphology, and taxonomy for the *Treatise,* we welcome all further assistance toward a valid and stable nomenclature, provided this be accomplished under the stipulations of the Code of Zoological Nomenclature. To this end we strongly recommend that zoologists and paleontologists develop a familiarity with the Code of Zoological Nomenclature and practice a close adherence to its rules.

REFERENCES

Bory de Saint-Vincent, J. B., 1823, Cercariées: Dict. Class. Hist. Nat., vol. 3, p. 355-356.

Girty, G. H., 1911, On some new genera and species of Pennsylvanian fossils from the Wewoka formation of Oklahoma: New York Acad. Sci., Ann., vol. 21, p. 119-156.

Henbest, L. G., 1958, Wyoming Geol. Assoc. Guidebook for 13th Annual Field Conference, p. 128.

———, 1960, Paleontologic significance of shell composition and diagenesis of certain late Paleozoic sedentary foraminifera: U. S. Geol. Survey, Prof. Paper 400-B, p. B386-B387.

———, 1963, Biology, mineralogy, and diagenesis of some typical late Paleozoic sedentary foraminifera and algal-foraminiferal colonies: Cushman Found. Foram. Research, Special Pub. 6, p. 1-44, pl. 1-7.

Loeblich, A. R., Jr. and Tappan, H., 1961a, Suprageneric classification of the Rhizopodea: Jour. Paleontology, vol. 35, no. 2, p. 245-330.

——— and ———, 1961b, The genera *Microaulopora* Kuntz, 1895, and *Guembelina* Kuntz, 1895, and the status of *Guembelina* Egger, 1899: Jour. Paleontology, vol. 35, no. 3, p. 625-627, 1 text-fig.

——— and ———, 1961c, The type species of *Marginulina* d'Orbigny, 1826: Cushman Found. Foram. Research, Contr., vol. 12, pt. 3, p. 77-78.

——— and ———, 1961d, The type species of the foraminiferan genus *Saccammina* Carpenter, 1869: *ibid.*, vol. 12, pt. 3, p. 79-80.

——— and ———, 1961e, Remarks on the systematics of the Sarkodina (Protozoa), renamed homonyms and new and validated genera: Biol. Soc. Washington, Proc., vol. 74, p. 213-234.

——— and ———, 1961f, The status of *Hagenowella* Cushman, 1933 and a new genus *Hagenowina*: *ibid.*, vol. 74, p. 241-244.

——— and ———, 1962a, *Quinqueloculina* d'Orbigny, 1826 (Foraminifera); Proposed validation under the plenary powers and designation of a neotype for *Serpula seminulum* Linnaeus, 1758. Z. N. (S.) 1494: Bull. Zool. Nomenclature, v. 19, pt. 2, p. 118-124.

——— and ———, 1962b, Six new generic names in the Mycetozoida (Trichiidae) and Foraminiferida (Fischerinidae, Buliminidae, Caucasinidae and Pleurostomellidae), and a redescription of *Loxostomum* (Loxostomidae, new family): Biol. Soc. Washington, Proc., vol. 75, p. 107-113.

——— and ———, 1962c, The status and type species of *Calcarina, Tinoporus* and *Eponides*: Cushman Found. Foram. Research, Contr., vol. 13, pt. 2, p. 33-38, text-fig. 1a-c.

——— and ———, 1962d, The foraminiferal genera *Cibicides, Heterolepa, Planulina* and *Holmanella*, new genus: *ibid.*, vol. 13, pt. 3, p. 71-73.

——— and ———, 1963a, *Discolithus* Fortis, 1802 (Foraminiferida), and its type species: Jour. Paleontology, vol. 37, p. 488-490.

——— and ———, 1963b, Comments and counter proposal on the type-species of *Ammodiscus* Reuss, 1862 (Foraminifera). Z. N. (S.) 1087: Bull. Zool. Nomenclature, v. 20, pt. 2, p. 88-90.

——— and ———, 1963c, Comments on *Endothyra bowmani* Phill ps, 1846, vs. *Endothyra bowmani* Brown, 1843 (Foraminifera). Z. N. (S.) 768: *ibid*, v. 20, pt. 4, p. 286-290.

NEAVE, S. A., 1940, Nomenclator zoologicus: vol. 4, Q-Z, p. 1-758, Richard Clay & Co. (London).

D'ORBIGNY, A., 1826, Tableau méthodique de la classe de céphalopodes: Ann. Sci. Nat., vol. 7, p. 245-314, pls. 10-17.

SILVA, P. C., 1960, Remarks on algal nomenclature III: Taxon, vol. 9, no. 1, p. 18-25.

TODD, RUTH, 1963, Nomenclature of foraminifera: Cushman Found. Foram. Research, Contr., vol. 14, pt. 3, p. 109-111.

CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
VOLUME XV, PART 1, JANUARY, 1964

279. THE TYPE OF *GLOBOROTALIA CRASSATA* (CUSHMAN)[1]

ORVILLE L. BANDY
Department of Geology, University of Southern California

ABSTRACT

A lectotype for **Globorotalia crassata** (= **Pulvinulinella crassata** Cushman) has been chosen.

INTRODUCTION

Recent works on early Tertiary planktonic foraminifera include few, if any, references to *Globorotalia crassata* (Cushman), mostly because of the inadequate figure in the original publication. Through the assistance of Dr. Richard Cifelli of the U. S. National Museum, cotypes of this species were examined and one of these was selected to be the lectotype of the species. The figures were made by Mr. Lawrence B. Isham, Museum Illustrator, U. S. National Museum.

SYSTEMATIC PALEONTOLOGY

Globorotalia crassata (Cushman), 1925

Text figure 1

Pulvinulina crassata CUSHMAN, 1925, Am. Assoc. Petroleum Geologists Bull., vol. 9, no. 2, p. 300, pl. 7, fig. 4.

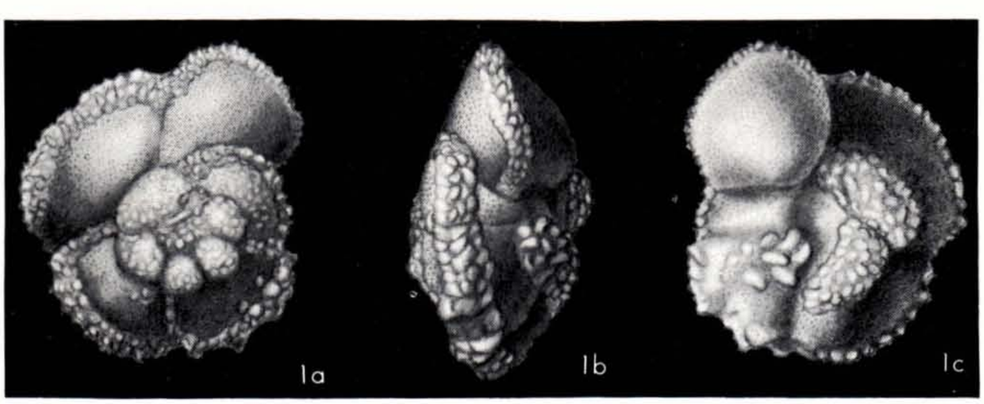
Globorotalia crassata (Cushman), CUSHMAN and BARKSDALE, 1930, Contr. Dept. Geology, Stanford Univ., vol. 1, no. 2, p. 68, pl. 12, fig. 8.

Globorotalia crassata (Cushman), SUBBOTINA, 1953, Trudy Vses. Neft. Naukno-Issledov. Geol.-Razved. Inst., new ser., vol. 76, p. 211, pl. 17, figs. 7-13.

Taxonomic remarks.—Cushman (1925) first described *Globorotalia crassata* from Eocene shale on the east bank of the Moctezuma River, on the eastern portion of the bend which makes its way into Hacienda Romance and near the mouth of the Rio Tamuin, Vera Cruz, Mexico. The sample was collected by Mr. Earl Oliver. Cushman's figure was of the dorsal side in his original description of the species. This has made it difficult to recognize the true proportions and character of the species. An examination was made of all of the syntypes of the species in the Cushman Collection at the U. S. National Museum. One syntype was selected, figured, and is herein designated the lectotype of *Globorotalia crassata.* It is mounted on a slide bearing the number 3026 in the U. S. National Museum collections. The lectotype agrees with the original description and figure by Cushman.

Description of lectotype.—The lectotype, 0.55 mm. in diameter and 0.31 mm. in thickness, consists of about 12 chambers trochospirally arranged in nearly three whorls with about 4½ chambers per whorl; dorsal side somewhat convex; chambers enlarge very slowly in the spire, slightly inflated dorsally, markedly convex ventrally with prominent shoulders surrounding the deep open umbilicus; periphery somewhat lobate, especially in the adult whorl; edge angled and characterized by short spines; sutures curved and limbate dorsally, with spines or papillae; sutures depressed and nearly radial on the ventral side; sutures of the early whorls are nearly radial and flush with the surface; umbilicus deep, open; aperture umbilical to extraumbilical, interiomarginal, with narrow lip; apertural face convex; wall finely perforate and covered with papillae and short spines along the edge of the test, on the dorsal sutures, in the central area of the

1 Contribution of the Allan Hancock Foundation No. 252.



TEXT FIGURE 1

Globorotalia crassata (Cushman) = *Pulvinulina crassata* Cushman, 1925; lectotype, × 62. 1a, dorsal view; 1b, edge view; 1c, ventral view. This specimen is from Eocene shale on the east bank of the Moctezuma River, near Hacienda Romance, Vera Cruz, Mexico. The lectotype is deposited in the Cushman Collection at the U. S. National Museum and is mounted on a slide numbered 3026.

dorsal side, and on the ventral shoulders surrounding the umbilicus.

Remarks.—Most of the syntypes of *Globorotalia crassata* agree very closely with the specimen selected and designated the lectotype herein. This species is intermediate between *Globorotalia angulata* (White, 1928) and *Globorotalia rex* Martin, 1943. *Globorotalia crassata* has a spinose edge and is unequally biconvex, *Globorotalia angulata* has spinose ornamentation over most of the surface and is nearly planoconvex, and *Globorotalia rex* has a definite spinose-keeled edge with spinose ornamentation over most of the surface of the test and its dorsal side is nearly flat.

Globorotalia crassata (Cushman) occurs in the Lower Eocene of many parts of the world. Its exact range is not known; however, it appears to extend from the upper Paleocene through the Lower Eocene into the Middle Eocene.

BIBLIOGRAPHY

CUSHMAN, J. A., 1925, An Eocene fauna from the Moctezuma River, Mexico: Bull. Am. Assoc. Petroleum Geologists, vol. 9, pp. 298-303.

MARTIN, L. T., 1943, Eocene foraminifera from the type Lodo Formation, Fresno County, California: Stanford Univ. Publ. Geol. Sci., vol. 3, no. 3, p. 117, pl. 8, fig. 2.

WHITE, M. P., 1928, Some index foraminifera of the Tampico Embayment area of Mexico: Jour. Paleontology, vol. 2, p. 191, pl. 27, fig. 13.

CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
VOLUME XV, PART 1, JANUARY, 1964

280. THE TYPE OF *GLOBIGERINA QUADRILOBATA* D'ORBIGNY[1]

ORVILLE L. BANDY
Department of Geology, University of Southern California

ABSTRACT

A recently designated lectotype of **Globigerina quadrilobata** d'Orbigny is shown to be invalid. Specimens of this species from the type area agree with the original figure and description of d'Orbigny and not with the lectotype. The lectotype is not one of the syntypes of the original; it is a different species and it belongs in a different genus.

INTRODUCTION

In a recent work seeking the clarification of some of d'Orbigny's foraminiferal species, Banner and Blow (1960) selected lectotypes for a number of species. According to the International Code of Zoological Nomenclature published by the International Trust (1961), article 74, if a nominal species has no holotype, any zoologist may designate one of the syntypes as the "lectotype." The first published designation of a lectotype fixes the status of the specimen, but if it is proved that the designated specimen is not a syntype, the designation is invalid. It is the purpose of this presentation to demonstrate that the lectotype of *Globigerina quadrilobata* d'Orbigny, selected by Banner and Blow in 1960, is not a member of a syntypic series of *Globigerina quadrilobata* d'Orbigny, 1846.

SYSTEMATIC PALEONTOLOGY

Globigerina quadrilobata d'Orbigny, 1846

Text figures 1, 2

Globigerina quadrilobata D'ORBIGNY, 1846, Foraminifères, fossiles du bassin tertiaire de Vienne, p. 164, pl. 9, figs. 7-10.

not *Globigerina quadrilobata* d'Orbigny, BANNER and BLOW, 1960, Contr. Cushman Found. Foram. Research, vol. 11, pt. 1, pp. 17-18, pl. 4, fig. 3.

Taxonomic remarks.—As indicated by d'Orbigny, the types of this species were from marly plastic clays (Vindobonian age) from the environs of Nussdorf, Austria. Banner and Blow could not find specimens in the collections of d'Orbigny that compared with the figure of d'Orbigny so they selected a lectotype admittedly differing from the concept presented by figure and description by d'Orbigny.

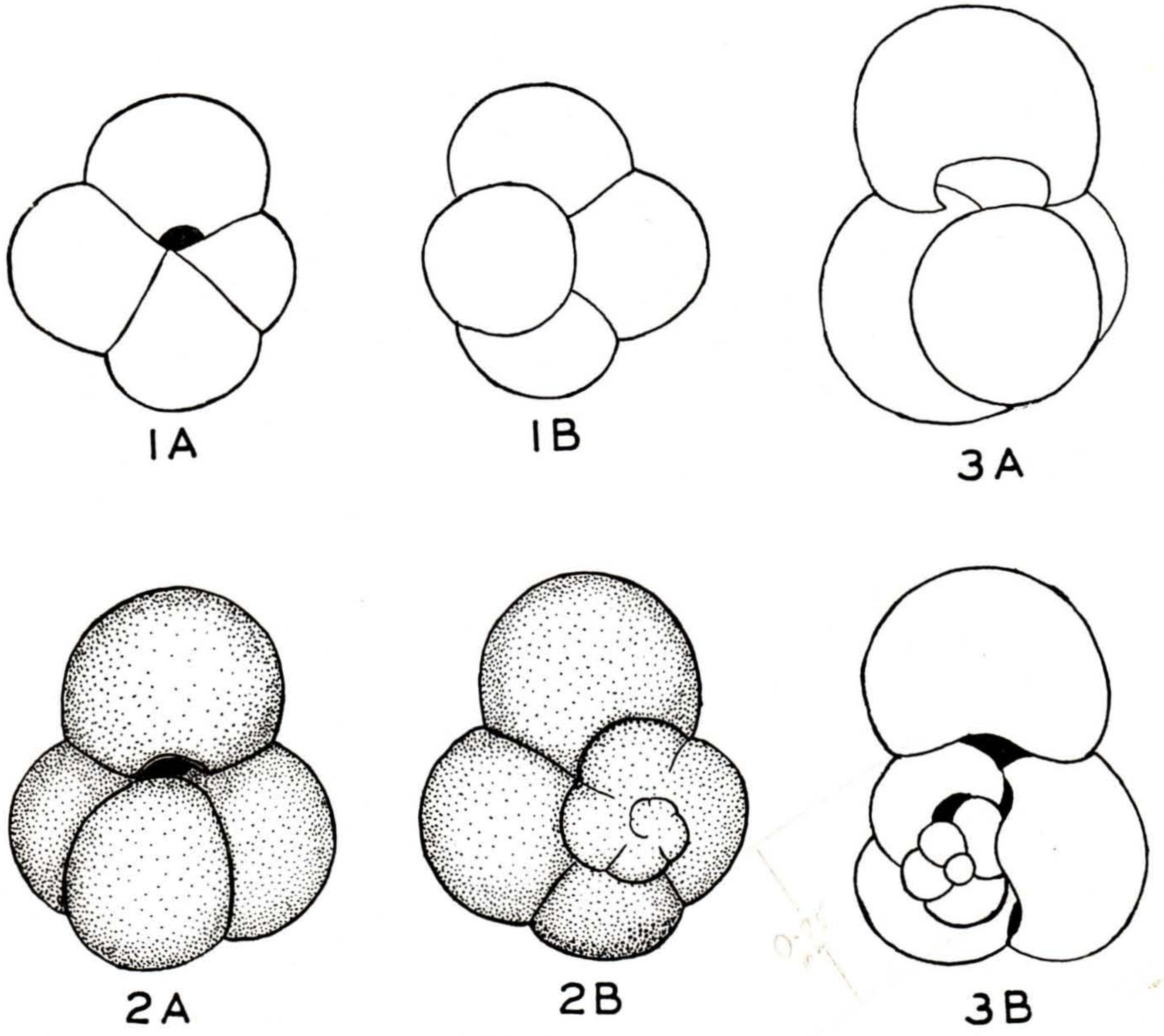
Samples of the marls of Nussdorf reveal specimens agreeing perfectly with d'Orbigny's figure in 1846. They have a primary aperture and they lack accessory apertures on the dorsal side, just as does the figured specimen of d'Orbigny (compare copy of d'Orbigny's figure herein with figure of a specimen from Nussdorf figured by this author). Banner and Blow selected as lectotype of this species a specimen which has marked dorsal accessory apertures and a much larger primary aperture. It is the opinion of this author that the specimen figured by Banner and Blow as a lectotype of *Globigerina quadrilobata* is actually *Globigerinoides triloba* (Reuss).[2] Their lectotype (outline copy of their lectotype is given in text fig. 3 herein) is a different species and it belongs in a different genus from the original of d'Orbigny—it cannot be a valid lectotype. From the presentation of Banner and Blow, apparently no syntypes exist in the collections of d'Orbigny. The original specimen which served for the illustration by d'Orbigny is hereby designated the lectotype of *Globigerina quadrilobata* d'Orbigny, 1846. This author has obtained specimens of this species from a number of European localities. The original designation and figure is adequate for understanding this species since identical specimens may be collected at the type locality.

Since Banner and Blow reported finding other species erected by d'Orbigny, *Orbulina bilobata* and *Globigerina bulloides,* in the tube with their lectotype, it is not reasonable to assume that d'Orbigny erected a new species based upon a mixture of his own earlier erected species. Such an assemblage in a tube labelled by Terquem is unacceptable as a type series. According to Article 72b of the International Code of Zoological Nomenclature, "The type-series of a species consists of all the specimens on which an author bases the species, except any that he refers to as variants, or doubtfully associates with the nominal species, or expressly excludes from it." In his own work, d'Orbigny excluded a number of the species reported in the tube which bears the label "*Globigerina quadrilobata* - etc." He would not have used such a grouping as a syntypic series. It must be assumed that the original collection has been tampered with and does not represent the same series upon which d'Orbigny based his species. Perhaps the original tube with d'Orbigny's label has been lost.

In summary, since (1) specimens cannot be found in d'Orbigny's collections which agree with the original

1 Contribution of the Allan Hancock Foundation No. 253.

2 A feminine ending is used here because **-oides**, an adjectival suffix meaning like, takes its gender from the gender of the generic name on which it is based (Nybakken, 1959, pp. 234, 235). It should be noted that the Botanical Code urges that all generic names ending in **-oides** shall be feminine (**See** article 75, Recommendation 75A, 4). The Zoological Code, conversely, has ruled on a masculine ending based upon the opinion of L. W. Grensted (Declaration 40, Opinions and Declarations Rendered by the International Commission on Zoological Nomenclature, vol. 19, part 14, p. xxiii, October 15, 1958). It is incorrect to say that all adjectives used as nouns are treated as masculine. **Editorial Note:** This violation of the I.C.Z.N. is permitted under protest, in the belief that it is better to change a rule than to break it.



TEXT FIGURES 1-3

Fig. 1. *Globigerina quadrilobata* d'Orbigny, 1846, copy of original figure by d'Orbigny (herein designated the lectotype) of a specimen from Tortonian marly clays near Nussdorf, Austria. 1a, ventral view, slightly oblique; 1b, dorsal view, slightly oblique; d'Orbigny showed a dorsal spire as a single chamber which is the general appearance of the spire unless special techniques are used to bring out the chambered structure there. No dorsal accessory apertures are figured nor are such features mentioned in the original description. Diameter 0.25 mm.

Fig. 2. *Globigerina quadrilobata* d'Orbigny, 1846, hypotype, U.S.C. No. 1080, from Tortonian marly clays near Nussdorf, Austria. 2a, ventral view; 2b, dorsal view. The figured topotype is deposited in the collections of the micropaleontology laboratory, Allan Hancock Foundation, University of Southern California. Diameter 0.30 mm.

Fig. 3. *Globigerinoides triloba* (Reuss), 1850, outline copy of figured lectotype of *Globigerina quadrilobata* d'Orbigny, 1846, by Banner and Blow, 1960. Note the marked development of accessory apertures on the dorsal side in contrast to the absence of these features in *Globigerina quadrilobata.* This figure represents a different species and it belongs in a different genus from that indicated by Banner and Blow. Maximum diameter 0.57 mm.

description and figure of *Globigerina quadrilobata* and (2) the only tube with this label contains a mixture of d'Orbigny's own species, it must be assumed that the original series of specimens serving as the basis for *Globigerina quadrilobata* has been lost. A specimen selected from such a mixture as the lectotype by Banner and Blow, which is so different from the original figure and description by d'Orbigny, cannot serve as a valid lectotype.

REFERENCES CITED

BANNER, F. T., and BLOW, W. H., 1960, Some primary types of species belonging to the superfamily Globigerinaceae: Contr. Cushman Found. Foram. Research, vol. 11, pp. 1-41, pls. 1-8.

NYBAKKEN, O. E., 1959, Greek and Latin in scientific terminology: Iowa State College Press, Ames, Iowa, 321 pp.

CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
VOLUME XV, PART 1, JANUARY, 1964

281. *GAUDRYINA KOREAENSIS*, A NEW NAME FOR *GAUDRYINA CONVEXA* CUSHMAN, 1911

N. DE B. HORNIBROOK
New Zealand Geological Survey

During a revision of the Lower Miocene Foraminifera collected from the Orakei Greensand, Orakei Bay, New Zealand, by the Novara-Expedition, currently being carried out in the British Museum of Natural History, the writer has determined beyond doubt that the type of *Textilaria convexa* Karrer (1865, p. 78, pl. 16, fig. 8) is a *Gaudryina*. A revised description and illustrations are being prepared for publication elsewhere.

A different species of *Gaudryina* from Albatross station D4878, in 59 fathoms in the eastern channel of the Korean Strait, was named *Gaudryina convexa* by Cushman (1911, p. 66, fig. 105). Miss Ruth Todd has kindly examined the type of *G. convexa* Cushman in the collections of the U. S. National Museum in Washington, and has confirmed that it is a *Gaudryina*. The name *Gaudryina convexa* Cushman is therefore a subjective homonym of *Gaudryina convexa* (Karrer) and requires renaming.

The name *Gaudryina koreaensis* is proposed, therefore, to replace *Gaudryina convexa* Cushman, 1911.

REFERENCES

CUSHMAN, J. A., 1911, Monograph of the Foraminifera of the North Pacific Ocean; Part II - Textulariidae: U. S. Natl. Mus. Bull. No. 71, pt. 2, pp. 1-108.

KARRER, F., 1865, Die Foraminiferen-Fauna des Tertiären Grünsandsteines der Orakei-Bei Auckland: Novara-Exped. Geol. Theil. Bd. 1, Abth. 2, pp. 71-86.

CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
VOLUME XV, PART 1, JANUARY, 1964

RECENT LITERATURE ON THE FORAMINIFERA

Below are given some of the more recent works on the Foraminifera that have come to hand.

AKIMEZ, V. S. Stratigrafija i Foraminifery Verkhnemelovykh Otlozhenij Belorussii.—Akad. Nauk Belorusskoy SSR, Instit. geol. nauk, Sbornik 3, Minsk, 1961, p. 1-245, pls. 1-19, text figs. 1-8 (maps), tables 1-7.—Illustrated systematic catalog of about 110 species and varieties (20 species and 3 varieties new) from Belorussia. The sequence, lower Cenomanian to Maestrichtian, is partitioned into 14 subdivisions and their characteristic Foraminifera are listed.

ALEKSEEVA, L. V. Nekotorye Kharakternye Vidy Foraminifer iz Nizhnego Mela Zapadnoj Turkmenii.—Akad. Nauk SSSR, Kompleksnoj Juzhnoj Geol. Eksped. (Kule), Trudy, vyp. 8, 1962, p. 529-534, pl. 1.—Five agglutinated species (2 new) and 1 new variety from the Lower Cretaceous of western Turkmenistan.

ALEXANDROWICZ, STEFAN WITOLD, and GEROCH, STANISLAW. Association de petits Foraminifères dans l'Eocene de la Tatra (French summary of Polish text).—Ann. Soc. Géol. Pologne, v. 33, fasc. 2, 1963, p. 219-228, text figs. 1-3 (correl. chart, graph, drawings), table 1.—An association of smaller Foraminifera, rich in planktonic kinds, found intercalated with nummulitic beds, is placed in the lower part of the upper Eocene.

ALIJULLA, KH. Analiz Foraminifer i Nekotorye Voprosy Paleobionomii v Verkhnemelovuju Epokhu v Vostochnykh Predgor'jakh Malogo Kavkaza.—Akad. nauk Azerbaidzh. SSR, Baku, ser. geol.-geogr. nauk i nefti, Izvest., No. 2, 1963, p. 39-46, figs. 1, 2 (graphs), table.—Some quantitative analyses bearing on paleoecology of a section from Cenomanian to Danian.

ANDERSON, GORDON J. Distribution patterns of Recent Foraminifera of the Bering Sea.—Micropaleontology, v. 9, No. 3, July 1963, p. 305-317, pl. 1, text figs. 1-12 (maps, graphs), table 1.—Six biotopes (deltaic, transitional, inner shelf, central shelf, outer shelf, and upper bathyal) are recognized in the eastern part of the Bering Sea. Samples from 29 stations between 12 and 250 meters are involved, and 68 species are recorded quantitatively.

ANDROSSOVA, V. P. Foraminifery Donnykh Otlozhenij Zapadnoj Chasti Poljarnogo Bassejna.—Vses. Nauchno-Issled. Instit. Morsk. Ryb. Khoz. Okean. (VNIRO), Trudy, tom 46, 1962, p. 102-117, text figs. 1-17, tables 1-4.—Quantitative analysis of Foraminifera from 7 short cores taken around 4,000 meters in the western part of the Polar Basin. *Globigerina polusi* Androssova sp. n. is described.

ANDRUSOV, DIMITRIJ, and KÖHLER, EDUARD. Nummulites, faciès et développement prétectonique des Karpates occidentales centrales au Paléogène. —Geol. Sbornik, Bratislava, roc. 14, cis. 1, June 1963, p. 175-192, text figs. 1-6 (maps, geol. sections), table 1.

ANDRUSOV, DIMITRIJ, and SCHEIBNEROVA, VIERA. On the origin of redepositions of Foraminifera in the Cretaceous and Paleogene of Carpathians.—Geol. Sbornik, Bratislava, roc. 14, cis. 1, June 1963, p. 145-148.

AYALA-CASTANARES, AGUSTIN. Foraminiferos Grandes del Cretacico Superior de la region central del estado de Chiapas, Mexico. Part 1. El genero *Orbitoides* d'Orbigny, 1847.—Univ. Nac. Auto. de Mexico, Instit. Geol., Paleont. Mex. No. 13, 1963, p. 57-73, pls. 1-5, text figs. 1-3 (map, table of characters, graph).—Descriptions and illustrations of two species.

BANDY, ORVILLE L. Cenozoic planktonic foraminiferal zonation and basinal development in Philippines.—Bull. Amer. Assoc. Petr. Geol., v. 47, No. 9, Sept. 1963, p. 1733-1745, text figs. 1-8 (maps, range chart, correl. chart, columnar sections, graphs).—Two basins underwent parallel development (beginning with shelf conditions and deepening to bathyal deposition) during late Oligocene to late Miocene. Subsequently one basin underwent filling to shallow-water facies during late Miocene while in the other basin deep conditions prevailed until middle Pliocene. Restricted ranges and approximate correlations with West Indian, European, and East Indian zonations are shown for 25 planktonic species and 3 benthonic ones between Chattian and Pleistocene. Thirteen local Assemblage Zones (based on species and/or coiling directions) are recognized and used in interbasin correlation.

BERMÚDEZ, PEDRO JOAQUIN, and DE RIVERO, FRANCES CHARLTON. Estudio Sistematico de los Foraminiferos quitinosos, micrograniulares y arenaceos.—Universidad Central de Venezuela, 1963, 398 p., 35 text figs.—Includes the superfamilies Lagynidea, Astrorhizidea, Endothyridea, and Lituolidea.

BIEDA, FRANCISZEK. Septième niveau de grands Foraminifères dans le Flysch des Karpates Polonaises

(French summary of Polish text).—Ann. Soc. Géol. Pologne, v. 33, fasc. 2, 1963, p. 189-218, pls. 11-14, table 1.—Oligocene nummulites.

BIGNOT, GÉRARD, and POISSON, ANDRÉ. Les Foraminifères du Callovo-Oxfordien des environs de Mamers (Sarthe).—Bull. Soc. Linné. Normandie, ser. 10, v. 3, Année 1962 (1963), p. 96-102, geol. section.—Lists of Foraminifera.

BLUMENSTENGEL, HORST. Zur Mikrofauna des Thüringer Ockerkalkes (Silur).—Geologie, Berlin, Jahrg. 12, heft 3, April 1963, p. 349-354, text figs. 1, 2.—Silicified specimens of Foraminifera are identified with 3 already-known North American Silurian species.

BOGUSH, O. I. Pozdnekamennougol'naja Foraminifera *Lasiodiscus alaicus* sp. nov.—Akad. Nauk SSSR, Paleont. Zhurnal, No. 3, 1961, p. 122-124, fig. 1.

BOGUSH, O. I., and YUFEREV, O. V. Foraminifery i stratigrafija Kamennougol'nykh Otlozhenij Karpatau i Talasskogo Alatau.—Akad. Nauk SSSR, Sibirskoe Otdel., Instit. Geol. Geofiz., 1962, p. 1-234, pls. 1-9, text figs. 1-9 (map, range charts, columnar sections), tables 1-3.—Illustrated systematic catalog includes almost 200 Carboniferous species, 24 new.

BRÖNNIMANN, PAUL, and RIGASSI, DANILO. Contribution to the geology and paleontology of the area of the city of La Habana, Cuba, and its surroundings.—Eclogae Geol. Helvetiae, v. 56, No. 1, 1963, p. 193-480, pls. 1-26 [pls. 1-6, correl. chart, geol. maps; pls. 7-9, photos of rock surfaces; pls. 10-15, discoasters; pls. 16-26, planktonic Foraminifera], text figs. 1-75 (geol. sections, maps, photos, columnar sections).—Planktonic Foraminifera are listed from many stations. About 40 diagnostic species are illustrated from rocks between Cenomanian and Miocene in age.

BROWNE, RUTH G., and HERRICK, STEPHEN M. Smaller Paleocene Foraminifera from Reidland, Kentucky.—Bull. Am. Paleontology, v. 46, No. 210, Aug. 23, 1963, p. 243-284, pls. 53-57, text figs. 1, 2 (map, columnar section).—An illustrated systematic catalog of about 60 species, represented by acid-insoluble replacements.

BROWNE, RUTH G., and SCHOTT, VIRGINIA J. Arenaceous Foraminifera from the Osgood Formation at Osgood, Indiana.—Bull. Am. Paleontology, v. 46, No. 209, July 15, 1963, p. 187-242, pls. 48-52, text fig. 1 (map), text pl. 1 (columnar section), table 1 (distrib. chart).—Illustrations and descriptions of 63 species of arenaceous Foraminifera from the Silurian. Twelve species are new and *Metamorphina* n. gen. (type species *Webbinella tholus* Moreman) is erected.

BUTTERLIN, JACQUES. A propos de l'Oligocène de la région des Caraïbes.—Bull. Soc. géol. France, ser. 7, tome 4, 1962, p. 390-393.—In Mexico and Haiti the Oligocene is recognized and separated into upper and lower zones on the basis of larger Foraminifera.

CARALP, MICHELLE, JULIUS, CHARLES, and VIGNEAUX, MICHEL. Considérations stratigraphiques sur le Miocène supérieur et le Pliocène marins en Aquitaine occidentale.—Soc. Belge Geol., Paleont. et Hydro., Bruxelles, Mem. No. 6, 1962 (March 30, 1963), p. 146-166, columnar sections.—Lists of Foraminifera in drillings from 5 well sections penetrating from Quaternary to upper Miocene (Girondian).

DAS, SAILENDRA KUMAR. Foraminifera and its stratigraphic significance—an analytical resume.—Jour. Bhu-Bijnan Parishad, Jadavpur Univ., v. 1, Aug. 1960, p. 16-22.—Characteristic species in Upper Cretaceous to Eocene of India and Pakistan.

DESSAUVAGIE, T. F. J. On the occurrence of *Neotrocholina* in Turkey.—Bull. Min. Res. Explor. Instit. Turkey, No. 60, April 1963, p. 71-75, pls. 1, 2, text figs. 1-6.—In limestones dated as Upper Malm (Tithonian)-Valanginian.

DESSAUVAGIE, T. F. J., and DAGER, ZEKI. Occurrences of Lasiodiscidae in Anatolia.—Bull. Min. Res. Explor. Instit. Turkey, No. 60, April 1963, p. 76-84, pls. 1-4, text figs. 1-12.—Seven species, 1 new and 2 indeterminate, in Carboniferous and Permian limestones.

DROOGER, C. W., and FELIX, R. Quelques observations paléo-écologiques sur des faunes de Foraminifères du Miocène nordique.—Soc. Belge Geol., Paleont. et Hydro., Bruxelles, Mem. No. 6, 1962 (March 30, 1963), p. 121-124, graphs.—In a section at Dingden, quantitative analysis reveals fluctuations of many species and increase upward of *Asterigerina gürichi* and decrease upward of *Spiroplectammina carinata* and *Martinottiella communis*.

DU BAR, JULES R., and HOWARD, JAMES F. Paleoecology of the type Waccamaw (Pliocene?) outcrops; South Carolina.—Southeastern Geology (Duke Univ.), v. 5, No. 1, Sept. 1963, p. 27-68, text figs. 1-3 (maps, columnar section), tables 1-10.—Interpretation of deposition in open unrestricted ocean on the inner shelf or shallow part of the intermediate shelf is based on associated mollusk and foram faunas. Includes an annotated list of 23 indicator species plus a quantitative checklist of the total fauna of about 60 species of smaller Foraminifera, none new, found in 3 sections.

EHREMEEVA, A. I., and BELOUSOVA, N. A. Stratigrafija i Fauna Foraminifer Melovykh i Paleo-

genovykh Otlozhenij Vostochnogo Sklona Urala, Zaural'ja i Severnogo Kazakhstana.—Minist. Geol. Okhrany Nedr SSSR, Ural'skoe Geol. Upravlenie, vyp. 9, 1961, p. 3-112, pls. 1-38, text figs. 1-7 (maps, illustrated columnar section, distrib. and abund. tables).—Illustrated systematic catalog of 125 species and varieties (52 species and 4 varieties new) from sections in the eastern Urals and northern Kazakh. Ten Foraminifera zones are recognized between Albian and Oligocene.

Espitalié, J., and Sigal, J. Contribution a l'étude des Foraminifères (Micropaléontologie-Microstratigraphie) du Jurassique Supérieur et du Néocomien du Bassin de Majunga (Madagascar).—Ann. Géol. Madagascar, fasc. no. 32, 1963, p. 1-100, pls. 1-36, 4 figs. (map, columnar sections, range chart).—Systematic catalog includes 172 species (50 new and 56 indeterminate) and 8 varieties (4 new), illustrated by beautiful photographs.

Faulkner, J. S., de Klasz, I., and Rérat, D. *Megastomella* nov. gen., nouveau Foraminifère de l'Afrique Occidentale.—Revue de Micropaléontologie, v. 6, No. 1, June 1963, p. 19-22, pl. 1, fig. 1 (map).—*Megastomella africana* n. sp. and *compressa* n. subsp., respectively from Gabon and eastern Nigeria, of early Miocene age. The genus also includes *Pulvinulinella purisima* Bramlette.

Foury, Geneviève. Deux nouvelles espèces d'Orbitolinidae du faciès urgonien des Alpilles (Bouches-du-Rhône).—Revue de Micropaléontologie, v. 6, June 1963, p. 3-12, pls. 1-3, text figs. 1, 2 (graphs).—*Dictyoconus cuvillieri* and *Coskinolina alpillensis*.

Fursenko, A. V., and Fursenko, K. B. Foraminifery Verkhnego Eothena Belorussii i iz Stratigraficheskо Znachenie.—Akad. Nauk Belorusskoy SSR, Instit. geol. nauk, Sbornik 3, Minsk, 1961, p. 246-347, pls. 1-10, text fig. 1 (map).—Illustrated systematic catalog of about 55 species (12 new) from the upper Eocene of Belorussia.

Gendrot, Cécile. Quelques Foraminifères nouveaux du Sénonien inférieur des Martigues (Bouches-du-Rhône).—Revue de Micropaléontologie, v. 6, No. 1, June 1963, p. 67-72, pls. 1, 2.—*Tetraminouxia* n. gen. (type species *T. gibbosa* n. sp.) and 2 new species of *Minouxia,* all finely agglutinated forms belonging in the Verneuilinidae.

Geroch, Stanislaw, and Nowak, Wieslaw. Lower Cretaceous in Lipnik near Bielsko, western Carpathians (English summary of Polish text).—Ann. Soc. Géol. Pologne, v. 33, fasc. 2, 1963, p. 241-264, text figs. 1-7 (map, geol. maps, columnar sections, correl. chart, drawings), tables 1, 2. —Distribution and abundance of 35 species of Foraminifera in a section from Hauterivian to Albian.

Gohrbandt, Klaus. Zur Gliederung des Paläogen im Helvetikum nördlich Salzburg nach planktonischen Foraminiferen (in German with English summary).—Mitteil. Geol. Gesellschaft Wien, Band 56, heft 1, June 1963, p. 1-116, pls. 1-11, text figs. 1-7 (maps, geol. sections, line drawings), table 1.—By planktonics, 6 zones are established —corresponding with the Danian, Montian, Thanetian (2 zones), Ilerdian, and Cuisian. Described and illustrated are 27 species (2 new) and 7 subspecies (1 new) of planktonics and 5 species and 1 subspecies of nummulites.

Graham, Joseph J., and Church, Clifford C. Campanian Foraminifera from the Stanford University Campus, California.—Stanford Univ. Publ., Geol. Sci., v. 8, No. 1, 1963, p. 1-107, pls. 1-8, text figs. 1, 2 (maps).—Illustrated systematic catalog includes 150 species, none new, 54 indeterminate.

Grigorjan, S. M. Nummulity Gorizonta s *Nummulites millecaput* iz Verkhneeothenovykh Otlozhenij Armjanskoj SSR.—Akad. Nauk Armjans. SSR, Izvestija, tom 14, No. 1, 1961, p. 7-24, pls. 1-3.—Three species and a new variety of another species from the upper Eocene of Armyansk.

Groiss, Josef Th. Geologische und mikropaläontologische Untersuchungen im Juragebiet westlich von Neuburg an der Donau.—Erlanger Geol. Abhandl., Heft 48, April 29, 1963, p. 1-53, pls. 1-3 (drawings, geol. map, columnar section and range chart), text figs. 1-11 (columnar sections, graphs, drawings), tables 1-13.—A rich middle Tithonian fauna reported with a few forms described and illustrated, including 9 new species, 1 new name, and 2 new subspecies.

Haake, Friedrich-Wilhelm. Untersuchungen an der Foraminiferen-Fauna im Wattgebiet zwischen Langeoog und dem Festland.—Meyniana, Univ. Kiel Geol. Inst., band 12, Dec. 1962, p. 25-64, pls. 1-6, text figs. 1-9 (map, graphs), tables 1-5.—Quantitative analysis of living and dead tests in 4 facies (mud, mixed, sand, and channel) in a tidal flat area. A total of 61 species are reported but only 7 occur in significantly varying quantities. A new *Elphidium* is described.

Hanzlikova, Eva, and Roth, Zdenek. Review of the Cretaceous stratigraphy of the Flysch zone in West Carpathians.—Geol. Sbornik, Bratislava, roc. 14, cis. 1, June 1963, p. 37-81, text figs. 1-7 (correl. charts, graphs, maps), tables 1-17.—Benthonic and planktonic Foraminifera are listed from many units between Valanginian and Maestrichtian.

Hanzlikova, Eva, Roth, Zdenek, and Gabrielova, Nadezda. A note to the stratigraphy and occur-

rence of the Tertiary autochthonous sediments of the Bohemian massif in the substratum of the Moravia-Silesian Beskids.—Geol. Sbornik, Bratislava, roc. 14, cis. 1, June 1963, p. 193-207, pls. 5-10, text figs. 1, 2 (geol. map, geol. section), table 1 (occur. chart).—Occurrence of Foraminifera in Eocene and Paleocene of deep bore holes.

HERRICK, STEPHEN M., and VORHIS, ROBERT C. Subsurface geology of the Georgia coastal plain.—Georgia State Div. Cons., Geol. Survey Information Circ. 25, 1963, p. 1-78, text figs. 1-28 (maps, geol. sections), tables 1-12.—Foraminifera listed from Oligocene, upper Eocene, middle Eocene, lower Eocene, Paleocene, post-Tuscaloosa Cretaceous, and marine Tuscaloosa.

HOFKER, JAN. *Cassigerinella* Pokorny, 1955, and *Islandiella* Norvang, 1958.—Micropaleontology, v. 9, No. 3, July 1963, p. 321-324, pl. 1.—Interpreted as belonging in the Cassidulinidae, with the latter a synonym of the former.

HOFKER, JAN, JR. Studies on the genus *Orbitolina* (Foraminiferida).—Thesis Rijksuniv. Leiden, 1963, p. 183-253, pls. 1-23, text figs. 1-24 (maps, columnar sections, drawings), chart I-X (graphs).—In this detailed monographic study all formerly recognized species are combined as one species, *O. lenticularis* (Blumenbach), which is in turn subdivided into 5 form-groups.

HUANG, TUNYOW. A bibliography of Foraminifera from Taiwan (1900-1962).—The Formosan Science, v. 17, No. 2, 1963, p. 55-62.

ISHIZAKI, KUNIHIRO. Verbeekininae from the inferred Upper Wolfcampian limestone in the west of Ryoseki, Kochi Prefecture.—Trans. Proc. Pal. Soc. Japan, n. ser., No. 50, June 10, 1963, p. 51-64, pl. 9, text fig. 1 (map), tables 1-5.—Five species, 2 new.

KAEVER, MATTHIAS. Über den Generationswechsel bei *Globorotalites* Brotzen (Kreide-Foram.).—Abhandl. Neues Jahrb. Geol. Paläont., Band 117 (Festband Lotze), April 1963, p. 160-168, text figs. 1-3 (graphs, drawings).—Concerning the dimorphism of this genus.

KENNETT, J. P. Evolution of *Textularia kapitea* Finlay, Cape Foulwind, New Zealand.—New Zealand Jour. Geol. Geophys., v. 6, No. 2, May 1963, p. 257-260, text figs. 1, 2, table 1.—Evolution proceeds from *T. miozea* in the upper Miocene to *T. kapitea maritima* n. subsp. in the lower Pliocene through suppression of peripheral spines, rounding of periphery, and decrease in width/depth ratio.

DE KLASZ, I., and RERAT, D. The stratigraphic range of the foraminiferal genus *Gabonella* in the Upper Cretaceous of Gabon (Equatorial Africa).—Micropaleontology, v. 9, No. 3, July 1963, p. 325, text fig. 1 (range chart).—Restricted ranges between Cenomanian and Maestrichtian are given for 9 species and a subspecies.

KRISTAN-TOLLMANN, EDITH. Entwicklungsreihen der Trias-Foraminiferen.—Paläont. Zeitschr., Band 37, No. 1/2, June 1963, p. 147-154, pls. 8, 9 (development-series chart, range chart).—Two new families (Trocholinidae and Variostomidae) are named. Reported ranges between upper Ladinian and Rhaetian are shown for 14 species of the Variostomidae.

KUWANO, YUKIO. Foraminiferal biocoenoses of the seas around Japan, a survey of Pacific-side biocoenoses.—Misc. Repts. Research Instit. Nat. Resources, Nos. 58-59, May 25, 1962, p. 116-138, pls. 14-24, text figs. 1-10 (maps, graphs), tables 1-6.—This first section of the study concerns Kagoshima Bay, an elongate narrow bay attaining depths over 200 meters, constricted by a threshold of 85 meters depth, and with an inner basin of calderan origin separated off by recent volcanism. Quantitative and qualitative analysis is based on 22 samples and involves over 500 species. In the bay 6 biocoenoses are recognized and many species are listed and illustrated.

LE CALVEZ, YOLANDE. Contribution à l'étude des Foraminifères de la région d'Abidjan (Côte d'Ivoire).—Revue de Micropaléontologie, v. 6, No. 1, June 1963, p. 41-50, pls. 1, 2, text fig. 1 (map).—Illustrations of 6 large arenaceous species and a list of the accompanying species in 6 samples from 40 to 200 meters.

LESLIE, R. J. Foraminiferal study of a cross-section of Hudson Bay, Canada.—Geol. Survey Canada, Paper 63-16, 1963, p. 1-28, text figs. 1-5 (maps, distrib. table, graphs).—Quantitative analysis of 62 species from 8 stations in an east-west cross-section reveals 3 distinctive faunas: near shore, central basin, and central high.

LLOYD, ADRIAN J. Fusulinids from the Zinnar Formation (Lower Permian) of northern Iraq.—Jour. Paleontology, v. 37, No. 4, July 1963, p. 889-899, pls. 116-120, text figs. 1, 2 (graphs).—Includes 3 new species.

MAMGAIN, V. D., and JAGANNATHA RAO, B. R. A note on the Orbitolines from Dras, J. and K. State.—Indian Minerals, Geol. Survey of India: Calcutta, v. 16, No. 2, April-June 1962, p. 184-186, pl. 6.—*Orbiqia drasensis* gen. et sp. nov., a genus intermediate between *Orbitolina* and *Iraqia*, ranging from Barremian to Albian.

MARTINI, JACQUES. Étude de la repartition des Nummulites Priaboniennes et Oligocène dans les massifs des Bornes et des Bauges (Savoie).—Archives des Sciences, Soc. Phys. Hist. Nat. Genève, v. 15,

fasc. 3, Sept.-Dec. 1962 (1963), p. 509-528, pls. 1-4, text figs. A, B (columnar sections, map).—Seven species of *Nummulites*.

MASLAKOVA, N. I. Raschlenenie Al'b- Senomanskykh Otlozhenij Utesovoj Zony Karpat po Foraminiferam.—Vestnik Moskovskogo Universiteta, ser. 4, Geol., No. 3, 1963, p. 44-48, tables 1, 2.—Occurrence of species in upper Albian and lower and upper Cenomanian.

McLEAN, JAMES D., JR. A study of the forms referred to *Ceratobulimina eximia* in America.—Repts. McLean Paleontological Lab., No. 5, 1963, p. 1-66, pls. 1-3, other illustr., 3 correl. charts.—Restudy results in abandonment of *C. eximia* and reclassification into 3 species (2 new and *C. stellata* Bandy), each one presumably establishing a subzone within the former *Ceratobulimina eximia* zone.

Two new species of Foraminifera from the Cretaceous of New Jersey.—Repts. McLean Paleontological Lab., No. 5, 1963, p. 67-71, pl. 4.

MOROZOVA, V. G. Datsko-Montskie Planktonnye Foraminifery Juga SSSR.—Akad. Nauk SSSR, Paleont. Zhurnal, No. 2, 1961, p. 8-19, pls. 1, 2.—Descriptions and illustrations of 13 species and 1 subspecies (all new) from the Danian and Montian of southern USSR.

NARCHI, WALTER. Sobre Nonionidae, Globorotalidae e Orbulinidae Recentes do Brasil.—Bol. Instit. Oceanografico, tomo 12, fasc. 3, 1962, p. 23-47, pls. 1-3.—Illustrations and descriptions of 29 species from 10 samples between 30 and 150 meters on the continental shelf. A new species of *Elphidium* is described.

D'ORBIGNY, ALCIDE. Foraminifères Fossiles du Bassin Tertiaire de Vienne (Autriche). Die Fossilen Foraminiferen des Tertiaeren Beckens von Wien.—Reprinted by offset: Classics in Paleontology, No. 2, 1963, McLean Paleontological Laboratory, Alexandria, Virginia, 312 p., 21 pls.

PAPP, A. Die Foraminiferenfauna, *in* BACHMANN, A., PAPP, A., and STRADNER, H., Mikropaläontologische Studien im "Badener Tegel" von Frättingsdorf N. Ö.—Mitteil. Geol. Gesellschaft Wien, Band 56, heft 1, June 1963, p. 119-120, pl. 1.—Illustrations of a few species.

Die biostratigraphische Gliederung des Neogens im Wiener Becken.—Mitteil. Geol. Gesellschaft Wien, Band 56, heft 1, June 1963, p. 225-317, pls. 1-14, tables 1, 2.—Includes descriptions and illustrations of about 40 species (1 new) and 13 subspecies (6 new), mostly in 3 groups: planktonics, *Uvigerina*, and *Elphidium*.

PERCONIG, ENRICO. Sur la constitution géologique de l'Andalousie Occidentale en particulier du bassin du Guadalquivir.—Livre a la mémoire du Professeur Paul Fallot, tome I, 1960-1962 (Soc. Géol. France), p. 229-256, text figs. 1-6 (map, geol. maps, columnar sections, geol. sections).—Lists of Foraminifera from various levels in many borings, ages from Paleozoic to Quaternary.

PETRUCCI, FRANCO. Segnalazione del genere *Cuvillierina* Debourle nel Flysch Eocenico della Val Baganza (Parma).—Atti Soc. Ital. Sci. Nat., v. 102, fasc. 1, March 1963, p. 75-82, pl. 12, text fig. 1 (map).

PISCHVANOVA, L. S. Novyj Gel'vetskij vid Foraminifer —*Quinqueloculina distorta*.—Akad. Nauk SSSR, Paleont. Zhurnal, No. 3, 1961, p. 124-125, text fig. 1.—From the Helvetian.

POKORNY, VLADIMIR. Principles of Zoological Micropaleontology. Volume I (translated by K. A. Allen, edited by John W. Neale).—Oxford, England, Pergamon Press, 1963, 652 p., 549 text figs.

PRONINA, M. T. Novye Predstaviteli Roda *Nonion* v Miothenovykh Otlozhenijakh Nakhichevanskoj ASSR.—Akad. nauk Azerbaidzh. SSR, Baku, ser. geol.-geogr. nauk i nefti, Izvest., No. 1, 1963, p. 29-36, 1 pl.—Four species and 2 varieties, all new, are described from the Miocene.

PUTRJA, F. S. Novye Predstaviteli Miliolid iz Verkhnejurskikh i Nizhnemelovykh Otlozhenij Zapadnoj Sibiri.—Akad. Nauk SSSR, Sibirskoe Otdel., Geol. Geofiz., No. 4, 1963, p. 100-108, 1 pl., text fig. 1. —Five new species of *Quinqueloculina*, 3 from the Upper Jurassic and 2 from the Lower Cretaceous.

RABITZ, GISELA. Foraminiferen des Göttinger Lias.—Paläont. Zeitschr., Band 37, No. 3/4, Aug. 1963, p. 198-224, pls. 16, 17.—Material from a new well is compared with Bornemann's 1854 report. Eighteen species and 6 subspecies are described and illustrated, and the entire fauna is listed.

RAUZER-CHERNOUSSOVA, D. M. Der Schwagerinen-Horizont und die Obere Grenze des Karbon.—Quatrième Congrès pour l'avancement des études de stratigraphie et de géologie du Carbonifère, Heerlen, 15-20 Sept. 1958, Compte Rendu, tome 3, 1962, p. 577-589, text figs. 1-4 (phylogenetic diagram, paleogeographic map, graphs, correl. table).—The boundary between Middle and Upper Carboniferous is marked by the appearance of the Schwagerinidae and disappearance of Fusulinidae.

REITLINGER, E. A. Limits of Lower Carboniferous in stratigraphic diagram of the USSR based on foraminiferal fauna.—Quatrième Congrès pour l'avancement des études de stratigraphie et de géologie du Carbonifère, Heerlen, 15-20 Sept. 1958, Compte Rendu, tome 3, 1962, p. 591-598, text fig. 1 (phylogenetic diagram).

ROZOVSKAJA, S. E. K Sistematike Semejstv Endothyridae i Ozawainellidae.—Akad. Nauk SSSR, Paleont. Zhurnal, No. 3, 1961, p. 19-21.—*Endostaffella* gen. nov. (type species *Endothyra parva* Möller, 1880) and *Mediocris* gen. nov. (type species *Eostaffella mediocris* Vissarionova, 1948).

SALAJ, JOZEF, and SAMUEL, ONDREJ. Contribution to the stratigraphy of Cretaceous of the Klippen Belt and central West Carpathians.—Geol. Sbornik, Bratislava, roc. 14, cis. 1, June 1963, p. 109-125, pls. 1, 2.—Characteristic Foraminifera species are listed.

SAMUEL, ONDREJ, and SALAJ, JOZEF. Contribution to Paleogene of Myjavska Pahorkatina, vicinity of Povazska Bystrica, Zilina and eastern Slovakia.—Geol. Sbornik Bratislava, roc. 14, cis. 1, June 1963, p. 149-163, pls. 3, 4, text figs. 1-5.—Lists of characteristic planktonic Foraminifera from 8 age divisions between upper Maestrichtian and lower Oligocene.

SCHEIBNEROVA, VIERA. Cretaceous stratigraphy and Cretaceous-Tertiary boundary in the klippen belt of West Carpathians.—Geol. Sbornik, Bratislava, roc. 14, cis. 1, June 1963, p. 127-138, map.—Characteristic Foraminifera species are recorded.

Some new Foraminifera from the middle Turonian of the klippen belt of West Carpathians in Slovakia.—Geol. Sbornik, Bratislava, roc. 14, cis. 1, June 1963, p. 139-143, text figs. 1-3.—Three new species.

SEIGLIE, GEORGE A., and AYALA-CASTANARES, AGUSTIN. Sistematica y Bioestratigrafia de los Foraminiferos Grandes del Cretacico Superior (Campaniano y Maastrichtiano) de Cuba.—Univ. Nac. Auto. de Mexico, Instit. Geol., Paleont. Mex. No. 13, 1963, p. 1-56, pls. 1-43, text figs. 1-5 (distrib. table, range chart, graph, tables of characters).—Illustrated systematic catalog of 52 species, subspecies, varieties and forma (3 species and 2 subspecies new). Zonation by larger Foraminifera with one zone in the Campanian and two in the Maestrichtian.

SKINNER, HUBERT C. A new species of Foraminiferida from the Miocene of South Louisiana.—Tulane Studies in Geol., v. 1, No. 4, Aug. 22, 1963, p. 149-150, text figs. 1, 2.

SOUAYA, FERNAND JOSEPH. Micropaleontology of four sections south of Qoseir, Egypt.—Micropaleontology, v. 9, No. 3, July 1963, p. 233-266, pls. 1-8, text figs 1-3 (geol. map, columnar sections, distrib. chart).—From the interval middle Miocene to Pleistocene 45 species (1 new *Borelis*) are reported and many illustrated in thin section.

TISCHLER, HERBERT. Fossils, faunal zonation, and depositional environment of the Madera Formation, Huerfano Park, Colorado.—Jour. Paleontology, v. 37, No. 5, Sept. 1963, p. 1054-1067, pls. 139-142, text figs. 1-6 (geol. map, columnar sections, correl. table, geol. section, check list, drawings).—Includes illustrations of fusulinids.

TURNOVSKY, KURT. Zonengliederung mit Foraminiferenfaunen und Ökologie im Neogen des Wiener Beckens (in German with English summary).—Mitteil. Geol. Gesellschaft Wien, Band 56, heft 1, June 1963, p. 211-224.—Interpretations of depth and other ecologic features of the Tortonian and Sarmatian Seas.

VDOVENKO, M. V. Opis Novikh Vidiv Foraminifer z Verkhn'oturnejs'kikh ta Nizhn'ovizejs'kikh Vidkladiv Doneth'kogo Basejnu.—Visnik Kijvs'kogo Univers. No. 3, 1960, ser. geol. geogr., vyp. 2, 1961, p. 30-37, pls. 1, 2.—Eight species (3 new and 3 indeterminate) and 1 new subspecies in the upper Tournaisian to lower Visean.

VAN VOORTHUYSEN, J. H. Die obermiozäne Transgression im Nordseebecken und die Tertiar-Quartärgrenze.—Soc. Belge Geol., Paleont. et Hydro., Bruxelles, Mem. No. 6, 1962 (March 30, 1963), p. 64-82, text figs. 1-4 (map, correl. tables, distrib. table), text figs. 1-3 (outline drawings, photomicrographs).—Correlation by Foraminifera of 3 well sections near Amsterdam that penetrate from Icenian to middle Oligocene. *Frondicularia dumontana* Reuss and *Glandulina morsumensis* spec. nov. proposed as guide fossils for the upper Miocene in the North Sea Basin.

WOSZIDLO, H. Foraminiferen und Ostrakoden aus dem marinen Elster-Salle-Interglazial in Schleswig-Holstein.—Meyniana, Univ. Kiel Geol. Inst., band 12, Dec. 1962, p. 65-96, pls. 1-5, text figs. 1-3 (map, graphs), tables 1-3.—Paleoecologic interpretations based on quantitative analysis of species from several clay pits and well sections. About 60 Foraminifera are reported and most of them illustrated.

ZERNETS'KYI, B. F. Numuliti ta Orbitoidi Paleogenovykh Vidkladiv Prichornomors'koi Zapadini.—Akad. Nauk Ukrain. RSR, Kiev, Instit. Geol. Nauk, ser. strat. paleont., vyp. 42, 1962, p. 1-73, pls. 1-18, text figs. 1-10 (map, drawings), tables 1, 2.—Descriptions and illustrations of 29 species and subspecies of *Nummulites, Assilina, Operculina,* and *Discocyclina,* 1 species and 2 subspecies new.

Ruth Todd
U. S. Geological Survey
Washington 25, D. C.