RELATIONSHIPS BETWEEN THE DISTRIBUTION OF *AMPHISTEGINA* AND THE SUBMERGED PLEISTOCENE REEFS OFF WESTERN PUERTO RICO*

GEORGE A. SEIGLIE**
UNIVERSITY OF PUERTO RICO, MAYAGUEZ

CONTENTS

ABSTRACT

The study area lies off the central part of the western coast of Puerto Rico. It has a maximum north-south extent of 12 kilometers and is 11 kilometers in the east-west direction. The sample net consists of over one hundred samples.

The remnants of an incipient Pleistocene reef at 80 to 85 meters of depth and a wave cut terrace at 55 meters of depth were found with five echo-sounder profiles.

Three main foraminiferal reef assemblages exist in the Antillean Caribbean region. Two are *Amphistegina* faunas (with no *Archaias* present): one in the Gulf of Mexico and the other one off eastern Venezuela. The third, an *Amphistegina-Archaias* fauna, occurs in the warmer waters of the Antilles.

Three shallow-water modern reefs were sampled bordering the eastern side of the area where *Amphistegina-Archaias* assemblage occurs. The highest percentage of *Amphistegina gibbosa* (up to 61%) is present in these reefs from 8 meters to 15 meters of depth. The percentage decreases down to approximately 80 meters where it increases to a maximum of 12% in front of Los Negros reefs. A relict foraminiferal fauna occurs at this depth. It consists mainly of *Amphistegina gibbosa* and *Quinqueloculina lamarckiana* indicating waters probably colder than present.

Amphistegina gibbosa was found living off Puerto Rico in the shallow reefs at 6 meters of depth down to 70 meters of depth. However, in the submerged Pleistocene reefs most of the specimens of this foraminifer are glauconitized. Its percentages are many times higher in the glauconitized assemblage than in the total assemblage of foraminifera.

The submerged reefs off western Puerto Rico correlate in depth with the calcareous prominences of the Gulf of Mexico and the submerged reefs off the western coast of Barbados.

I. INTRODUCTION

This paper is part of a project conducted for the Marine Biology Program of the Puerto Rico Nuclear Center at Mayagüez. The purpose of the project is the study of the distribution of the species of foraminifera in the sediments of the continental shelf and upper slope from Guanajibo to Añasco Bay.

When the distribution of *Amphistegina gibbosa* d'Orbigny was plotted on a map it was evident that a relation existed between its distribution and certain topographic features at a depth of 80 to 100 meters. This paper deals with the significance of these relationships.

More than 100 samples were taken as shown in figure 1. Samples were taken with a tube dredge, a gravity corer, and a box corer. Reference to each type is made in the figure 1.

*This project was supported by the U.S. Commission of Atomic Energy under contract AT(40-1)-1833. Presented to the Fifth Caribbean Geological Conference, Saint Thomas, Virgin Islands, July 1968.

**Department of Geology, University of Puerto Rico, Mayagüez, Puerto Rico; and Marine Biology Program, Puerto Rico Nuclear Center.

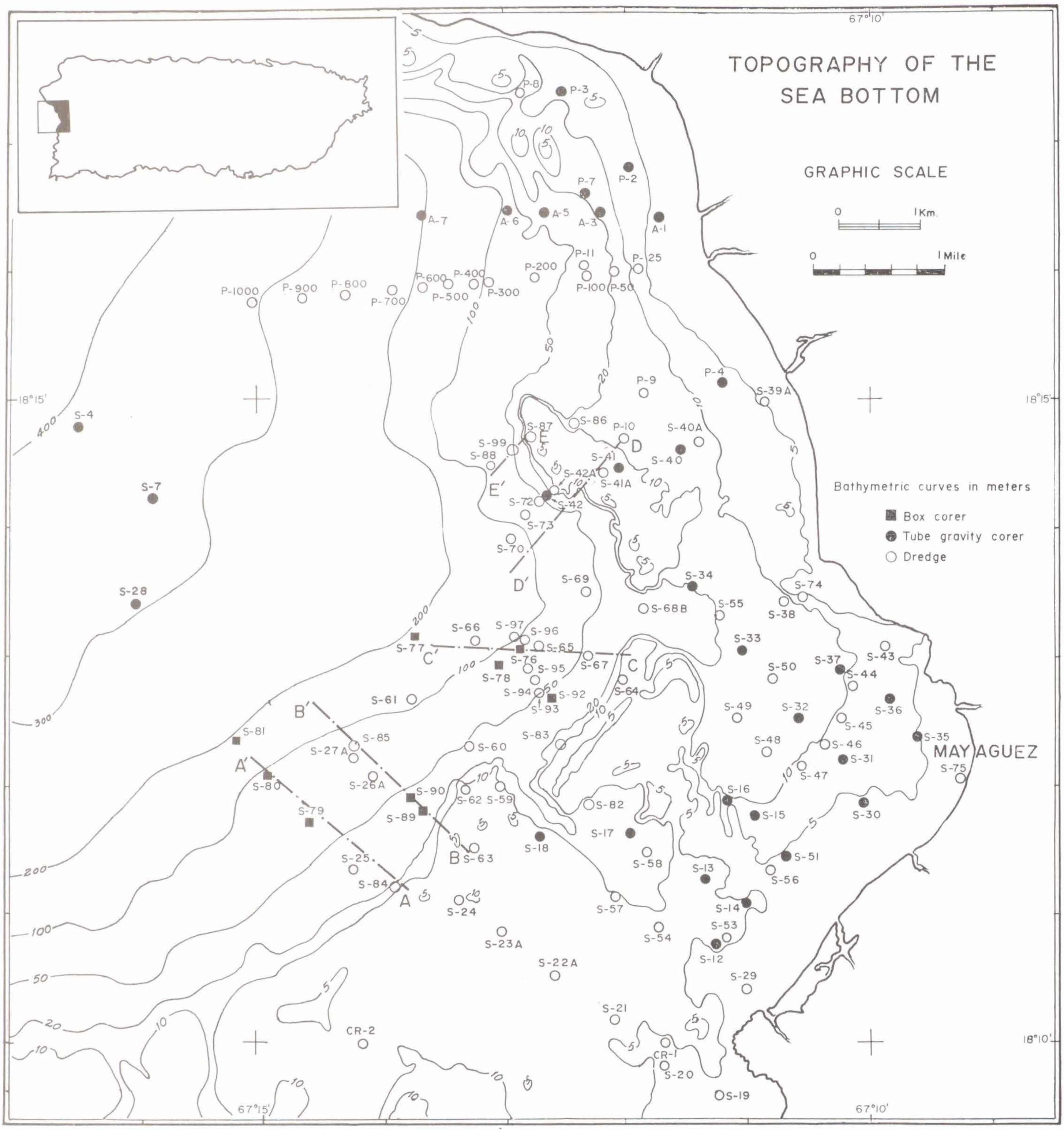

FIGURE 1

Thanks are given to Stephen Walsh and Gregory Telek from the Puerto Rico Nuclear Center for assistance in the field. The writer is also indebted to Dr. Donald Swift from Duke University, North Carolina, for the review of the manuscript, and to Rafael Pabón, Enrique W. Lithgow and María E. Rodriguez for the preparations of glauconitized foraminifera.

II. SIMILAR TOPOGRAPHIC FEATURES IN OTHER AREAS

Parker and Curray (1956) and Ludwick and Walton (1957) described the calcareous prominences at the middle and outer shelf of the Gulf of Mexico. Curray (1960) obtained radiocarbon dates on the molluscan shells from these prominences. He concluded that an erosional stillstand elapsed between 14,000 and 16,000 years B.P. at a depth of approximately 88 meters, and that a regression of the sea from a depth of 45 to 70 meters occurred between 11,000 and 12,000 years B.P.

MacIntyre (1967) reported two submerged reefs off the west coast of Barbados, one at a depth of 79 meters and the other with the base at a mean depth of 40 meters.

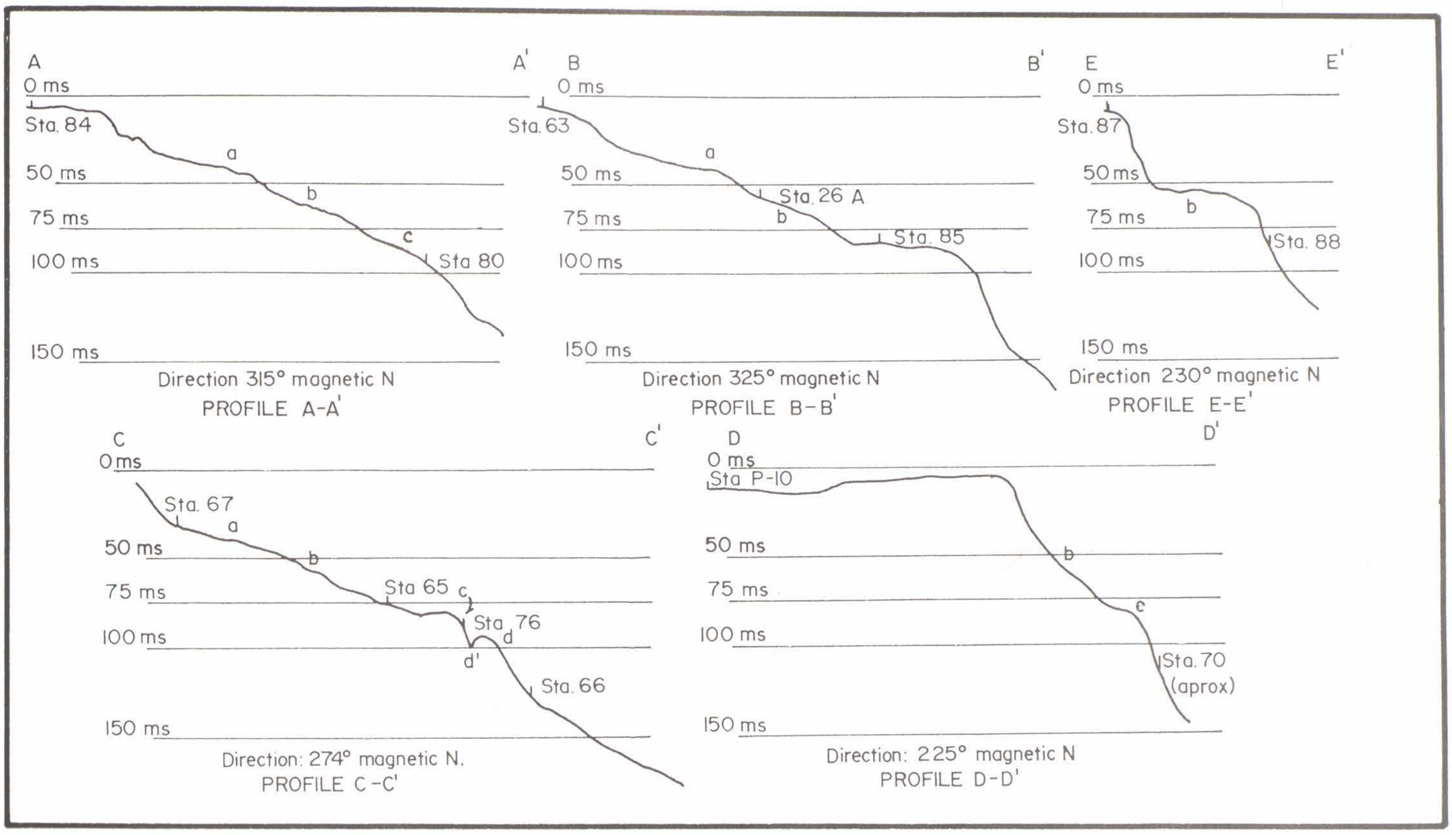

FIGURE 2

These reefs were correlated with the erosional levels at the Gulf of Mexico on the basis of depths.

Emery (1958) reported a series of submerged terraces in Southern California. Three of them lie at depths of 49 meters, 81 meters and 88 meters respectively. These depths coincide with the submerged reefs off western Puerto Rico but little confidence should be placed upon this coincidence because of the tectonic instability in Southern California.

III. Topography of the Sea Bottom Between Guanajibo and Añasco Bay

The area of study is located along the central part of the western coast of Puerto Rico. It includes Mayagüez and Añasco Bays. The maximum north-south extent is 12 kilometers, and 11 kilometers in the east-west direction. Sampling range from a depth of 4 meters to 410 meters.

The topographic map of the sea bottom of the area is shown in figure 1 according to the soundings in the charts of the U.S. Navy.

The coast is bordered by three groups of shallow reefs: Negro Reef at the south; Manchas Grandes reefs at the center; and Manchas Interiores and Manchas Exteriores at the north. The shallowest ones are the Manchas Grandes reefs that in part emerge from the surface of the sea as Rodriguez shoals.

The middle and outer parts of the Island shelf are very narrow and it is difficult to detect significant topographic features. However, reliable information was obtained from five profiles taken with the echo sounder of the R/V "Shimada" of the Puerto Rico Nuclear Center. Their positions are shown in figure 2 and their locations in figure 1. The approximate horizontal distance may be taken from the figure 1.

The profiles present a series of significant points that are indicated in figure 2 by the letters *a*, *b*, *c*, *d*, *d'*, and *e*.

The points *a* and *b* at profiles AA', BB', and CC' are found at depths of 40 and 55 meters respectively. They are poorly developed and only in the profile EE', northwest of Manchas Exteriores a wavecut terrace is found at a depth of 55 meters (point *b*). This terrace or flat reef has been reported previously by Swift (1967).

The third significant point, *c*, appears in profiles AA', BB', CC', and DD'. It is well developed and the most important one for the purpose of this paper. The elevation of point *c* in relation to its fore and back base shows it as a barrier of hard bottom at a depth of 80 to 85 meters, approximately

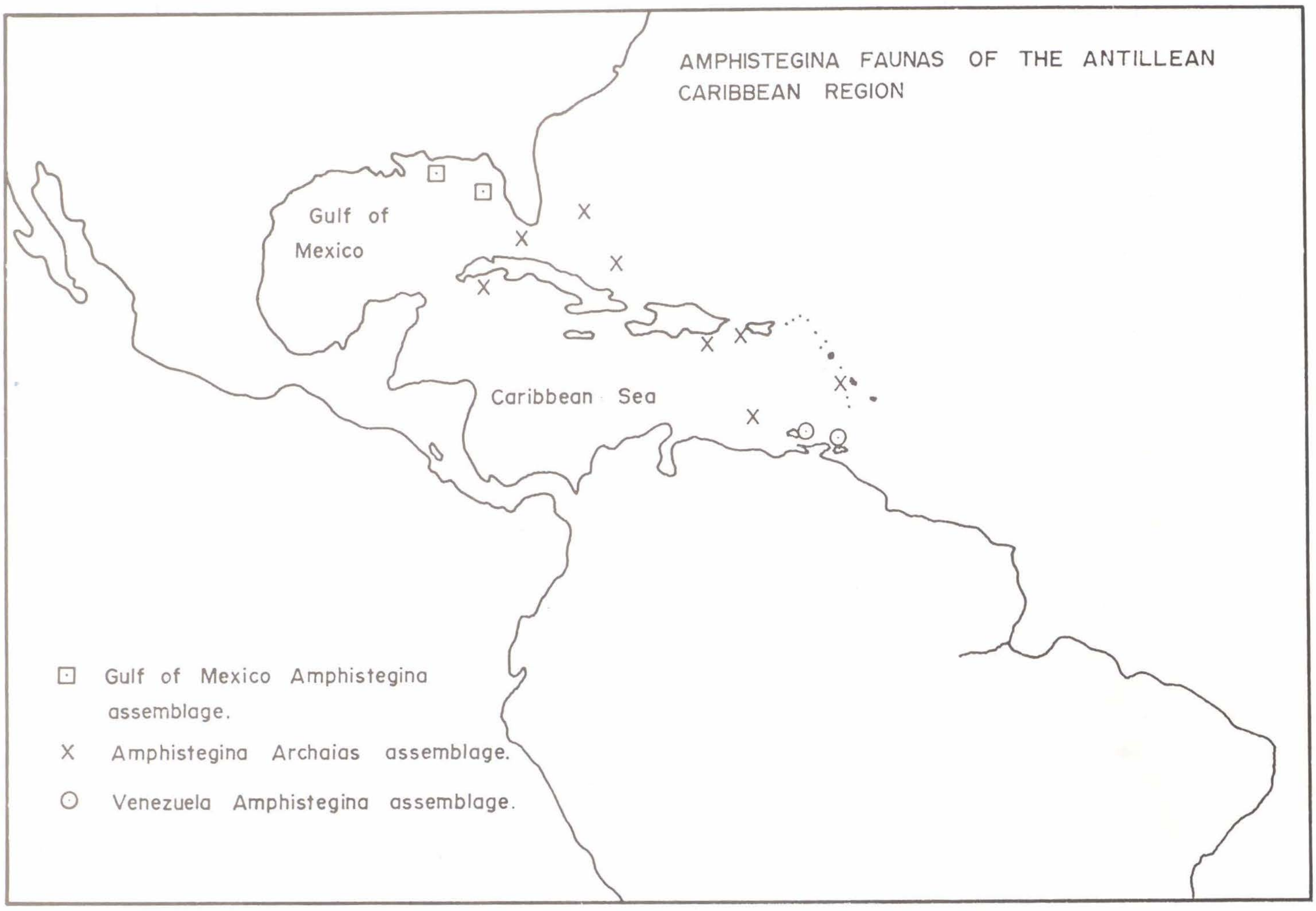

FIGURE 3

parallel to the coast. This submerged fringing or barrier reef, has been sampled several times with a tube dredge, but it has been impossible to recover any samples with the gravity corer or with the box corer.

The interpretation of the remaining inflection points *d*, *d'*, and *e* are beyond the scope of this paper.

IV. DISTRIBUTION OF *AMPHISTEGINA*

Amphistegina in the Reef Assemblages in the Antillean-Caribbean Region

The writer considers that the Antillean-Caribbean region extends from off south Brazil up to the eastern part of the Gulf of Mexico, on the Atlantic side of the Americas.

The four most abundant and significant reef foraminifera in this region are: *Amphistegina gibbosa* d'Orbigny, *Archaias angulatus* (Fichtell and Moll), *Asterigerina carinata* d'Orbigny and *Rotorbinella rosea* (d'Orbigny). They have been reported by Bandy (1964) as the dominant reef assemblage in the Batabanó Gulf, Cuba. The writer has found this assemblage, at least in the lagoon of Los Roques Archipelago, in calcareous beach sands of Dominican Republic and in the reefs off Puerto Rico. Hofker (1964) has reported it from many calcareous beach sands of the Lesser Antilles. Cushman (1922) reported these foraminifera in Tortugas region and Illing (1950, 1952) in Bahama Banks with some differences in the assemblages. The calcareous sands of Puerto Rico and Dominican Republic observed by the writer are skeletal reef sands and, probably, a great part of the ones observed by Hofker (1964) are also skeletal reef sands. *Amphistegina gibbosa* and *Archaias angulatus* are by far the most abundant of the four species. This fauna is referred to *Amphistegina-Archaias* assemblage in the map of figure 3.

It is important to remark that Illing (1950, 1952) and Bandy (1964) report Archaias as a back-reef foraminifer and *Amphistegina* as a fore-reef one. However, this separation of the fauna does not occur in the shallow reefs off the western coast of Puerto Rico, where *Amphistegina gibbosa, Archaias angulatus, Rotorbinella rosea* and *Asterigerina carinata* are all found living together, from 6 meters to 25 meters of depth (Pirie, Swift and Seiglie, 1967). However in the Sponge Banks, a submerged reef off the western shelf of Puerto Rico, *Amphistegina* occurs, living from 30 meters (shallowest depth of the banks) down to 70 meters of depth.

Walton (1964) reports an *Amphistegina* fauna in the eastern Gulf of Mexico, although living specimens do not occur in significant numbers in the shallow waters, *Asterigerina carinata* occurs in smaller percentages. No *Rotorbinella rosea* or *Archaias angulatus* have been reported in this area by Walton (1964) nor Parker (1954). This fauna is referred to on figure 3 as the Gulf of Mexico *Amphistegina* assemblage.

A third fauna is the Venezuelan *Amphistegina* assemblage, reported by Drooger and Kaaschieter (1958), and Seiglie (1966) off eastern Venezuela. No *Rotorbinella rosea* is present and *Archaias* and *Asterigerina* are extremely rare or absent. (See figure 3). The upwelling waters off eastern Venezuela produce lower temperatures in its seas permitting the occurrence of temperate zone species of algae (Diaz Piferrer, 1967) and a temperature planktonic foraminiferal assemblage (Miró, 1967). This fact explains the presence of an *Amphistegina* fauna similar to the one from the Gulf of Mexico.

Nota (1958, fig. 36), shows a belt of Pleistocene sediments in the western Guiana shelf, from 65 meters to 95 meters, this belt coincides with the distribution of *Amphistegina* in that area (Drooger and Kaasschieter, 1958).

Two main reef assemblages occur in the Antillean-Caribbean region according to the above mentioned report: a warm water *Amphistegina-Archaias* assemblage and two less warm water *Amphistegina* assemblages.

These assemblages permit the subdivision of the Antillean-Caribbean foraminiferal province in three subprovinces: Eastern Gulf of Mexico subprovince, Antillean subprovince and Venezuelan subprovince. The foraminifera from Bahama Banks and from off South Florida are tentatively included in the Antillean subprovince.

It is important to remark that *Sorites marginalis* Lamarck is present only in the warmer waters of the Caribbean, but in percentages lower than one per cent. *Sorites marginalis* and *Archaias angulatus* are taxonomically related to the Miocene and probably Pliocene foraminifer *Marginopora matleyi* (Vaughan). The writer has observed beds constituted mainly by *Amphistegina* sp. (no *Marginopora* is present) in the middle and late Miocene of southern Puerto Rico, alternating with beds in which *Marginopora matleyi* is the dominant species. If these two Miocene assemblages may be compared to the Recent ones they indicate temperature changes in that epoch. Recently, Tanner (1967) has stated the possibility that glacioeustatic sea level changes have commenced in the Miocene or Oligocene. Nevertheless, the *Marginopora matleyi* assemblage may be also interpreted as a reef platform or back-reef assemblage and *Amphistegina* as a fore-reef one.

Distribution of Amphistegina off Western Puerto Rico

The four species of reef foraminifera characteristic of *Amphistegina-Archaias* assemblage are present in high percentages in the Recent shallow water reefs off the western coast of Puerto Rico (Pirie, Swift and Seiglie, 1968 and Seiglie, 1967).

The distribution of *Amphistegina gibbosa* in Guanajibo to Añasco Bay area is shown in figure 4. The distribution of the species is expressed in percentages in relation to the total assemblage of benthonic foraminifera. The higher percentages are found in the shallower reefs: 40% at Negro reefs, 36% at Manchas Grandes reefs and 61% at Manchas Exteriores reefs. Living specimens of *Amphistegina* have been found in Negro, Manchas Grandes and Manchas Exteriores reefs from 8 to 20 meters of depth. However, the number of living specimens observed at Manchas Exteriores reefs is rather small. The three groups of reefs are separated from the coast by slightly deeper bottoms that, at least in part, are under the influence of the river muds, so that the back-reef assemblage is modified.

Table 1 shows the relative percentages of the two most significant foraminifers of this assemblage in relation to the total foraminiferal benthonic assemblage.

Relatively high percentages of *Amphistegina gibbosa* are present at two different levels in wave-cut terraces at 55 meters and submerged reefs at 85 meters of depth approximately. *Archaias angulatus, Rotorbi-*

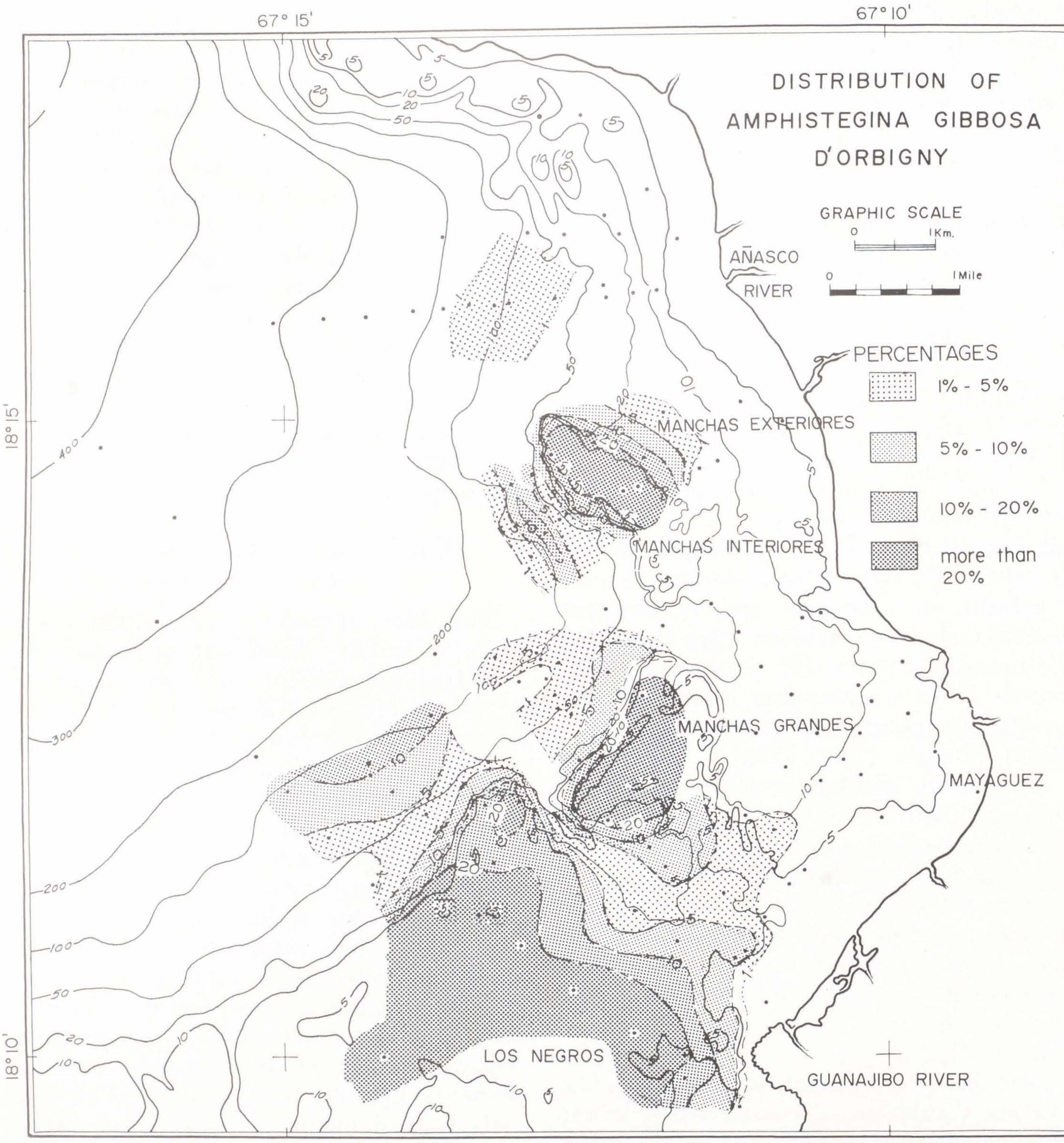

FIGURE 4

Percentages in relation to the total foraminiferal benthonic assemblage.

nella rosea and *Asterigerina carinata* are mostly absent or exceedingly rare. *Amphistegina* is associated with *Quinqueloculina lamarckiana* in some of the samples from the submerged reefs, and they are relatively more abundant in the glauconitized fauna. This association is found in shallow waters from Venezuela (Bermúdez and Seiglie, 1963 and Seiglie, 1966), from 30 to 40 meters of depth. Its presence off Puerto Rico may indicate colder climates when the sea level was lower. The original population of *Amphistegina* has been diluted by the assemblages that succeeded after the submersion of the reefs.

The only relatively high percentage (7.8%) of *Amphistegina,* was found at 55 meters of depth in the wave-cut terrace northwest of Manchas Exteriores, represented by the Profile E-E′, figure 2. Other relatively high percentages probably occur at 55 meters in other places. However, no appropriate samples have been obtained probably because of the narrow width of the terrace (points *b* in the profiles of figure 2).

The submerged reefs whose highest points are approximately at 80 meters are relatively the most easily sampled group. They coincide with the points *c* in the profiles of figure 2 where they lie before the three shallow water modern reefs. They have significant percentages of *Amphistegina*: 12.8% in front of Negro reef, 5% in front of Manchas Grandes, and 11% in front of Manchas Exteriores.

The highest percentages of *Amphistegina* are slightly displaced in the submerged reefs of the central part, up to 100 meters of depth. Station 97 from this depth included large fragments of reef-rock consisting mainly of worm tubes, bryozoans, attached foraminifera and corals. These fragments appear identical with those reported by Ludwick and Curray (1957, in figure 13A) from the pinnacles of the deep reef banks at the edge of the continental shelf of the Gulf of Mexico.

Reef-rock fragments were washed to separate free foraminifera. *Amphistegina* constitutes 11% of the foraminiferal benthonic assemblage. Most of the remaining species of foraminifera are characteristic of this depth, including *Carpenteria monticularis* Carter and *C. proteiformis* Goës, that are the only observed species attached to the fragments.

Station	*Amphistegina gibbosa*	*Archaias angulatus*
	1. Negro Reefs	
22A	37%	29%
23	20%	43%
24	39%	26%
59	26%	20%
62	18%	10%
	2. Manchas Grandes	
82	36%	7%
105	39%	35%
	3. Manchas Exteriores	
41A	62%	19%
87	41%	13%
100	54%	23%
101	50%	24%
102	51%	27%

TABLE 1. Percentages of *Amphistegina gibbosa* and *Archaias angulatus* in relation to the total benthonic foraminiferal assemblage.

In the submerged back-reefs at 80 meters as well as in the wave-cut terraces from 80 to 60 meters depth, coarse to medium muddy sands contains low percentages of *Amphistegina* in relation to the total foraminiferal benthonic assemblage. Similar calcareous sands were reported by Swift (1967) as relict Pleistocene sands in Añasco Bay. Relatively high percentages of *Amphistegina* occurs in actual beaches and back-reefs sands, but the foraminifer is generally diluted by large amounts of sediment. Thus foraminifera now living at 60 to 80 meters of depth have rendered the original population of *Amphistegina* more dilute than in the submerged reefs.

Another important fact in relation to *Amphistegina gibbosa* is that its percentage in the glauconitized assemblage of submerged reefs, is several times higher than in the total population. This fact requires for *Amphistegina* tests a longer *in situ* residence and thus an older age than the foraminiferal fauna now living at that depth. Percentages of *Amphistegina* in these reefs and sands are (see figure 3) from 0.5% to 4% of the total population. However, the percentages of glauconitized *Amphistegina* increases up to more than 35% in relation to the total glauconitized foraminiferal populations.

Table 2 shows the percentages of *Amphistegina* to the total benthonic population and percentages of glauconitized *Amphistegina* to the glauconitized benthonic population in several stations.

It must be stated also that the difficulty of locating and sampling the 80 meter reefs indicate that they are probably narrow and thin. No Pleistocene reefs above the sea level have been reported for Puerto Rico, perhaps on account of its scarcity. However,

Station	% in the Total Population	% in the Glauconitized Population
S-66	4 %	16%
S-79	2 %	35%
S-80	8.5%	16%
S-95	4.5%	33%
S-96	2.5%	24%
S-97	5 %	68%

TABLE 2. Percentages of *Amphistegina gibbosa* in relation to the total foraminiferal benthonic assemblage.

a Pleistocene reef occurs about 8 meters above the sea level, south of Higuera point, western Puerto Rico. Its elevation coincide with the ones reported for Barbados (Broecker *et al.,* 1968) from 6 to 19 meters, corresponding to an interglacial, approximately 80,000 years ago. In any case, the height above sea level of the Puerto Rican reefs indicates a warm climate. The foraminiferal fauna contained in the Puerto Rican reefs consist of *Archaias angulatus* and *Amphistegina gibbosa,* that indicate also a warm climate.

V. Conclusions and Summary

The following conclusions are based on the distribution of *Amphistegina gibbosa* and/or the topographic features representing submerged reefs.

(1) Three main reef foraminiferal faunas are present in the Antillean-Caribbean region: *Amphistegina-Archaias* assemblage in the warmer waters and two *Amphistegina* assemblages in the less warm waters. Described assemblages permit the subdivision of the Antillean-Caribbean foraminiferal province in three subprovinces: the Eastern Gulf of Mexico subprovince, the Antillean subprovince and the Venezuelan subprovince.

(2) The submerged reefs present at 80 meters of depth off western Puerto Rico correspond approximately in depth and position with those in the Gulf of Mexico at 88 meters of depth reported by Curray (1960) and off Barbados at 79 meters of depth reported by MacIntyre (1967).

(3) The distribution of *Amphistegina gibbosa* is associated with the position of the submerged Pleistocene reefs off western Puerto Rico and also in the Gulf of Mexico (Walton, 1964); it is also associated with the position of the Pleistocene sediments of the western Guiana shelf. This association is true irrespective of whether *Amphistegina* is Pleistocene or Holocene.

(4) The ratio *Amphistegina* to benthonic foraminifera is much higher if only glauconitized tests are considered. This indicates that the *Amphistegina* assemblage of the submerged reefs is older than the living assemblage.

References

Bandy, O. L., 1964. Foraminiferal Biofacies in Sediments of Batabamó, Cuba, and their Geologic Significance. American Assoc. Petr. Geol., Bull., v. 48, no. 10, p. 1666-1679.

Bermúdez, P. J., and G. A. Seiglie, 1963. Estudio Sistemático de Los Foraminíferos del Golfo de Cariaco, Univ. Oriente, Inst. Oceanogr., Bol., v. 2, no. 2, p. 1-279.

Bloom, A. L., and M. Stuiver, 1963. Submergence of the Coast, v. 139, p. 332-334.

Bradley, W. C., 1958. Submarine Abrasion and Wave-cuts Platforms. Geol. Soc. America, Bull., vol. 69, p. 967-974.

Broecker, W. S., D. L. Thurber, T. Ku, R. K. Matthews, and K. J. Mesoleila, 1968. Milankovitch Hypothesis Supported by Precise Dating of Coral Reefs and Deep-Sea Sediments, Science, vol. 129, p. 297-300.

Curray, J. R., 1960. Sediments and History of Holocene Transgression, Continental Shelf, Northwest Gulf of Mexico, *in* Shepard, Phleger and Van Andel, Recent Sediments Northwest Gulf of Mexico. American Assoc. Petr. Geol., p. 221-266.

Curray, J. R., 1961. Late Quaternary Sea Level: A discussion. Geol. Soc. America, Bull., v. 72, p. 1707-1712.

Cushman, J. A., 1922. Shallow Water Foraminifera of the Tortugas Region, Carnegie Inst. Washington, Publ. 311, 85 p.

Diaz-Piferrer, M., 1967. Efectos de las aguas de afloramiento en la flora marina de Venezuela. Caribbean Jour. Sci., v. 7, no. 1-2, p. 1-14.

Drooger, C. W., and J. P. H. Kaasschieter, 1958. Foraminifera of the Orinoco-Trinidad-Paria Shelf Expedition. Rept. Orinoco Shelf Exp. vol. 4, p. 1-107.

Emery, K. O., 1958. Shallow Submarine Terraces of Southern California. Geol. Soc. America, Bull., v. 72, p. 39-60.

Emery, K. O., 1958. Shallow Submerged Marine Terrace of Southern California. Geol. Soc. America, Bull., v. 69, p. 39.

Goreau, T. F., and K. Burke, 1965. Pleistocene Geology of the Shelf off Kingston Harbour, Jamaica. Fourth Caribbean Geol. Conf.

Hofker, J., 1964. Foraminifera from the Tidal Zone in the Netherlands Antilles and other West Indian Islands. Stud. Fauna Curacao Caribbean Is., vol. 21, 119 p.

Illing, M., 1950. The Mechanical Distribution of Recent Foraminifera in Bahama Banks Sediments. Ann. and Mag. Nat. Hist., ser. 12, v. 3, p. 757-761.

Illing, M., 1952. Distribution of Certain Foraminifera Within the Littoral Zone on the Bahama Banks. *Ibid.,* ser. 12, v. 5, p. 275-285.

Kaye, C. A., 1959. Shoreline Features and Quaternary Shoreline Changes, Puerto Rico. U.S. Geol. Surv., Prof. Pap. 317-B, p. 49-138.

Ludwick, J. C., and W. C. Walton, 1957. Shelf-edge, calcareous prominences in the northeastern Gulf of Mexico. American Assoc. Petro. Geol., v. 41, no. 9, p. 2054-2101. Fig. 13A.

Miro, M. D. de, and J. A. Marval, 1967. Foraminíferos planctónicos vivos de la fosa de Cariaco y el talud continental de Vene-

zuela. Soc. Cienc. Nat. La Salle, t. 27, no. 76, p. 12-34.
MacIntyre, I. G., 1967. Submerged Coral Reefs, West Coast of Barbados, West Indies. Canadian Jour. Earth Sci., v. 4, p. 461-474.
Nota, D. J. G., 1958. Sediments of the Western Guiana Shelf. Proefschrift, Wageningen, 98 p.
Parker, F. L., 1954. Distribution of the Foraminifera in the Northeastern Gulf of Mexico. Mus. Comp. Zool., Bull., v. 111, no. 10, p. 453–588.
Parker, R. H., and J. R. Curray, 1956. Fauna and Bathymetry of Banks on Continental Shelf, Northwest Gulf of Mexico. American Assoc. Petr. Geol., v. 40, no. 10, p. 2428-2439.
Pirie, R. G., D. J. P. Swift, and G. A. Seiglie, 1968. Cabo Rojo Platform Sediments, Southwestern Puerto Rico, Abstract for the Fifth Caribbean Geol. Conf.
Seiglie, G. A., 1966. Distribution of Foraminifers in the Sediments of Araya-Los Testigos Shelf and Upper Slope. Caribbean Jour. Sci., v. 6, no. 3-4, p. 93-118.
Seiglie, G. A., 1967. Progress Report on the Study of the Foraminifers from off the Western Coast of Puerto Rico. Puerto Rico Nuclear Center Marine Biol. Progr., Progress Summ. Rept. no. 5, p. 107-117.
Seiglie, G. A., 1967. Sediment Dispersal Patterns and Trace Element Distribution Coastal Western Puerto Rico. *Ibid.*, p. 121-146.
Suitver, M., and J. J. Daddario, 1963. Submergence of the New Jersey Coast., Science, v. 142, p. 951.
Swift, D. J. P., 1967. Topography and Bottom Sediments of an Offshore-Onshore Transect, Añasco Bay, Puerto Rico Nuclear Center, Marine Biol. Progr., Progress Summ. Rept. no. 5, p. 118-120.
Tanner, W. F., 1967. Tertiary Sea Levels *in* Geological Notes. Geotimes, v. 12, no. 8, p. 23-24.
Tinoco, I. Medeiros, 1968. Foraminíferos quaternários de Olinda, Estado de Pernambuco. Monografía 14, Div. Geol. Miner., Min. Agricult., Brasil, p. 1-61.
Walton, W. R., 1964. Recent Foraminiferal Ecology and Paleoecology, *in* Imbrie and Newell, Approaches to Paleoecology, p. 151-237.

December 30, 1968

REVIEWS

ELECTRICAL PROPERTIES OF ROCKS; U.S. NAVAL OCEANOGRAPHIC GEOMAGNETIC SURVEYS, INFORMAL REPORT; REPORT ON AEROMAGNETIC SURVEY IN JAPAN

HAMILTON M. JOHNSON
TULANE UNIVERSITY

ELECTRICAL PROPERTIES OF ROCKS, by Eleonora Ivanova Parkhomenko; translated from Russian, edited and supplemented by George V. Keller; *Monographs in Geoscience* series, edited by Rhodes W. Fairbridge. Published by Plenum Press, New York, 1967, xi + 314 p., $19.50

This book is the first devoted specifically to the electrical properties of rocks. While until recently these were studied mainly in connection with the requirements of well logging, their use has now been extended to mining and various types of electrical prospecting for minerals. Therefore where previous use was primarily in the shallow crust and required data essentially at or near atmospheric pressures and room temperature, extension of interest deep into the earth's crust and mantle will need data concerning electrical properties at high pressures (tens of kilobars) and high temperatures (at least 1000°C). Laboratory analysis under these conditions is the only source of such information. She has determined that these electrical properties depend on the chemical and mineral content of the rocks, the genesis and petrographic characteristics, structure, texture, porosity, water content (both percentage and conductivity), etc. and discusses specific electrical properties in terms of each of these factors.

The book is divided into a brief review of petrography and chapters on dielectric properties of rocks, electrical resistivity of rocks (methods used to measure and factors causing variations), and dielectric loss in rocks. Extensive tables of dielectric constants of both minerals (133) and rocks (62) include all of the common ones and many less frequently encountered. Discussion of value ranges, explanations of variations, etc. are sufficient and readily understandable; the writing is easy to follow and sentence struc-