Late Tertiary Planktonic Foraminifera Associated with a Basaltic Boulder from the Mid-Atlantic Ridge[1]

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ABSTRACT

A dredge haul obtained from the mid-Atlantic Ridge at 22° 56′ N, 46° 35′ W yielded a consolidated, partially silicified foraminiferal ooze and some fragments of an apparently altered basalt. The age of the consolidated ooze, determined from its assemblage of planktonic Foraminifera, is late Tertiary and probably late Miocene. The inference is that deposition of the consolidated ooze preceded the extrusion of the basalt, with silicification of the ooze occurring during the periods of extrusion and alteration of the basalt.

Introduction. During the return trip of the R.V. Chain from cruise 17 in May 1961, a dredge haul was obtained from the western slope of the mid-Atlantic Ridge. In addition to sampling a large quantity of Recent unconsolidated foraminiferal ooze, the dredge penetrated a late Tertiary surface represented by small chunks of consolidated, partially silicified ooze. The age of this ooze has been established from its contained planktonic Foraminifera (recorded and illustrated in the Systematic Catalogue, pp. 78–84).

Associated with the consolidated and unconsolidated oozes were fragments of basaltic rocks. These fragments, as shown below, represent volcanism that probably occurred after the deposition of the late Tertiary ooze.

The pipe dredge was hauled up the western slope of a valley in the mid-Atlantic Ridge for a little over a mile, at approximately 22° 56′N, 46° 35′W. The dredged depth ranged from 3586 to 2893 m.

The Basaltic Fragments and Their Age Relationships with Associated Materials in the Dredge. The sampled basaltic fragments have been described by Nicholls et al. (1964: 337), who concluded that the basalt probably has been considerably altered from its original composition.

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The largest fragment, measuring approximately one foot in its longest dimension, has been sectioned and sketched (Fig. 1). Its sides are subrounded, and the core consists of a dark red-brown aphanitic matrix containing scattered phenocrysts of plagioclase feldspar. Around the rim of the core is a tan, powdery, altered layer with devitrified glass and poorly preserved remains of Foraminifera. The altered layer is considerably thicker on one side than on the others, but

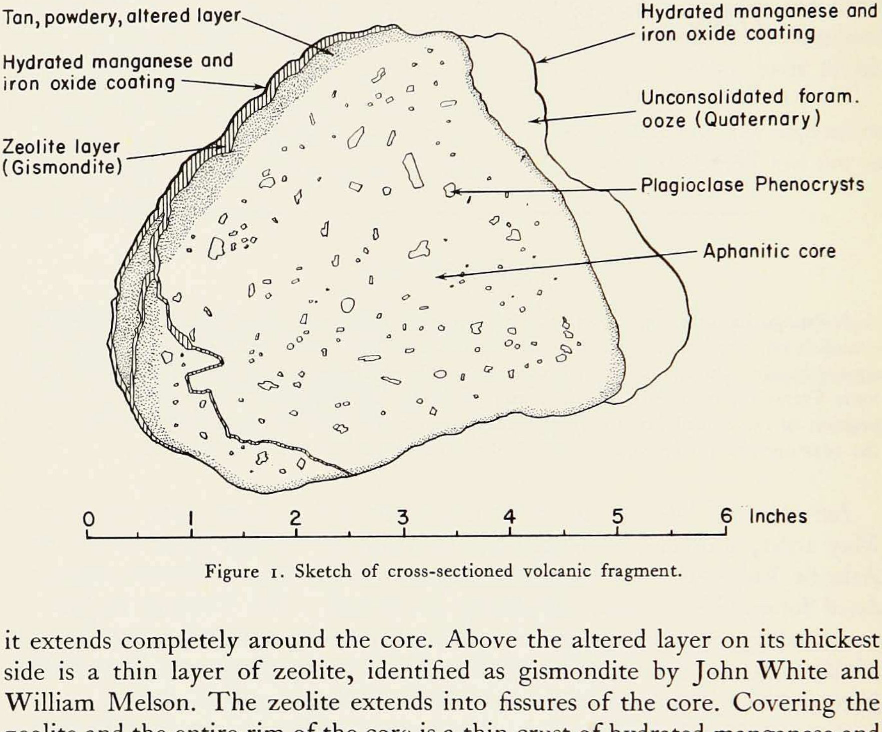

Figure 1. Sketch of cross-sectioned volcanic fragment.

it extends completely around the core. Above the altered layer on its thickest side is a thin layer of zeolite, identified as gismondite by John White and William Melson. The zeolite extends into fissures of the core. Covering the zeolite and the entire rim of the core is a thin crust of hydrated manganese and iron oxide. On the side opposite to the thickened, altered layer is a layer of unconsolidated foraminiferal ooze. The planktonic foraminiferal assemblage in this ooze, which is similar to the one in the overlying unconsolidated ooze, is no older than Quaternary. Above the unconsolidated ooze and adhering to the fragment is a second crust of hydrated manganese and iron oxide.

The thickened, altered layer on one side indicates that the fragment at one time lay on the bottom with the altered side facing upward. The period of time involved here cannot be determined paleontologically, since the Foraminifera in the altered layer are too poorly preserved for specific identification. At a later date, the fragment must have rolled over, and foraminiferal ooze accumulated on the newly exposed surface. This accumulation occurred during the Quaternary.

Also sampled were some chunks of tan, altered volcanic rock containing devitrified glass and poorly preserved remains of Foraminifera. These bits of rock are apparently identical to the altered layer of the volcanic fragment.

Much of the consolidated late Tertiary ooze appeared to be mostly calcareous, but a few pieces contained appreciable amounts of silica, occurring as cement and as fillings in the foraminiferal chambers. None of the consolidated late Tertiary ooze was observed on the basaltic fragments; this ooze appears to be the oldest material sampled. It is suggested that deposition of the late Tertiary ooze preceded the extrusion of the basalt. The silicified portions probably represent the surficial layers of this ooze penetrated by silica, which was released during volcanism and during alteration of the basalt on the sea floor.

Comparison of the Unconsolidated and Consolidated Ooze Assemblages. The faunal composition of the two oozes is shown in Table I.

TABLE I. Occurrence and Relative Abundance of Planktonic Foraminifera in the Unconsolidated and Consolidated Oozes.

Species and subspecies	Unconsolidated ooze	Consolidated ooze
Candeina nitida	Rare	—
*Globigerina altispira altispira	—	Present
*Globigerina apertura	—	Rare
Globigerina cf. bulloides	—	Rare
Globigerina dutertrei	Rare	—
*Globigerina nepenthes	—	Rare
Globigerinella aequilateralis	Common	—
?Globigerinella cf. aequilateralis	—	Rare
Globigerinita glutinata	Present	Rare
Globigerinoides conglobatus conglobatus	Common	—
*Globigerinoides conglobatus gomitulus	—	Present
*Globigerinoides obliquus	—	Rare
Globigerinoides ruber	Dominant	Present
Globigerinoides trilobus trilobus	Present	Dominant
*Globoquadrina dehiscens	—	Present
*Globorotalia cf. acostaensis	—	Rare
*Globorotalia fohsi robusta	—	Common
Globorotalia hirsuta	Rare	—
Globorotalia menardii	Present	—
Globorotalia punctulata	Present	—
Globorotalia scitula gigantea	—	Rare
Globorotalia truncatulinoides	Common	—
Globorotalia tumida	Rare	—
Orbulina universa universa	Present	—
*Orbulina universa suturalis	—	Present
*Sphaeroidinella disjuncta	—	Rare
*Sphaeroidinella kochi	—	Rare
*Sphaeroidinella seminulina	—	Abundant

* Extinct form.

The unconsolidated ooze contains a modern subtropical assemblage characteristic of the latitude at which the sample was taken. Species of *Globigerinoides* are dominant, with *G. ruber* being the chief representative; *Globigerinella aequilateralis* and *Globorotalia truncatulinoides* are the other common species. *Globorotalia menardii* and *G. tumida*, important tropical species, are present but not common. *Globigerina*, a genus that occurs abundantly in the cool waters north of the Gulf Stream, is represented only by the rare occurrence of *G. dutertrei*.

The consolidated ooze is also dominated by species of *Globigerinoides*, but *G. trilobus* rather than *G. ruber* is the chief representative. *Gl. truncatulinoides* is absent, as might be expected, since the deposition of the ooze probably preceded the first arrival of this species. In the remaining part of the assemblage, 11 species and subspecies include extinct forms, most of which show close morphologic affinities with modern subtropical and tropical forms. For example, the closest living relative of the abundant *Sphaeroidinella seminulina* is *S. dehiscens*, a species that is widely distributed in the present oceans but shows a preference for the equatorial latitudes (Bradshaw 1959: 50). Keeled globorotalids, suggestive of tropical or subtropical waters, are represented by the common-occurring *Globorotalia fohsi robusta*, a form closely resembling *G. menardii*. Except for the rare occurrence of *Globigerina* cf. *G. bulloides*, forms having apparent affinities with cool-water species are absent. The composition of the assemblage, therefore, indicates surface water temperatures that were at least as warm as, and possibly warmer than, the present water temperatures.

Age and Correlation of the Consolidated Ooze. Over half of the planktonic Foraminifera in the consolidated ooze have not been reported as being taken previously in either plankton tows or in Quaternary sediments. Therefore, an appreciable discontinuity in age is indicated between the consolidated ooze and the overlying unconsolidated ooze containing a modern, subtropical assemblage. The consolidated ooze, however, can be no older than the Neogene or late Tertiary, since all forms present are characteristic of the Aquitanian or younger sediments, and several of them (*Globigerina nepenthes*, *Orbulina universa suturalis*, *Sphaeroidinella kochi*, and *Globorotalia fohsi robusta*) have been reported as taken only from post-Aquitanian sediments. Moreover, Paleogene or early Tertiary index species are conspicuously absent.

Several of the species in the consolidated ooze are important index markers for the late Tertiary of the Caribbean and other regions. However, two of them, *Gl. fohsi robusta* and *Gl. nepenthes*, have not been recorded previously in association with each other. In the Caribbean (Bolli 1959, Blow 1959), *Gl. fohsi robusta* is restricted to the *G. fohsi robusta* zone while *G. nepenthes* makes its first appearance in the upper part of the overlying *Globigerina mayeri* zone. The evidence for the remainder of the assemblage is insufficient to determine whether this association represents a higher occurrence for *G. fohsi* *robusta*, a lower one for *G. nepenthes*, or an indeterminate one for both. It is also possible that the ooze is a mixture from two different ages. However, it can be reasonably inferred from their presence that the consolidated ooze is at least no older than the age of the *G. fohsi robusta* zone. This zone has been correlated with the upper part of the Burdigalian stage (Bolli 1959, Blow 1959, Saito 1963).

On the other hand, the assemblage indicates an age that is at least as old as, or older than, that of the *Sphaeroidinella seminulina* zone. *G. fohsi robusta*, as noted above, has not been previously reported as taken from above the *robusta* zone. *G. nepenthes* and *Globigerina altispira altispira* appear to range no higher than the *menardii* zone, while *Sphaeroidinella kochi* is known to extend only up to the top of the *seminulina* zone. Allowing for the possibility of some future adjustments in the upper ranges of these species, since a good faunal succession above the *seminulina* zone has yet to be established, the association is, nevertheless, characteristic of an age within the limits of the *robusta* to the *seminulina* zones.

However, there is no general agreement on the European equivalents of the zones above *robusta*, although the consensus is that the *seminulina* zone is older than the Pliocene. Bolli (1959) regards the *menardii* zone as equivalent to the Helvetian stage, but Saito (1963) places it in the lower part of the Tortonian stage. The *seminulina* zone is considered by Blow (1959) to be equivalent to, or younger than, the Vindobonian (= Helvetian + Tortonian), but Saito equates this zone partly with the upper Tortonian and partly with the lower Sarmatian stages. Bandy (1964) places the apparent equivalent of this zone in the Pontian stage. Bandy, moreover, proposes the first occurrence of *Sphaeroidinella dehiscens dehiscens* as a datum marking the boundary of the Pliocene with the underlying Pontian; Bandy recognizes the first appearances of *Globorotalia truncatulinoides*, *G. puncticulata*, and *Globigerina inflata*, and the last appearance of *Sphaeroidinella seminulina seminulina* as being associated with this boundary in the Philippines. This assemblage does not occur in the Caribbean, and it clearly represents an interval above the *seminulina* zone. However, there is no evidence that this interval corresponds to the mio-Pliocene boundary of Europe and, in fact, it is doubtful that the planktonic foraminiferal fauna in the younger Tertiary of Europe is sufficiently well known for a correlation to be made at this level of refinement.

Moreover, there are difficulties involved in the stratigraphic relationships of the European younger Tertiary column. The Upper Miocene is represented in western Europe by terrestial deposits, and the Pontian (the uppermost stage of the Miocene) has no confirmed marine equivalents in Europe. The Sarmatian stage is represented at its type locality by a Caspian fauna that occupies a stratigraphic position as yet undetermined with regard to the Tortonian stage (Gignoux 1955). Therefore, it may be questioned whether usage of these uppermost Miocene stages in a marine sense is in any way realistic.

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SYSTEMATIC CATALOGUE

Globigerina altispira altispira Cushman and Jarvis

Plate I, Figs. 1, 2

Globigerina altispira Cushman and Jarvis, 1936, Contr. Cushman Fdn., 12(1): 5, pl. 1, figs. 13a-c. Bermudez, 1949, Spec. Publ. Cushman Fdn., 25: 277, pl. 21, fig. 43. Phleger, Parker, and Pierson, 1953, Rep. Swed. Deep-sea Exped., 7(1): 11, pl. 1, figs. 1, 2, 6. Hamilton and Rex, 1959, Prof. Pap. U.S. geol. Surv., 260M: 791, pl. 254, figs. 1–3.
Globoquadrina altispira altispira Bolli, 1957, Bull. U.S. nat. Mus., 215: 111, pl. 24, figs. 7a, 8b. Blow, 1959, Bull. Amer. Paleont., 39(178): 183, pl. 8, figs. 51a-c. Takayanagi and Saito, 1962, Sci. Rep. Tohoku Univ., Sendai, (2)5: 92, pl. 25, figs. 7a-b.

The specimens vary considerably in the height of the spire. On a few individuals, a reduced final chamber partially or completely covers the umbilicus. The umbilical teeth are weakly developed or absent. *G. altispira altispira* shows a close relationship to *G. dutertrei*, the main difference being in the high trochoid spire of the former. Further study may show that these two forms represent conspecific subspecies.

There are many records of *G. altispira altispira* from the Miocene and a few from the Oligocene. In America it does not range higher than the *Globorotalia fohsi* s.l. zone. In Japan, however, Takayanagi and Saito (1962: 92) have found this species in association with *G. nepenthes* and therefore consider that it ranges into the *Globorotalia menardii menardii* zone, or even higher.

Globigerina apertura Cushman

Plate I, Figs. 11, 12

Globigerina apertura Cushman, 1918, Bull. U.S. geol. Surv., 676: 57, pl. 12, fig. 8. Dieci, 1959, Paleont. Ital. — 88, pl. 7, figs. 20a, b. Takayanagi and Saito, 1962, Sci. Rep. Tohoku Univ., Sendai, (2)5: 83, pl. 24, figs. 9a-c.

This species is represented in the consolidated ooze by only three specimens. It is very similar to *G. bulloides* but has an unusually high and large aperture confined mostly to the base of the last chamber.

There are no records of *G. apertura* from either plankton tows or Recent sediments and it appears to be an extinct form. Most of the records are from the Miocene, but Hamilton (1953: 20) has reported it from Eocene mid-Pacific seamounts. Bermudez (1961: 1156) has recorded it as ranging in the Caribbean from the Middle Oligocene to the Pliocene.

Globigerina cf. *G. bulloides* d'Orbigny

Plate I, Figs. 3, 4

The material consists of four small specimens. This form closely resembles *G. bulloides*, but the test is more compact and the aperture is smaller and more restricted. It also resembles *G. conglomerata* Schwager, as figured by Bradshaw (1959: 33, pl. 6, figs. 6, 7), except that it lacks the apertural lip shown in Bradshaw's figure.

G. bulloides has been reported throughout from most of the Tertiary. In the Recent seas it is one of the most common of the planktonic Foraminifera.

Globigerina nepenthes Todd

Plate I, Figs. 7, 8

Globigerina nepenthes Todd, 1957, Prof. Pap. U.S. geol. Surv., 280-H: 301, pl. 78, figs. 7a, b. Bolli, 1957, Bull. U.S. nat. Mus., 215: 111, pl. 24, figs. 2a-c. Blow, 1959, Bull. Amer. Paleont., 39(178): 179, pl. 8, figs. 44, 45. Saito, 1962, Trans. paleont. Soc. Jap., (N.S.) 48: 332, pl. 51, figs. 1-4, pl. 52, figs. 1-8.

This species is rare in the consolidated ooze, but the specimens, characterized by a protruding last chamber and a large umbilical aperture, are distinctive and compare well with the holotype.

G. nepenthes was originally described from the Miocene deposits of Saipan. This species is widely distributed, occurring commonly in the Miocene of the Caribbean and Japan. It has also been recorded from the type Tortonian in the Mediterranean (Saito 1962: 337).

? *Globigerinella* cf. *G. aequilateralis* (Brady)

Plate I, Figs. 5, 6

Hastigerina cf. *aequilateralis* Bolli, 1957, Bull. U.S. nat. Mus., 215: 108, pl. 22, figs. 1a-c. Jenkins, 1960, Micropaleontology, 6(4): 349, pl. 1, figs. 1a-c.

The species is represented by only three specimens, which are highly involute and do not reveal an early trochoid stage. They compare exceptionally well with the specimens from the Miocene of Trinidad figured as *Hastigerina* cf. *aequilateralis* by Bolli and with those from the Miocene of Australia illustrated by Jenkins.

G. aequilateralis is widely distributed in the upper Tertiary and is a dominant element of the Recent subtropical planktonic foraminiferal faunas.

Globigerinita glutinata (Egger)

Plate I, Figs. 13, 14

Globigerina glutinata Egger, 1893, Abh. bayer. Akad. Wiss. (Math.-nat.) 18: 371, pl. 13, figs. 19–21. Takayanagi and Saito, 1962, Sci. Rep. Tohoku Univ., Sendai, (2)5: 86, pl. 27, figs. 13a-c, 17a-c.

Takayanagi and Saito (1962: 861) have given an extensive synonomy of this species, including *G. naparimaensis* Bronniman, *G. incrusta* Akers, *G. juvenilis* Bolli, and *Tinophodella ambitacrena* Loeblich and Tappan. These four species were previously separated from *G. glutinata* on the basis of the bulla, primary aperture, and supplementary apertures. But, as Takayanagi and Saito as well as others have noted, these characters are highly inconstant within the limits of single assemblages. The present specimens, which are relatively scarce, do not have supplementary apertures, but they include forms that do and do not have a bulla.

By grouping these five species, *G. glutinata* becomes a long-ranging species, extending through most of the Tertiary to the Recent.

Globigerinoides conglobatus gomitulus (Seguenza)

Plate I, Figs. 9, 10

Globigerina gomitulus Sequenza, 1880, Mem. Accad. Lincei, Roma (Sci. Fis. Mat. Nat., 3)6: 308, pl. 17, fig. 16.

Globigerinoides gomitulus Longinelli, 1956, Paleont. Ital., 49 (N.S. 19): 179, pl. 15, fig. 8. AGIP Mineraria, 1957, Foram. Padani, Milan — pl. 46, fig. 3.

The specimens in the consolidated ooze compare well with *G. gomitulus* as figured in the references above. The form *G. conglobatus gomitulus* differs from *G. conglobatus conglobatus* in the last chamber, which is flattened in *gomitulus* and rounded in *conglobatus*. This character is variable, however, and a few of the specimens have rounded final chambers that compare well with typical *conglobatus*. Supplementary apertures are poorly developed or absent in the present specimens.

The form *gomitulus* was originally described from the Pliocene of Calabria, Italy. There are no records of occurrences of this species outside of the Mediterranean, and it has not been reported in the Recent. AGIP Mineraria (1957: pl. 46, fig. 3) has recorded it as ranging in Italy from the Lower Miocene to the Quaternary.

Globigerinoides obliquus Bolli

Plate I, Figs. 21, 22

Globigerinoides obliqua Bolli, 1957, Bull. U.S. nat. Mus., 215: 113, pl. 25, figs. 9, 10. Blow, 1959, Bull. Amer. Paleont., 39(178): 191, pl. 11, fig. 68. Bermudez, 1961, Mem. Congr. geol., Venez. 3 (Boll. geol. 3): 1231, pl. 10, fig. 3. Takayanagi and Saito, 1962, Sci. Rep. Tohoku Univ., Sendai, (2)5: 96, pl. 25, fig. 10.

The present specimens have lower spires, with the apertures of the final chambers more reduced than in the holotype and paratype of *G. obliquus*. However, the specimens agree in the essential characteristics of this species in that the final chamber is flattened, with an aperture that is oblique with respect to the penultimate two chambers (Takayanagi and Saito 1962: 93). The present specimens also include a single supplementary aperture at the base of the final chamber.

This species was first described from the Oligocene and Miocene deposits of Trinidad. It has been reported from the Miocene of Venezuela, Cuba, the Philippines, and Japan.

Globigerinoides ruber (d'Orbigny)

Plate I, Figs. 15, 16

Globigerina rubra d'Orbigny, 1839, *in* de la Sagra, Hist. Phys. Pol. Nat. Cuba, Foraminiféres, 8: pl. 4, figs. 12–14. Banner and Blow, 1960, Contr. Cushman Fdn., 11(1): 19, pl. 3, fig. 8.

This species is poorly represented in the dredge sample. The last chamber is slightly flattened, similar to that in *G. elongatus*, which may be a variant form of *G. ruber*. In other respects the specimens compare well with modern representatives of G. *ruber*.

This species ranges from the Lower Miocene and is a dominant element of the modern subtropical planktonic foraminiferal faunas.

Globigerinoides trilobus trilobus (Reuss)

Plate I, Figs. 17–20

Globigerina triloba Reuss, 1850, Denkscr. Acad. Wiss., Wien (Math-nat.cl.) 1: 374, pl. 47, figs. 11a-d.

Globigerinoides triloba triloba Bolli, 1957, Bull. U.S. nat. Mus., 215: 112, pl. 25, figs. 2a-c. Blow, 1959, Bull. Amer. Paleont., 39(178): 187, pl. 11, figs. 60a-b.

G. trilobus trilobus is the dominant species in the dredge sample. The specimens vary from relatively large, with inflated chambers and broad well-depressed sutures, to small and compact, with slightly depressed sutures. The supplementary aperture is usually small, but on some of the larger forms it is relatively large for the species. The sac-like final chamber is poorly developed and was observed on only a few specimens.

This subspecies is widely distributed in the Tertiary and is a dominant element of Recent subtropical and tropical planktonic foraminiferal faunas. It ranges at least as far back as the early Miocene, and possibly earlier.

Globoquadrina dehiscens (Chapmann, Parr, and Collins)

Plate II, Figs. 1, 2

Globorotalia dehiscens Chapman, Parr, and Collins, 1934, J. linn. Soc. (Zool.), 38: 569, pl. 11, figs. 36a-c.

Globoquadrina dehiscens Bolli, 1957, Bull. U.S. nat. Mus., 215: 111, pl. 24, figs. 3a-4c. Blow, 1959, Bull. Amer. Paleont., 39(178): 182, pl. 8, figs. 49a-c.

The present specimens are moderately compressed laterally and the periphery is subrounded. The umbilicus is deep but relatively narrow and elongated. There are four chambers in the last whorl, and the umbilical teeth are weakly to moderately well developed. These specimens fall within the range of variation of *G. dehiscens*, but in equatorial profile the chambers are less truncated and the test less quadrate than in the typical form.

This species was originally described as taken from the Oligocene of Victoria, Australia, but it is a common, widely distributed form in the Miocene and has been reported to occur in the Pliocene.

Globorotalia scitula gigantea Blow

Plate II, Figs. 8, 9

Globorotalia scitula gigantea Blow, 1959, Bull. Amer. Paleont., 39(178): 220, pl. 16, figs. 127a-c.

These specimens include forms ranging from *G. scitula praescitula* to *G. scitula scitula* to *G. scitula gigantea.* However, most of the specimens are large and comparable to the holotype and paratypes of *G. scitula gigantea*; the suite is referred to that subspecies.

G. scitula gigantea ranges from the Lower Burdigalian in the Miocene to the Recent (Banner and Blow 1960: 29).

Globorotalia fohsi robusta Bolli

Plate II, Figs. 3, 4

Globorotalia fohsi robusta Bolli, 1950, Contr. Cushman Fdn., 1 (3, 4): 84, 89, pl. 15, figs. 3a-c. Bolli, 1957, Bull. U.S. nat. Mus., 215: 119, pl. 28, figs. 16a-e. Blow, 1959, Bull. Amer. Paleont., 39(178): 213, pl. 16, figs. 114a-c.

The specimens referred to this species have well-developed keels and peripheries that are slightly lobulate in the later chambers. On the ventral side, the sutures are thin, radial, and depressed; those on the dorsal side are slightly limbate. These specimens are somewhat smaller on the average than the holotype and paratypes of *G. fohsi robusta*, but otherwise they agree well.

This species is common in the Miocene of the Caribbean, where it is an index species. Todd (1964: 1094) has recorded the presence of *G. fohsi robusta* in late Tertiary cores from Eniwetok in the Pacific.

Globorotalia cf. *G. acostaensis* Blow

Plate II, Figs. 10, 11

The material consists of a single specimen with 12 chambers, five of which are visible on the ventral side. The sutures are radial and depressed while the periphery is moderately lobulate. The aperture is extraumbilical. In diameter and thickness, the specimen compares favorably with the holotype of *G. acostaensis* Blow. However, the specimen differs from that holotype in its less-lobulate periphery and in lacking an apertural lip.

Orbulina universa suturalis Bronniman

Plate II, Figs. 12, 13

Orbulina suturalis Bronniman, 1951, Contr. Cushman Fdn., 2(4): 135, text figs. 2–22.
Orbulina universa d'Orbigny. Belford, 1962, Bull. Geol. Geophys., Bur. mineral. Res. (Australia), 62–1: 6, pl. 1, figs. 1–15.

Besides typical *O. suturalis*, the present specimens include single-chambered forms, referable to *O. universa*, and bichambered forms, referable to *Biorbulina bilobata*. I agree with Belford (1962: 6) in regarding these three forms as variants of a single population, since they manifest a transitional series. They are placed in the subspecies *O. universa suturalis* to distinguish populations of *O. universa* that include the form *suturalis* from populations that do not; *suturalis* is an extinct form, whereas *bilobata* and *universa* occur in the Recent. Modern assemblages of *O. universa* are dominated by the form *universa* while *bilobata* is rare.

The form *suturalis* occurs commonly in the Miocene and appears to range from the Lower Miocene to Pliocene.

Sphaeroidinella disjuncta Finlay

Plate II, Figs. 18, 19

Sphaeroidinella disjuncta Finlay, 1940, Trans. roy. Soc. N.Z., 69(4): 469, pl. 67, figs. 224–228. Hornibrook, 1958, Micropaleontology, 4(1): 34, pl. 1, fig. 14.

This species is represented by two specimens that closely resemble *S. seminulina* but are distinguished by coarsely pitted surfaces that stand in sharp contrast to the smooth polished specimens of the latter.

This species was originally described from the Altonian stage (lower Miocene) of New Zealand. Todd (1964: 1089) has recorded it from late Tertiary core samples from Eniwetok.

Sphaeroidinella kochi (Caudri)

Plate II, Figs. 14, 15

Globigerina sp. Koch, 1923, Ecl. geol. Helv., 18: 355, text fig. 8.
Globigerina kochi Caudri, 1934, Tertiary deposits of Soemba, Amsterdam, p. 144.
Sphaeroidinella kochi Todd, 1957, Prof. Pap. U.S. geol. Surv., 280-H: pl. 79, fig. 6.
Sphaeroidinella seminulina kochi Blow, 1959, Bull. Amer. Paleont., 39(178): 198, pl.12, figs. 78, 79.

This species is represented by rare specimens. It is distinguished from *S. seminulina* in that it has five or six chambers in the last whorl rather than three or four as in *S. seminulina*. The periphery of *S. kochi* is strongly lobulate and the sutures are broad and deeply depressed.

The type locality of *S. kochi* is from the Tertiary of the island of Soemba, near Timor. It has also been recorded from Miocene deposits of Saipan, Eniwetok, and Venezuela.

Sphaeroidinella seminulina (Schwager)

Plate II, Figs. 16, 17

Globigerina seminulina Schwager, 1886, Novara Exped. 1857–1859, Vienna, (Geol.) 2(2): 256, pl. 7, fig. 112. Banner and Blow, 1960, Contr. Cushman Fdn., 11(1): 24, pl. 7, figs. 2a, b.

Sphaeroidinella rutschi Cushman and Renz, 1941, Contr. Cushman Lab., 17(1): 25, pl. 4, fig. 5.

Sphaeroidinella dehiscens subdehiscens Blow, 1959, Bull. Amer. Paleont., 39(178): 195, pl. 12, figs. 71a-c, 72.

This species, abundantly represented in the consolidated ooze, includes a wide range of intergrading forms. The specimens have either three or four chambers in the last whorl; the periphery ranges from smoothly rounded to lobulate. On some specimens the sutures are deeply depressed, but there is gradation to others with flush, obscure sutures. The apertures, too, show much variation, ranging from a broad diamond-shaped umbilical opening to a narrow asymmetrically located slit.

The dredge specimens compare favorably with *Globigerina seminulina*, as figured by Schwager, and with the neotype of that species, figured by Banner and Blow (1960: 24, pl. 7, figs. 2 a, b).

The holotypes of both *S. rutschi* and *S. dehiscens subdehiscens* fall within the range of variation of the present specimens. Therefore, these two latter forms are not considered distinguishable from *S. seminulina* at the specific level.

This species is widely distributed in the upper Tertiary and has a relatively long range. It has not been recorded for the Recent, but AGIP Mineraria (1957: pl. 17, fig. 6) has reported it for the Quaternary and Pliocene of Italy. The lowermost occurrence of this species is from the Aquitanian.

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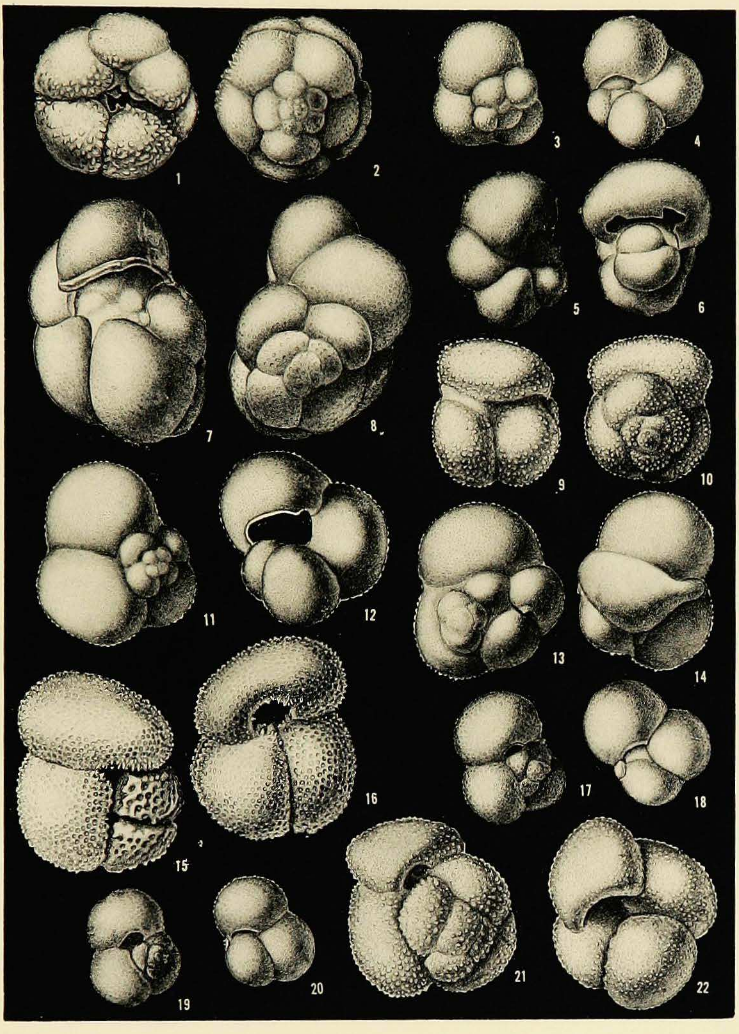

Plate I. Planktonic Foraminifera from consolidated ooze dredged from the mid-Atlantic Ridge, 22°56′N, 46°35′W.

Figs. 1, 2, *Globigerina altispira altispira*, X82, USNM 642333;
Figs. 3, 4, *Globigerina* c.f. *G. bulloides*, X98, USNM 642334 ;
Figs. 5, 6, *Globigerinella* c.f. *G. aequilateralis*, X62, USNM 642335 ;
Figs. 7, 8, *Globigerina nepenthes*, X98, USNM 642336;
Figs. 9, 10, *Globigerinoides conglobatus gomitulus*, X93, USNM 642337;
Figs. 11, 12, *Globigerina apertura*, X62, USNM 642338 ;
Figs. 13, 14, *Globigerinita glutinata*, X98, USNM 642339;
Figs. 15, 16, *Globigerinoides ruber*, X98, USNM 642340 ;
Figs. 17, 18, *Globigerinoides trilobus trilobus*, X44, USNM 642341 ;
Figs. 19, 20, *Globigerinoides trilobus trilobus*, X44, USNM 642342 ;
Figs. 21, 22, *Globigerinoides obliquus*, X98, USNM 642343.

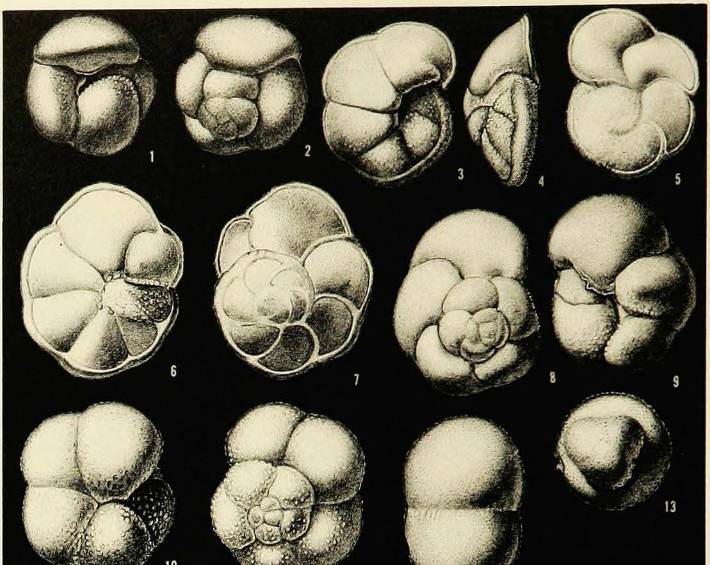

Plate II. Planktonic Foraminifera from consolidated ooze dredged from the mid-Atlantic Ridge, 22°56′N, 46°35′W.

Figs. 1, 2, *Globoquadrina dehiscens*, X46, USNM 642344;
Figs. 3, 4, 5, *Globorotalia fohsi robusta*, X44, USNM 642345 ;
Figs. 6, 7, *Globorotalia fohsi robusta*, X62, USNM 642346 ;
Figs. 8, 9, *Globorotalia scitula gigantea*, X62, USNM 642347 ;
Figs. 10, 11, *Globorotalia* c.f. *G. acostaensis*, X98, USNM 642348 ;
Fig. 12, *Orbulina universa suturalis* (bilobed form), X65, USNM 642349 ;
Fig. 13, *Orbulina universa suturalis*, X62, USNM 642350 ;
Figs. 14, 15, *Sphaeroidinella kochi*, X44, USNM 642351;
Figs. 16, 17, *Sphaeroidinella seminulina*, X44, USNM 642352 ;
Figs. 18, 19, *Sphaeroidinella disjuncta*, X62, USNM 642353;
Figs. 20, 21, *Sphaeroidinella seminulina*, X44, USNM 642354.

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