TULANE STUDIES IN GEOLOGY AND PALEONTOLOGY

Volume 18, Number 1 October 31, 1984

THE WALL STRUCTURE OF SUPERFAMILY MILIOLACEA AND ITS LINEAGE IN THE GULF COASTAL PLAIN

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ILLUSTRATIONS

I. ABSTRACT

A study of *Quinqueloculina tuberculata* Cushman and Todd from the Moodys Branch Formation (Jackson, Eocene) at Jackson, Mississippi, eventually evolved into this report on the wall structure of the foraminiferal superfamily Miliolacea and its genera and species from the Gulf Coastal Plain.

From the Moodys Branch Formation *Massilina jacksonensis* Cushman and its variety *punctatocostata* Cushman have been assigned to the new genus *Tappanella; Quinqueloculina tuberculata* Cushman and Todd is considered to be the quinqueloculine stage of *Massilina jacksonensis* Cushman; *Miliola saxorum* Lamarck and *Miliola jacksonensis* Cushman remain as originally described.

From the Weches Formation (Claiborne, Eocene) at Smithville, Texas, *Spiroloculina smithvillensis* Feray (nomen nudum) is redescribed as *Texina ferayi*, n. sp., which in turn is selected as the type species for the new genus *Texina*.

The Cane River Formation (Claiborne, Eocene), a Louisiana lithologic unit equivalent to the Weches of Texas, contains *Spiroloculina lamposa* Hussey, which has been assigned to the genus *Neaguites*, new genus.

Species related to *Miliola* present in the Byram Formation (Oligocene) include: *Triloculina mississippiensis* Cushman, which has been selected as the type of a new genus *Picouina; Spiroloculina byramensis* Cushman and *Spiroloculina imprimata* Cushman, which have been assigned to the new genus *Neaguites;* and *Quinqueloculina byramensis* Cushman, which has been assigned to the genus *Miliola*.

Tappanella, Picouina, Neaguites and *Texina*, the foraminiferal genera described as new, are calcareous perforate; have pitted chamber walls; and most aper-

tures have a trematophore (are cribrate). They are assigned to the family Miliolidae, because the type genus *Miliola* has the same structural features. These features in turn, necessitate an emended diagnosis of the superfamily Miliolacea to accommodate genera with calcareous perforate chamber walls.

II. INTRODUCTION

An enigmatic, knobby species of foraminifera, *Quinqueloculina tuberculata* Cushman and Todd (fig. 1), from the Moodys Branch Formation is responsible for this paper. While attempting to collect topotypes of this species, it became apparent that tubercles or knobs were neither restricted nor unique to *Q. tuberculata* (figs. 5 and 6); that knobs occurred only on weathered or fragmented specimens (fig. 2); and that the knobs were associated only with species with pits in the wall of the chambers. These observations led to an expansion of the study to include: 1) the wall structure of the superfamily Miliolacea; and 2) the pitted species described from Eocene and Oligocene formations in the Gulf Coastal Plain. This *Miliola* lineage includes species reported from the Weches and Cane River Formations (Claiborne, Eocene) in Texas and Louisiana, the Moodys Branch Formation (Jackson, Eocene) and the Red Bluff and Byram Formations (Oligocene) in Mississippi.

The holotype of *Q. tuberculata* was recovered from the type locality of the Moodys Branch Formation located, according to Cushman and Todd (1945, p. 81), on the "E. bank of Moody's Branch 250 feet upstream from bridge across Moody's Branch on Monroe Street, NE part of Jackson, Miss." Because the type locality of the Moodys Branch Formation is no longer accessible, the samples used herein, for the recovery of "topotypes" of *Q. tuberculata,* came from the alternate type locality located in Riverside Park at Jackson, Mississippi. These samples provided the same fauna, depositional environment and subsequent weathering conditions that affected the specimens of *Q. tuberculata* described by Cushman and Todd in 1945.

The Moodys Branch Formation of the Jackson Group, as described by Cushman and Todd (1945, p. 79), underlies the Yazoo Formation; however, it does not overlie the Cockfield and Yegua conformably. In Louisiana, at least, a major unconformity separates the Moodys Branch Formation from the underlying Cockfield Formation of the Claiborne Group. Anderson (1971, p. 96) states that the "Moodys Branch represents an open marine transgressive facies disconformably onlapping the deltaic Yegua and Cockfield Formations and the Gosport Formation, which is the beach facies of the Yegua-Cockfield."

The Weches sample were collected from the Viesca Member located on the right bank of the Colorado River at Smithville, Texas. Feray (1941, p. 14) reports that, "the [Weches] formation rests disconformably upon the Queen City sands in the outcrop section throughout most of Texas," and that the overlying Sparta contact is "more transitional in character" in Bastrop County, where the Smithville outcrop is located.

The Cane River Formation sample studied came from outcrops in a tributary to Limekiln Bayou located in section 3 of T. 8 N., R. 8 W., about six miles west of Natchitoches, Louisiana. The formation in this area conformably overlies the Carrizo Formation and underlies the Sparta Sand of the Claiborne, Eocene.

The Oligocene Series is represented by the Red Bluff Formation at the base of the series, and by the Byram Formation at the top below the Catahoula sands of the Miocene Series. Both formations apparently are conformable in their relationship with the underlying and overlying formations.

All specimens figured are deposited in the Louisiana State University Geoscience Museum (LSU GM).

III. SYSTEMATICS*

Order FORAMINIFERIDA Eichwald, 1830
Suborder MILIOLINA Delarge and Héruard, 1896

Emended Diagnosis (Loeblich and Tappan, 1964, p. 436): Test calcareous, *wholly or in part* porcelaneous, commonly with pseudochitinous lining, may also include some adventitious material in wall. Carboniferous-Recent.

Remarks: Only the chamber floor of the genus *Miliola* is porcelaneous and imperforate. The chamber wall attached to the chamber floor is calcareous perforate. (See Family Miliolidae for discussion of chamber wall.)

Superfamily MILIOLACEA Ehrenberg, 1839

Emended Diagnosis (Loeblich and Tappan, 1964, p. 436): Wall *calcareous perforate, pitted,* may have adventitious material in *chamber wall;* proloculus followed by *two chambers to whorl,* arranged in different planes; aperture single *and simple* or cribrate. Eocene-Oligocene.

Remarks: Fragments of the final chamber of the following species were mounted on cover glass slides with canada balsam to determine the microstructure of the chamber wall.

Miliola saxorum Lamarck (from Mississippi and France)
Miliola jacksonensis Cushman
Massilina jacksonensis Cushman (1935 version)
Massilina jacksonensis punctatocostata Cushman

All wall fragments of the above were translucent, revealing a myriad of intertwining dark brown to black thread-like structures randomly distributed throughout the chamber wall (fig. 8). None showed an interference figure with the converging lens in place and the Bertrand lens introduced in the polarizing microscope tube. This indicates, but does not prove conclusively, that the chamber walls of the above species and variety assigned herein to the superfamily Miliolacea are composed of granular calcite. To test the accuracy of these observations, fragments of the pitted Holocene porcelaneous chamber wall of *Triloculina bicarinata* d'Orbigny, mounted on a slide in canada balsam, also showed no interference figure; however, the fragments were opaque.

The proposed placement for the porcelaneous Miliolacea, as described previously is in a new superfamily, the Soritacea. The Soritidae and Alveolinidae, described in 1839, are the oldest families with porcelaneous genera. According to Loeblich and Tappan (1964, p. 506) however, the type genus of Alveolinidae "is unquestionably a junior objective synonym." It appears, therefore, that the genus *Sorites* is the logical choice of a type genus for the superfamily of all porcelaneous genera.

Family MILIOLIDAE Ehrenberg, 1839

Emended Diagnosis (Loeblich and Tappan, 1964, p. 458): Test free, septate; *chambers with floor, simple interior, and pitted surface;* typically with 2 chambers to whorl arranged in varying planes about longitudinal axis; aperture terminal, simple or cribrate. Eocene-Oligocene.

Remarks: The wall structure of the Miliolidae as described herein, is based upon a study of the type species of the family, *Miliola saxorum* Lamarck, from the Lutetien samples collected in the Paris Basin, France, and specimens from the Moodys Branch Formation in Jackson, Mississippi. The difference between the species from the two localities is considered to be insignificant, particularly with respect to the wall structure. The descriptions of the *M. saxorum* wall, however, are based principally upon the Moodys Branch Formation specimens for comparison with species related to the *M. saxorum* present in the Moodys Branch, but not in the Lutetien of France.

The chamber wall of the family

*Emendations to Loeblich and Tappan's 1964 definitions are in italics; vital omissions are discussed under Remarks.

Miliolidae in general terms: is calcareous perforate; can be extremely porous but not alveolar; and has a pitted exterior. The arcuate chamber wall is attached to a thick, flat chamber floor (fig. 16), which is porcelaneous and imperforate. The genera and species with these wall structures are:

Miliola saxorum Lamarck

Miliola jacksonensis Cushman

Miliola byramensis (Cushman) = *Quinqueloculina byramensis*

Miliola rolandi Andersen, new species

Tappanella punctatocostata (Cushman) = *Massilina jacksonensis punctatocostata*

Tappanella jacksonensis (Cushman) = *Massilina jacksonensis*

Picouina mississippiensis (Cushman) = *Triloculina mississippiensis*

Neaguites inusitatus Andersen, new species

Neaguites byramensis (Cushman) = *Spiroloculina byramensis*

Neaguites lamposus (Hussey) = *Spiroloculina lamposa*

Neaguites imprimatus (Cushman) = *Spiroloculina imprimata*

Texina ferayi, new species = *Spiroloculina smithvillensis* (nomen nudum)

Detailed characteristics of the Miliolidae are revealed in the scanning electron microscope photomicrographs, with some magnifications up to × 5000. The wall section of *Miliola saxorum* (fig. 13), for example, clearly cuts through the center of four pits. The second and fourth pit from the left side of the photomicrograph appear to have platforms located midway between the inner and outer walls of the chamber, or at the base of the pit. That portion of the pit seen on the exterior of the chamber is open; the inner portion is filled with shell material, which looks very much like a sieve plate or a small cribrate aperture (fig. 10). The platform at the base of the pit is more clearly defined in figure 15; the perforation openings on the inside of the chamber wall are shown in figure 14.

The perforations at the base of the platform in the pits are frequently arranged in a circular pattern adjacent to the exterior wall as shown in figures 7 and 28. The distribution of perforations between the pits can be seen below the cribrate aperture in figure 32.

The distribution of the perforations described above is characteristic of *Miliola saxorum, M. jacksonensis,* and the two species of *Tappanella.* The remaining species examined under a scanning electron microscope appear to have their perforations restricted to the pits in the chamber wall. This is true of *Miliola* sp. (fig. 23), *M. rolandi* (fig. 25), *Picouina mississippiensis* (fig. 35), *Neaguites inusitatus* (fig. 38), *N. byramensis* (fig. 40), *N. lamposus* (fig. 42), and *Texina ferayi* (fig. 46). *"Spiroloculina" imprimata* Cushman, borrowed from the U.S. National Museum, could not be subjected to scanning electron microscope study.

The proposed placement for the porcelaneous genera formerly included in the family Miliolidae is in the Fabularidae. Although specialized, it is part of the Miliolacea, and the oldest subfamily in the porcelaneous assemblage of genera.

Subfamily MILIOLINAE Ehrenberg, 1839

Emended Diagnosis (Loeblich and Tappan, 1964, p. 468): Wall simple; *may have cribrate aperture* (trematophore). Eocene-Oligocene.

Remarks: The small costate species of *Miliola* with relatively large pits for the size of the test, which occur in the Moodys Branch, Red Bluff and Byram formations in the Gulf Coastal Plain, and Damery and Grignon in France, have open, circular to semicircular apertures. Whether one presumes that the apertures were cribrate originally, or that they never had a cribrate aperture is inconsequential. No special consideration was given the aperture by Kaasschieter in 1961 (p. 161) when he wrote: "It is now doubtful that any *Quin-*

queloculina species with striae and pits occurs in the Eocene or Oligocene of France and Belgium." This statement can also be applied to all pitted Eocene and Oligocene *Quinqueloculina* species in the Gulf Coastal Plain.

Genus MILIOLA Lamarck, 1804

Type species: *Miliolites saxorum* Lamarck, 1804.

Emended Diagnosis: Test free, quinqueloculine chamber arrangement, latter chambers with floor; wall calcareous, perforate, and pitted; aperture simple or cribrate. Range: Eocene-Oligocene, North America and Europe.

Remarks: The two largest species of *Miliola* in the Gulf Coastal Plain, *M. saxorum* and *M. jacksonensis*, are well represented in the Moodys Branch Formation in Jackson, Mississippi. A smaller species, *M. rolandi*, n.sp., which occurs with the two large species above, ranges into the Red Bluff Formation (Oligocene). Present, but not abundant in the Byram Formation (Oligocene), is *M. byramensis*.

Quinqueloculina tessellata Cushman, described from the Byram Formation (not included in this report) probably should be assigned to the genus *Miliola*.

MILIOLA SAXORUM Lamarck
Figures 5-16.

Miliolites saxorum LAMARCK, Annales du Museum, vol. 5, no. 5, p. 352, 1804.

Quinqueloculina saxorum (Lamarck), D'ORBIGNY, Annales Sci. Nat., vol. 7, p. 301, no. 1, pl. 16, figs. 10-14, 1826.

Miliola saxorum Lamarck, CUSHMAN, U.S. Geol. Survey Prof. Paper 181, pp. 12, 13, pl. 3, figs. 1-3, 1935; BERGQUIST, Miss. Geol. Surv. Bull., no. 49, p. 25, pl. II, fig. 8, 1942; CUSHMAN and TODD, Contr. Cushman Lab. Foram. Res., vol. 21, pt. 4, p. 83, 1945; KAASSCHIETER, Inst. Royal Sci. Nat. Belgium, Memoir n. 147, p. 161, pl. IV, fig. 25-27, pl. V, fig. 1, 1961.

Emended Diagnosis: Test large, elongate, fusiform, quinqueloculine; chambers numerous, distinct, and pitted, chamber floor at least in the adult, estimated wall thickness of 0.023 mm to 0.03 mm; periphery normally rounded but occasionally with a slightly flattened surface; wall smooth, perforated, and with small, rounded pits arranged in oblique and longitudinally aligned rows, pits with none to several perforations at its base, which continue through the remaining portion of the chamber wall; aperture at the end of a very short neck, cribrate. Length 2.50 mm; diameter 0.60 mm.

Figured Specimens: LSU GM Nos. 10484-10487, 10489-10491, from the Moodys Branch Formation, Riverside Park, Jackson, Mississippi; LSU GM No. 10488, from the Lutetien at Damery, France.

Remarks. The type locality of *Miliola saxorum* is the Lutetien (Eocene) of the Paris Basin, France. Cushman's assignment of specimens from the Jackson (Eocene) of Mississippi to *Miliola saxorum* is reaffirmed.

Scanning electron microscope study of a *Miliola saxorum* specimen from the Moodys Branch Formation in Mississippi (figs. 9, 10) and a specimen from the Lutetien of Damery, France (figs. 11, 12), shows two picayunish differences between the two specimens. The Moodys Branch specimen is more pointed at the end opposite the aperture, and the aperture has a longer neck. These differences, however, are not considered important enough to recall Cushman's assignment of the Mississippian *Miliola* to the species *saxorum*.

MILIOLA JACKSONENSIS Cushman
Figures 17-19.

Miliola jacksonensis CUSHMAN, Contr. Cushman Lab. Foram. Res., vol. 9, pt. 1, p. 2, pl. 1, figs. 2, 3, 1933; CUSHMAN, U.S. Geol. Surv. Prof. Paper 181, p. 13, pl. 3, figs. 4-6, 1935; CUSHMAN and TODD, Contr. Cushman Lab. Foram. Res., vol. 21, pt. 4, p. 83, pl. 13, fig. 13, 1945; BANDY, Bull. Amer. Paleontology, vol. 32, no. 131, p. 22, pl. 2, figs. 6a-c, 1949.

Miliola cf. *jacksonensis* FRANKLIN, Journ. Paleontology, vol. 18, p. 308, pl. 45, fig. 6, 1944.

Emended Diagnosis: Test large, elongate, fusiform, quinqueloculine; chambers numerous, distinct, perforated, developing a chamber floor in the adult; periphery

rounded to very slightly angular; wall ornamented with thin, relatively high costae, aligned with the long axis of the test, not equally spaced; pits randomly distributed between costae; pits with one or more perforations, which continue from the base of the pit into the chamber; aperture at the end of a very short neck, cribrate. Length 2.00 mm; diameter 0.55 mm.

Figured Specimens: Topotypes, LSU GM Nos. 10492-10493, from the Moodys Branch Formation, Riverside Park, Jackson, Mississippi.

Remarks: Cushman made the following statement relative to *Miliola jacksonensis,* which he described originally from the Jackson Formation (now Jackson Group), in Jackson, Mississippi.

> In some respects it *[Miliola jacksonensis]* resembles the *Quinqueloculina parisiensis* of d'Orbigny, as figured by Terquem, but Fornasini's tracings of d'Orbigny's original plates show only the longitudinal costae with no sign of punctae.

Kaasschieter (1961, p. 182), in his memoir on the foraminifera of the Eocene of Belgium, considers Terquem's *Quinqueloculina parisiensis* a junior synonym of *Miliola disticha* (Terquem). The distinction made is that "the ornamentation of this species *[M. disticha]* is close to that of striated variants of *Miliola saxorum,* but typical specimens are more flattened." It appears, therefore, that *Miliola jacksonensis* Cushman does not resemble any European species.

Excerpts from the description of a *Miliola jacksonensis* reported by Bandy (1949) from the Yazoo Clay, Jackson, Eocene, at Little Stave Creek in Clarke County, Alabama, follows:

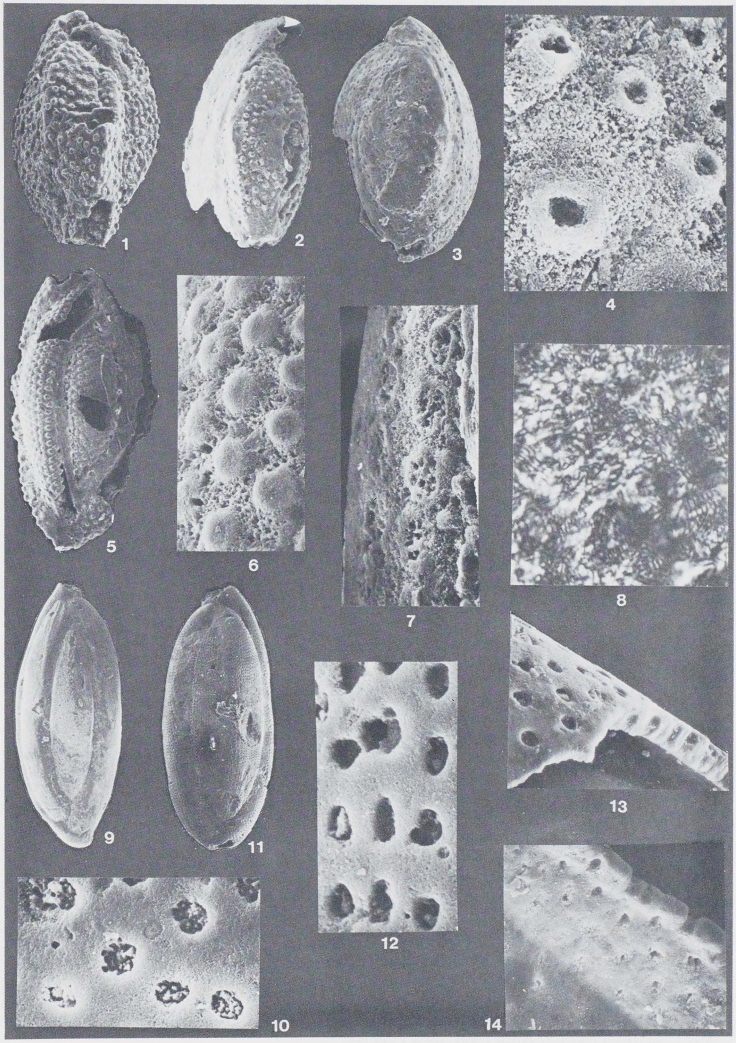
> . . . chambers with rounded backs; . . . ; wall silicious, white, surface ornamented with numerous fine longitudinal costae . . . Length 1.13 mm, diameter 0.37 mm.

Bandy's species, as illustrated, definitely has rounded chambers with costae so faint or fine that they do not project beyond the periphery of the chamber wall. Topotype specimens of *Miliola jacksonensis* have very pronounced, thin costae, which extend far enough beyond the periphery of each chamber to obscure partially the shape of the chamber. Also, the Alabama specimen, which is about half the length of the Mississippi specimens, is equally as close to the size of *Miliola rolandi;* and must have undergone diagenesis for its calcium carbonate test to be replaced with silica.

FIGURES

1-4. *Quinqueloculina tuberculata* Cushman and Todd
1. Weathered specimen, × 75 (LSU GM No. 10480)
2. Partially weathered specimen, × 100 (LSU GM No. 10481)
3. Unweathered specimen, × 75 (LSU GM No. 10482)
4. Weathered fragment, × 100 (LSU GM No. 10483)

5-14. *Miliola saxorum* Lamarck
5. Broken specimen showing knobs on interior chambers, × 63 (LSU GM No. 10484)
6. Enlargement of pits in figure 5 showing that the pits were filled when the floor above was secreted, × 1000 (LSU GM No. 10484)
7. Perforations at base of pits, × 500 (LSU GM No. 10485)
8. Polarizing microscope study of chamber wall, × *ca.* 2360 (LSU GM No. 10486)
9. Lateral view of specimen from Moodys Branch Formation, × 33 (LSU GM No. 10487)
10. Enlargement of pits, × 1000 (LSU GM No. 10487)
11. Lateral view of specimen from Lutetien at Damery, France, × 33 (LSU GM No. 10488)
12. Enlargement of pits, × 1000 (LSU GM No. 10488)
13. Section through chamber wall, × 200 (LSU GM No. 10489)
14. Interior of chamber wall, × 200 (LSU GM No. 10489)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MILIOLA BYRAMENSIS (Cushman)
Figures 20-22.

Quinqueloculina byramensis CUSHMAN, U.S. Geol. Surv. Prof. Paper 133, p. 54, pl. VIII, fig. 3, 1923.

Emended Diagnosis: Test quinqueloculine, approximately twice as long as broad, final chamber projects slightly beyond the penultimate chamber at both ends of test; chambers with broad, elevated costae longitudinally disposed, undermined by pits spaced at relatively regular intervals longitudinally, which produces eyelets in the costae; pits between costae are offset to those beneath the costae; periphery rounded; aperture on a slight neck. Length 0.3 mm to 0.4 mm.

Figured Specimens: LSU GM Nos. 10494-10495, from the Byram Formation at its type locality on the right bank of the Pearl River, east of Byram, Mississippi.

Remarks: Five specimens of *Quinqueloculina byramensis* Cushman were available from the H. V. Howe Collection, curated by the LSU Geoscience Museum. The most complete specimen, figure 20, was used for the lateral view; the best apertural view of two specimens (fig. 22), which appeared to have remnants of a cribrate aperture, in the photomicrograph proved to have only a highly polished apertural opening with no sign of cribrations.

Asssignment of this species to the genus *Miliola* is based upon the fact that the chambers are quinqueloculine, pitted and costate, and the species occurs in the Oligocene.

MILIOLA ROLANDI, new species
Figures 24-25.

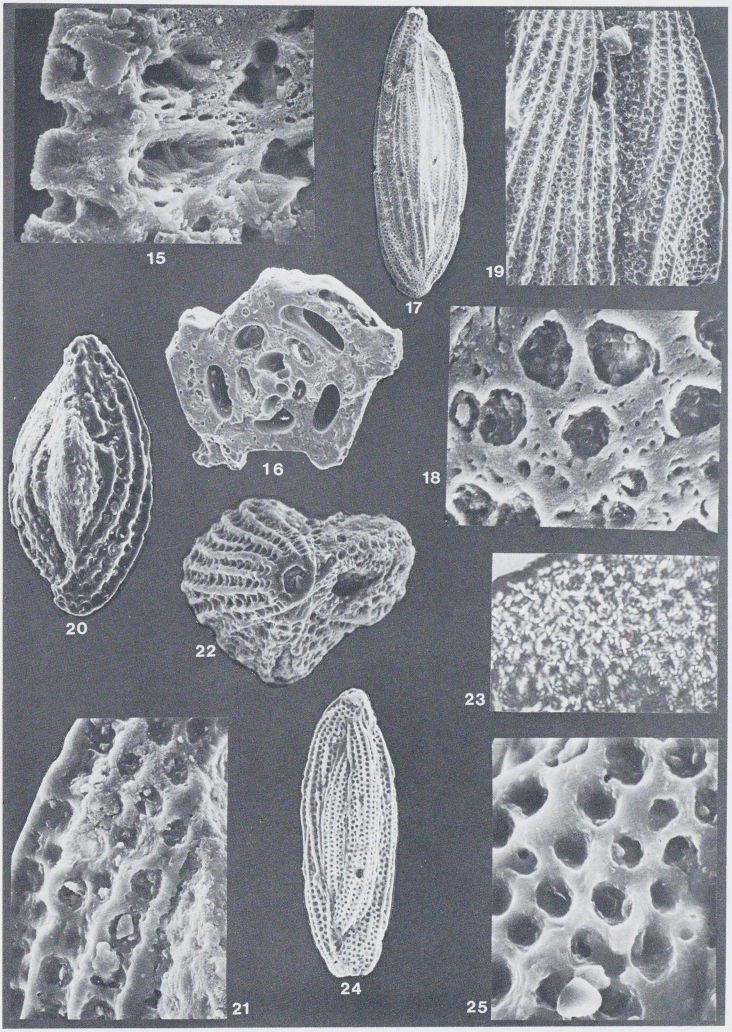
Diagnosis: Test small, elongate, approximately 2.5 times as long as broad, quinqueloculine; base rounded, final chamber extends above the penultimate chamber; periphery rounded; chambers numerous, with low, broad ridges between rows of pits aligned with the long axis of the test; pits with a single perforation leading into the chamber; aperture at the end of a very short neck. Length of holotype 0.54 mm; breadth 0.20 mm.

Figured Specimen: Holotype, LSU GM No. 10497, from the Moodys Branch Formation, Riverside Park, Jackson, Mississippi.

Remarks: This species is similar to several of the small species of *Miliola* described in France and Belgium. The European forms appear to be much longer and narrower than *M. rolandi,* which has the general appearance of *M. jacksonensis. Miliola rolandi,* however, is much smaller; has broader and less elevated costae; and

FIGURES

15-16. *Miliola saxorum* Lamarck
15. Wall section and interior of chamber showing perforations through the chamber wall, × 750 (LSU GM No. 10490)
16. Transverse section showing flat chamber floors around the perimeter of the test, × 175 (LSU GM No. 10491)
17-19. *Miliola jacksonensis* Cushman
17. Lateral view of topotype, × 33 (LSU GM No. 10492)
18. Enlargement of pits, × 1000 (LSU GM No. 10492)
19. Enlargement of costae and pits, × 80 (LSU GM No. 10493)
20-22. *Miliola byramensis* (Cushman)
20. Lateral view, figured specimen, × 150 (LSU GM No. 10494)
21. Eyelets in costae, × 500 (LSU GM No. 10494)
22. Apertural view, × 250 (LSU GM No. 10495)
23. *Miliola* sp.
Polarizing microscope study of chamber wall × *ca.* 2360 (LSU GM No. 10496)
24-25. *Miliola rolandi* Andersen, new species.
24. Lateral view of holotype, × 88 (LSU GM No. 10497)
25. Enlargement of pits, × 1000 (LSU GM No. 10497)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has a completely different wall structure. (See figures 18 and 25.)

The specimen destroyed, to produce the shell fragment shown in figure 23, was similar in size and shape to *Miliola rolandi*. The polarizing microscope study revealed, however, that the pits are smaller and more abundant than those in the wall of the holotype of *M. rolandi*, figure 25. It appears, therefore, that figure 23 (LSU GM No. 10496), is a wall fragment from an undescribed species of *Miliola* from the Moodys Branch Formation at Jackson, Mississippi.

Genus TAPPANELLA new genus

Type species: *Massilina jacksonensis* Cushman var. *punctatocostata* Cushman.

Diagnosis: Test free, elliptical to nearly round in outline, flattened, chambers one-half coil in length, early chambers quinqueloculine, later ones added to approximately 180° in a single plane, later chambers with a floor; wall calcareous, perforate, with a series of pits on the surface of the chambers; pits aligned with the long axis of the test; aperture cribrate. Range: Eocene.

Remarks: Luczkowska (1972, p. 350), in a revision of the Miliolidae from the Miocene of Poland, considers *Massilina* an invalid genus. The conclusion is that "*Quinqueloculina seminulum*, the genotype of *Quinqueloculina*, and *Quinqueloculina secans*, the genotype of *Massilina*, belong to the same taxonomic group," and that, "further investigations of a greater amount of material available will permit to find definite massiline forms of *Q. seminulum*."

Be that as it may, it is safe to say that *Tappanella*, which has the identical chamber arrangement of *Massilina*, cannot suffer its fate. There is no apparent massiline stage in the ontogeny of *Miliola saxorum;* therefore, the genus *Tappanella*, the massiline form of the *Miliola* lineage, has no direct relationship with the type of *Miliola, M. saxorum* Lamarck.

Both *Heterillina* and *Tappanella* have a massiline chamber arrangement; however, neither the description nor the illustrated specimen of *Heterillina* in the *Treatise on Foraminiferida* by Loeblich and Tappan, (1964, p. 470, fig. 357, 7a-c) accommodates *Tappanella punctatocostata* (Cushman) with its pitted chambers, costae and perforate test.

This genus is named for Dr. Helen Tappan whose contributions to the field of micropaleontology are inestimable.

FIGURES

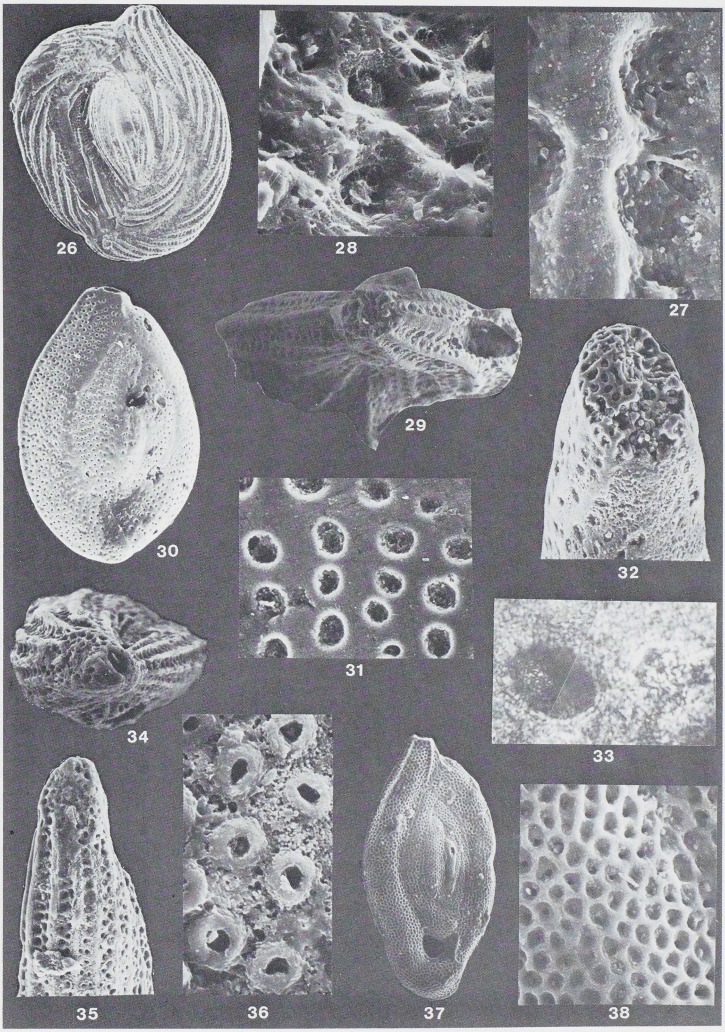
26-29. *Tappanella punctatocostata* (Cushman)
- 26. Lateral view of topotype, × 25 (LSU GM No. 10498)
- 27. Enlargement of pits, × 100 (LSU GM No. 10498)
- 28. Inside of test at base of pits, × 800 (LSU GM No. 10499)
- 29. Fragment of cribrate aperture, × 100 (LSU GM No. 10500)

30-33. *Tappanella jacksonensis* (Cushman)
- 30. Lateral view of topotype, × 30 (LSU GM No. 10501)
- 31. Enlargement of pits, × 500 (LSU GM No. 10501)
- 32. Apertural view, × 200 (LSU GM No. 10502)
- 33. Polarizing microscope study of chamber wall, × *ca.* 2360 (LSU GM No. 10503)

34-35. *Picouina mississippiensis* (Cushman)
- 34. Apertural view of topotype, × 300 (LSU GM No. 10504)
- 35. Side view of aperture, × 200 (LSU GM No. 10504)

36. *Neaguites* sp.
Weathered specimen, × 1000 (LSU GM No. 10505)

37-38. *Neaguites inusitatus* Andersen, new species.
- 37. Lateral view of holotype, × 150 (LSU GM No. 10506)
- 38. Enlargement of pits, × 1000 (LSU GM No. 10506)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TAPPANELLA PUNCTATOCOSTATA (Cushman)
Figures 26-29.

Massilina jacksonensis Cushman var. *punctatocostata* CUSHMAN, Contr. Cushman Lab. Foram. Res., vol. 9, pt. 1, p. 3, pl. 1, figs. 5, 6, 1933; CUSHMAN, U.S. Geol. Surv. Prof. Paper 181, p. 14, pl. 3, figs. 11-13, 1935; CUSHMAN and TODD, Contr. Cushman Lab. Foram. Res., vol. 21, pt. 4, p. 82, pl. 13, fig. 18, 1945; BANDY, Bull. Amer. Paleontology, vol. 32, no. 131, p. 25, pl. 2, figs. 8a-c, 1949.

Emended Diagnosis: Test broadly elliptical to nearly round, much compressed, periphery ranging from acute to slightly rounded depending on the position of the costae relative to the periphery; apertural end extending slightly beyond the penultimate chamber; wall calcareous, perforate; early chambers quinqueloculine, later ones added at 180° in a single plane with a chamber floor; surface ornamentated with low, thick costae oriented either parallel to the long axis of the chamber or cutting diagonally across the chamber, sutures difficult to discern because of the costae; costae separated by punctae, usually two offset rows; aperture at the end of a distinct but short neck, cribrate. Length of figured specimen 2.95 mm; breadth 2.05 mm.

Figured Specimens: Topotypes, LSU GM Nos. 10498-10500, from the Moodys Branch Formation, Riverside Park, Jackson, Mississippi.

Remarks: Over fifty adult topotypes of the type species of the new genus *Tappanella* were available at the time the emended diagnosis of the species was written. Not one of the specimens had a complete aperture, and only one (fig. 29) has fragments of a cribrate aperture in the apertural opening.

TAPPANELLA JACKSONENSIS (Cushman)
Figures 30-33.

Massilina jacksonensis CUSHMAN, Journ. Paleontology, vol. 1, p. 150, pl. 23, figs. 5, 6, 1927; CUSHMAN, U.S. Geol. Surv. Prof. Paper 181, pp. 13-14, pl. 3, figs. 7-10, 1935; CUSHMAN and TODD, Contr. Cushman Lab. Foram. Res., vol. 21, pt. 4, p. 82, pl. 13, fig. 17, 1945.

Massilina cf. *jacksonensis*. PURI, Florida Geol. Survey, Bull. 38, p. 108, pl. 3, figs. 2a,b, 1957.

Quinqueloculina tuberculata CUSHMAN and TODD, Contr. Cushman Lab. Foram. Res., vol. 21, pt. 4, p. 81, pl. 13, fig. 17, 1945.

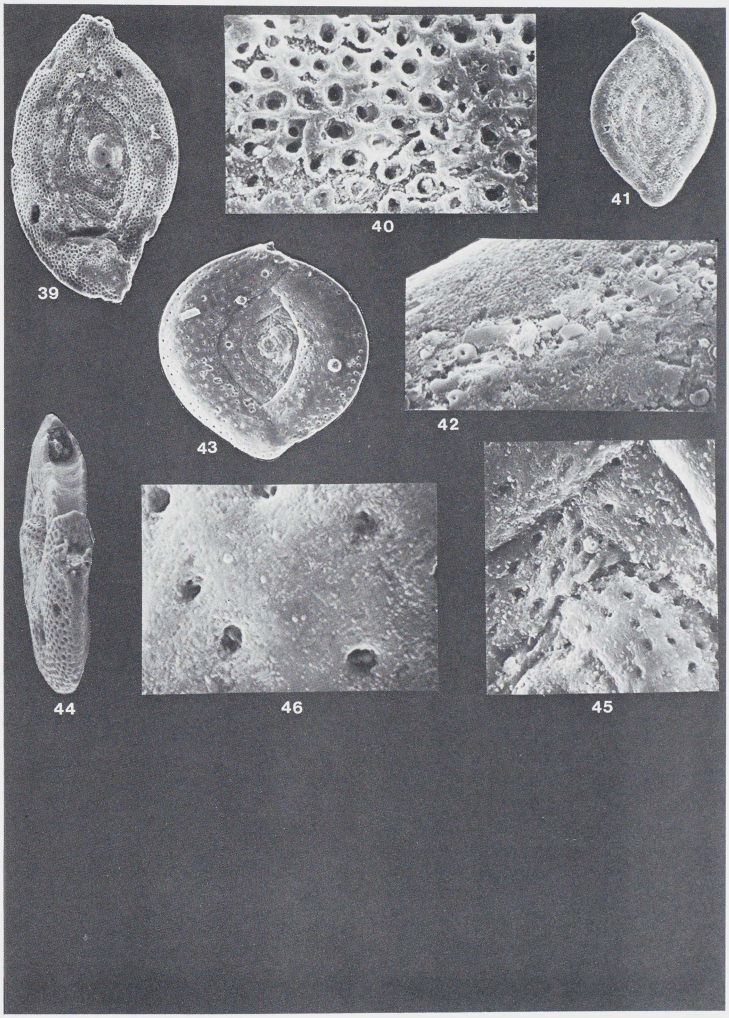
Emended Diagnosis: Test broadly oval or elliptical, compressed, periphery ranging from acute to slightly rounded, ultimate chamber extends slightly beyond the penultimate chamber; wall calcareous, perforate with pits randomly distributed on the smooth chamber wall; early chambers quinqueloculine, later ones added at 180° in a single plane and with a chamber floor; sutures fairly distinct; aperture with a trematophore on a short neck. Length 1.40 mm; breadth 1.00 mm; thickness 0.20 mm.

Figured Specimens: LSU GM Nos. 10501-10503, from the Moodys Branch Formation, Riverside Park, Jackson, Mississippi.

Remarks: Cushman described the foraminiferal species *Massilina jacksonen-*

FIGURES

39-40. *Neaguites byramensis* (Cushman)
39. Lateral view of topotype, × 113 (LSU GM No. 10507)
40. Enlargement of pores, × 1000 (LSU GM No. 10507)
41-42. *Neaguites lamposus* (Hussey)
41. Lateral view of figured specimen, × 100 (LSU GM No. 10508)
42. Enlargement of pores, × 1000 (LSU GM No. 10508)
43-46. *Texina ferayi* Andersen, new species
43. Lateral view of holotype, × 125 (LSU GM No. 10509)
44. Apertural view of paratype, × 225 (LSU GM No. 10510)
45. Enlargement of pores, × 1000 (LSU GM No. 10509)
46. Enlargement of pores, × 2500 (LSU GM No. 10509)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sis as a new species in 1927 and again in 1933. The descriptions were identical. The holotype for the 1927 *M. jacksonensis* USNM 369305, came from the Alazan clay, Rio Buena Vista, Vera Cruz, Mexico; the holotype for the 1935 *M. jacksonensis*, USNM 371529, came from the Jackson Group (Moodys Branch Formation) at Jackson, Mississippi.

Dr. Richard Cifelli, Curator of Paleobiology at the National Museum of Natural History, reported (personal communication) that the holotype of the 1927 *M. jacksonensis* is "non-existent." This leaves only the 1935 "holotype" upon which to base the species characteristics, providing the Commission on Zoological Nomenclature approves a petition that the 1927 name be suppressed because the holotype is no longer available, and that it would be nearly impossible to establish a neotype.

An angular *Quinqueloculina* in the Moodys Branch samples (fig. 3), satisfies the description of both *Quinqueloculina tuberculata* Cushman and Todd, 1945, and the quinqueloculine, microspheric stage of *Massilina jacksonensis* Cushman, 1935. For that reason, *Quinqueloculina tuberculata* Cushman and Todd is considered to be a junior synonym of the 1935 version of *Massilina jacksonensis* Cushman.

Genus PICOUINA new genus

Type species: *Triloculina mississippiensis* Cushman, 1935.

Diagnosis: Test free, triloculine chamber arrangement; wall calcareous perforate; chambers with a series of pits with single perforation extending into the chamber; aperture cribrate. Range: Oligocene.

Remarks: The genus *Picouina* differs from *Triloculina* in having a cribrate aperture, and a pitted and perforated test; and from *Austrotrillina* in having chambers with thin walls and a simple interior in contrast to the thick, alveolar wall of *Austrotrillina.*

This genus is named for Edward B. Picou, Jr., affiliated with Shell Offshore Incorporated, located in New Orleans, Louisiana.

PICOUINA MISSISSIPPIENSIS (Cushman)
Figures 34, 35.

Triloculina mississippiensis CUSHMAN, Contr. Cushman Lab. Foram. Res., vol. 11, pt. 2, p. 25, pl. 4, figs. 1a-c, 1935.

Emended Diagnosis: Test calcareous, perforate, small, elongate, triloculine; periphery broadly rounded; chambers fairly distinct, interior simple, semicircular in transverse section; final chamber extending well beyond the penultimate chamber, apertural end pointed; wall ornamented with numerous longitudinal costae extending the entire length of the chamber, very fine, circular, uniform sized pits in grooves between costae; sutures indistinct due to the costate ornamentation; aperture cribrate. Length 0.60-0.65 mm; breadth 0.15 mm; thickness 0.12 mm.

Figured Specimen: Topotype, LSU GM No. 10504, from the Byram Formation, about one foot above ledge under the expansion bridge on Pearl River, Byram, Mississippi.

Remarks: The description of *Picouina mississippiensis* (Cushman) was emended to accommodate the discovery of a single specimen with a cribrate aperture. Also, the research in this report justifies placing the genus in the perforate *Miliola* lineage.

Subfamily NEAGUITESINAE
Andersen, 1984, new subfamily

Diagnosis: Wall simple, chambers planispirally coiled, simple aperture.

Genus NEAGUITES, new genus

Type species; *Spiroloculina byramensis* Cushman.

Diagnosis: Test free, elliptical to round in outline, sides flattened to slightly concave on both sides of test; chamber arrangement planispiral (proloculus followed by two chambers per volution, added at 180° in a single plane); wall calcareous, perforate with perforations oc-

cupying a series of pits on the surface of the chambers; aperture terminal, simple. Range: Eocene-Oligocene, North America.

Remarks: The chamber arrangement of *Neaguites* and *Spiroloculina* is identical. They differ in wall structure: *Spiroloculina* has a calcareous, porcelanous test; *Neaguites* is calcareous, perforate with pitted chambers. Neither a complete nor vestige of a cribrate aperture was present on any species studied.

The two species of *Neaguites, N. byramensis* and *N. lamposus,* appear to have chamber walls composed of three layers of calcium carbonate. The outer layer certainly, and the inner layer, in all probability, is denser than the middle layer. The erosion of the outer layer appears to be mechanical rather than chemical, as shown in figures 40 and 42, and the collar surrounding the pit is as well defined on *N. lamposus* as it is on weathered specimens of *Miliola saxorum,* except that the structure is smaller because the chamber wall is thinner.

Neaguites Andersen, new genus, is represented by *N. inusitatus*, n. sp., from the Red Bluff (Oligocene) Formation at Hiwanee Station, Mississippi; by *N. byramensis, N. imprimatus,* and *N.* sp. (fig. 36) from the type locality of the Byram (Oligocene) Formation in southern Mississippi; and by *N. lamposus* Hussey, from the Cane River (Claiborne, Eocene) Formation in Louisiana.

This genus is named for Dr. Theodor Neagu of the Paleontology Department, University of Bucharest, author of a Romanian Treatise on Micropaleontology, and contributor of an Upper Cretaceous foraminiferal study to the Louisiana Geological Survey's bulletin on the Geology of Natchitoches Parish, Louisiana, soon to be published.

NEAGUITES INUSITATUS, new species
Figures 37, 38.

Diagnosis: Test small, elliptical in outline, twice as long as broad; flat, megalospheric form with visible proloculus followed by two chambers per volution added in a single plane, microspheric form with early chambers at an angle to the plane of coiling; periphery rounded to broadly acute; aperture end extends beyond the penultimate chamber, final chamber frequently forming an eyelet at the base of the test by not remaining in juxtaposition with the preceeding chamber; chambers with a frosted appearance produced by its intensely pitted surface wherein there are perforations; aperture on a slight neck. Length of holotype 0.60 mm; breadth 0.30 mm.

Figured Specimen: Holotype, LSU GM No. 10506, from the Red Bluff Formation at Hiwanee Station, Mississippi.

Remarks: This pitted species was discovered by accident. A scanning electron microscope study was requested, because the test had a strange dull, frosted appearance not observed on any *Spiroloculina* species in the sample. The pits on the surface of the chambers are not visible under the normal magnifications used in a binocular microscope for studying foraminifera.

Those specimens with the eyelet at the base of the test can not be confused with any other species. When the eyelet is missing, the microspheric form looks a little like the calcareous, porcelaneous species *Massilina decorata;* the megalospheric forms are more elongate, and with a much more acute periphery than *Neaguites imprimita.*

NEAGUITES BYRAMENSIS (Cushman)
Figures 39, 40.

Spiroloculina byramensis CUSHMAN, U.S. Geol. Surv. Prof. Paper 129, p. 101, pl. 25, figs. 4a-b, 1922.

Emended Diagnosis: Test compressed, elliptical to broadly elliptical, perforated with perforations occupying a series of pits randomly distributed on the surface of the chamber; proloculus and initial chambers concealed in a coil positioned at an angle to the side of the test in the microspheric gen-

eration, latter chambers added at approximately 180° in a single plane, megalospheric generation with proloculus and initial chambers exposed on each side of test; latter chambers with floor; periphery of penultimate chamber rounded, final chamber slightly acute; aperture at the end of a short neck. Length of figured specimen 0.65 mm; breadth 0.51 mm.

Figured Specimen: Topotype, LSU GM No. 10507, from the type locality of the Byram Formation, right bank of Pearl River, east of Byram, Mississippi.

Remarks: Cushman's specimen figured in 1922 (pl. 25, figs. 4a-b), unfortunately not available to be reexamined, must have been the basis for the description of *Spiroloculina byramensis*, because the periphery is "squarely truncate" as originally diagnosed. Two specimens in the assemblage recovered from Byram Formation samples have squarely truncated peripheries formed by the chamber floors of the penultimate and final chambers. The perforated chamber wall, which forms an arch over the chamber floors, had been destroyed by erosion. It appears very likely that Cushman described a weathered specimen.

A paratype labeled "Cushman Collection 3703," a very poor example of a microspheric generation, is more complete than the specimen figured by Cushman in 1922 (pl. 25, figs. 4 a-b) and is clearly without a squarely truncated periphery. The final chamber has an acute periphery, the same as figure 39 in this report.

NEAGUITES LAMPOSUS (Hussey)
Figures 41, 42.

Spiroloculina lamposa HUSSEY, Journ. Paleontology, vol. 23, no. 2, p. 121, pl. 26, fig. 6, 1949.

Emended Diagnosis: Test small, elliptical in outline, compressed, slightly biconcave; chambers pitted, spiroloculine (proloculus followed by two chambers per volution added at 180° in a single plane), perforations restricted to pits in chamber wall; periphery rounded; aperture terminal on a short, constricted neck. Length of figured specimen 0.45 mm; breadth 0.28 mm.

Figured Specimen: LSU GM No. 10508, from an outcrop in a tributary to Limekiln Bayou, Section 3, T8N, R8W, approximately 7 miles west of Natchitoches, Louisiana.

Remarks: This is the earliest occurring species of the genus *Neaguites* in the Gulf Coastal Plain. A contemporary species, also with a spiroloculine chamber arrangement, *Texina ferayi*, occurs in an intensely glauconitic unit in the Weches Formation in Texas as does *Neaguites lamposus* from the Cane River Formation in Louisiana. It is strange that the two species, both in the Claiborne Eocene, never occur together in either the Weches or Cane River formations.

NEAGUITES IMPRIMATUS (Cushman)

Spiroloculina imprimata CUSHMAN, U.S. Geol. Surv. Prof. Paper 129-E, p. 101, pl. 25, figs. 3a-b, 1922.

Remarks: The holotype (Cushman Collection 25520) and a paratype (Cushman Collection 3771) were examined. If the size of the pits on the chamber walls is consistent within a species, which certainly is true in *Miliola saxorum*, then the two types examined are not the same species. The holotype has extremely small pits on the chamber walls, so small that they could be missed in binocular microscope examination. The pits on the paratype are large enough to be seen with the binocular microscope; not as readily as those of *S. byramensis*, but nevertheless are discernible.

Also, Cushman's description of the holotype does not apply to the paratype. The former has chambers "of the last-formed coil failing to extend to the base of the preceeding chamber, leaving a gap."

Not a single specimen was recovered from the Byram Formation samples, which could be assigned to this species. Examination of the types, however, reveals that both belong to the genus *Neaguites*. A more thorough study with additional specimens is needed to determine the relationship of the holotype to the paratype of *Spiroloculina imprimata* Cushman.

Subfamily TEXININAE Andersen, 1984, new subfamily

Wall with adventitious material, planispirally coiled, aperture cribrate.

Genus TEXINA, new genus

Type species: *Texina ferayi*, new species.

Diagnosis: Test free, wall with adventitious material, rounded outline, sides flattened; planispiral chamber arrangement with two chambers per volution; wall calcareous, pitted, with perforations occupying the pits on the surface of the test; aperture cribrate.

Remarks: This genus is named for the State of Texas, wherein the type species was recovered, and to which it appears to be restricted.

TEXINA FERAYI, new species
Figures 43-46.

Spiroloculina smithvillensis FERAY, nomen nudum, Dissertation, University Wisconsin, 1948.

Diagnosis: Test calcareous with adventitious material, spiroloculine chamber arrangement (proloculus followed by two chambers per volution), nearly round in outline, much compressed; periphery acute; apertural end nearly flush with periphery; chambers embracing, pits randomly distributed over unornamented chambers with apparently one to two perforations in each pit; aperture at the end of a short neck, cribrate. Length of holotype 0.48 mm; breadth 0.45 mm.

Figured Specimen: Holotype, LSU GM No. 10509; paratype LSU GM No. 10510, from the Weches Formation outcrop on the Colorado River at Smithville, Texas.

Remarks: Spiroloculina smithvillensis Feray, nomen nudum, and *Texina ferayi* Andersen, n. sp., are considered to be the same species because *S. smithvillensis* was the only spiroloculine species recovered by Feray in the samples studied for his dissertation in 1948 and this is the only spiroloculine species present in the Weches samples studied for this report. The two species must be the same, although the specimen selected by Feray as a "holotype" is more embracing than the holotype selected herein, or any paratype observed.

The photomicrograph of *Texina ferayi* (fig. 45), revealed the presence of white particles associated with the chamber wall. At the magnification in figure 45, × 2000, it would have been presumptious to make a positive statement relative to the relationship between the chamber wall and extraneous particles. Photomicrograph figure 46 at × 5000 magnification, however, provided the proof that the white particles are embedded in the chamber wall and, of equal importance, that the perforations are restricted to the pits. Unfortunately, the × 5000 magnification did not make it possible to identify the particles embedded in the test. They are relatively uniform in size and apparently composed of the same material. The question - were the particles selected or adventitious? - may be important at the species level.

IV. DISCUSSION

The Enigmatic Knobs on Quinqueloculina tuberculata *Cushman and Todd.* Weathering of a pitted chamber wall should be indiscriminate in that the removal of calcium carbonate would be at the same rate in the pits as on the surface of the test between pits (fig. 3). It is illogical, therefore, for the pits in *Quinqueloculina tuberculata* to become a rounded knob when weathered (figs. 1, 2).

A partial solution to this enigma lies in the fact that two weathered specimens, *Q. tuberculata* (fig. 4), and an unidentified species of *Neaguites* (fig. 36), and a freshly broken specimen of *Miliola saxorum* (fig. 5), which exposes the inner chambers of the test, all have knobs. Figures 4 and 36 show that a collar surrounding each pit is denser then the rest of the material in the test. Obviously, these collars were strong enough to withstand the erosional process, which destroyed the intervening, softer material between the pits. The knobs, therefore, were produced by differential weathering. The knobs in figure 5, how-

ever, can not be the product of differential weathering, because the chambers exposed in the photomicrograph were covered and protected by the floors of the overlying chambers. The collar surrounding the pit was strong enough to hold onto the inner membrane of the chamber wall; the intervening, softer material in the chamber wall was removed with the overlying chamber floor.

It appears that either the composition, structure, or density of the collar surrounding the pits is responsible for producing the knobs on the chamber wall. Concentrating a sufficient number of knobs for an x-ray defraction study was conceivably possible but not with the laboratory equipment available; the polarizing microscope study contributed nothing to a study of the microstructure of the wall. Only the scanning electron microscope showed that the collar is denser than the intervening shell material; however, it gave no clue as to how this was accomplished.

Environmental Implications. The Lutetien of the Paris Basin must be regarded as the model environment in which the genus *Miliola* thrived, because more species are recognized in Europe than in the Gulf Coastal Plain and their distribution is more widespread. The Moodys Branch Formation is probably as widespread as the Lutetien; however, the genus *Miliola* is restricted, apparently, to Mississippi, and Alabama.

The foraminiferal assemblages recovered from the Damery and Grignon, France, samples consisted of an abundance of species from families known to live in a warm, clear water, shallow marine environment. The marker families present are: Alveolinidae, Asteigerinidae, "Miliolidae," Penerolipidae, and Polymorphinidae. Pelagic families were missing. This Lutetien environmental assemblage could best be duplicated in the calcareous deposits of Florida, from which one species of the *Miliola* lineage has been questionably referred to *Tappanina jacksonensis* (Cushman).

The Moodys Branch foraminiferal assemblage contains some of the genera from the shallow water families in the Lutetien, as does the Red Bluff and Byram Formations of the Oligocene. The Weches Formation is least like the Lutetien; however, its sediment is also considered to have been deposited in shallow water.

The common denominator in all sample studied is that they represent deposition in shallow water. It appears, therefore, that the foraminifers, with which members of the *Miliola* lineage are associated, prefer a shallow, warm water, marine environment.

Biostratigraphic Markers. The geographical distribution of outcrops in the Gulf Coastal Plain, from which the genus *Miliola* has been reported, is restricted to southern Mississippi and Alabama; the stratigraphic range is from the Moodys Branch Formation of the Jackson Eocene, to the Byram Formation near the top of the Oligocene. The size of the species within the genus ranges from 2.0 mm in length in the Moodys Branch Formation to less than 1.0 mm in length in the Byram Formation.

The foraminiferal assemblage varies from outcrop to outcrop in the Moodys Branch Formation in its lateral distribution from Mississippi into Texas. *Miliola saxorum* and the two species of *Tappanella* have been reported only from the Moodys Branch Formation, and only from those outcrops in the vicinity of Jackson, Mississippi. Any one of the three species above recovered from the subsurface in the southern part of Mississippi is proof positive that the age of the sediment, from which the species are recovered, is basal Jackson.

Two of the remaining genera described herein, *Picouina* and *Neaguites*, are too rare to be considered good marker fossils. *Picouina* has been reported only from the Byram Formation at its type locality; *Neaguites* ranges from the Cane River Formation in Louisiana to the Byram Formation in Mississippi.

The genus *Texina* is abundant enough to be a good marker fossil for the Weches Formation in Texas.

V. ACKNOWLEDGMENTS

This study was made possible by students and friends, who supplied the binocular microscope needed to search the samples for the specimens used in this report; by Harry L. Roland, Jr., of Andersen & Roland, Inc., who approved the use of corporate funds for photomicrographs and other necessary expenses; and by the Louisiana Geological Survey staff, who permitted me to use their polarizing microscope.

Dr. Richard Cifelli, Curator of the Department of Paleobiology at the National Museum of Natural History contributed time and energy answering numerous questions related to foraminiferal species in the U.S. Museum of Natural History and allowed me to observe some of the specimens redescribed in this study.

Dr. Willem van den Bold, Professor of Geology at Louisiana State University, was consulted frequently in the preparation of this report, provided pertinent publications, and served as the principal critic of the revised manuscript.

Alvin Phillips, Jr., Curator of the LSU micropaleontological collections and library, supplied much of the literature and a few specimens used in this study.

I especially wish to thank Richard Cifelli, Edward B. Picou, Jr., and Hubert C. Skinner for their time spent reviewing this paper, and their suggestions, which have improved the contents immeasurably.

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