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Foraminifera of the Cenozoic and recent genus Sphaerogypsina Galloway

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FORAMINIFERA OF THE CENOZOIC AND RECENT GENUS SPHAEROGYPSINA GALLOWAY

BY

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A

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ABSTRACT

The morphology of Sphaerogypsina as seen in thin section affords various characters useful in classification: 1) arrangement and composition of the wall (calcareous-perforate, radially crystalline); 2) layering of wall (like Gypsina, without layering or black line, having only microlamellae); 3) shape of test (always spherical); and 4) specific characters: size of test, order/unorder ratio, size of chambers, wall thickness, pore diameter, and type of embryonic apparatus.

Correlation of the above characters has allowed recognition of two new species. Comparisons with other genera strongly suggest placing the genus in the Family Gypsinidae (nom. correct.) rather than in the Acervulinidae or Planorbulinidae. Study of the wall of Sphaerogypsina has revealed apertures and stolons which were observed by Carpenter, Uhlig, and Bursch, but were overlooked by Brady, Galloway, and most other workers.

Compilation of data from the literature on Sphaerogypsina has resulted in a distribution chart and some ecological interpretations of the genus.

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I INTRODUCTION

Sphaerogypsina is a large, spherical foraminifer with calcareous-perforate, radially crystalline, unlayered walls. Its exterior is composed of numerous alternating raised and depressed chambers giving the test a pustulose appearance. The exterior chambers are large to very large, perforated with numerous large to very large pores, and with one or more apertures in the lateral wall. The interior, as seen in thin section, is composed of numerous chambers growing outward from an embryonic apparatus. Some chambers in the central area usually are unordered, and the remaining chambers are arranged in radial columns, sometimes with columns bifurcating near the periphery. The lateral walls are without pores, but contain stolons used for communication of protoplasm between chambers. In vertical section the stolon is marked by an upward projecting lip, and in plan view as a circular to semicircular opening.

The type species of the genus was originally named *Ceriopora globulus* Reuss and was thought to be a bryozoan. The species was later transferred to the foraminiferal genus *Gypsina* and then to *Sphaerogypsina*. The specific name "*globulus*" was used, and almost every record of the genus was referred to *Gypsina* (or *Sphaerogypsina*) *globulus* (Reuss), because all species of the genus are globular. It is now known that species of *Sphaerogypsina* may be separated by thin section study of the different characters of the wall and chambers, although those of the exterior are fewer and not as useful for classification purposes.

Many authors have placed *Sphaerogypsina* in the Families Acervulinidae or Planorbulinidae, and only one (Puri, 1957, p. 143) has used the Family Gypsinidae Silvestri (1905, p. 142; *nom. correct.*) for the genus. After comparison of the genus *Sphaerogypsina* with the genera *Gypsina*, *Acervulina*, and *Planorbulinella*, it is here accepted that the Gypsinidae is a valid family for the genera *Gypsina* and *Sphaerogypsina*.

The material used by the writer is from the middle Eocene of Peru and Ecuador, the upper Eocene of Mississippi, Alabama, Florida, and Ecuador, the upper Oligocene of Mississippi and Alabama, and the Miocene of Jamaica and Austria. The Jamaican material consisted of isolated specimens, the Ecuadorian and Peruvian material were with two exceptions random thin sections of limestones, and the remaining material was unwashed sample.

Thin sections of *Sphaerogypsina* were studied with a compound microscope, which provided sufficient magnification of wall structure to permit interpretation. Test diameters in thin section were measured by an ocular micrometer. Measurements of wall thickness, pore diameter, and chamber dimensions were made by projecting the thin section from a microprojector and measuring the parts on a screen with a millimeter scale.

A considerable amount of research remains to be done on Sphaerogypsina. The various records of Gypsina globulus (Reuss) outside the United States need to be checked. The genus Gypsina is in taxonomic disorder, and "Gypsina" vesicularis (Parker and Jones) may not even belong to Gypsina as proposed by Carter (1877, p. 172). If "G." vesicularis (P. & J.) does not belong to the genus, the Family Gypsinidae may not be valid. The type species of the genus Gypsina is G. melobesioides Carter (= G. plana (Carter)) and since a specimen is not figured by Carter a comparison cannot be made until a specimen is seen.

Acknowledgements.— Dr. Don L. Frizzell proposed and directed work on the problem, provided specimens and material from his personal collection, and acquainted the writer with localities where specimens might be found. Mr. C. Kurt Lamber, graduate student at the Missouri School of Mines, gave many helpful suggestions on the manuscript and illustrations. Dr. L. R. Wilson, University of Oklahoma, photographed numerous specimens and made equipment available to the writer. Mr. Ralph Harris, of the Department of Geological Engineering and Geology, developed films and made suggestions on photographs, and Mr. Wolfgang Haederle, graduate student at the Missouri School of Mines, instructed the writer in use of a camera-microscope mount used to take photographs of thin sections. Mr. Bryan Williams, Assistant Librarian, provided literature through inter-library loan. The research was supported by a McNutt Memorial Foundation Grant-in-Aid award.

II HISTORICAL REVIEW

Species of the genus have been placed in the genera _Ceriopora_ (Bryozoa), _Orbitolina_, _Tinoporus_, _Gypsina_, and _Sphaerogypsina_. The type species, _S. globulus_ (Reuss), was described from the Miocene of Austria as _Ceriopora_, a globular bryozoan (Reuss, 1847, p. 33, pl. 5, fig. 7).

Parker and Jones (1860, p. 38) described specimens of _Sphaerogypsina_ as _Orbitolina laevis_. Several Tertiary to Recent localities were given, where specimens presumably occurred. Another species, now known as _Sphaerogypsina pilaris_ (Brady), was named _Tinoporus pilaris_ Brady (1876, p. 103) from the Miocene Bowden Beds of Jamaica. Recent specimens from Australia(?) were described by Carter (1877, p. 215, figs. 18, 20-23), which he called _Tinoporus vesicularis_ Parker and Jones var. _sphaeroidalis_ Carter. Carter was the first to recognize stolons in the lateral wall, illustrate them, and use the term "holes of intercameral communication." In the text of his paper he states that "_T. vesicularis_ P & J var. _sphaeroidalis_ Carter has no pseudopodial canal system like that of _Polytrema miniaceum_ Carter (1877, p. 215), but is dependent entirely upon foraminated plates of its chambers for communication between the centre and the circumference or the interior and exterior." Carter's statement in reference to canal system of Polytrema is entirely correct, but his statement about the pores being the only means of communication of protoplasm shows that he did not recognize the function of the stolons which he illustrated.

Brady (1884, p. 117, pl. 101, fig. 8) apparently was the first to record *Ceriopora globulus* Reuss as a foraminifer when he described and illustrated Recent specimens (as *Gypsina*) collected by the Challenger Expedition from reefs at Honolulu. The writer believes that the Recent species which Brady described and illustrated is not *G. globulus* (Reuss), but probably is *Sphaerogypsina laevis* (Parker and Jones). Specimens were not available to confirm this conclusion.

Brady apparently overlooked Carter's diagram showing the "holes of intercameral communication." As the apertures are very hard to see on the exterior of the test, he had no reason to question Carter's statement about the mural pores being entirely responsible for communication of protoplasm between chambers. When Brady recognized Reuss's species as a foraminifer and used the name "*G.*" *globulus*, he formed a name, through following the rules of nomenclature, which has been used for almost all species of *Sphaerogypsina* due to their globular shape.

Uhlig (1886, p. 197-200, text figs. 7-9) misidentified Eocene specimens from the Western Carpathians as *Gypsina globulus* (Reuss). He recognized and illustrated stolons in a thin section of peripheral chamber walls (figure 4). The Family Gypsinidae (*nom. correct.*) was proposed by Silvestri (1905, p. 142) with only *G. carteri* Silvestri mentioned.

Cushman (1928; 1933; 1940; 1948, p. 343) used the generic name Gypsina rather than Sphaerogypsina, and placed the genus in the Family Planorbulinidae. Cushman inadvertently changed the specific name to "globula," although "globulus" is a noun in apposition.

A species from the middle Eocene of Peru was named Gypsina peruviana Berry (1929, pp. 239-240, figs. 1, 2). In his comparisons, Berry distinguished the Peruvian species from "globulus" by the well developed bifurcation of radial columns which he thought was absent in the type species. The writer's study has shown that the type species also has this pattern of growth, and the two species are separated on other characters. Berry's specimens appear to be so highly recrystallized that neither pores or stolons were preserved in the sections he observed.

Galloway (1933, p. 309, pl. 28, figs. 13-14) proposed a new generic name for Ceriopora globulus Reuss and Brady's Gypsina globulus (Reuss), naming them Sphaerogypsina globulus (Reuss). He recognized the globular species as different from Gypsina and put them in the Family Acervulinidae and Subfamily Acervulininae, but he did not refer Brady's specimens to the Recent species S. laevis (Parker and Jones). Galloway apparently did not know of Uhlig's work and used Brady's ideas about the absence of stolons in the lateral wall.

Tinoporus pilaris Brady was recognized to be related to Brady's Recent specimens of "Gypsina globulus (Reuss)" by

Hill (1899, pp. 147-148), and Rutten (1940, p. 165, pl. 24) identified specimens as Gypsina pilaris (Brady) from the Miocene of Cuba. This name combination was short lived due to Galloway and Heminway's (1941, p. 406, pl. 27, figs. 7-8) paper describing specimens Sphaerogypsina pilaris (Brady) from the Oligocene and Miocene of Puerto Rico. The authors also described and illustrated specimens which they named S. globulus (Reuss), which are possibly another species. They still placed the genus in the Family Acervulinidae and failed to notice stolons and apertures in the walls of sectioned specimens.

Cushman and Todd (1945, p. 105, pl. 16, fig. 25) described and illustrated specimens from the Jackson Eocene (Moody's Branch Marl) of Jackson, Mississippi, using the name Gypsina "globula" (Reuss), known as Sphaerogypsina n. sp. A in this paper. Glaessner (1945, p. 153) did not recognize the genus Sphaerogypsina but placed Gypsina in the Family Planorbulinidae.

Bursch (1947, pp. 43-46, text figs. 21-22) used the name Gypsina globulus (Reuss) for Eocene and Oligocene specimens from the Kai Islands. Oligocene specimens described and illustrated by Bursch closely resemble S. globulus (Reuss), but specimens were not available to the writer to check this idea. Bursch recognized apertures and stolons in the wall of Sphaerogypsina, and described and illustrated them in a block diagram (text figure 4 of this paper). Matthes (1956, p. 93) did not recognize the genus Sphaerogypsina but placed Gypsina in the Family Planorbulinidae.

Hanzawa (1957, pp. 27, 31, 32, 66, pl. 38, figs. 4, 8, 9, tables 1-5) described Eocene to Pliocene specimens from Micronesia, using the name Gypsina globulus (Reuss), and placed them in the Family Planorbulinidae. He agreed with Hofker that the genus Gypsina has stolons and apertures. The specimens which Hanzawa described and illustrated are probably not S. globulus (Reuss) but possibly consist of two or more other species of the genus. Puri (1957, p. 143, pl. 14, fig. 7; pl. 15, fig. 9) described specimens from the Jackson Eocene (Ocala Limestone) of Florida using the name Sphaerogypsina "globula" (Reuss) and placed the genus in the Family "Gypsininae." This is the first record of the genus being referred to this family but he failed to revise the name to have a conventional "-idae" ending for family names. After studying specimens from the Ocala Limestone of Alabama and Florida the writer considers that they are the same species as those of the Moody's Branch Marl that are here called Sphaerogypsina n. sp. A.

Pokorny (1958, pp. 331-332, abb. 393) recognized Sphaerogypsina and placed the genus in the Family Planorbulinidae (omitting Gypsina).

Loeblich and Tappan (1961, p. 303) placed Sphaerogypsina in the Family Acervulinidae, making "Gypsininae" a synonym.

Most records of "Gypsina globulus (Reuss)" may be presumed not to belong to the species as restricted and can be accepted only upon verification. These records include Brady (1884, p. 117, pl. 101, fig. 8); Uhlig (1886, p. 197, text figs. 7, 8, and 9); Schlumberger (1896, p. 90, pl. 3, fig. 4); Hill (1899, pp. 147, 148); Provale, I.(1908, p. 56, pl. 6), figs. 14, 15; Chapman, F.(1909, p. 290); Schubert (1911, p. 114); Schubert (1913, pp. 129, 132, 137, 140); Rutten (1914, p. 27, pl. 6, fig. 8); Tobler (1918, p. 190, pl. 34, fig. 2); Trauth (1918, pp. 72, 242, pl. 3, fig. 1); Cushman (1919, p. 44, pl. 4, fig. 7); Yabe & Hanzawa (1925, p. 48, pls. 8, 4, fig. 7); Yabe & Hanzawa (1926, p. 3, pl. 1, fig. 3); Yabe & Hanzawa (1929, p. 179, pl. 18, fig. 6); Yabe & Hanzawa (1930, p. 37, pl. 1, fig. 9; pl. 6, fig. 9; pl. 10, figs. 7, 10); Hanzawa (1931, p. 156, pl. 25 (2), figs. 19, 20); Umbgrove (1931, p. 64); Gravell, D. W. (1933, p. 19, pl. 2, fig. 2); Cushman (1935, p. 54, pl. 23, figs. 4, 5); Silvestri (1937, p. 156, pl. 13, fig. 1).

Later records, with transfer to the nominal genus Sphaerogypsina, also are subject to verification: Galloway & Heminway (1941, p. 406, pl. 27, fig. 7); Cushman & Todd (1945, p. 105, pl. 16, fig. 25); Bursch (1947 (in part), pp. 43-46, text figs. 21-22); Cushman & Renz (1947, p. 46, pl. 8, fig. 15); Bermudez (1949, p. 312); Hanzawa (1957, pp. 27, 31, 32, 66, pl. 38, figs. 4, 8, 9, tbls. 1-5); Puri (1957, p. 143, pl. 14, fig. 7; pl. 15, fig. 9).

III MORPHOLOGY

A thin section study of species of *Sphaerogypsina* has revealed morphologic characteristics which are important in determining the systematic position of the species. The morphologic characteristics which are important for classification of the genus are wall structure, plan of growth, and apertures and stolons present in the walls.

Wall Structure.— Chamber walls of the species of *Sphaerogypsina* in the original crystalline state are composed of minute crystals of calcite oriented perpendicular to the wall surfaces. The highly perforate walls of the genus are not layered, and except for microlamellae (pl. 2, fig. 1) the walls are without structure.

The black line described by Deaver (1955, p. 29, fig. 3) also is absent from the wall, although in recrystallized specimens an apparent black line is formed through recrystallization. In the recrystallized walls of those specimens, the calcite crystals have been enlarged and reoriented perpendicular to the original acicular crystals.

Walls of the chamber are arched between previous chambers in an alternating row of columns, one lateral wall cemented to the septal faces of the surrounding previous chambers (pl. 3, fig. 4).

Plan of Growth.— *Sphaerogypsina* has a unique plan of growth, much different from other genera of foraminifera. The test is composed of an embryonic apparatus, unordered chambers sharply arched between earlier chambers (sometimes not developed), and ordered chambers arranged in radial columns with radial lines bifurcating near the periphery. The number of unordered and ordered chambers is dependent on the species.

Three types of embryons occur within the genus *Sphaerogypsina*: trochoid spiral, unilocular, and bilocular.

Trochoid spiral embryons (pl. 3, fig. 3) have many associated unordered chambers in the central interior. *Sphaerogypsina* n. sp. A has the highest number of unordered chambers, *S.* n. sp. B has less unordered and more ordered chambers, and *S. pilaris* (Brady) has only 3 unordered and numerous ordered chambers.

Unilocular embryons are accompanied by no unordered chambers or only a few. *Sphaerogypsina peruviana* (Berry) has no unordered chambers; the embryon is surrounded by many small angular chambers which can be traced to the periphery in a radial column with bifurcating radial lines (pl. 3, fig. 2). *S. globulus* (Reuss) also belongs in the unilocular group, but it has two or three unordered rows of chambers in the central interior. The unilocular embryon may actually be a bilocular apparatus which, due to the orientation of the section, appears as a single chamber.

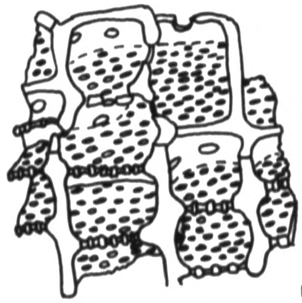
The bilocular embryon is known only from Quaternary specimens of the Malaya Archipelago (Scheffen, 1939, p. 167, pl. 1, fig. 1). From Scheffen's illustration, one can detect ordering of chambers from the embryonic apparatus to the periphery. As there are no sections of Sphaerogypsina laevis (Parker and Jones) shown in the literature there is no way to ascertain what type of embryon exists in this species.

Apertures and Stolons.— Apertures and stolons of Sphaerogypsina are circular to semicircular openings in the lateral wall of chambers, which provide communication to the exterior and to surrounding chambers in the interior of the test. The openings are formed by a thickening of the lateral wall into an upward projecting apertural or stolon lip (stolons shown in cross section and plan view in pl. 3, fig. 4). The stolons, numbering at least as many as there are surrounding chambers, are directed upward from previous chambers and earlier chambers forming a network of openings to provide communication of protoplasm between chambers.

Uhlig (1886, pp. 197-200, text fig. 8) described and illustrated stolons in the chamber walls of a species of Sphaerogypsina from the Eocene of the Carpathians (text figure 2). Oligocene specimens from the Kai Islands were also found to have stolons in the chamber walls. Bursch (1947, pp. 43-46, text fig. 22) described these and illustrated a section of the peripheral chambers in a block diagram, pointing out stolons, pores, and the relationship of all parts of

EXPLANATION OF FIGURES

1. "*Gypsina*" *vesicularis* (Parker and Jones); block diagram showing chambers near periphery (after Carpenter, 1862, pl. 15, fig. 4).
2. *Sphaerogypsina* sp.; median section showing chambers near periphery (after Uhlig, 1886, text fig. 7).
3. *Sphaerogypsina* sp.; embryonic apparatus and central chambers (after Bursch, 1947, text fig. 21).
4. *Sphaerogypsina* sp.; block diagram showing chambers near periphery (after Bursch, 1947, text fig. 22).



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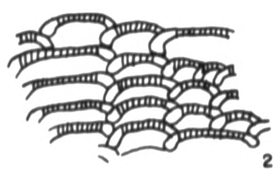

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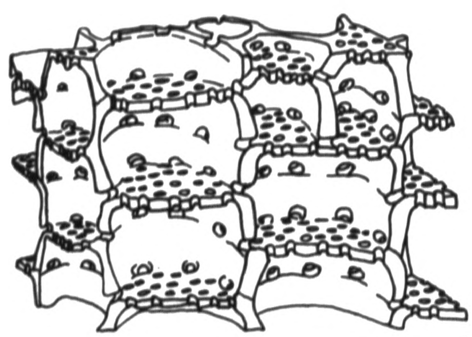


4

the wall (text fig. 4). Illustrations and descriptions by Carpenter (1862, pp. 224-226, pl. 15, figs. 1-4) show the size, shape, and relationship of stolons and pores to chambers of "*Gypsina*" *vesicularis* (Parker and Jones) (text figure 1). Comparison of text figures 1 and 4 strongly suggests the familial relationship of *Gypsina* and *Sphaerogypsina*.

IV FAMILY RELATIONSHIPS

Brady (1884, p. 117) reported Recent specimens from the British and Hawaiian Islands for which he used the name Gypsina globulus (Reuss), placing it in the Family Rotaliidae (Ehrenberg, 1839), and employed the Subfamily Tinoporinae to include the genus. This was 37 years after Reuss had described a Miocene species, believing that it was a bryozoan, Ceriopora globulus Reuss.

Silvestri (1905, p. 142) proposed the Family "Gypsininae" for Gypsina carteri Silvesteri. At that date family names had not been conventionalized to have "-idae" endings. Puri (1957, p. 143) recognized the family and was the first to include the genus Sphaerogypsina in the family, but he failed to correct the "-inae" ending to conventionalize the name. Loeblich and Tappan (1961, p. 303) synonymized the "Gypsininae" with the Family Acervulinidae Schultz (1854).

Cushman (1928, 1933, 1940, 1948, p. 343) placed the genus Gypsina (including Sphaerogypsina as a synonym) in the Family Planorbulinidae Schwager (1877). Many workers referring to the genus since that time have used this family. Glaessner (1945, p. 153), Bursch (1947, pp. 43-46), Hanzawa (1957, pp. 27, 31, 32, 66) and others have placed species of Sphaerogypsina and Gypsina in the Family Planorbulinidae.

Galloway (1933, p. 309) proposed the genus Sphaerogypsina for Ceripora globulus Reuss and Brady's Gypsina globulus (Reuss), placing the genus in the Family Acervulinidae Schultz (1854) and Subfamily Acervulininae. Pokorny (1958, pp. 331-332) and Loeblich and Tappan (1961, p. 303) agree with Galloway's allocation.

Planorbulinella in the Planorbulinidae (Plate 2, figures 3-4) and Acervulina in the Acervulinidae (Plate 2, figure 2) have layered structure and a black line in their chamber walls. The description and illustrations of the chamber walls of "Gypsina" vesicularis (Parker and Jones) by Carpenter (1862, pp. 224-226, pl. 15, figs. 1-4) show that no marked layering or black line is present in the genus. Study of all available thin sections of Sphaerogypsina disclosed no layering in the chamber walls except for microlamellae. An apparent black line is present only in the chamber walls of some highly recrystallized specimens. The black line, in these specimens, was formed when the radial crystals were replaced by larger crystals formed with 90 degree reversal of orientation. Taking into account the differences in wall structure between Planorbulinella- Acervulina and Gypsina-Sphaerogypsina, and the similarities between Gypsina and Sphaerogypsina, the Family Gypsinidae is accepted here to include Sphaerogypsina and Gypsina. The family may not be valid if "G." vesicularis (P. & J.), which is used for comparison with Sphaerogypsina, does not belong to Gypsina as originally proposed by Carter (1877, p. 152). Gypsina *plana* (Carter), the type species of *Gypsina*, was not adequately illustrated, and comparison with "*G.*" *vesicularis* is not possible until a specimen may be examined.

V RANGE AND DISTRIBUTION

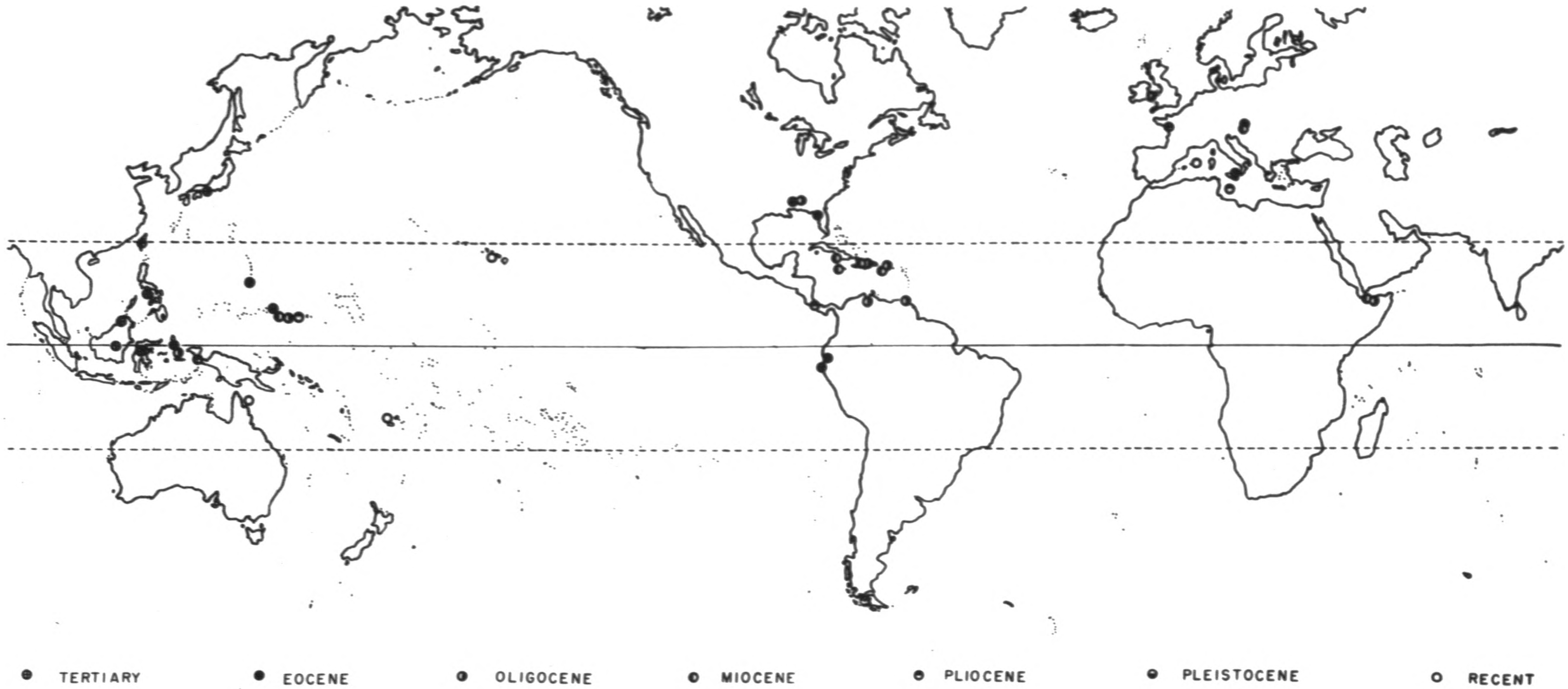
Species of Sphaerogypsina are distributed in a pattern of geosynclinal and coastal plains belts of Europe and the Americas and in island arcs of the West and East Indies and associated areas (test figure 5). Most of the localities where the genus is found are in reef areas or sites of limestone deposition. The species of Sphaerogypsina range in age from middle Eocene to Recent.

The earliest record of the genus is two middle Eocene species, Sphaerogypsina sp. and S. peruviana (Berry), found in sandstones, limestones, and shales of northwestern Peru and southwestern Ecuador. The next occurrence is in the upper Eocene of Mississippi, Alabama, Florida, Micronesia, Kai Islands, Ecuador, and Czechoslovakia. Species occurring in the North American Eocene are here called Sphaerogypsina n. sp. A. Specimens from the other localities were not available for study.

During the Oligocene the species of Sphaerogypsina were distributed over a much larger area and are found in limestones and marls from Mississippi, Alabama, Cuba, Dominican Republic, Puerto Rico, Trinidad, Somalia, and Micronesia. The Mississippi-Alabama species was not found recorded in the literature and is here called Sphaerogypsina new sp. B. There are West Indies species which have been called S. pil-

EXPLANATION OF FIGURE

5. Distribution chart showing occurrence of Cenozoic and Recent species of Sphaerogypsina.


TERTIARY
EOCENE
OLIGOCENE
MIOCENE
PLIOCENE
PLEISTOCENE
RECENT

aris (Brady) and another which is probably mistakenly called *S. globulus* (Reuss). Specimens, however, were not available to check these identifications.

During the Miocene the genus disappeared from North America but species were still abundant in the West Indies. The localities in this area are the Dominican Republic, Puerto Rico, and Jamaica. In Europe specimens were reported from Austria, Hungary, and Malta. In addition, there are reports from Somalia, Africa, and Micronesia. The West Indian species is called *Sphaerogypsina pilaris* (Brady) and possibly misidentified specimens called *S. globulus* (Reuss). European specimens are *Sphaerogypsina globulus* (Reuss), from the type locality in Austria. Specimens reported from Micronesia probably are misidentified as *S. globulus* (Reuss).

Pliocene occurrences are reported from Costa Rica and Micronesia, probably misidentified as *S. globulus* (Reuss).

Some references only recorded the age of locality as Tertiary. In Europe these are Bordeaux, France, and Palermo, Sicily. Pacific localities are Japan, Formosa, Philippines, Borneo, British North Borneo, Celebes Islands, New Guinea, and the Marianas Islands. All specimens from these localities were reported as *S. globulus* (Reuss). Thin section study of these specimens would probably suggest placing of the above specimens into species other than *S. globulus* (Reuss).

Quaternary occurrences are reported from the Malay Archipelago as *Sphaerogypsina* sp. These are probably not *S. globu-*

lus (Reuss), but a new species.

Recent records include Hawaii (Honolulu), Fiji Islands, Australia, British Isles, and the Mediterranean Sea. These localities are tropical to subtropical and are mostly reef areas.

VI ECOLOGY

The ecology of Sphaerogypsina is interpreted from records of environments of Tertiary and Recent species in the literature, and from associations of Tertiary rocks and faunas. Brady (1884, p. 117, pl. 101, fig. 8) described specimens from the coast of Honolulu, Hawaii, in a reef area at 40 fathoms (Barker, 1960, p. 208, pl. 101, fig. 8). Carter (1877, p. 215) described Recent specimens in the tubes of corals. All of the records of Tertiary species of the genus are in limestones or shell marls except for rarely in sandstone (W. Berry, 1929, pp. 235-240, figs. 1, 2), and extremely rare in shale formations in northwestern Peru. Tertiary strata studied had a high calcium carbonate content and usually a very large associated assemblage of smaller foraminifera with somewhat fewer larger foraminifera.

Recent Occurrences.— Sphaerogypsina is a tropical to subtropical shallow water foraminifer associated with reefs in the Pacific Ocean and Mediterranean Sea, and along the west coast of England. Brady (1884, p. 117) stated that the spherical type of Gypsina was usually associated with G. vesicularis (Parker and Jones), but the spherical type was not as abundant or always present with G. vesicularis (P. and J.). He also stated that specimens of Sphaerogypsina occur in coral-sands of warm latitudes at depths ranging from littoral zone to about 400 fathoms. There is an anomalous record along the west coast of England which seems to be much farther north than the tropical to subtropical species should occur. It would seem that the temperature in this area is about 10^{o} to 20^{o} C. too low for the genus to exist. Salinity tolerances must be rather narrow due to the absence of reports of the species in the bays of these areas where much of the year the salinities might be much lower than sea water concentrations and it might fluctuate greatly with rainfall. The oxygen requirements might be quite high since specimens are sometimes found associated with algae and the size of the individual is such that it would require more oxygen per individual than most other foraminifera.

Fossil Records.— Associated Tertiary faunas containing the genera *Lepidocyclina*, *Operculina*, *Gypsina* and other larger foraminifera along with the type of sediment in which these fossils are found, suggest that the Tertiary species of the genus lived under much the same conditions as do the Recent species. Tertiary formations were studied to determine the possible ecological conditions as follows.

The middle Eocene limestones of Peru and Equador contain abundant specimens of *S. peruviana* (Berry). Associated with this species are numerous algal remains, many smaller foraminifera, and larger foraminifera such as the lepidocyclines, discocyclines, and nummulites.

Specimens are common in the Moody's Branch Marl, Jackson Eocene, of Jackson, Mississippi. This formation is known to be a near shore open marine deposit of a highly fossiliferous shell marl on a nonmarine shale. The Moody's Branch Marl has a very large assemblage of smaller foraminifera and a small assemblage of larger foraminifera such as operculines. The same formation to the west in Montgomery, Louisiana, has very approximately the same fauna as the Jackson, Mississippi, equivalent, but it did not yield any specimens of Sphaerogypsina. It is not known exactly why the genus apparently is not present at this locality, but it might be guessed that substratum, food supply, or other factors could be responsible. The Mississippi Embayment may also be a controlling factor in keeping this particular foraminifer out by forming a temperature or salinity barrier to the west of the embayment.

Above the Moody's Branch Marl, and gradational with it in Alabama and Florida, is the Ocala Limestone, also of Jackson age. This formation is an earthy white limestone with a large fauna of smaller foraminifera and a moderate fauna of larger foraminifera such as Asterocyclina, Lepidocyclina, Nummulites, Operculina, Operculinoides, and Pseudophragmina. The abundance of Sphaerogypsina n. sp. A increases in this formation; therefore the conditions which permit formation or precipitation of calcium carbonate are probably more favorable for growth and development of the genus. The substratum of lime mud may provide an optimum environment.

The Byram Marl, of the Oligocene, is a very fossiliferous shell marl much like the Moody's Branch Marl. The Byram Marl has a very large assemblage of smaller foraminifera and very numerous larger foraminifera such as Lepidocyclina and Nummulites. The formation is also a shallow water open sea deposit, and the specimens are of the genus and are here called Sphaerogypsina n. sp. B.

The middle Miocene shell marl at Nussdorf, Austria, is much like the Moody's Branch Marl and the Byram Marl. This formation appears to be a near shore open sea deposit with a large association of smaller foraminifera and a moderate assemblage of larger foraminifera such as nummulites. The specimens were abraded and are not always spherical but were possibly subject to transportation for a considerable time or distance.

VII DESCRIPTION OF LOCALITIES

MIOCENE

Nussdorf near Vienna, Austria, MSM collection no. 219. Collector unknown.

Bowden Beds, Jamaica. Collectors: J. W. Henderson and Simpson, 1890.

OLIGOCENE, VICKSBURG GROUP

BYRAM MARL (TYPE): Old Byram, Hinds County, Mississippi; west bank of Pearl River at old suspension bridge; buff, highly fossiliferous, sandy shell marl. Collectors: D. L. Frizzell, August 31, 1957; W. C. Horton, June 18, 1960. (Stations F-57-5; WCH 660-9)

BYRAM MARL (BASAL): Conecuh County, Alabama; ditch at side of Alabama highway 6 across murder creek, about 1 mile east of Castleberry; brown calcareous clay just above the Glendon Limestone contact.

UPPER EOCENE

JAVITA LIMESTONE: Ecuador, north fork of Rio Nuevo. Collection of D. L. Frizzell.

EOCENE, JACKSON GROUP

MOODY'S BRANCH MARL: Riverside Park, Jackson, Hinds County, Mississippi (reassigned type locality); basal greensand and shell marl with abundant mega- and micro-fossils, just above unconformable contact with blue nonmarine Cockfield formation. Collectors: E. Adams and D. L. Frizzell, November 24, 1959; W. C. Horton, August 21, 1961. (Stations F-59-10; WCH 861-3)

OCALA LIMESTONE: Claiborne, Monroe County, Alabama; Claiborne bluff on Alabama River just above US Highway 84 on east bank; poorly consolidated white limestone at top of bluff, underlain by highly weathered Moody's Branch greensand and shell marl. Collector: W. C. Horton, June 20, 1960. (Station WCH 660-20)

OCALA LIMESTONE: Florida; Bureau of Economic Geology locality "Fla. 50." Collector: H. B. Stenzel.

MIDDLE EOCENE

SAN EDUARDO LIMESTONE (TYPE): Guayaquil, Ecuador; San Eduardo quarry. Collection of D. L. Frizzell.

SAN EDUARDO LIMESTONE: Branch of Rio de Chongon Viejo, Ecuador. Collection of D. L. Frizzell.

SAN EDUARDO LIMESTONE: 1 km. NE of Hda. Sta. Lucia, Ecuador. Collection of D. L. Frizzell.

SAN EDUARDO LIMESTONE: 3 km. ENE of Hda. Sta. Lucia, Ecuador. Collection of D. L. Frizzell.

ORGANOS LIMESTONE: Algal limestone near Organos Chico, Peru. Collection of D. L. Frizzell.

TALARA SHALE: Negritos, Peru; upper third of formation. Collector: D. L. Frizzell. (Station F-44-3)

MIDDLE EOCENE ?

CONCHUDO LIMESTONE: Province of Tumbez, Peru; head of Quebrada Conchudo. Collection of D. L. Frizzell.

VIII SYSTEMATIC DESCRIPTIONS

Order FORAMINIFERA

Family GYPSINIDAE Silvestri, 1905 (*nom. correct.*)

Gypsininae Silvestri, 1905, Rivista Ital. Paleontologia, Anno 11, Fasc. 4, p. 142, (including only *G. carteri* Silvestri, 1905).- Puri, 1957, Fla. Geol. Survey, p. 143, pl. 14, fig. 7; pl. 15, fig. 9(*Sphaerogypsina* "*globula*" (Reuss)). (Proposed as a family contrasted with Buluminlnae, Nodosarinae, etc., although with the ending since conventionalized for the subfamily.)

Diagnosis.— Calcareous-perforate, radially crystalline, unlayered (in "*G.*" *vesicularis* and *Sphaerogypsina*). Test large to very large; individuals lenticular (*G. plana*), subconical ("*G.*" *vesicularis*), or spherical (*Sphaerogypsina*); usually free; with pores perforating septal face, one or more circular to semicircular apertures at base of lateral wall. Interior median section with large to very large, angular to subangular, polygonal to quadrate chambers; chambers formed in columns, radiating from a trochoid, unilocular or bilocular embryon to the periphery, usually with unordered initial chambers changing to later ordered chambers. Large circular to semicircular stolons connect chambers in interior of test; each chamber having at least as many stolons as there are surrounding chambers.

Content.— The Gypsinidae contains the genus *Gypsina* and possibly "*G.*" *vesicularis* and *Sphaerogypsina*. The original proposal of the genus *Gypsina* Carter (1877, p. 152) included *G. plana* (Carter), "*G.*" *vesicularis* (P. and J.), and forms now placed in *Sphaerogypsina*.

Remarks.— The type species of *Gypsina* is *G. melobesioides* Carter = *G. plana* (Carter) (subsequent designation, Carter, 1880- according to Ellis and Messina, 1940-). Cushman's (1915) later designation of *Tinoporus vesicularis* Parker and Jones is invalid.

"*Polytrema*" *plana* Carter was based on a juvenile specimen. *Gypsina melobesioides* is a replacement name and an objective synonym of *G. plana* (Carter). The genus included, in the proposal, *G. melobesioides* (=*G. plana*), "*G.*" *vesicularis* (P. and J.), and "*G. vesicularis* var. *sphaeroidalis*" Carter (?*Sphaerogypsina laevis* (P. and J.)).

It is not certain that *Gypsina plana* is congeneric with "*G.*" *vesicularis* and the species of *Sphaerogypsina*. Familial identity may not be inferred with complete safety. Consequently, reference to the Gypsinidae of *Sphaerogypsina* and "*Gypsina*" *vesicularis* is no more than provisional.

Genus SPHAEROGYPSINA Galloway

Gypsina Carter (in part), 1877, Ann. Mag. Nat. Hist., ser. 4, vol. 20, p. 172.

Sphaerogypsina Galloway, 1933, Man. Foram., p. 309, pl. 28, figs. 13, 14.

Type Species.— Ceriopora globulus Reuss (1847, p. 33, pl. 5, fig. 7)(by original designation).

Diagnosis.— Calcareous-perforate, radially crystalline, unlayered. Test large to very large (0.62 to 4.18 mm. diameter), free, spherical, surface with alternating raised and depressed chambers giving some tests a pustulose appearance. Chambers large to very large, subrounded to polygonal, highly perforate with large to very large, circular to subcircular pores; apertures large to very large, semicircular, with prominent apertural lip.

Interior showing typically unordered chambers at center; ordered and arranged in radial columns, sometimes bifurcating near periphery; in some species only embryonic apparatus unordered. Septa thin to thick, sharply to broadly arched, oriented parallel to periphery, highly perforate with large to very large pores. Lateral walls short, projecting diagonally to perpendicular, meeting previous chambers except at stolons, where walls thicken into upward projecting stolon lip; thin to thick, imperforate, with large to very large circular to semicircular stolons connecting chambers; at least one stolon for each surrounding chamber; pores filled at junction of chambers.

SPHAEROGYPSINA GLOBULUS (Reuss)

Plate 1, figure 4; Plate 3, figure 1

Ceriopora globulus Reuss, 1847, Haidinger's Nat. Abhandl., vol. 2, p. 33, pl. 5, fig. 7.

Sphaerogypsina globulus (Reuss) (in part), Galloway, 1933, Manual of Foram., (Bloomington Principia Press), p. 309, pl. 28, fig. 13 (not fig. 14= S. laevis).

Description of Exterior.— Test medium size to large (4 mm. maximum diameter), free, spherical, with alternating raised and depressed chambers. Septal face polygonal, angular, highly perforate with small pores. Lateral walls thin, with at least one small semicircular aperture for each raised chamber.

Description of Median Section.— Test circular with chambers arranged in radial columns, ordered near periphery, unordered in central interior. Order/unorder ratio 5. Chambers have second order bifurcation of radial lines near periphery. Wall unlayered, composed of many minute radial calcite crystals oriented perpendicular to the wall surfaces. Central chambers small, subcircular to polygonal, with width about equal to height. Septal wall very thin, rounded to angular, broadly arched between previous chambers, perforate with numerous small pores. Lateral wall imperforate, bent diagonally to join previous chambers or ending in thickened upward projecting stolon lip. Pores filled at junction with earlier chambers. Peripheral chambers small, angular, hexagonal, 2 times wider than high. Walls thin, septal wall straight and parallel to periphery, highly perforate with small pores, lateral wall imperforate, bent diagonally to join previous chamber or ending in thickened upward projecting stolon lip. Each chamber has at least as many stolons as there are surrounding chambers. Dimensions are as follows (mm.):

Specimen number	Test diameter	Unordered	Ordered	Wall thickness	Pore diameter
3	1.16	3	15	0.006	recrystallized

Comparisons.— Sphaerogypsina globulus (Reuss) differs from all other species of the genus in having very thin walls. S. pilaris (Brady) has approximately the same maximum test diameter, but all other known species are much smaller. The chamber walls of S. globulus (Reuss) are more angular than other species except S. peruviana (Berry). S. globulus (Reuss), like S. peruviana, and S. n. sp. B, has intercalated radial columns of the second or third order which differs from the other species. S. peruviana (Berry) and possibly S. laevis (Parker and Jones) are the only known species which have higher ordered chambers than S. globulus (Reuss).

Type Locality.— Miocene, Unter Leithakalkschichten, Nussdorf near Vienna, Austria.

Range and Distribution.— Miocene: Nussdorf near Vienna, Austria; Hungary (Brady, 1884, p. 117). (?)Oligocene: Kai Island, Molucca Islands, East Indies. Common at type locality.

Remarks.— The specific name "*globulus*" has been incorrectly applied to many specimens found from Eocene to Recent because of the globular shape that characterizes the genus. Specimens from the type locality were recrystallized and abraded.

SPHAEROGYPSINA LAEVIS (Parker and Jones)

Orbitolina laevis Parker and Jones, 1860, Ann. Mag. Nat. Hist., ser. 3, vol. 6, p. 31.

?*Tinoporus baculatus* var. *sphaeroidalis* Carter, 1877, Ann. Mag. Nat. Hist., ser. 4, vol. 19, p. 215, pl. 13, figs. 18, 20.

?*Tinoporus vesicularis* var. *sphaeroidalis* Carter, 1877, Ann. Mag. Nat. Hist., ser. 4, vol. 20, p. 173.

?*Gypsina globulus* (Reuss)(in part). Brady, 1884, Rept. Sci. Res. Voy. H.M.S. Challenger, Zool., vol. 9, p. 117, pl. 101, fig. 8 (exclusive of synonymy; probably not specimens from British Isles).

?*Sphaerogypsina globulus* (Reuss)(in part). Galloway, 1933, Manual Foram. (Bloomington Principia Press), p. 309, pl. 28, fig. 14 (not fig. 13 = *S. globulus*).

Description of Exterior.— Test large (1.5 mm. maximum diameter), free, spherical, with surface having alternating raised and depressed chambers. Septal face small, slightly pustulose, perforated by numerous pores. Lateral walls imperforate with at least one aperture in each raised chamber.

Description of Median Section.— Test outline circular with chambers arranged in radial columns possibly with bifurcating radial lines near periphery. Chambers probably ordered throughout test except for the embryonic apparatus. Unlayered wall composed of minute radial acicular calcite crystals oriented perpendicular to chamber walls. Chambers small, angular, with highly perforate septal wall parallel to periphery, and imperforate lateral wall bent diagonally toward previous chambers ending in thickened upward projecting stolon lip. There are at least as many stolons as there are surrounding chambers.

Type Locality.— Not designated

Range and Distribution.— Recent: Honolulu, Hawaii, reefs; Australia; Fiji Islands; Mediterranean Sea; anomalous record, west coast of British Isles. Abundance not known.

Remarks.— Comparisons could not be made because specimens were not available to the writer for study, and drawings are only of outer portions of the test (Carter, 1877, p. 215).

SPHAEROGYPSINA PERUVIANA (Berry)

Plate 1, figure 3; Plate 3, figure 2

Gypsina peruviana Berry, 1929, Wash. Acad. Sci., Jour., vol. 19, no. 12, pt. III, pp. 239-240, text figs. 1,2.

Description of Median Section.— Test outline circular, chambers arranged in columns with radial lines extending in second order bifurcations near periphery. All chambers, except embryonic apparatus, have ordered arrangement. Order/

unorder ratio 18. Layered structure absent from chamber walls. Minute, radial calcite crystals form walls, with crystal orientation perpendicular to wall surfaces. Embryonic apparatus large, circular, consisting of one chamber with moderately thick wall. Chambers occurring just outside embryonic apparatus very small, hexagonal to polygonal, angular, sharply arched between previous chambers, increasing in size toward periphery. Septal and lateral walls thick. Septal walls perforate by numerous very small pores. Chambers near periphery small, quadrate, angular, 2 times wider than high. Septal wall very thick, moderately long, straight, paralleling periphery, very highly perforate, with very small pores. Lateral wall very thick, very short, broadly arched between previously formed chambers, imperforate, bent perpendicular to septal wall forming pillars. Stolons of lateral wall medium size, with thickened upward projecting lip, present between earlier and later chambers. Dimensions are as follows (mm.):

Specimen number	Test diameter	Unordered	Ordered	Wall thickness	Pore diameter
F500	2.75	1	18	0.011	recrystallized

Comparisons.— Sphaerogypsina peruviana (Berry) differs from all other species of the genus in having very highly ordered chambers throughout the test, angular quadrate chambers, and very small pores. It compares in size with S. n. sp. A, but is distinguished by thicker chamber walls, higher ordering of chambers into radial columns, and intercalation of radial columns like S. globulus (Reuss) and S. n. sp. B.

Type Locality.— Near Caleta Sal, Department of Piura, Peru; Talara shale (middle Eocene); "gray-brown, gritty sandstone."

Range and Distribution.— middle Eocene: Talara shale near Caleta Sal, Peru; Talara shale, upper third, Negritos, Peru; San Eduardo Limestone (type locality), San Eduardo quarry, Guayaquil, Ecuador; San Eduardo Limestone, NE of Hda. Sta. Lucia, Ecuador; San Eduardo Limestone, Rio de Chongon Viejo, Ecuador; Organos Limestone, Organos Chico, northwestern Peru.

Remarks.— Specimens were abundant in thin sections of limestones studied. They are closely associated with other larger foraminifera.

SPHAEROGYPSINA PILARIS (Brady)

Plate 1, figure 6

Tinoporus pilaris Brady, 1876, Ann. Soc. Mal. Belg., vol. 11, p. 103.

Gypsina globulus (Reuss). Hill, 1899, Bull. Mus. Comp. Zool., vol. 34, p. 147.

Gypsina globulus (Reuss) var. pilaris (Brady). Cushman, 1919, Carnegie Inst. Wash. Pub. 291, p. 44, pl. 9, figs. 1, 2.

Gypsina pilaris (Brady). Rutten, 1940, Mem. Soc. Cubana Hist. Nat., vol. 14, no. 2, p. 165, pl. 24.

Sphaerogypsina pilaris (Brady). Galloway and Heminway, 1941, N. Y. Acad. Sci., Sci. Survey Puerto Rico and Virgin Is., vol. 3, pt. 4, p. 406, pl. 27, fig. 8.

Description of Exterior.— Test large (4.2 mm. maximum diameter), free, spherical, with surface having alternating raised and depressed chambers. Septal faces small, moderately pustulose, pentagonal to polygonal, perforate with numerous large circular pores. Lateral wall thick, short, imperforate, with at least one large aperature.

Description of Median Section.— Test outline circular, chambers arranged in radial columns with second order bifurcating radial lines near periphery. Ordered arrangement of chambers near periphery, unordered near central interior. Order/unorder ratio 9. Minute radial calcite crystals form unlayered walls, with crystals oriented perpendicular to wall surfaces. Central chambers variable in size and shape, commonly small, pentagonal, with width about equal to height. Septum thick to very thick, angular, highly perforate with large pores, broadly to sharply arched between previous chambers, ending in thickened upward projecting stolon lip. Pores filled at junction of chambers. Peripheral chambers medium size, hexagonal, angular to subangular, 2.5 times more wide than high, broadly arched between previous chambers. Septal wall very thick, long, straight parallel to periphery, highly peripherate with large pores. Lateral wall thick, very short, imperforate, bent diagonally to perpendicular toward previously formed chambers, ending in thickened upward projecting stolon lip. Stolons large, semicircular, present at contacts with earlier and later chambers. Dimensions are as follows (mm.):

Specimen number	Test diameter	Unordered	Ordered	Wall thickness	Pore diameter
1	3.26	2	18	0.021	recrys-tallized
2	4.18	3	21	0.024	recrys-tallized
3	3.95	3	27	0.022	recrys-tallized

Comparisons.— *Sphaerogypsina pilaris* (Brady) is larger than all other species of the genus except *S. globulus* (Reuss), and has the thickest chamber walls and largest pores and stolons. *S. peruviana* (Berry) and *S. globulus* (Reuss) are the only species which have as many ordered chambers as *S. pilaris* (Brady).

Type Locality.— Miocene, Bowden Beds, Jamaica.

Range and Distribution.— Miocene: Bowden Beds, Jamaica; Dominican Republic. Oligocene-Miocene: Puerto Rico. Oligocene: La Cruz Marl, Cuba. Abundance not known.

Remarks.— Specimens sectioned by the writer were highly recrystallized, causing most sections to be without pores or stolons. A black line was formed by the recrystallization process. Some specimens are abraded and are therefore not spherical.

SPHAEROGYPSINA n. sp. A

Plate 1, figures 1-2; Plate 2, figure 1;

Plate 3, figures 3-4

Gypsina globula (Reuss). Cushman, 1945, Contr. Cushman

Lab. Foram. Research, vol. 21, pt. 4, no. 272, p. 105, pl. 16, fig. 25.

Sphaerogypsina globula (Reuss). Puri, 1957, Fla. Geol. Survey, Geol. Bull. no. 38, pt. 2, p. 143, pl. 14, fig. 7; pl. 15, fig. 9.

Description of Exterior.— Test medium size (1.49 mm. maximum diameter), free, spherical, with alternating raised and depressed chambers. Septal face large to very large, polygonal to subangular, containing large circular pores. Pore size and number dependent on chamber size. Lateral wall medium thick, with at least one large semicircular aperture in each raised chamber.

Description of Median Section.— Test outline circular with chambers arranged in straight columns increasing in width toward periphery. Ordered arrangement of chambers near periphery, unordered near central interior. Order/unorder ratio 1 to 10. Walls have no layered structure and are composed of numerous minute radial crystals of calcite oriented perpendicular to wall surfaces. Central chambers variable in size and shape, usually large, subelliptical to subcircular. Chamber walls moderately thick, rounded to subangular, broadly to sharply arched between previous chambers ending in thickened, upward projecting stolon lip. Septum highly perforate with medium to large pores, filled at junction of chambers. Wall imperforate, with circular to semicircular stolons providing communication of protoplasm to surrounding chambers. Chambers near periphery depressed, commonly large, angular to subangular, polygonal to elliptical 4 times more wide than high. Septum thick, long, straight, oriented parallel to periphery, highly perforate with medium to large pores. Wall thick, very short, imperforate, bent diagonally toward earlier chambers, ending in thickened upward projecting stolon lip. Number of stolons present dependent on number of surrounding chambers. Dimensions are as follows (mm.):

Specimen number	Test diameter	Unordered	Ordered	Wall thickness	Pore diameter
Moody's Branch 1	0.94	3	10	0.010	recrystallized
2	1.38	3	10	0.012	0.005
3	1.38	2	10	0.014	0.006
4	0.48	2	3	0.013	
5	0.62	4	4	0.013	
6	1.34	3	9	0.010	0.006
7	1.31	3	10	0.011	0.006
8	0.99	3	7	0.011	0.006
9	1.22	4	7	0.011	0.006
10	1.38	3	11	0.014	0.006
11	0.59	2	5	0.013	0.006
12	1.17	4	8	0.014	0.006
13	1.22	4	8	0.014	0.006
14	1.22	2	9	0.010	0.006
15	1.02	3	9	0.012	0.006
16	1.02	3	6	0.014	0.008

Specimen number	Test diameter	Unordered	Ordered	Wall thickness	Pore diameter
18	1.05	3	7	0.012	0.006
19	0.43	5	0	0.013	0.006
20	0.31	4	0	0.012	0.006
Ocala Ala. 1	1.28	2	9	0.014	filled
2	1.28	3	7	0.014	0.006
4	1.49	2	9	0.014	0.006
6	0.93	2	7	0.014	0.006
Ocala Fla. 1	1.02	3	7	0.014	0.005
2	1.07	1	10	0.014	0.006

Comparisons.— Sphaerogypsina n. sp. A differs from all other species of the genus in having less ordered chambers for its size. S. globulus (Reuss) and S. pilaris (Brady) are much larger, S. n. sp. B is much smaller, and S. peruviana is the same size. Wall thickness is comparable to S. peruviana (Berry), much larger than S. globulus (Reuss) and S. n. sp. B, and much smaller than S. pilaris (Brady). Intercalation of chambers is least developed in this species.

Type Locality.— Eocene: Jackson Group, Moody's Branch Marl, greensand and shell marl, located in Riverside Park, Jackson, Mississippi.

Range and Distribution.— Eocene: Moody's Branch Marl, Riverside Park, Jackson, Mississippi; Ocala Limestone, Claiborne Bluff, Claiborne, Alabama; Ocala Limestone, Florida; (?)Javita Limestone, north fork of Rio Nuevo, Ecuador (identification uncertain). Specimens very common at Jackson, Mississippi, very abundant at the Alabama and Florida localities, and the abundance is not known at the Peruvian locality.

Remarks.— Intensive examination of material from the Moody's Branch Marl at Creole Bluff, Montgomery, Louisiana, failed to yield specimens of Sphaerogypsina. Specimens from the Moody's Branch at Jackson, Mississippi, are excellently preserved. Specimens from the limestone localities of Alabama, Florida, and Peru were badly calcite-filled.

SPHAEROGYPSINA n. sp. B

Plate 1, figure 5

Description of Exterior.— Test small (0.6 mm. maximum diameter), free, spherical, with surface having alternating slightly raised and depressed chambers. Septal face small, slightly pustulose, polygonal to circular, perforate with numerous small circular pores. Lateral chamber walls medium thick, short, imperforate with at least one small semicircular aperture.

Description of Median Section.— Test outline circular, chambers arranged in radial columns, bifurcating near periphery. Ordered arrangement of chambers near periphery, unordered near central interior. Order/unorder ratio 4 to 5. Walls unlayered, composed of minute, radial crystals of calcite oriented perpendicular to wall surface. Central chambers variable in size and shape, usually large, subelliptical to subcircular, with width about equal to height. Septum moderately thick, rounded to subrounded, highly perforate with small pores. Wall imperforate, moderately thick, sharply arched between previous chambers, ending in thickened upward projecting stolon lip. Pores filled at junction of chambers. Chambers near periphery medium size, hexagonal, rounded to subangular, 3 times wider than high, very broadly arched between previous chambers. Septum moderately thick, long, straight, parallel to periphery highly perforate with relatively small pores. Lateral wall moderately thick, very short, imperforate, bent diagonally toward previously formed chambers ending in thickened upward projecting stolon lip. Stolons small, semicircular, present at contacts with previous and later chambers. Dimensions are as follows (mm.):

Specimen number	Test diameter	Unordered	Ordered	Wall thickness	Pore diameter
2	0.62	2	7	0.008	recrystallized
3	0.64	2	10	0.008	recrystallized
4	0.64	2	10	0.010	recrystallized

Comparisons.— *Sphaerogypsina* n. sp. B differs from all other species of the genus by having the smallest test diameters. Intercalated radial columns are well developed like those of *S. globulus* (Reuss) and *S. peruviana* (Berry). Wall thickness is much greater than *S. globulus* (Reuss), much less than *S. pilaris* (Brady), and comparable to *S.* n. sp. A and *S. peruviana* (Berry).

Type Locality.— Upper Oligocene: Byram Marl, Conecuh

County, Álabama at Murder Creek, brown clacareous clay just above Glendon Limestone.

Range and Distribution.— Upper Oligocene: Byram Marl, Conecuh County, Alabama at Murder Creek; type Byram Marl, Old Byram, Hinds County, Mississippi on banks of Pearl River. Specimens are rare at the type Byram in Mississippi and were abundant at the Murder Creek locality in Alabama.

Remarks.— Specimens were highly recrystallized destroying pores and stolons.

Two large specimens (1.5 mm. diameter) were found in the type Byram Marl. These were, in some areas of the test, replaced by glauconite making thin sectioning of specimens very difficult. It is thought by the writer that these large specimens represent microspheric individuals of S. n. sp. B. Rarity and poor preservation of specimens prohibited solving of the problem by the writer.

SPHAEROGYPSINA sp.

A medium sized species occurs in the Conchudo Limestone, (?)middle Eocene, Province of Tumbez, Peru. Specimens occurring in this formation are almost completely calcite filled making it difficult to distinguish important characters. Comparison of this species with S. peruviana (Berry) and S. n. sp. A, which are approximately the same size, suggests that this is a species not yet described. If a method can be found to remove the calcite filling, or if cleaner specimens can be found, the specimens could be classified as to species.

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EXPLANATION OF PLATE 1

Figure 1. _Sphaerogypsina_ new species A; median section of paratype; Eocene, Jackson group, Ocala Limestone; Alabama (X50).

Figure 2. _Sphaerogypsina_ new species A; median section of holotype; Eocene, Jackson group, Moody's Branch Marl; Mississippi (X50).

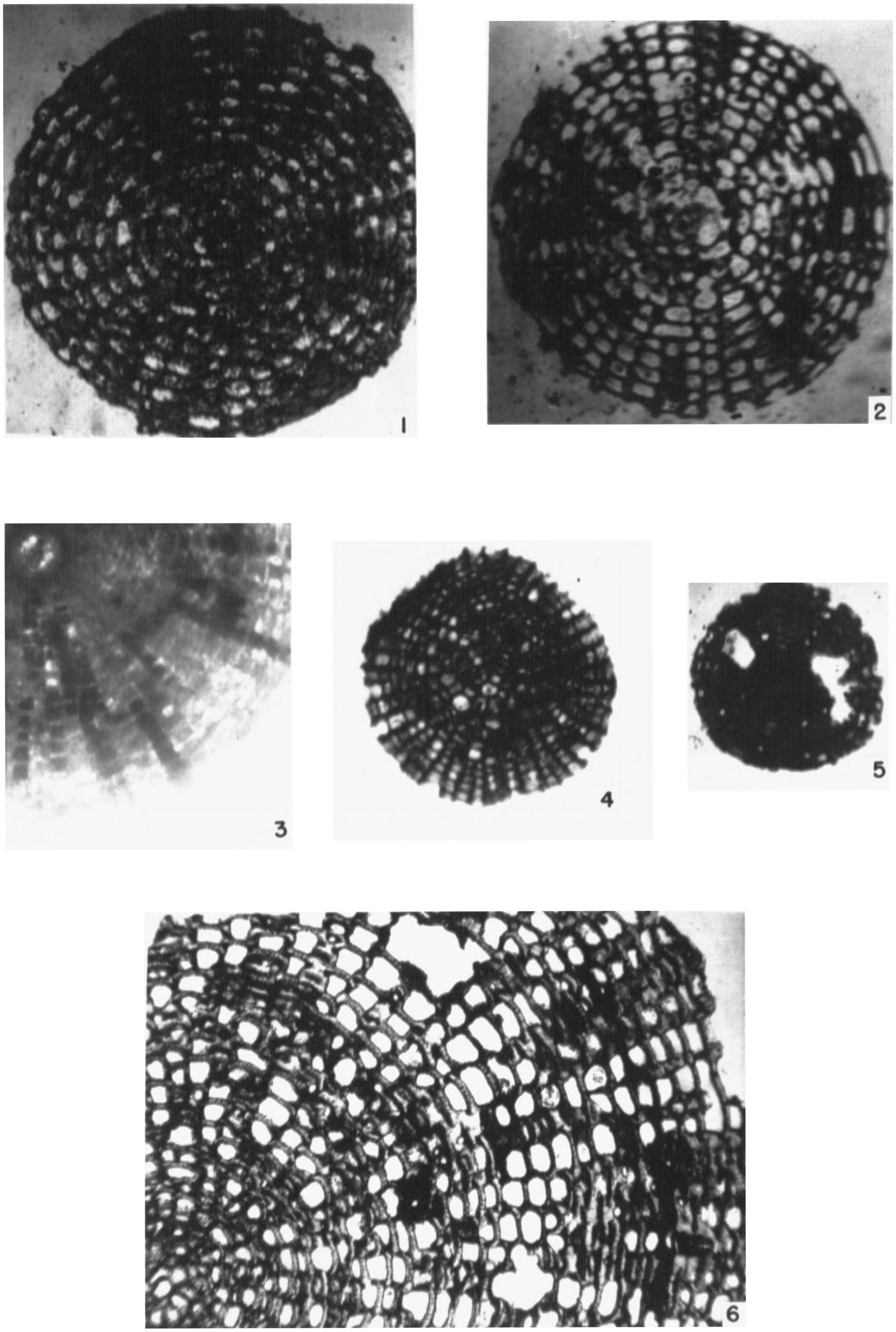
Figure 3. _Sphaerogypsina_ _peruviana_ (Berry); median section; middle Eocene, Talara Shale; Peru (X50).

Figure 4. _Sphaerogypsina_ _globulus_ (Reuss); median section of topotype; Miocene; Nussdorf, Austria (X50).

Figure 5. _Sphaerogypsina_ new species B; median section of holotype; Oligocene, Vicksburg group, Byram Marl; Alabama (X50).

Figure 6. _Sphaerogypsina_ _pilaris_ (Brady); median section of topotype; Miocene, Bowden beds; Jamaica (X50).

PLATE I



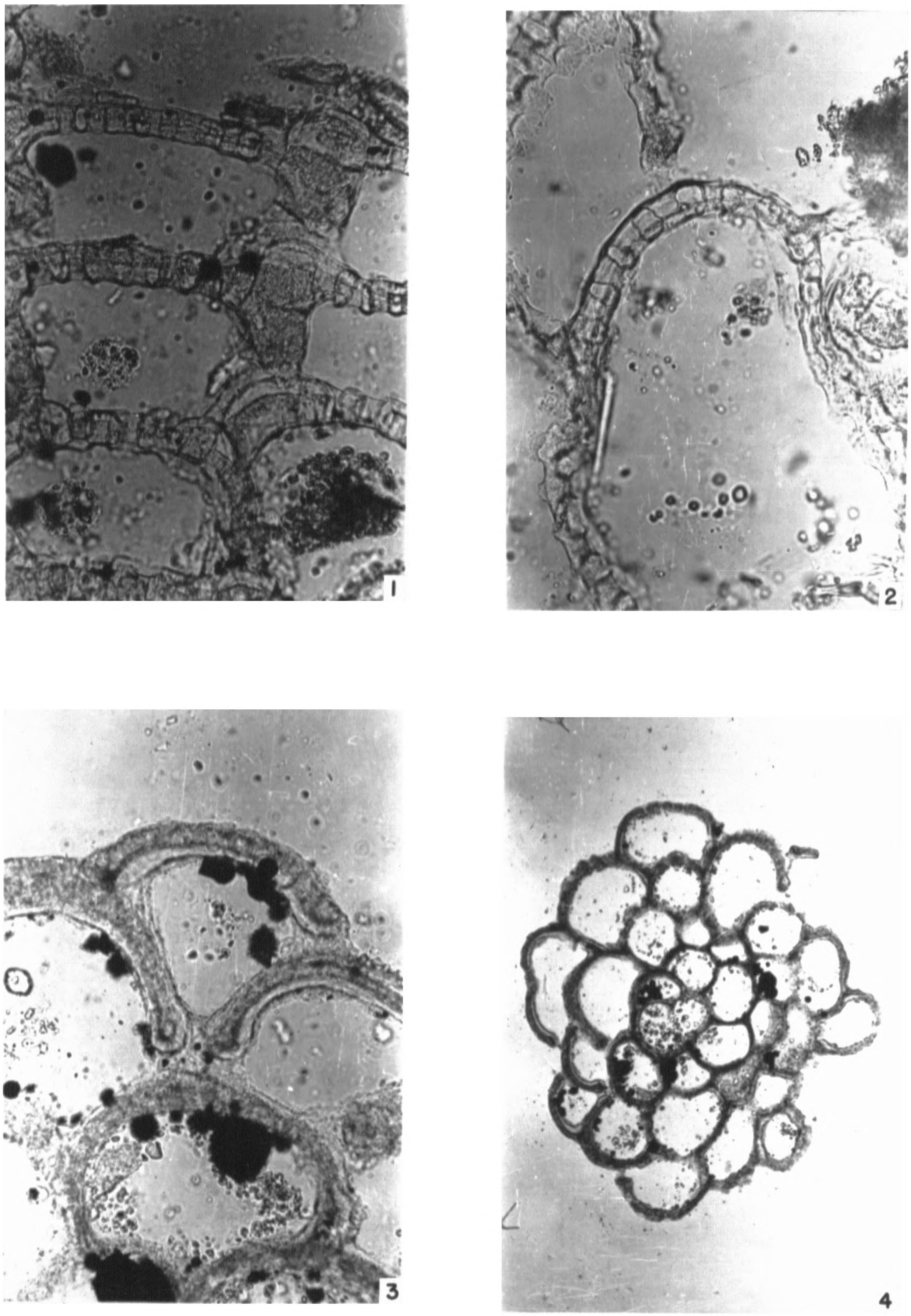
EXPLANATION OF PLATE 2

Figure 1. *Sphaerogypsina* new species A; median section of holotype; pores, apertures, stolons, and micro-lamellae (X500).

Figure 2. *Acervulina* sp.; Recent, Bahama Islands; pores, stolons, and pronounced black line (X500).

Figure 3 and figure 4. *Planorbulinella* sp.; Oligocene, Vicksburg group, type Byram Marl; Mississippi; stolons and pronounced black line (fig. 3, X500, fig. 4, X115).

PLATE 2



EXPLANATION OF PLATE 3

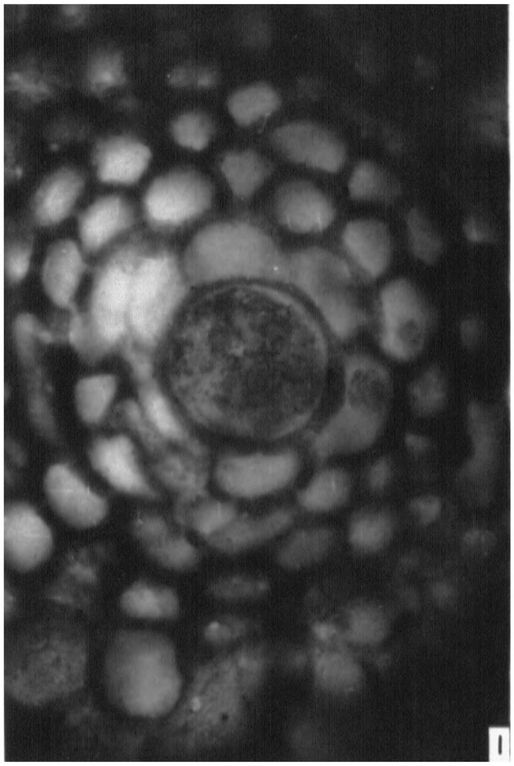
Figure 1. Sphaerogypsina globulus (Reuss); median section showing embryonic apparatus and central chambers (X300).

Figure 2. Sphaerogypsina peruviana (Berry); median section showing embryonic apparatus and central chambers (X150).

Figure 3. Sphaerogypsina new species A; median section of holotype showing embryonic apparatus and central chambers (X300).

Figure 4. Sphaerogypsina new species A; median section of paratype showing stolons in cross section and plan view (X300).

PLATE 3



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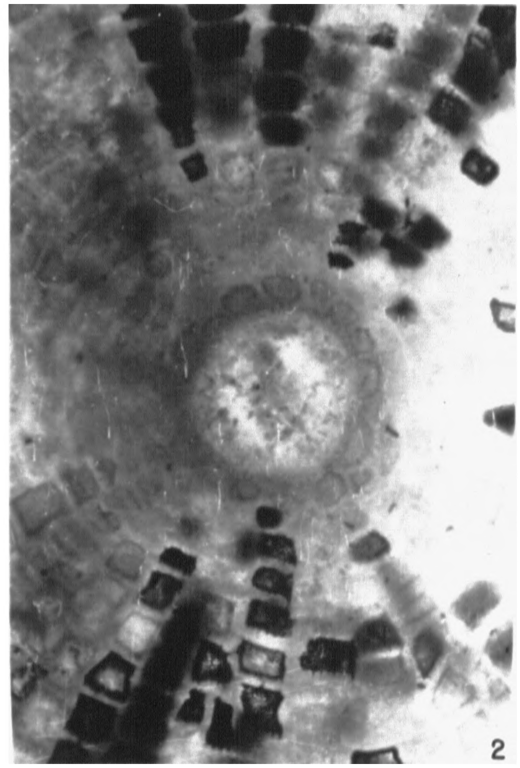

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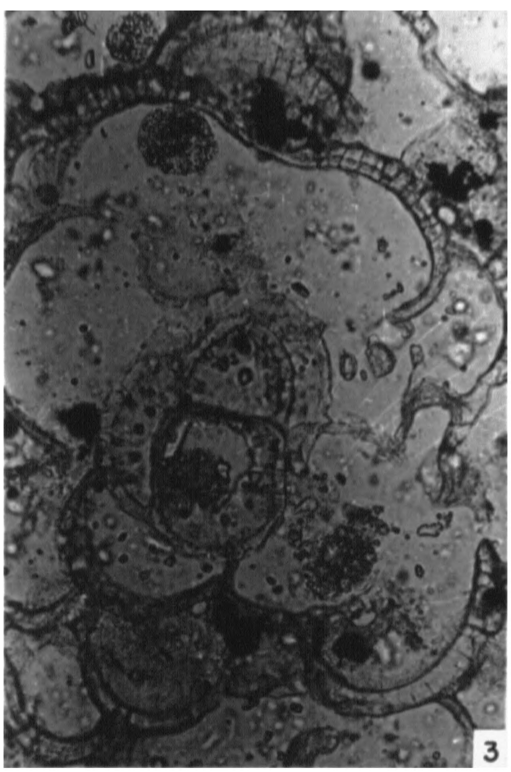

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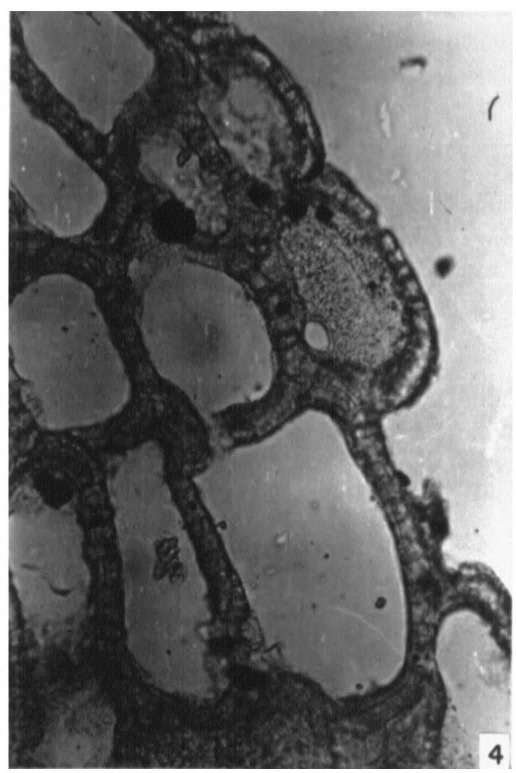

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X VITA

Wayne C. Horton was born on August 2, 1938, in Cape Girardeau, Missouri. He completed primary and secondary education in the same city, graduating from Central High School in June, 1956. In September, 1956, he entered the Missouri School of Mines and Metallurgy and received a bachelor of science degree in geology from the institution in 1961.

He has been enrolled in graduate school at the Missouri School of Mines and Metallurgy since January, 1961, and attended summer graduate school at The University of Texas Institute of Marine Science at Port Aransas, Texas for work in oceanography. In January, 1962, he became a member of Sigma Gamma Epsilon, Eta chapter at this school. In March, 1962, he was awarded a McNutt Memorial Foundation Grant-in-Aid fund for support of this thesis.