AMERICAN SPECIES OF OPERCULINA AND HETEROSTEGINA AND THEIR FAUNAL RELATIONS.

By JOSEPH AUGUSTINE CUSHMAN.

INTRODUCTION.

Almost nothing is known of the American fossil species of *Operculina* and *Heterostegina*. In the Ocala limestone, next to the larger *Orthophragmina* and *Lepidocyclina*, these genera are the most conspicuous members of the foraminiferal fauna. That there are several species, well marked in their characteristics, and that they have definite stratigraphic positions seems very clear from a study of the material.

Most of the localities at which the material here described was obtained are in the Ocala limestone of Florida; a few are in Georgia and Alabama.

STRATIGRAPHIC RELATIONS OF THE SPECIES.

The oldest beds in which *Operculina* occurs, so far as is shown by the material studied, are on Flint River, Ga., at the locality represented by stations 7116 and 7117, in a bluff on the west bank of the river about 1¾ miles above the bridge of the Georgia Southwestern & Gulf Railroad near Oakfield. The section at this locality is as follows:[1]

Section on Flint River, near Oakfield, Ga.

	Feet.
3. Covered slope to top of hill	22
2. Hard ledges of compact white semicrystalline limestone (station 7117)	3
1. Compact white limestone, mostly soft but with harder places (station 7116). To water level at 4-foot stage	20

At both these stations (Nos. 1 and 2 of the section) *Orthophragmina flintensis* Cushman occurs, and at each of them there is a different species of *Operculina*. The basal member of the section contains *Operculina cookei* Cushman, n. sp., and the member directly above has the allied *Operculina vaughani* Cushman, n. sp.

As stated by Cooke,[2] this material comes from a horizon low in the Ocala formation.

A similar white compact limestone containing *Operculina vaughani* Cushman and *Orthophragmina flintensis* Cushman occurs at station 7115, on the east bank of Flint River at the bend to the west 6 miles below Burke Ferry and about 6 miles above the bridge of the Georgia Southwestern & Gulf Railroad near Warwick, Worth County, Ga., and at station 7119, on the east bank of Flint River about 16 miles above Albany, in Worth County, near the Dougherty County line. At station 7237, a small quarry on the Averitt property, 300 or 400 yards southwest of the corner of lots 26 and 27, half a mile east of Huguenen Ferry and 1 mile south of Daphne station, Crisp County, Ga., *Operculina vaughani* occurs in company with *Orthophragmina flintensis* in a soft, white limestone.

Specimens apparently of *Operculina vaughani* occur at U. S. G. S. station 7192, Marianna, Fla., near the base of the following section:

Section on the west bank of Chipola River at the wagon bridge half a mile east of Marianna, Fla.[3]

	Feet.
Marianna limestone:	
5. Alternating hard and softer beds of light-colored limestone, very hard and compact in places, locally semicrystalline. The lower portion contains a considerable amount of glauconite. The floor of the bridge is 9 feet above the base of this bed	33
Ocala limestone:	
4. Concealed	3
3. Hard creamy-white semicrystalline limestone, apparently a more indurated phase of bed No. 1	1½
2. Concealed	4
1. Soft cream-colored porous limestone or marl, composed largely of Foraminifera loosely packed together. Extends beneath water in the river	5

[1] Cooke, C. W., The stratigraphic position and faunal associates of the orbitoid Foraminifera of the genus *Orthophragmina* from Georgia and Florida: U. S. Geol. Survey Prof. Paper 106, p. 110, 1917.

[2] Cooke, C. W., op. cit., p. 109.

[3] Idem, pp. 109–110.

There is then a definite zone which is characterized by *Orthophragmina flintensis* and which on the basis of its contained specimens of *Operculina* can be subdivided into a lower member with *Operculina cookei* and an upper one with *Operculina vaughani*.

Stratigraphically somewhat above these beds is the horizon characterized by *Operculina ocalana*. Beds at this horizon are widely distributed in Florida and Georgia, and at most places the *Operculina* is associated with *Orthophragmina georgiana*, the only species of *Orthophragmina* which seems to be found in the Ocala limestone south of the extreme northern part of Florida.

Operculina ocalana occurs rarely with *Heterostegina ocalana* and with *Lepidocyclina ocalana* and *L. floridana*, as the accompanying table shows, but this association is not characteristic, and more abundant material may show that the forms of *Operculina* in the two groups should be distinguished from one another. *Operculina ocalana* occurs in association with *Lepidocyclina georgiana* at several stations.

These three species of *Operculina* seem to have a definite relation to one another in development. The lowest and oldest of the three, *Operculina cookei*, has 28 to 32 chambers in the typical adult coil. The somewhat higher and younger *Operculina vaughani* has 20 to 22 chambers in the typical adult coil. The still younger *Operculina ocalana* has typically but 16 to 18 chambers in the adult coil, and its ornamentation is much more distinct than that of the other two species. These three then seem to show a definite evolution, at least in the progressive reduction in the number of chambers.

The zone that is characterized by the several species of *Lepidocyclina*, of which *Lepidocyclina ocalana* Cushman and *L. floridana* Cushman are the most common, also has *Operculina willcoxi* (Heilprin) Cushman and *Heterostegina ocalana* Cushman. This zone is exposed in the region of Levy and Marion counties, Fla. The species of *Lepidocyclina* mentioned also occur in the upper part of the Ocala limestone at Marianna.

Operculina floridensis does not show so definite a relation to the other forms, but it seems to be related to *Operculina willcoxi* and perhaps is a derivative from that species.

The three large species of *Operculina* occur with *Orthophragmina* and seem to justify a definite correlation of the Ocala limestone of the Flint River region, the Brito formation of Nicaragua, and the St. Bartholomew formation of the Leeward Islands. These formations are apparently in the lower portion of the upper Eocene, as in Florida, Georgia, and Alabama there seems to be another horizon above these characterized by *Operculina ocalana* and associated species. The *Heterostegina* occurs both in the upper Eocene and the middle Oligocene; the middle Oligocene form is found especially in the eastern group of the West Indies, in Santo Domingo, the Virgin Islands, and Antigua.

Distribution of Operculina, Heterostegina, and some associated Foraminifera in Georgia and Florida.

Operculina cookei Cushman.	Operculina vaughani Cushman.	Orthophragmina flintensis Cushman.	Operculina ocalana Cushman.	Orthophragmina georgiana Cushman.	Lepidocyclina georgiana Cushman.	Operculina willcoxi (Heilprin).	Heterostegina ocalana Cushman.	Heterostegina ocalana var. glabra Cushman.	Lepidocyclina ocalana Cushman.	Lepidocyclina floridana Cushman.	Operculina floridensis (Heilprin).	Station. [For fuller descriptions of localities, see systematic descriptions of species.]
×	....	....	?	×?	....	....	....	....	....	....	....	3626. 4½ miles southwest of Philema, Ga.
×	....	×	....	....	....	....	....	....	....	....	....	7116. Flint River above Oakfield, Ga.
....	×	....	....	....	....	....	....	....	....	....	....	3617. Muckafoonee Creek near Albany, Ga.
....	×	×	....	....	....	....	....	....	....	....	....	7115. Flint River near Warwick, Ga.
....	×	×	....	....	....	....	....	....	....	....	....	7117. Flint River above Oakfield, Ga.
....	×	×	....	....	....	....	....	....	....	....	....	7119. Flint River 16 miles above Albany, Ga.
....	×	....	....	....	....	....	....	....	....	....	....	7120. Albany, Ga.
....	×	×	....	....	....	....	....	....	....	....	....	7237. Crisp County, Ga., near Huguenen Ferry.
....	×	....	....	....	....	....	....	....	....	....	....	7192. Marianna, Fla., bed 3.
....	....	....	×	....	×	....	....	....	....	....	....	3390. Bainbridge, Ga.
....	....	....	×	×	....	....	....	....	....	....	....	3760. Tivola, Ga.
....	....	....	×	....	....	×	....	....	×	×	....	4965. Fort White, Fla.
....	....	....	×	....	....	....	....	....	....	....	....	6747. Steamboat Point, Sepulga River, Ga.
....	....	....	×	×	....	....	×	....	....	....	....	6785. Dutton's phosphate spur, Columbia County, Fla.
....	....	....	×	×	×	....	....	....	....	....	....	7097. Bainbridge, Ga.
....	....	....	×	....	....	....	....	....	....	....	....	7123. Flint River, 9½ miles below Albany, Ga.
....	....	....	×	×	×	....	....	....	....	....	....	7126. Dry Bread Shoals, Flint River, Ga.
....	....	....	×	×	×	....	....	....	....	....	....	7127. Normans Ferry, Flint River, Ga.
....	....	....	×	....	....	×	....	....	×	....	....	7337. Florida Railway (Seaboard Air Line) bridge, Suwannee River, Fla.
....	....	....	×	×	....	....	....	×	....	....	....	7348. Troy Springs, Suwannee River, Fla.
....	....	....	×	×	....	....	....	×	×	×	....	7349. Fort McComb, Suwannee River, Fla.
....	....	....	×	×	×	....	....	....	....	....	....	3887. Red Bluff, Flint River, Ga.
....	....	....	×	×	×?	....	....	....	....	....	....	8259. 12 miles northwest of Marianna, Fla.
....	....	....	....	×	×	....	×	....	....	....	....	7098. Red Bluff, Flint River, Ga.
....	....	....	....	....	....	×	×	....	×	....	....	322. Newmansville, Alachua County, Fla.
....	....	....	....	....	....	×	....	....	×	×	....	329. Wells at Padlock, Suwannee County, Fla.
....	....	....	....	....	....	×	×	....	×	×	....	6817. Fort White, Fla.
....	....	....	....	....	....	×	....	....	×	×	....	6790. Alachua, Fla.
....	....	....	....	....	....	×	×	....	×	×	....	6804. Ocala, Fla.
....	....	....	....	....	....	×	×	....	×	×	....	6805. 2 miles southeast of Ocala, Fla.
....	....	....	....	....	....	×	×	....	×	×	....	6808. Martin station, Fla.
....	....	....	....	....	....	....	×	....	×	....	....	365. Johnson's sink, Levy County, Fla.
....	....	....	....	....	....	....	×	....	×	....	....	380. Alachua County, Fla.
....	....	....	....	....	....	....	×	....	....	....	....	3174. Well in Putnam County, Fla.
....	....	....	....	....	....	....	×	....	×	....	....	3685. Martin station, Fla.
....	....	....	....	....	....	....	×	....	×	....	....	5030. Ocala, Fla.
....	....	....	....	....	....	....	×	....	....	....	....	6787. New Sink, Alachua County, Fla.
....	....	....	....	....	....	....	×	....	×	×	....	6789. North Alachua, Fla.
....	....	....	....	....	....	....	×	....	×	×	....	6810. Newberry, Fla., Cummer No. 10.
....	....	....	....	....	....	....	×	....	×	×	....	6812. Newberry, Fla., Cummer No. 6.
....	....	....	....	....	....	....	×	....	×	×	....	6814. Newberry, Fla., Franklyn phosphate.
....	....	....	....	....	....	....	×	....	×	×	....	7338. Dowling Springs, Fla.
....	....	....	....	....	....	....	×	....	×	×	....	7341. Branford, Fla.
....	....	....	....	....	....	....	×	....	×	....	....	7365. Pineola, Citrus County, Fla.
....	....	....	....	....	....	....	×	....	×	×	....	7367. Willow Sink, Levy County, Fla.
....	....	....	....	....	....	....	....	×	×	....	....	7345. Suwannee River 2¼ miles above Branford, Fla.
....	....	....	....	....	....	....	....	....	×	×	....	362. Fort White, Fla.
....	....	....	....	....	....	....	....	....	....	....	×	3636. Spring Hill schoolhouse, Alachua County, Fla.
....	....	....	....	....	....	....	....	....	....	....	×	3684. Pemberton Ferry, Hernando County, Fla.
....	....	....	....	....	....	....	....	....	....	....	×	3686. Martin station, Fla. (?).

DETAILED DESCRIPTIONS.

Operculina cookei Cushman, n. sp.

Plate XVIII, figures 1, 2.

Test coiled, planospiral, very thin, composed of 2½ to 3 coils rapidly increasing in breadth, chambers very numerous, 28 to 32 in the last-formed coil, fairly constant in size and shape, in the adult the length of the chamber 10 to 12 times the height, each chamber gradually widening toward the center or slightly beyond the center, sutures starting in a slightly tangential curve which rapidly increases in convexity toward the periphery, near which it bends back at a sharp angle, joining the peripheral margin of the test.

Surface of the test in the central region with numerous rounded bosses irregularly placed, the sutures in the last-formed coil ornamented by raised ridges, in the earlier part broken into separate knobs or bosses, toward the later part fused into continuous raised ridges. Surface of the chambers between the sutures somewhat concave, smooth, translucent. Length of adult specimens as much as 10 millimeters.

Geologic occurrence, Ocala limestone and Jackson formation.

Type specimen from U. S. G. S. station 7116, bluff on west bank of Flint River 1¾ miles above the Georgia Southwestern & Gulf Railroad bridge near Oakfield, Lee County, Ga., bed No. 1 of section (base of bluff); C. W. Cooke, collector; Ocala limestone.

This species occurs stratigraphically below *O. vaughani*, which is found in bed No. 2 of the same section. Both are found in considerable numbers and seem to be very constant in their characters.

A single, very beautifully preserved specimen showing the exterior was obtained at U. S. G. S. station 6458, in the Moodys calcareous marl member of the Jackson formation, at Moodys Branch, Jackson, Miss.; C. W. Cooke, collector.

A specimen from U. S. G. S. station 3626, though not well preserved, seems to be *O. cookei*, but its occurrence with *Orthophragmina georgiana* and perhaps *Operculina ocalana* makes this identification seem rather doubtful.

The occurrence of this species near the base of the Ocala of Georgia and in the Moodys calcareous marl member of Mississippi shows that these two portions of the lower part of the Jackson formation at these widely separated localities are to be correlated. At Jackson it also occurs with *O. ocalana* var. and *Lepidocyclina fragilis* Cushman, both of which are known higher up in the Ocala, in Florida especially.

Operculina vaughani Cushman, n. sp.

Plate XIX, figures 6, 7.

Test coiled, planospiral, very thin, composed of about three coils rapidly increasing in breadth; chambers numerous, 20 to 22 in the last-formed coil, fairly constant in size and shape, in the adult the length of the chamber 5 to 6 times the height, each chamber gradually increasing in height from the proximal end to the maximum height near the distal end; sutures usually starting from the proximal end in a nearly straight radial line and keeping so for about one-third the length, then gently rounded backward toward the periphery, near which the rate of curvature is abruptly increased. Length of adult specimen 7 to 8 millimeters.

Geologic occurrence, Ocala limestone and Brito formation.

Type specimen from U. S. G. S. station 3617, Muckafoonee Creek, Albany, Ga.; T. Wayland Vaughan, collector. Other specimens were obtained at the following U. S. G. S. stations:

7115. East bank of Flint River at bend to west 6 miles below Burke Ferry and about 6 miles above Georgia Southwestern & Gulf Railroad bridge near Warwick, Worth County, Ga.; C. W. Cooke, collector.

7117. Bluff on west bank of Flint River 1¾ miles above Georgia Southwestern & Gulf Railroad bridge near Oakfield, Lee County, Ga., upper bed, No. 2 of section; C. W. Cooke, collector.

7119. East bank of Flint River about 16 miles above Albany, Worth County, Ga.; C. W. Cooke, collector.

7237. Small quarry on Averitt plantation, 300 or 400 yards southwest of corner of lots 26 and 27, half a mile east of Huguenen Ferry, Crisp County, Ga.; C. W. Cooke and J. E. Brantley, collectors.

This species, with *Orthophragmina flintensis* Cushman, seems to characterize this particular horizon, being replaced directly below by *Operculina cookei*, which differs from *O. vaughani* in the relative number of chambers in the coils and also in the general shape of the chambers. Specimens apparently identical with this species were found with *Orthophragmina flintensis* Cushman and *O. georgiana* Cushman at U. S. G. S. station 6408, in the Brito formation on the Pacific coast of Nicaragua, 2 miles northwest of Brito Harbor; C. W. Hayes, collector.

Operculina antillea (Cushman) Cushman.

Plate XIX, figure 3; Plate XXI, figure 20.

Nummulites antillea Cushman, Carnegie Inst. Washington Pub. 291, p. 51, pl. 4, figs. 1, 2, 1919.

Test complanate, much compressed, partly involute in the earlier portion, the last coil broad and thin, with 30 or more chambers in the final whorl; sutures raised, the length of the chambers about eight times the height, the backward curve of the sutures beginning at less than one-half their length from the inner margin. Diameter 15 to 18 millimeters or more.

Geologic occurrence, St. Bartholomew limestone (Eocene).

The type locality for this species is U. S. G. S. station 6924, in bed of limestone at top of section, at point on northwest side of St. Jean Bay, St. Bartholomew, Leeward Islands; T. W. Vaughan, collector. Here specimens are abundant. The sectioned specimen (Pl. XXI, fig. 20), which seems to represent a young individual or the central portion of this species, came from U. S. G. S. station 6895, spur on southwest side of cay northwest of St. Jean Bay, St. Bartholomew, 170 feet above sea level; T. W. Vaughan, collector.

This species, on account of its partly involute character first assigned to *Nummulites*, seems on further study to be a species of *Operculina* closely related to *O. cookei* and *O. vaughani*. Like both those species, it occurs in association with *Orthophragmina* and seems to indicate that the St. Bartholomew limestone is very closely correlated with the lower portion of the Ocala.

Operculina ocalana Cushman, n. sp.

Plate XIX, figures 4, 5.

Test complanate, much compressed, composed of two to three coils, the last with 16 to 18 chambers; sutures raised, confluent in the center, somewhat rounded, the area between concave and smooth; chambers three to four times as long as wide; central area of the test umbonate; periphery somewhat raised by a thickening in which the raised sutures terminate. Length as much as 6 millimeters.

Geologic occurrence, Ocala limestone and Jackson formation.

Type specimen (U. S. N. M. catalogue No. 328249) from U. S. G. S. station 6747, Steamboat Point, on west side of Sepulga River at sharp bend near middle of sec. 20, T. 3 N., R. 13 E., Escambia County, Ala.; C. W. Cooke, collector. The species has also been found at the following stations:

3626. 4½ miles southwest of Philema, Lee County, Ga.; T. W. Vaughan, collector.

3760. Half a mile south of Tivola, Ga.; S. W. McCallie, collector.

3387. Red Bluff, on Flint River, 7 miles above Bainbridge, Decatur County, Ga.; T. W. Vaughan, collector.

3390. Below Plant System railroad wharf, Bainbridge, Ga.; T. W. Vaughan, collector.

4965. Half a mile southwest of Fort White, Columbia County, Fla.; G. C. Matson, collector.

6785. Dutton's phosphate spur, on Atlantic Coast Line Railroad, west side of track, at head of culvert, one-half to three-fourths mile south of Herlong's station, Columbia County, Fla.; T. W. Vaughan and C. W. Cooke, collectors.

7097. East bank of Flint River at bar three-fourths mile northeast of Atlantic Coast Line Railroad station at Bainbridge, Ga.; C. W. Cooke and W. C. Mansfield, collectors.

7123. East bank of Flint River, 9½ miles below Albany, and 4½ miles below Blue Spring, Dougherty County, Ga.; C. W. Cooke, collector.

7126. East bank of Flint River at Dry Bread Shoals, 8½ or 9 miles below Newton, Mitchell County, Ga.; C. W. Cooke, collector.

7127. East bank of Flint River one-fourth mile below Norman's Ferry, Mitchell County, Ga.; C. W. Cooke and J. E. Brantley, collectors.

7337. Left bank of Suwannee River above bridge of Florida Railway, Suwannee County, Fla.; C. W. Cooke, collector.

7348. Left bank of Suwannee River about 1 mile above Troy Springs, Fla.; C. W. Cooke, collector.

7349. Left bank of Suwannee River about half a mile below Fort McComb, Fla.; C. W. Cooke, collector.

This species is more characteristic of that part of the Ocala limestone in which *Orthophragmina georgiana* occurs than of that marked by *Lepidocyclina ocalana* and its associated species. It seems to be related to *Operculina vaughani* and *Operculina cookei* but is more definitely ornamented, has fewer chambers, and occurs stratigraphically above those species. The decrease in number of chambers in each whorl is continued from the greater number in *O. cookei* through the lesser number in *O. vaughani* to the still fewer in *O. ocalana*.

The species occurs in the Moodys calcareous marl member at Moodys Branch, Jackson, Fla., with *O. cookei* and *Lepidocyclina fragilis*. These came to me as loose specimens, apparently from the same horizon. The specimen referred to *O. ocalana* is not typical, however, as it has 24 chambers in the final whorl, whereas the typical form has only 16 to 18.

A similar form also occurs at station 6747, with the typical form of the species. A figure of this form is given on Plate XX, figure 8.

Operculina willcoxi (Heilprin) Cushman.

Plate XX, figures 9–11.

Nummulites willcoxi Heilprin, Acad. Nat. Sci. Philadelphia Proc., 1882, p. 191, text figs. 1, 2; idem, 1884, pp. 321, 322, text figs. 1, 2.

Test regularly rounded, tumid (more especially in the earlier stage), and measuring in the largest specimen about one-third inch in diameter; external surface distinctly marked by the arcuate and somewhat wavy outlines of the septal prolongations; volutions about 5, completely

enveloping; septa close set, about 35 to 45 in the last whorl, and well flexed; central initial chamber distinctly visible.

The above description is that given by Heilprin. I have studied material evidently representing this species from numerous stations, and it seems questionable whether the species should be considered as belonging to *Operculina* or *Nummulites*. All the whorls except the last are involute but very thin, the line of the coiling being easily visible for one or two coils in many specimens. The test is not thick, and the fact that the megalospheric proloculum is usually visible, as noted by Heilprin, shows that the test, although involute, is but very slightly built over in the central portion.

The species seems to be characteristic of that portion of the Ocala which is characterized by certain species of *Lepidocyclina* but not of that portion in which *Orthophragmina* is the predominating orbitoid genus. It occurs usually in company with *Heterostegina*.

It has been collected in the Ocala limestone at the following stations:

322. Newmansville, Fla.; L. C. Johnson, collector.

329. Padlock, Suwannee County, Fla.; L. C. Johnson, collector.

4965. Half a mile southwest of Fort White, Columbia County, Fla.; G. C. Matson, collector.

6790. 300 feet south of Alachua Manufacturing Co.'s plant at south edge of Alachua, Alachua County, Fla.; H. Gunter and C. W. Cooke, collectors.

6804. Quarry No. 1, Florida Lime Co., on southwest edge of Ocala, Marion County, Fla.; C. W. Cooke, collector.

6805. Quarry of Oakhurst Lime Co., south of Atlantic Coast Line Railroad, 2 miles southeast of Ocala, Marion County, Fla.; C. W. Cooke, collector.

6808. Quarry one-eighth mile southeast of Martin station, Atlantic Coast Line Railroad, 9 miles north of Ocala, Fla.; H. Gunter and C. W. Cooke, collectors.

6817. Old phosphate mine one-fourth mile southeast of Fort White, Fla.; C. W. Cooke, collector.

7337. Left bank of Suwannee River above bridge of Florida Railway, Suwannee County, Fla.; C. W. Cooke, collector.

Operculina floridensis (Heilprin) Cushman.

Plate XX, figure 12.

Nummulites floridensis Heilprin, Acad. Nat. Sci. Philadelphia Proc., 1884, pp. 321, 322, text fig., 1885.

Test coiled, planospiral, very thin, composed of three or four coils, gradually increasing in breadth, chambers very numerous, 30 or more in the last-formed coil of the adult, the length about five times the height, somewhat irregular in size, each chamber very gradually increasing in size toward the greatest height, which is near the periphery; sutures slightly curved at first but gradually increasing in convexity, not so strongly recurved at the periphery as in some of the other species; in the adult specimen the height of the coil does not increase, and in some specimens there is actually a decrease, indicating senescence toward the end of the development. Length as much as 8 millimeters.

Geologic occurrence, Ocala limestone.

Heilprin's specimens were from Pemberton's Ferry (now Croom), Hernando County, Fla.; Joseph Willcox, collector. Specimens from this material are here figured. The species has also been obtained at station 3636, 6 miles north of Spring Hill schoolhouse, Alachua County, Fla., by T. W. Vaughan, and is said to have been found at station 3686, Martin Station, Fla., by Joseph Willcox (?).

Heterostegina ocalana Cushman, n. sp.

Plate XXI, figures 15–18.

Test broadly complanate, central portion thickest, biconvex, rapidly thinning to the periphery, which is rounded; central portion with irregularly radial costae fusing near the base of the convex portion with the raised ribs of the sutures; in well-preserved specimens the lines between the chamberlets often marked by raised ribs, giving that portion of the test a reticulate appearance. Length as much as 8 millimeters.

Geologic occurrence, Ocala limestone.

Type specimen (U. S. N. M. catalogue No. 328250) from U. S. G. S. station 6812, Cummer Lumber Co.'s phosphate plant No. 6, 1¼ miles south of Newberry, Alachua County, Fla.; C. W. Cooke, collector.

In some ways this species resembles *H. reticulata* Rütimeyer, but it differs in the general proportions and in the shape, size, and angle of the subdivisions.

Heterostegina ocalana has been found at the following U. S. G. S. stations:

322. Newmansville, Fla.; L. C. Johnson, collector.

365. Johnson's Sink, Levy County, Fla.; L. C. Johnson, collector.

380. Vicinity of Gainesville and Arredonda, Alachua County, Fla.; L. C. Johnson, collector.

3174. Edgar kaolin works, Edgar, Putnam County, Fla.; halfway from St. Augustine to Cedar Key at a depth of 130 feet.

3685. Martin station, Fla.; W. H. Dall, collector.

5030. Quarry, Ocala, Marion County, Fla.; G. C. Matson, collector.

6785. Dutton's phosphate spur on Atlantic Coast Line Railroad, west side of track, at head of culvert, one-half to three-fourths mile south of Herlong's station, Columbia County, Fla.; T. W. Vaughan and C. W. Cooke, collectors.

6787. New Sink, 2 miles north of High Springs, Alachua County, Fla.; T. W. Vaughan and C. W. Cooke, collectors.

6789. North side of Alachua and High Springs public road, 1 mile west of North Alachua station, Atlantic Coast Line Railroad, Alachua Manufacturing Co.'s plant, south edge of Alachua, Alachua County, Fla.; H. Gunter and C. W. Cooke, collectors.

6804. Quarry No. 1, Florida Lime Co., on southwest edge of Ocala, Marion County, Fla.; C. W. Cooke, collector.

6805. Oakhurst Lime Co. (plant No. 2, Florida Lime Co.), south of Atlantic Coast Line Railroad, 2 miles southeast of Ocala, Marion County, Fla.; C. W. Cooke, collector.

6808. Quarry one-eighth mile southeast of Martin station, Atlantic Coast Line Railroad, 9 miles north of Ocala, Fla.; H. Gunter and C. W. Cooke, collectors.

6810. Cummer Lumber Co.'s phosphate plant No. 10, 1 mile northwest of Newberry, Alachua County, Fla.; C. W. Cooke, collector.

6812. Cummer Lumber Co.'s phosphate plant No. 6. 1¼ miles south of Newberry, Alachua County, Fla.; C. W. Cooke, collector.

6814. Quarry of Franklyn Phosphate Co., 1½ miles northwest of Newberry, Alachua County, Fla.; C. W. Cooke, collector.

6817. Old phosphate mine one-fourth mile southeast of Fort White, Fla.; C. W. Cooke, collector.

7098. Red Bluff, Flint River, 7 miles above Bainbridge, Ga.; C. W. Cooke, collector.

7338. Suwannee River at Dowling Springs, Suwannee County, Fla.; C. W. Cooke, collector.

7341. Left bank of Suwannee River at Branford, Suwannee County, Fla.; C. W. Cooke, collector.

7365. Pineola, 5 miles south of Floral City, Citrus County, Fla.; C. W. Cooke, collector.

7367. Willow Sink, 1½ to 2 miles west of Chiefland, Levy County, Fla.; C. W. Cooke, collector.

The variety described below seems distinct at a few stations. It usually accompanies *Orthophragmina georgiana* Cushman.

Heterostegina ocalana Cushman var. glabra Cushman, n. var.

Plate XXI, figure 19.

Variety differing from the typical form mainly in the smoother surface of the test.

Geologic occurrence, Ocala limestone.

Type specimen (U. S. N. M. catalogue No. 328251) from U. S. G. S. station 7348, left bank of Suwannee River about 1 mile above Troy Springs, Fla.; C. W. Cooke, collector. It has also been obtained at the following U. S. G. S. stations:

7345. East bank of Suwannee River 2¼ miles above Branford, Suwannee County, Fla.; C. W. Cooke, collector.

7349. Left bank of Suwannee River about half a mile below Fort McComb, Fla.; C. W. Cooke, collector.

Heterostegina antillea Cushman.

Plate XX, figures 13, 14.

Heterostegina antillea Cushman, Carnegie Inst. Washington Pub. 291, p. 49, pl. 2, figs. 1, 6; pl. 5, figs. 1, 2, 1919.

Test compressed, unequally lenticular; umbo excentric, somewhat thicker than the remainder of the test; surface over the septal lines slightly raised in a series of somewhat papillate ribs; area between ribs granular; chambers regularly curved, divided into numerous chamberlets. Diameter 6 millimeters or more.

The type locality for this species is U. S. G. S. station 6869, Antigua formation, Long Island, Antigua, Lesser Antilles; T. W. Vaughan, collector. The sections figured came from U. S. G. S. station 6854, Rifle Butts, Antigua. At this station the specimens are very numerous, making up a large proportion of the rock. This species occurs in the middle Oligocene, and seems to be characteristic of that horizon. It has been found in the Virgin Islands at station 8647, St. Croix, 1.4 miles in a straight line from Christiansted lighthouse, on south side of North Shore Road at Evening Hill, T. W. Vaughan, collector; and in Santo Domingo at station 8557 (lower bed), Baitoa.

PLATES XVIII–XXI.

PLATE XVIII.

Operculina cookei Cushman, n. sp.

FIGURE 1. Sectional view of specimen, × 15, less finely developed than that shown in figure 2. U. S. G. S. station 7116.

FIGURE 2. Sectional view of large, adult specimen, × 15, showing the proloculum or initial chamber and sections of all the other chambers of the whole test. U. S. G. S. station 7116.

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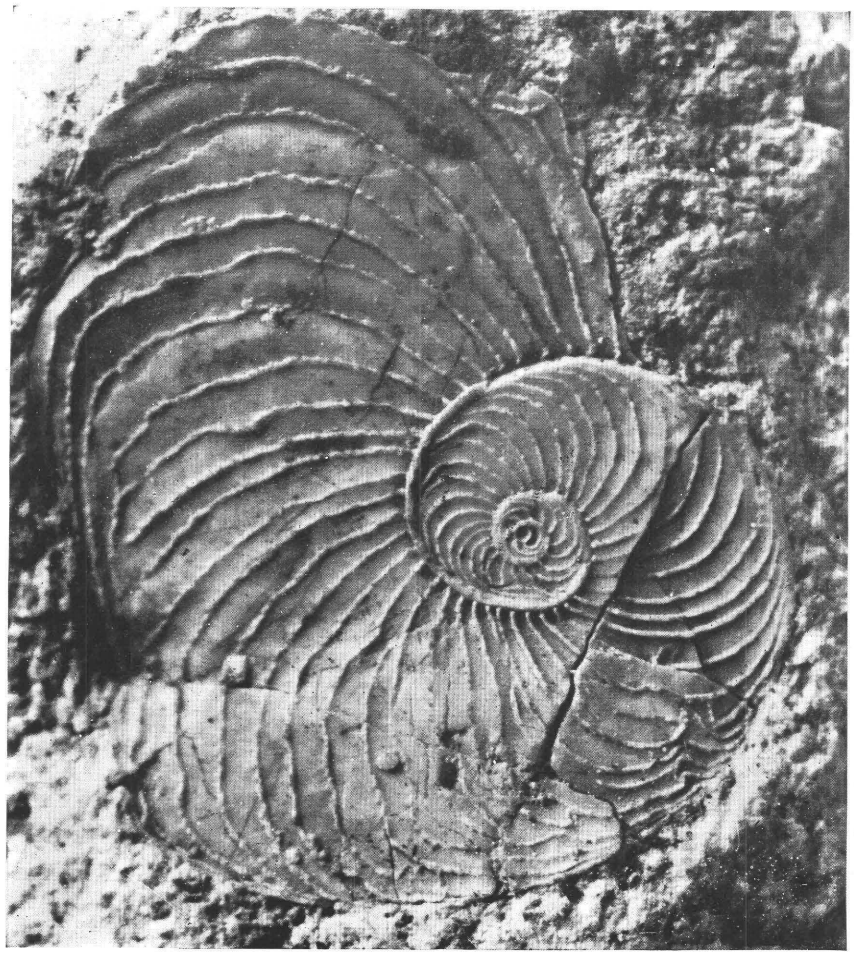

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OPERCULINA COOKEI CUSHMAN, N. SP.

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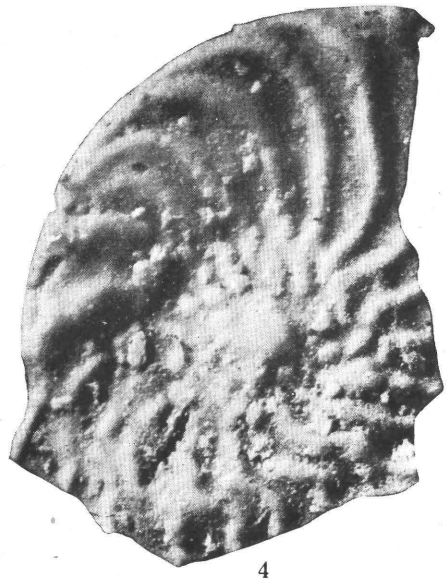

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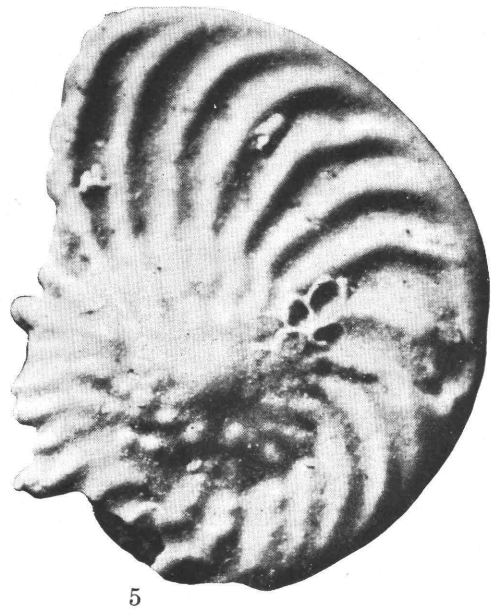

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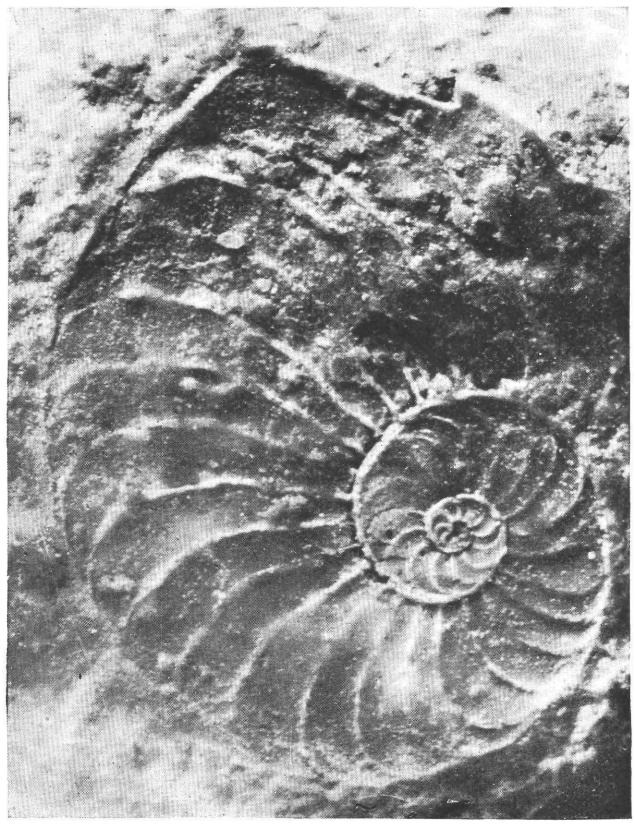

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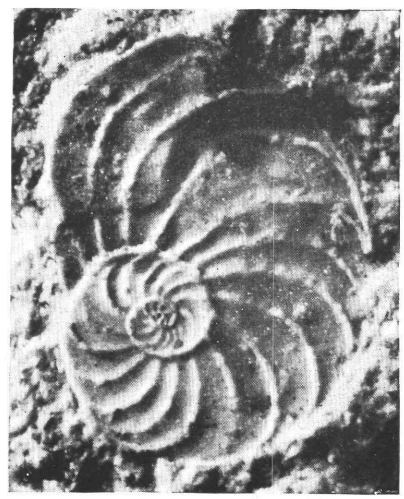

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AMERICAN SPECIES OF OPERCULINA.

PLATE XIX.

Operculina antillea (Cushman).

FIGURE 3. Exterior view of type specimen, × 5, somewhat eroded and showing traces of the chamber walls. U. S. G. S. station 6924.

Operculina ocalana Cushman, n. sp.

FIGURE 4. Surface view of specimen, × 15, showing ornamentation of the exterior. U. S. G. S. station 6747.

FIGURE 5. Surface view of type specimen, × 15. The angular condition of the border on the left is due to the breaking away of the later chambers. U. S. G. S. station 6747.

Operculina vaughani Cushman, n. sp.

FIGURE 6. Sectional view of type specimen, × 15, showing proloculum or initial chamber and the general character of later chambers. U. S. G. S. station 3617.

FIGURE 7. Sectional view of younger specimen, × 15. U. S. G. S. station 7115.

PLATE XX.

Operculina ocalana Cushman, n. sp., var.

FIGURE 8. Surface view, × 15. The test thinner and the sutures less marked than in the typical form. U. S. G. S. station 6747.

Operculina willcoxi (Heilprin) Cushman.

FIGURE 9. Partly broken specimen, × 15, showing the slight thickness of the wall, the early chambers, and the involute character. U. S. G. S. station 6790.

FIGURES 10, 11. Surface view of two specimens, × 15, showing the wide revolving edge and the surface markings. U. S. G. S. station 6790.

Operculina floridensis (Heilprin) Cushman.

FIGURE 12. Surface view, × 15. U. S. G. S. station 3684.

Heterostegina antillea Cushman.

FIGURE 13. Oblique section, × 20, showing some of the chamberlets. U. S. G. S. station 6869.

FIGURE 14. Vertical sections, × 20, one through the proloculum. U. S. G. S. station 6869.

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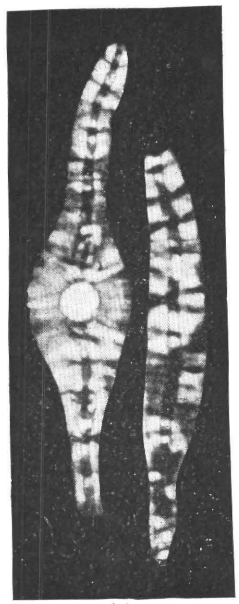

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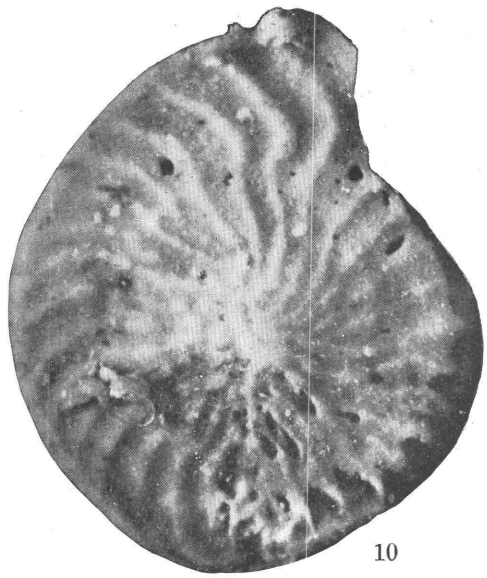

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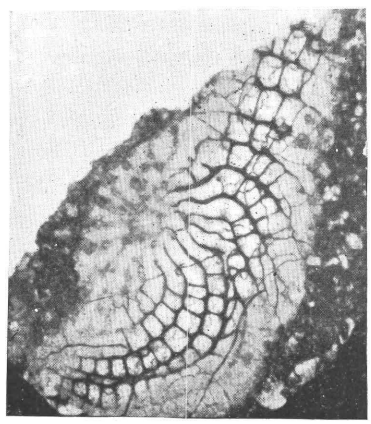

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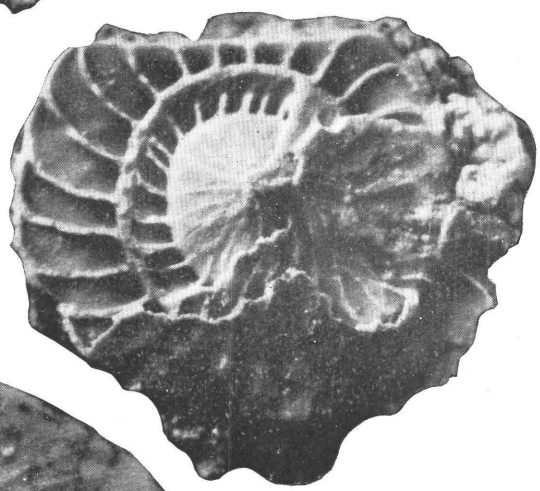

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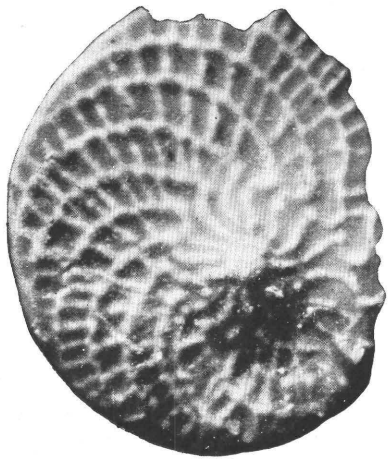
AMERICAN SPECIES OF OPERCULINA AND HETEROSTEGINA.



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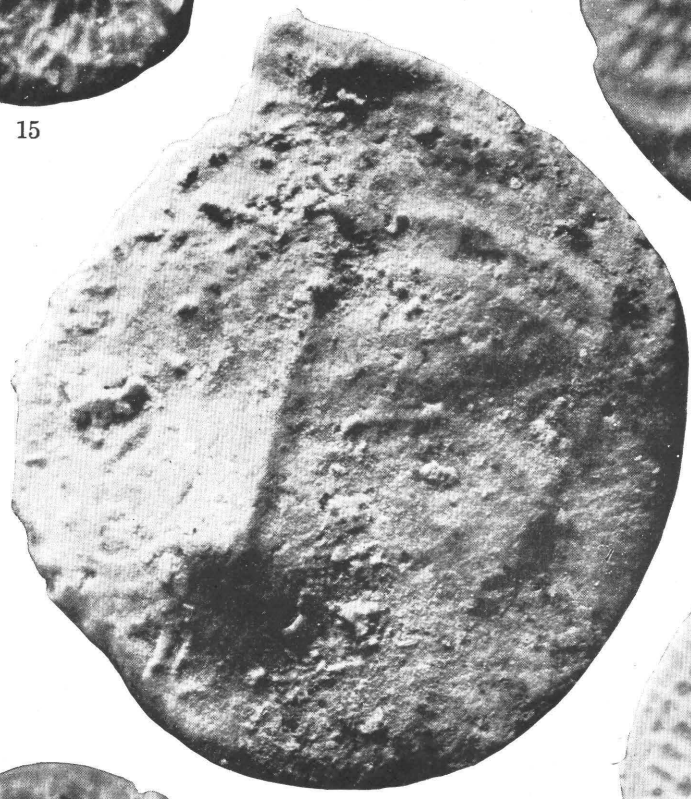

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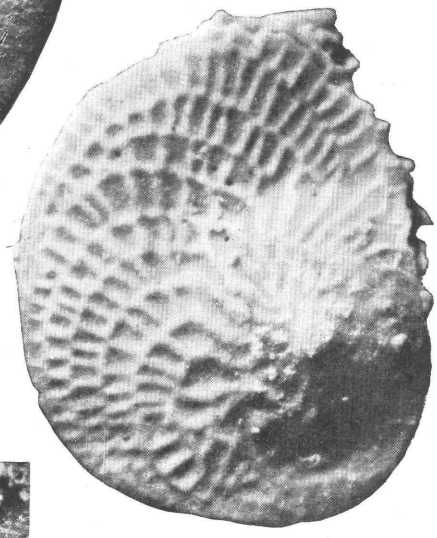

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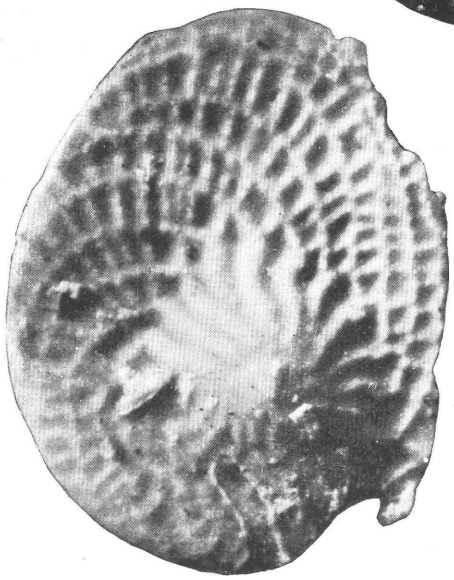

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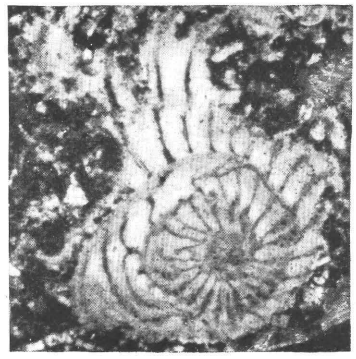

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AMERICAN SPECIES OF OPERCULINA AND HETEROSTEGINA.

PLATE XXI.

Heterostegina ocalana Cushman, n. sp.

FIGURES 15, 16, 17. Surface views, × 15, showing the characters of the exterior. U. S. G. S. station 6808.
FIGURE 18. Surface view of type specimen, × 15. U. S. G. S. station 6812.

Heterostegina ocalana Cushman, n. sp., var. glabra Cushman, n. var.

FIGURE 19. Surface view of type specimen, × 15. U. S. G. S. station 7348.

Operculina antillea (Cushman) Cushman.

FIGURE 20. Section, × 20. U. S. G. S. station 6924.

A NEW SPECIES OF ORTHOPHRAGMINA FROM LOUISIANA.

By JOSEPH AUGUSTINE CUSHMAN.

The National Museum collections from the Eocene of Louisiana contain abundant specimens of a small discoid foraminifer. These specimens are very uniform in size, and those that are well preserved show a definitely concave center on the two sides. Horizontal sections of a number of the tests show that they belong to the genus *Orthophragmina,* which is characteristic of the Eocene. The group of *Orthophragmina* possessing such concave-centered sides has hitherto been found chiefly in the East Indian region. This species from Louisiana, which has been named *O. advena,* may be compared with the young of *O. omphalus* Fritsch,[1] figured by H. Douvillé from the Eocene of Borneo. It is still closer to *O. umbilicata* Deprat,[2] of New Caledonia. The Louisiana species is smaller, however, and is especially different in the character of its embryonic chambers, which in *O. umbilicata* are more or less angular, especially the smaller one. In *O. advena* the embryonic chambers are both circular and excentric, so that the outer and larger chamber makes a complete circle with the smaller one. The species is found with *Lepidocyclina mortoni* Cushman at one of the stations.

The great abundance of specimens of this species at this horizon should make it easily distinguishable if it occurs to any extent outside of this small area in Louisiana. I have not seen it, however, in the large quantity of material which I have had from other parts of the Coastal Plain, Central America, and the West Indies. There are hundreds of specimens in the National Museum collections free from the matrix, showing the great numbers that occur at this horizon.

[1] Soc. géol. France Bull., 4th ser., vol. 5, p. 440, fig. 1, 1905.
[2] Idem, p. 497, pl. 16, figs. 2–11.

Orthophragmina advena Cushman, n. sp.

Plate XXII, figures 1–5.

Test circular, compressed, center depressed, surrounded by a thicker excentric area, beyond which toward the periphery the test again becomes thinner; unequally biconvex, one side usually being flatter than the other; the surface comparatively smooth, slightly granular, representing the peripheral ends of slender pillars. Diameter 5 to 7 millimeters.

Vertical sections show the general form of the test, with a concave thin center, thickening and then thinning again toward the periphery, and the very narrow band of equatorial chambers, which increase but slightly toward the periphery. The numerous vertical chambers are largest in the thickest portion of the test, where they are separated by numerous small pillars.

Horizontal sections show the equatorial chambers, two in number, both circular, excentric, the wall of the smaller coinciding with the wall of the larger, so that the larger chamber forms with it a complete circle; equatorial chambers rectangular, nearly square, annuli being very numerous but close together, much more so than in other American species of *Orthophragmina.*

Type specimen, U. S. N. M. No. 328252, from Natchitoches, La; L. C. Johnson, collector. At this station the species is very abundant. Large numbers of this species were collected by T. W. Vaughan at U. S. G. S. stations 2914, near Provencal, Natchitoches Parish, La., and 3570, "Foraminifera horizon" of the *Ostrea sellaeformis* zone, Natchitoches, La.

Geologic occurrence, St. Maurice formation.

PLATE XXII.

PLATE XXII.

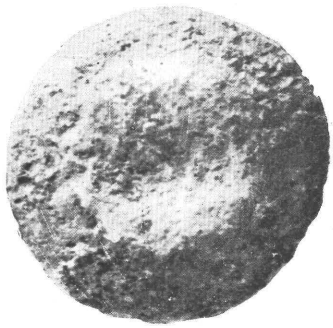
Orthophragmina advena Cushman, n. sp.

FIGURES 1, 2. Surface view of two specimens, × 5, showing the circular form and the concave center. U. S. G. S. station 2006.

FIGURE 3. Embryonic chambers in section, × 100.

FIGURE 4. Section through the equatorial band of chambers, × 20. U. S. G. S. station 2914.

FIGURE 5. Outline of vertical section showing the central depressed area, × 25. U. S. G. S. station 2914.



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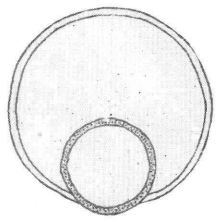

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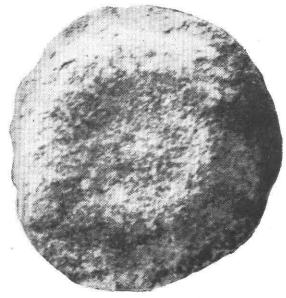

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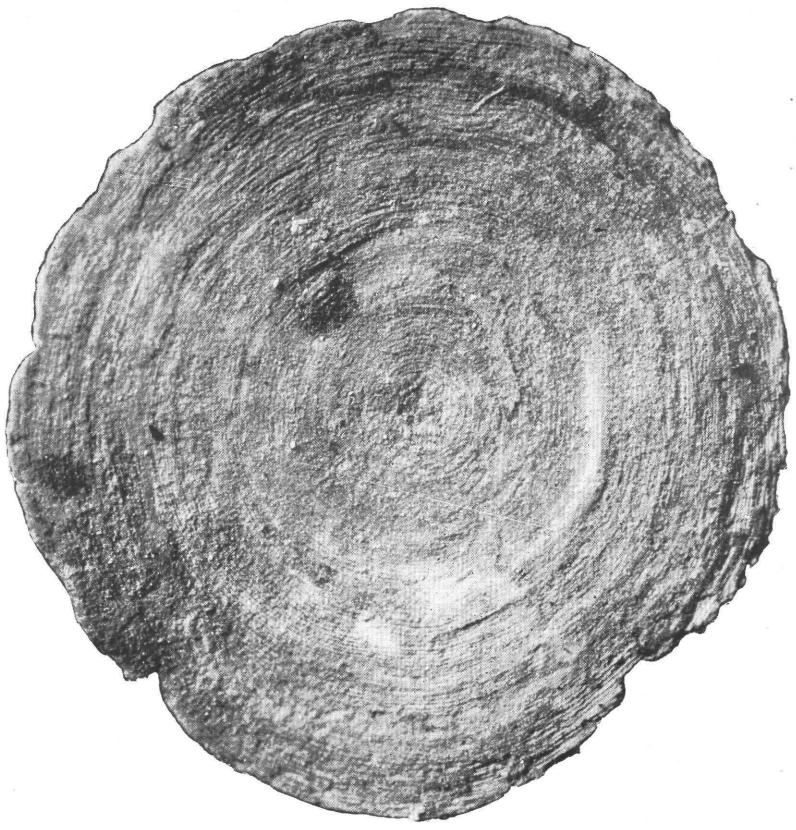

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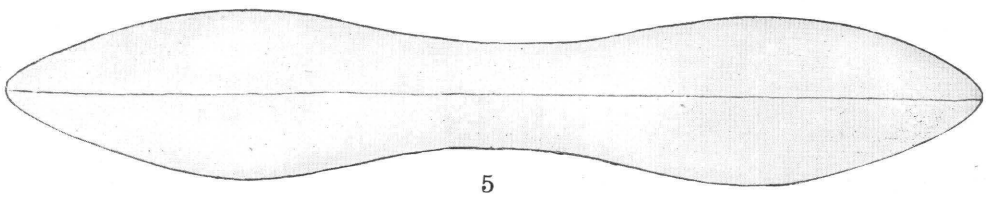

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ORTHOPHRAGMINA ADVENA CUSHMAN, N. SP.

INDEX.

[Names of fossils in *italic* are synonyms; figures in **black face** indicate description; figures in *italic* indicate illustrations.]