A COMPARATIVE STUDY OF TWO CRETACEOUS VAGINULINAS.

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ABSTRACT. *Vaginulina wadei* Kelley and *V. webbervillensis* Carsey are studied as to distinguishing characteristics, stratigraphic position, and evolutionary relationship; and are found to be suitable index fossils for a part of the Upper Cretaceous.

THE genus *Vaginulina* is one of the most widely distributed and best developed of the many large and striking foraminifera in the Upper Cretaceous of the Gulf Coastal Region. The present study was undertaken in an attempt to distinguish clearly between two of the species of *Vaginulina* which superficially resemble each other, and, by a study of their stratigraphic distribution, to make them more useful for correlation purposes.

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VAGINULINA WADEI KELLEY.

Plate 1, Figs. 1-8.

Vaginulina wadei Kelley, in W. Berry and Kelley, Proc. U. S. Nat. Mus., vol. 76, Art. 19, 1929, p. 8, pl. 1, fig. 7.

Vaginulina webbervillensis Cushman (not Carsey), Tenn. Div. Geol., Bull. 41, 1931, p. 33, pl. 4, fig. 6.—Jennings, Bull. Amer. Pal., vol. 23, No. 78, 1936, p. 21, pl. 2, fig. 15.

Test large, elongate, compressed, broadest toward the apertural end, periphery usually carinate on the ventral edge, thickened and channelled on the dorsal edge, dorsal edge straight, ventral edge gradually tapering from the rounded proloculum; chambers as many as 25, distinct, increasing gradually in height and breadth as added, very slightly inflated toward the apertural end; sutures somewhat limbate but not raised, straight or very slightly curved backward as they approach the ventral edge; wall very finely perforate, with ornamentation varying from numerous, close-set branching costae over the entire test to a nearly smooth surface except for the costate proloculum and early portion of the test, the

costae being usually more strongly developed over the sutures and occasionally confined there; aperture at the dorsal angle, protruding, radiate.

Length up to 9.00 mm.; breadth of adult specimens, 1.20 to 2.00 mm.; thickness 0.40 to 0.55 mm.

This species, recorded as "very rare," was described from the Coon Creek tongue of the Ripley formation, Dave Weeks' place on Coon Creek, three and one-half miles S. of Enville, seven and one-half miles N. of Adamsville, and one-eighth of a mile E. of the main Henderson-Adamsville road, in the NE. part of McNairy County, Tennessee. The type specimen measured 1.38 mm. in length and is believed to be an immature specimen. An unpublished figure of the type, redrawn, shows more clearly than the type figure, the straight sutures, the thick intercameral walls, and the discontinuous costae.

Vaginulina wadei appears to be restricted to the Taylor group and the two lower members of the Navarro group: the Neylandville marl and the Nacatoch sand. Its greatest development, in size and abundance, is in the Marlbrook marl of southwestern Arkansas. Its areal distribution includes eastern Texas, southwestern Arkansas, northeastern Mississippi, western Tennessee, and New Jersey.

The following list of localities shows all the known occurrences of *Vaginulina wadei*, including the type locality, the localities from which it has been recorded by subsequent authors, and the localities represented by material in the Cushman Collection.

Taylor marl.

(Lower part) Bear Creek, 0.8 mi. S. by E. of Lavon, Collin Co., Texas. L. W. Stephenson.

(Lower part) On road to Little River and Temple, 3 mi. W. of Rogers, Bell Co., Texas. C. H. Dane.

(Wolfe City sand member) Road ditch, W. side of road, 1 mi. out of Wolfe City on road to Pecan Gap, Hunt Co., Texas. Cushman and Waters.

(Pecan Gap chalk member, basal part) On road to Lavon, Collin Co., 0.75 mi. W. of secondary road, 0.75 mi. N. of Rockwall, Rockwall Co., Texas. C. H. Dane.

Selma chalk.

(Mooreville tongue) From bed of gully, 40 feet below top of hill, Fulton road, ¾ mi. W. of Mooreville, Lee Co., Miss. L. W. Stephenson. U.S.G.S. 9520.

(Middle part) Jim Wilkin's property, 300 yards NW. of Union Church, Hardin Co., Tenn. I. G. Reimann.

(Upper part) ½ mi. W. of Guys, McNairy Co., Tenn. I. G. Reimann.

Ripley formation.

Blue Cut, Mobile and Ohio RR. at state line, McNairy Co., Tenn. I. G. Reimann.

2½ mi. E. of Pontotoc, Pontotoc Co., Miss. G. W. Ponton.

(Coon Creek tongue) Dave Weeks' place on Coon Creek, 3½ mi. S. of Enville, 7½ mi. N. of Adamsville, and ⅛ mi. E. of the main Henderson-Adamsville road, in the NE. part of McNairy Co., Tenn. *V. wadei* was described from this locality.

Marlbrook marl.

(Upper contact) On highway 26, 6.5 mi. W. of corner of Tenth and Pine Streets in Arkadelphia, turn N. on country road to Cox place, sec. 29, T. 7 S., R. 20W, Clark Co., Ark. W. H. Deaderick.

Highway 51, 10.7 mi. SW. of junction with highway 26, at Tower No. 6, Unit 6, Arkansas Forestry Service, 3.0 mi. NE. of Okolona, Clark Co., Ark. W. H. Deaderick.

Natural erosion on E. side of road, highway 4, 3.8 mi. N. of Washington on road to Ozan, Hempstead Co., Ark. W. H. Deaderick.

¾ mi. NE. of Columbus, about ¼ mi. E. of road from Columbus to Yancey, Hempstead Co., Ark. W. H. Deaderick.

Tom Clark's Burns place. On highway 8, 4.0 mi. NW. of corner of Tenth and Pine Streets in Arkadelphia, turn N. at Trinity Church and 0.3 mi. further enter gate on left, Clark Co., Ark. W. H. Deaderick.

Saratoga formation.

Highway 26, about 150 yards W. of Wright's Store at junction with highway 51, Clark Co., Ark. W. H. Deaderick.

Highway 51, 0.7 mi. SW. of its junction with highway 26, natural erosion about 300 yards S. of road, Clark Co., Ark. W. H. Deaderick.

Neylandville marl.

S. side of U. S. highway 80, 2 feet above pavement, 12.5 mi. E. of Dallas-Kaufman county line, 0.6 mi. E. of Lawrence, Kaufman Co., Texas. C. G. Lalicker.

Nacatoch sand.

Ditch, 2nd class road, 1.7 mi. NE. of Ardis Heights, 3.5 mi. ENE. of Court House, Greenville, Hunt Co., Texas. L. W. Stephenson.

2 mi. S. of Oak Grove, Bowie Co., Texas. J. A. Gardner. U.S.G.S. 12932.

Mt. Laurel sand.

Nutt's Farm, on Crosswick's Creek, 0.6 mi. N. of New Egypt, Ocean Co., New Jersey. Recorded by Jennings.

Navesink marl.

Crawford's Corner, about 5 mi. S. of Keyport, New Jersey. Recorded by Jennings.

VAGINULINA WEBBERVILLENSIS CARSEY.

Plate 1, Figs. 9-18.

Vaginulina webbervillensis Carsey, Univ. Texas Bull. 2612, 1926, p. 39, pl. 2, fig. 7.—Cushman, Contr. Cushman Lab. Foram. Res., vol. 6, 1930, p. 27, pl. 4, fig. 14.—Plummer, Univ. Texas Bull. 3101, 1931, p. 160.—Cushman, Special Publ. No. 5, Cushman Lab. Foram. Res., 1933, pl. 20, fig. 12.—Cushman and Todd, Contr., vol. 19, 1943, p. 59, pl. 10, fig. 21.

Test large, compressed, broadest toward the apertural end, dorsal edge nearly straight, thickened, tricarinate, ventral edge curved, sometimes undulating; proloculum costate and with a distinct spine; chambers as many as 25, distinct, of about equal height throughout, last-formed ones sometimes slightly inflated; sutures distinct, becoming limbate toward the dorsal edge and almost invisible toward the ventral edge, nearly straight in the early portion, becoming strongly curved backward in the adult test so that the ventral portions of the sutures are almost parallel with the ventral edge of the test; wall smooth, very finely perforate, sometimes ornamented along the ventral edge with a few curved, discontinuous costae most strongly developed toward the initial end; aperture at the dorsal angle, protruding, radiate.

Length up to 7.5 mm.; breadth of adult specimens, 1.50 to 3.00 mm.; thickness 0.50 to 0.60 mm.

The type locality of this species was not designated in the original description, but was subsequently stated by Mrs. Plummer (Univ. Texas Bull. 3101, 1931, p. 121) to be the strata exposed in a steep 80-foot slope on the right bank of Onion Creek just east of the bridge (known as Jones' Crossing) on the Austin-Bastrop highway, Travis Co., Texas.

The original description gives the length as "up to 6 mm., but more commonly about 4 mm.," and the species was recorded as "rather common in some parts of this formation" [Navarro].

Vaginulina webbervillensis appears to be restricted to the upper beds of Navarro age: Corsicana marl, Kemp clay, Arkadelphia marl, and Prairie Bluff chalk. Its areal distribution includes a north-south belt in eastern Texas extending from Bexar to Hunt counties, southwestern Arkansas, northeastern Mississippi, and southern Alabama.

Vaginulina webbervillensis occurs at the following localities represented by material in the Cushman Collection:

Prairie Bluff chalk.

Houston road, in a shallow gully W. of road near foot of large hackberry tree about 10 feet below top of chalk in nearby road cut, 1.4 mi. N. by E. of Sparta, Chickasaw Co., Miss. L. W. Stephenson and W. H. Monroe. U.S.G.S. 17235.

Houston road, in road cut about 8 feet below top of section, 7.4 mi. N. by E. of Sparta, Chickasaw Co., Miss. L. W. Stephenson and W. H. Monroe.

17 feet down N-facing slope of Cane Creek valley in sec. 10, T. 15 S., R. 3 E., 1.3 mi. N. by E. of Sparta, Chickasaw Co., Miss. W. H. Monroe.

Old Canton Landing, Alabama River, Wilcox Co., Ala. U.S.G.S. 6439.

Arkadelphia marl.

Branch E. of road, ½ mi. N. by W. of Reed's Store (SW. ¼ sec. 29, T. 11 S., R. 24 W.) 6 mi. N. by W. of Hope, Hempstead Co., Ark. L. W. Stephenson.

(Lower part) 4.5 mi. E. of Washington, in creek ½ mi. N. of Reed's Store, Hempstead Co., Ark. U.S.G.S. 8211.

(Near base) 7 mi. N. by W. of Hope, Hempstead Co., Ark. L. W. Stephenson. U.S.G.S. 13411.

Corsicana marl.

Small branch below road 2½ mi. N. of Tona siding, about 5 mi. SW. of Quinlan, Hunt Co., Texas. L. W. Stephenson.

Pit at Corsicana Brick Co. 2 mi. S. of Court House at Corsicana, Navarro Co., Texas. L. W. Stephenson.

(Within 1 foot of top of Corsicana marl) Road ditch, 3.5 mi. NW. of Union Seminary School, 4.3 mi. SSE. of Corbet, Navarro Co., Texas. L. W. Stephenson.

Mexia highway at forks of Wortham road, 2.8 mi. ESE. of Cooledge, Limestone Co., Texas. Cushman and Thomas.

Mexia road, 2¾ mi. E. of Cooledge on E-facing slope of Elm Creek valley, Limestone Co., Texas. L. W. Stephenson and C. H. Dane.

Ditch, W-facing slope of Big Creek valley, 3 mi. SW of Stranger, 1.3 mi. SE. of Parsons Bridge, Falls Co., Texas. L. W. Stephenson.

Bluff on Onion Creek, ¼ mi. below Bastrop road crossing, 2¼ mi. W. of Old Garfield, Travis Co., Texas. L. W. Stephenson.

Steep 80-foot slope on right bank of Onion Creek just E. of bridge (known as Jones' Crossing) on the Austin-Bastrop highway, Travis Co., Texas. *V. webbervillensis* was described from this locality.

Gully in W-facing slope of Cottonwood Creek valley, ¼ mi. W. of Kimbro, 2 mi. S. of Manda, Travis Co., Texas. L. W. Stephenson. U.S.G.S. 14129.

San Marcos River, left bank, 100 yards below a ford, ½ mi. below Martindale, Caldwell Co., Texas. L. W. Stephenson. U.S.G.S. 7621.

3 feet below base of *Exogyra-Gryphaea* bed, San Antonio road, 6 mi. E. of Castroville, Bexar Co., Texas. L. W. Stephenson.

Kemp clay.

(Upper part) Branch ½ mi. S. of McLeod School, 6½ mi. SW. of Curry, Navarro Co., Texas. L. W. Stephenson.

90 feet below base of Midway group, Wortham road, 5 mi. due E. of Cooledge, Limestone Co., Texas. L. W. Stephenson.

Mustang Creek, about 6 mi. ESE. of Taylor, Williamson Co., Texas. L. W. Stephenson and W. P. Popenoe.

Sandy marl, 6 to 8 feet above bottom of pit of Seguin Brick and Tile Co., 0.8 mi. S. of McQueeney Station, Guadalupe Co., Texas. L. W. Stephenson.

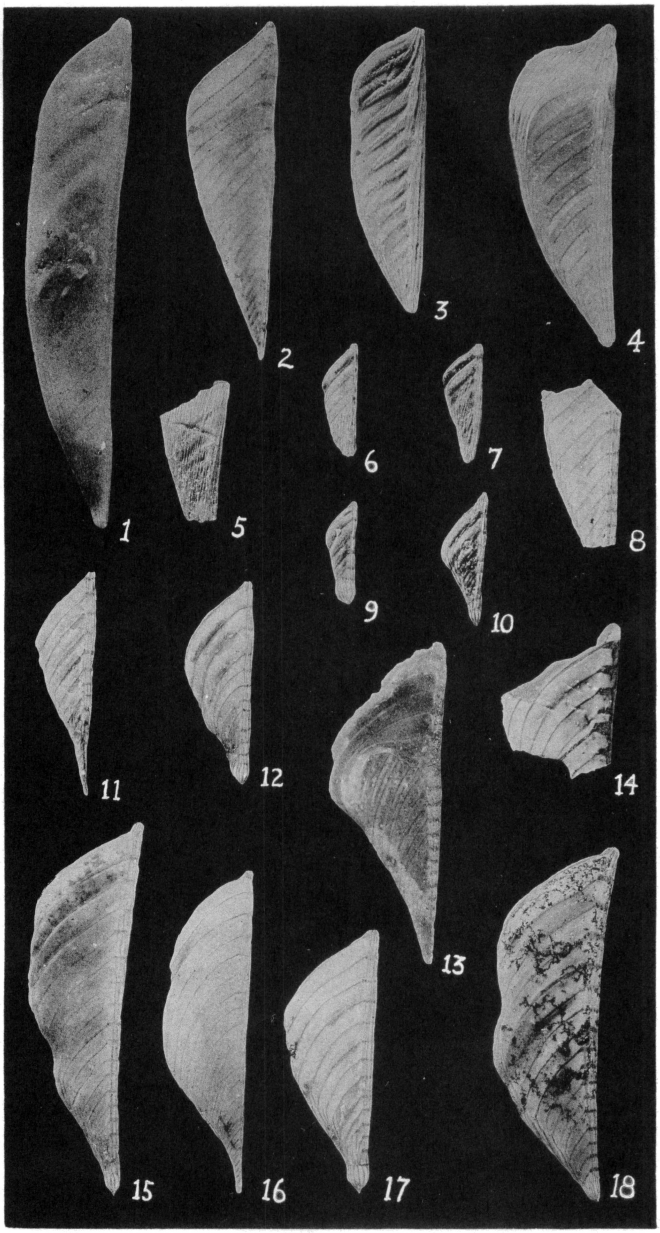
There is one record for *V. webbervillensis* in the Eagle Ford shale (Moreman, Journ. Pal., vol. 1, 1927, p. 98, pl. 16, fig. 2).

EXPLANATION OF PLATE 1.

All figures x 8.

Figures 1-8. *Vaginulina wadei* Kelley. Marlbrook marl (upper contact), on highway 26, 6.5 mi. W. of corner of Tenth and Pine Streets in Arkadelphia, turn N. on country road to Cox place, sec. 29, T. 7 S., R. 20 W., Clark Co., Ark. 1, Megalospheric, narrow form. 2, Microspheric form. 3, Megalospheric form showing ornamentation. 4, Megalospheric, broad form. 5, Fragment showing extremely fine and dense costae. 6, 7, Young forms. 8, Fragment showing straightness of sutures.

Figures 9-18. *Vaginulina webbervillensis* Carsey. 9-12, 14, 15, 17, 18, Mexia highway at forks of Wortham road, 2.8 mi. ESE. of Cooledge, Limestone Co., Texas. 13, 30 feet above base of bluff on Onion Creek, 2½ mi. W. of Old Garfield, Travis Co., Texas. 16, about 17 feet above base of bluff on Onion Creek. 9-12, Young forms. 11, 13, 16, Microspheric forms. 13, Broken and repaired test. 14, Fragment showing curvature of sutures. 15, 17, 18, Megalospheric forms.



A Comparative Study of Two Cretaceous Vaginulinas

Mrs. Plummer stated (Univ. Texas Bull. 3101, 1931, p. 160) that she had examined the plesiotype and found it "to conform well to many of the variations that characterize the species at any locality in the Navarro where it is abundant." Nevertheless, in view of the fact that there are no other records for this species in either the Taylor or Austin groups, some doubt must remain as to the authenticity of this earlier record.

REPAIR OF BROKEN TESTS.

During the examination of specimens in this study a considerable number of tests which had been broken and repaired were observed. Two of these are figured (Figs. 2 and 13). In Fig. 2 the test was broken at a point about 1/3 the length from the apertural end where there is a slight jog in the dorsal edge. From this point to the aperture there are 4 chambers, the first of which truncates 2 of the previous ones. Fig. 13 shows a specimen which seems to have lost a much greater proportion of its test as the break truncates 5 of the previous chambers and the rebuilt chambers are about twice the height of the broken-off ones as well as much longer as they curve around the broken-off edges. This increase in size of the rebuilt chambers suggests that as the animal grew something in the living protoplasm determined the size of chamber to be built regardless of the size of the immediately preceding chamber. From this assumption one might judge how large the test had been before the break and how much was missing due to the break.

DISTINGUISHING CHARACTERISTICS.

The most striking difference between *Vaginulina webbervillensis* and *V. wadei* is the presence of an initial spine on *webbervillensis* and its absence on *wadei*. In the over 600 specimens examined, no cases were found where both forms, with and without spines, were found in the same sample.

The shape of the test, especially of the early part, may be used as a distinguishing characteristic. In *V. webbervillensis* the test broadens much more rapidly than in *V. wadei* and the ventral edge is curved or undulating. In *V. wadei* the test broadens gradually and evenly so that the ventral edge is almost as straight as the dorsal, and is frequently angled at the point where the last-formed chamber reaches the ventral periphery.

When only small fragments are available (such as Figs. 8 and 14) it is usually possible to distinguish between the two species on the basis of sutures. In *V. wadei* they are straight almost to the ventral periphery while in *V. webbervillensis* they become distinctly curved as they approach the ventral periphery.

In ornamentation the two species differ chiefly in degree. *V. webbervillensis* has the costae usually confined to the periphery and the first few chambers. In *V. wadei* the costae appear commonly, but not always, over the entire surface of the test.

POSSIBLE EVOLUTIONARY CONNECTION.

From a study of young specimens, it became evident that the general appearance of *V. wadei* (i.e., straight sutures and straight ventral periphery with an angle where the last-formed chamber meets it) is repeated in the young specimens of *V. webbervillensis* (See Figs. 6, 7, 9, 10). This ontogenetic relationship suggests that the later species developed from the earlier one.

There does not seem to be any noticeable difference between specimens of *V. webbervillensis* from the four different formations in which it occurs. *V. wadei*, on the other hand, becomes larger, more robust, and somewhat broader in the younger formations in which it occurs. It is largest and most abundant in the Marlbrook marl; but in the Navarro group, especially the Nacatoch sand, it approaches *V. webbervillensis* in its curved sutures and proportionately broader and smoother form. On the basis of fragments these Nacatoch specimens probably could not be distinguished from *V. webbervillensis*. However, all specimens showing the initial end are rounded and without a spine, and on this basis are considered to be true *V. wadei*.

Thus two lines of evidence suggest that *V. webbervillensis* may have developed from *V. wadei* through the curving of the sutures, broadening of the test, loss of some surface ornamentation, and the development of an initial spine. These two lines of evidence are: first, that young specimens of *V. webbervillensis* resemble adult specimens of *V. wadei* except in size and initial spine: and second, that specimens of *V. wadei* which are nearest to *V. webbervillensis* in age are nearest to them in their characteristics.

CONCLUSIONS.

The two species of *Vaginulina* may be distinguished by the following features: presence of initial spine of *webbervillensis*; shape of test, broad in *webbervillensis* and narrow in *wadei*; straightness of sutures in *wadei* and curvature in *webbervillensis*; and degree of ornamentation greater in *wadei* than in *webbervillensis*. The wide occurrence of both species in strata where the other is not known makes them suitable for index fossils; *V. wadei* being restricted to beds of the Taylor group and the lower beds of the Navarro group, and *V. webbervillensis* being restricted to the upper beds of the Navarro group.

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