

CONTRIBUTIONS
from the
CUSHMAN LABORATORY
for
FORAMINIFERAL RESEARCH

Volume 2, Part 4

January 1927

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SHARON, MASSACHUSETTS, U. S. A.

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These contributions will be issued quarterly. They will contain short papers with plates, describing new forms and other interesting notes on the general research work on the foraminifera being done on the group by the workers in this laboratory. New literature as it comes to hand will be briefly reviewed.

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CONTRIBUTIONS FROM THE CUSHMAN
LABORATORY FOR FORAMINIFERAL RESEARCH

33. SOME NEW GENERA OF THE FORAMINIFERA.

BY JOSEPH A. CUSHMAN.

In the closer study of several genera it has become increasingly apparent that some of these include species that have different developments with definite phylo-genetic relationships and as such should be separated from one another. Several generic names are therefore proposed for these different groups for the benefit of greater definiteness and to show better the relationships.

GENUS PLANOGLOBULINA Cushman, new genus.

Genotype, *Planoglobulina acervulinoides* (EGGER) (*Guembelina acervulinoides* EGGER.)

Test with the earliest chambers in the microspheric form planospiral, followed by a series arranged biserially and in the adult by a series of globular chambers spread out fan shaped or even partially extending back toward the earlier chambers on either side, the later chambers in a single plane; wall calcareous, perforate.

This genus represents an end form developed from *Pseudotextularia* Rzehak which in its earlier stages is similar but in the adult has the chambers in a coiling series about the apertural end. Both genera are characteristic of the Upper Cretaceous of Europe and America.

GENUS SPIROPLECTOIDES Cushman, new genus.

Genotype, *Spiroplecta rosula* EHRENBERG, *Mikrogeologie*, 1854, pl. 32 (2), fig. 36.

Test with the early chambers planospiral, later ones biserial, the test elongate, sides nearly parallel and the biserial chambers very numerous; wall calcareous, finely perforate; aperture elliptical, terminal or nearly so in the adult.

Ehrenberg described this species from the Upper Cretaceous of America. I have lately had specimens from the Upper Cretaceous of Texas and Mexico which are evidently identical with Ehrenberg's species. The genus *Heterohelix* afterward changed to *Spiroplecta* by Ehrenberg has as its type *H. americana* Ehrenberg with planospiral young but the later chambers as in *Guembelina*, a genus derived from it.

GENUS SPIROPLECTINA Cushman, new genus.

Genotype, *Textularia annectens* PARKER AND JONES, Ann. Mag. Nat. Hist., ser. 3, vol. 11, 1863, p. 92, fig. 1, (in text).

Test with the early chambers planospiral, later ones biserial, sides of the test straight and nearly parallel, the last group of chambers uniserial with distinctly constricted necks and a rounded terminal aperture.

The specimens from the Cretaceous (Gault) show the uniserial adult stage and probably represent an end stage developing from *Spiroplectoides*. Many arenaceous biserial forms have been referred to *Spiroplecta* but they should be referred elsewhere.

GENUS TUBULOGENERINA Cushman, new genus.

Genotype, *Textularia (Bigenerina) tubulifera* PARKER AND JONES, Ann. Mag. Nat. Hist., ser. 3, vol. 11, 1863, p. 94, fig. 2, (in text).

Test with the early chambers biserial, later ones uniserial, compressed or rounded in transverse section; wall with numerous tubuli extending out from the test either open, forming a tubular connection with the interior or closed, forming lobular connections with the chamber; wall calcareous; aperture elongate, narrow or in the adult with numerous rounded openings in the terminal face, the interior of the chambers at least in some species with a curved structure from roof to floor.

This genus occurs in the Upper Eocene of the Paris Basin and in the Miocene of Australia. It was originally figured in the above reference from Grignon by Parker and Jones. Later Terquem in 1882 (Mém. Soc. Géol. France, ser. 3, vol. 2, p. 121, pl. 12, fig. 35 a, b) referred it to *Clavulina eocenica* Gümbel. Heron-Allen and Earland (Journ. Roy. Micr. Soc., 1909, p. 329, pl. 16, fig. 1) had a specimen from the Eocene of Selsey and recognizing that Terquem's placing of the species was erroneous gave it a new name *Bigenerina conica* not recognizing the earlier name of Parker and Jones. Heron-Allen and Earland place under *B. conica* much larger specimens from the Miocene of Aus-

Already
name used
by Schuchert
but never
mentioned

tralia (Pl. 16, figs. 2-6) which from a study of specimens in my own collection from the Filter Quarry of Moorabool River and comparison with *T. tubulifera* from the Eocene of the Paris Basin appears to be a different species. The Australian species is much larger, has the biserial development much more restricted, the rows of tubules two or three in the adult whereas they are usually single in the Eocene species. This Australian Miocene species may be known as *Tubulogenerina mooraboolensis* Cushman, new species. Other species are *Tubulogenerina ferox* (Heron-Allen and Earland) from the same locality and *T. papillosa* (Halkyard) from the Eocene of Biarritz.

GENUS BOLIVINELLA Cushman, new genus.

Genotype, *Textularia folium* PARKER AND JONES, Trans. Roy. Soc., vol. 155, 1865, pp. 370, 420, pl. 18, fig. 19.

Test much compressed, the proloculum in the megalospheric form rectangular, in the microspheric form the young is apparently planospiral, later chambers biserial, chambers long and recurved, not overlapping; wall calcareous, perforate; aperture transverse to the compression of the test with numerous papillae at the base of the opening.

This genus is most nearly related to *Guembelina* and its allies. It occurs as far back as the Eocene and continues to the present ocean where it is found in the Indo-Pacific. Besides *Bolivinella folium* (Parker and Jones) there are other species occurring both fossil and in the present ocean.

GENUS NODOGENERINA Cushman, new genus.

Genotype, *Nodogenerina bradyi* CUSHMAN, new species.

Test uniserial, straight, chambers increasing in size as added, distinct, inflated, constricted at the connection between the chambers; wall calcareous, finely perforate; aperture terminal, central, rounded, with a cylindrical neck and phialine lip.

NODOGENERINA BRADYI Cushman, new species.

Sagrina virgula H. B. BRADY (in part), Rep. Voy. *Challenger*, Zoology, vol. 9, 1884, pl. 76, fig. 8 (not 4-6, 9, 10).

Test uniserial, chambers increasing in size as added, inflated, widest near the base, which is finely spinose, lower portion rapidly constricted; wall smooth except at the basal ridge, finely perforate; aperture rounded or elliptical, with a short neck and slightly flaring phialine lip.

Brady does not give the locality for this specimen although

those figured on the same plate, figs. 9, 10 came from off the Ki Islands.

The genus resembles *Nodosaria* in its superficial characters but is not glassy, and does not have a radiate aperture. It is a derivative as an end form from *Siphogenerina*.

GENUS NODOMORPHINA Cushman, new genus.

Genotype, *Nodosaria compressiuscula* NEUGEBOREN, Verh. Mitth. Siebenburg Ver. Nat., vol. 3, 1852, p. 59, pl. 1, figs. 54-56; Denkschr. Akad. Wiss. Wien, Vol. 12, pt. 2, 1926, p. 79, pl. 2, figs. 1-7.

Test compressed, especially in the earlier portion; chambers numerous, early ones quadrilateral in section, later ones more nearly circular; sutures distinct, slightly depressed, especially between the later chambers; wall ornamented by numerous raised costae in pairs one at either side of the median line giving a bilateral symmetry to the test; aperture circular or elliptical without teeth or radiate fissures, terminal.

This genus includes those forms figured above. *Nodomorphina compressiuscula* may be distinguished from *Nodosaria* by the lack of a radiate aperture and by the paired character of the costae making up the ornamentation and compressed test. It is an end form developed through *Plectofrondicularia* and *Amphimorphina*.

GENUS CRIBROBULIMINA Cushman, new genus.

Plate 11, figs. 1-5.

Genotype, *Valvulina mixta* PARKER AND JONES in Carpenter, Parker and Jones, Introd. Foram., 1862, p. 146, pl. 11, fig. 19.

Test in the early stages trihedral, angled, the sides flattened, chambers triserially arranged, adult chambers in a loose spiral, five or more in a coil; sutures distinct; wall arenaceous; aperture in the young as in *Valvulina* later developing an opening in the plate-like tooth and in the adult a series of small openings forming a cribrate plate, pl. 11, fig. 5.

The type species, *Cribrbulimina mixta* (Parker and Jones) is from Australia. It develops from an angular verneuiline form while the next genus came from a rounded one and is more accelerated.

GENUS ARENOBULIMINA Cushman, new genus.

Genotype, *Bulimina presli* REUSS, Verstein Böhm. Kreide, 1845-46, pt. 1, p. 38, pl. 13, fig. 72.

Test with the earlier chambers triserial, the angles rounded,

later chambers spirally arranged, close-coiled; sutures distinct, not depressed, of fine calcareous cement; wall finely arenaceous, smoothly finished; aperture with a broad rounded tooth.

Arenobulimina presli (Reuss) occurs in the Upper Cretaceous of Europe with other related species. I have for study a set of this species named and selected by Reuss himself and they show even better than the published figures the differences between this and the calcareous, finely perforate, thin walled *Bulimina*.

GENUS PSEUDOUVIGERINA Cushman, new genus

Genotype, *Uvigerina cristata* MARSSON, Mitth. Nat. Ver. Neu-Vorpommern u. Rügen, Jahrg. 10, 1878, p. 150, pl. 3, figs. 20 a-c.

Test in the early stages biserial, later triserial; wall calcareous, coarsely perforate; aperture with a tubular neck and phialine lip.

Pseudouvigerina cristata (Marsson) is one of the species which have apparently originated from the triserial condition foreshadowed by *Eouvigerina*. There are a number of very small species in the Upper Cretaceous of Europe and America which evidently arose in this manner and should not be confused with the later developed group represented by *Uvigerinella* Cushman and *Uvigerina* d'Orbigny which are apparently a direct derivation from *Bulimina*. The squarish periphery seen in *Eouvigerina cretacea* (Heron-Allen and Earland) and *E. americana* Cushman is seen in *Pseudouvigerina cristata* (Marsson) and in some of the American Cretaceous species. All the species noted are angular in character.

34. SOME ARENACEOUS FORAMINIFERA FROM THE UPPER CRETACEOUS OF TEXAS.

BY JOSEPH A. CUSHMAN AND JAMES A. WATERS.

A study of the species of the Upper Cretaceous of Texas has resulted in the finding of numerous species of arenaceous foraminifera. As there are certain zones especially in the Navarro formation where few other forms occur, it has seemed best to

describe a number of these. After a careful search of the literature nearly all these species seem to be undescribed in spite of the fact that so many of the calcareous Upper Cretaceous species of Texas and Mexico are identical with European ones. The arenaceous species considered here, belong to the genera *Proteonina*, *Reophax*, *Haplophragmoides* and *Trochammina*.

PROTEONINA DIFFLUGIFORMIS (H. B. Brady.)

Plate 10, figure 1.

Reophax difflugiformis H. B. BRADY, Quart. Journ. Micr. Sci., vol. 19, 1879, p. 51, pl. 4, figs. 3 *a*, *b*; Rep. Voy. *Challenger*, Zoology, vol. 9, 1884, p. 289, pl. 30, figs. 2-4 (not 1, 5).

Proteonina difflugiformis RHUMBLER, Arch. Prot., vol. 3, 1903, p. 245, figs. 80 *a*, *b* (in text).—CUSHMAN, Bull. 71, U. S. Nat. Mus., pt. 1, 1910, p. 42, figs. 40, 41 (in text).

Test a single elongate oval or pyriform chamber with a more or less distinct tubular neck usually tapering gradually from the body of the chamber, undivided; wall fairly thick, of sand grains of variable size, firmly cemented, aperture circular, simple, terminal. Length up to 0.5 mm.

Just east of Richland, specimens occurred in the Navarro formation in cores from Navarro County, Texas. In some of these specimens, the neck is more pronounced than in the figured specimen.

REOPHAX TEXANA Cushman and Waters, new species.

Plate 10, figure 2.

Test generally rectilinear, uniserial, the chambers spherical or nearly so, slightly overlapping; wall coarsely arenaceous of angular sand grains with the cement mostly inconspicuous, aperture small, rounded or angular, central, terminal. Length up to 1.25 mm., diameter 0.50 mm.

Holotype, (Cushman Coll. No. 6087) from Navarro formation, east of Richland, Navarro County, Texas.

This species is widely distributed in the Navarro formation breaking easily at the sutures so that complete specimens are rare, single chambers or two chambered fragments being most frequently met with.

HAPLOPHRAGMOIDES EXCAVATA Cushman and Waters, new species.

Plate 10, figures 3 *a*, *b*.

Test close-coiled, planospiral, compressed, periphery subacute;

chambers distinct, ten in the last-formed coil in the adult, the borders of each chamber distinctly thickened, central portion depressed; sutures straight, radial, not usually distinct; wall finely arenaceous with little cement, smoothly finished; color light gray. Length 0.45-0.50 mm., breadth 0.35-0.40 mm., thickness 0.15-0.18 mm.

Holotype, (Cushman Coll. No. 6089) from Navarro formation, near Quinlan, Hunt Co., Texas.

This is a common species especially in the upper part of the Navarro where it is often almost the only species present in certain zones.

HAPLOPHRAGMOIDES RUGOSA Cushman and Waters, new species.

Plate 10, figures 4 *a*, *b*.

Test close-coiled, planospiral, only slightly compressed, deeply umbilicate, periphery broadly rounded; chambers about 7 in the last-formed coil, subspherical; sutures slightly depressed, radial; wall coarsely arenaceous, of coarse but rather neatly fitted angular sand grains, usually dark colored. Diameter 0.50-0.60 mm.

Holotype, (Cushman Coll. No. 6088) from the Navarro formation just east of Richland, Navarro County, Texas.

In some respects this resembles most closely some of the fossil forms referred to *H. canariensis* (d'Orbigny). It is very distinct from that species however.

HAPLOPHRAGMOIDES CALCULA Cushman and Waters, new species.

Plate 10, figures 5 *a*, *b*.

Test close coiled, planospiral, very strongly compressed, sometimes slightly lobulated; chambers and sutures usually indistinct except in exceptional specimens: wall very coarsely arenaceous, roughly finished in spite of the considerable amount of cement: color dark greenish black. Length 0.67-0.75 mm., thickness 0.18-0.20 mm.

Holotype, (Cushman Coll. No. 6090) from the Navarro formation from dug well at Tona School, near Quinlan, Hunt Co., Texas collected by Mrs. Helen J. Plummer. The species seems rather limited in its vertical distribution, and varies very little in its general characters.

HAPLOPHRAGMOIDES GLABRA Cushman and Waters, new species.

Plate 10, figures 6 *a*, *b*.

Test close-coiled, planospiral, somewhat compressed and um-

bilicate, periphery rounded; chambers fairly distinct, 9-11 in the last-formed coil in the adult, rounded, evenly curved; sutures slightly curved, slightly depressed; wall finely arenaceous, smoothly finished; color dark gray. Length of type specimen 0.33 mm; breadth 0.30 mm; thickness 0.14 mm.

Holotype, (Cushman Coll. No. 6091) from Navarro formation, Hunt Co., Texas.

While this species occurs with *H. excavata* it is a very different species.

TROCHAMMINA DIAGONIS (Carsey).

Plate 10, figures 7 a-c.

Haplophragmoides diagonalis CARSEY, Univ. of Texas Bull. 2612, 1926, p. 22, pl. 3, fig. 1.

Test trochoid, compressed, periphery lobulated; chambers distinct, 6 or 7 in the last-formed coil; sutures distinct, depressed, on the dorsal side slightly curved, on the ventral side nearly radial; wall arenaceous with considerable cement. Diameter 0.65-0.80 mm.

This species was described as a *Haplophragmoides* but a study of a large series of specimens including some from the type locality seems to show that the form is trochoid. The last-formed coil is slightly below the preceding one so that when shearing takes place as is frequent in this formation, there is a tendency for the specimens to show a peculiar irregular appearance. Well preserved specimens like that figured are found with those which have been subjected to strain and connect the two. The figured specimen (Cushman Coll. No. 6092) is from the Navarro formation, from core at Mexia, Limestone Co., Texas.

TROCHAMMINA GYROIDES Cushman and Waters, new species.

Plate 10, figures 8 a, b.

Test trochoid, thick, dorsal side flattened, ventral side strongly convex, periphery subacute; chambers distinct, usually 6 in the last-formed coil; sutures less distinct on the dorsal side where they are very slightly depressed and gently curved, on the ventral side deeply depressed and radial; wall arenaceous with much cement, smoothly finished; aperture ventral, narrow. Diameter, 0.65 mm.

Holotype, (Cushman Coll. No. 6093) from Navarro formation, east of Richland, Navarro County, Texas.

This species is much the thickest of those described. It varies

somewhat having the chambers occasionally more loosely arranged.

TROCHAMMINA TEXANA Cushman and Waters, new species.

Plate 11, figures 8 a-c.

Test trochoid, much compressed, plano-convex, dorsal side flat or even slightly concave; ventral side slightly convex, umbilicate; chambers fairly distinct, 6 in the last-formed coil, the later ones more distinct, the earlier ones much less so, the borders of the last chambers raised on the dorsal side, the central portion of each concave, on the ventral side the greatest thickness near the umbilical angle of each chamber; sutures on the dorsal side indistinct except between the last two or three chambers, on the ventral side distinct and depressed; wall very finely arenaceous, smoothly finished. Diameter 0.55 mm.

Holotype, (Cushman Coll. No. 6094) from the Navarro formation, Tona School near Quinlan, Hunt Co., Texas, collected by Mrs. Helen J. Plummer.

This species resembles *Haplophragmoides excavata* somewhat in the last chambers and the texture of the test. It is typically a *Trochammina* however.

35. AMERICAN UPPER CRETACEOUS SPECIES OF
BOLIVINA AND RELATED SPECIES.

BY JOSEPH A. CUSHMAN.

Many of the Upper Cretaceous species of Europe and America are identical and others while they may be distinguished in one area from the other are nevertheless closely related. A study of the species usually assigned to *Bolivina* shows this same relationship. I am indebted to several European workers for excellent sets of Cretaceous species from the type formations from which they were described. It has thus been possible to make accurate comparisons of material from the two areas. Ehrenberg apparently figures species of *Bolivina* on Plate 32 of his *Mikrogeologie* which is entirely of American Cretaceous species.

None of them shows the exterior however and it is difficult to place them.

There are several different genera which may be recognized in the Upper Cretaceous and these are described here. The species have very definite vertical ranges and make excellent markers for correlation purposes.

GENUS BOLIVINA D'Orbigny 1839.

BOLIVINA INCRASSATA Reuss.

Plate 12, figs. 1 *a*, *b*.

Bolivina incrassata REUSS, Haidinger's Nat. Abhandl., vol. 4, 1851, p. 29, pl. 4, fig. 13; Sitz. Akad. Wiss. Wien, vol. 44, pt. 1, 1861 (1862), p. 332.—EGGER, Abhandl. kön. bay. Akad. Wiss. München, Cl. II, vol. 21, pt. 1, 1899, p. 45, pl. 16, figs. 4, 5; Sitz. kön. bay. Akad. Wiss. München, 1909, p. 23, pl. 1, fig. 18.—FRANKE, Abhandl. geol. pal. Instit. Univ. Greifswald, vol. 6, 1925, p. 21, pl. 2, fig. 8.—CUSHMAN, Contrib. Cushman Lab. Foram. Res., vol. 2, pt. 1, 1926, p. 19, pl. 2, figs. 1 *a*, *b*.

This smooth species I have already recorded from the Upper Cretaceous of Mexico where it is very common in the upper part of the Mendez shale. From the United States I have specimens from the Upper Cretaceous of Bartons Bluff, Tombigbee River, Ala., from the Navarro of Texas N. W. of Annona, Red River Co., and east of Richland, Navarro Co., and it occurs in the Annona Chalk, 10 miles N. E. of Dekalb, Bowie Co., Texas. The American specimens are identical with those from north central Europe.

BOLIVINA INCRASSATA Reuss, var. LIMONENSIS Cushman.

Bolivina incrassata REUSS, var. *limonensis* CUSHMAN, Contrib. Cushman Lab. Foram. Res., vol. 2, pt. 1, 1926, p. 19, pl. 2, fig. 2.

This elongate variety described from the Mendez Shale of Mexico has not been found in the material I have had from the United States.

BOLIVINA TEGULATA Reuss.

Plate 12, fig. 2.

Bolivina tegulata REUSS, Haidinger's Nat. Abhandl., vol. 4, 1851, p. 29, pl. 4, fig. 12.—EGGER, Abhandl. kön. bay. Akad. Wiss. München, Cl. II, vol. 21, pt. 1, 1899, p. 45, pl. 16, figs. 10, 11.—FRANKE, Abhandl. geol. pal. Instit. Univ. Greifswald, vol. 6, 1925, p. 21, pl. 2, fig. 7.

Bolivina textularioides REUSS, Sitz. Akad. Wiss. Wien, vol. 46, pt. 1, 1862 (1863), p. 81, pl. 10, fig. 1.

Test slender, much elongate, about 4 times as long as broad,

gradually tapering to the greatest breadth near the apertural end, periphery broadly rounded, chambers numerous, often 20 or more in the adult, slightly inflated, higher than broad; sutures distinct, nearly at right angles to the periphery, very slightly depressed; wall smooth, finely perforate; aperture elongate, narrow.

Length 0.45 mm., breadth 0.12 mm., thickness 0.08 mm.

There are numerous records for this species in the European Cretaceous but it seems to be less common in America. I have it from the Upper Cretaceous of Bartons Bluff, Tombigbee River, Ala., and from material collected by Mrs. Helen J. Plummer as follows: Navarro formation, $\frac{1}{2}$ mile S. of Kemp, Texas; Taylor marl, Clay pit of Dallas Brick Co., $\frac{1}{2}$ mile west of Mesquite, Texas, and Brownstown marl, RR. cut $\frac{1}{2}$ mile W. of Okolona, Arkansas.

BOLIVINA GEMMA Cushman, new species.

Plate 12, figs. 3 a, b.

Test elongate, rather stout, slightly tapering, somewhat twisted, periphery rounded; chambers 17 or more in the adult, distinct, slightly inflated, nearly as high as broad in the adult; sutures very distinct, somewhat limbate, very slightly depressed near the periphery, the inner margins raised, forming a row of beadlike ornamentations of clear shell material, finely striate; wall thick, opaque, very finely perforate; aperture elongate, elliptical.

Maximum length 1 mm., breadth 0.30 mm., thickness about 0.12 mm.

Type specimen from the Upper Cretaceous, Arkadelphia clay, 7 miles W. of Hope, Hempstead Co., Arkansas. The species is a common one in the American Cretaceous occurring in the Navarro formation of Texas and in the Brownstown marl of Arkansas.

BOLIVINA CLAVATA Cushman, new species.

Plate 12, figs. 5 a, b.

Test elongate, very tapering, club-shaped, the last-formed portion nearly circular in section, periphery rounded, 23 or more chambers in the adult; chambers fairly distinct, somewhat inflated, especially in later growth, the lower margin with backward projecting, short, blunt lobes with depressed areas be-

tween; sutures fairly distinct, slightly depressed, earlier ones at right angles to the periphery; wall finely perforate, earlier chambers finely pitted in longitudinal lines; aperture ovate.

Length 0.60 mm., breadth 0.20 mm., thickness 0.16 mm.

Holotype (Cushman Coll. No. 5272) from Upper Cretaceous, Taylor marl, Clay pit of Dallas Brick Co., $\frac{1}{2}$ mile W. of Mesquite, Texas, collected by Mrs. Helen J. Plummer. It occurs also in the Navarro in Limestone and Navarro Counties, Texas.

BOLIVINA VELASCOENSIS Cushman.

Bolivina velascoensis CUSHMAN, Bull. Amer. Assoc. Petr. Geol., vol. 10, 1926, p. 586, pl. 16, figs. 1 a, b.

This species is only known from the Upper Cretaceous, Velasco shale of Mexico.

BOLIVINA DECURRENS (Ehrenberg).

Plate 12, fig. 4.

Grammostomum decurrens EHRENBURG, Mikrogeologie, 1854, pl. 30, fig. 17.

Bolivina decurrens MARSSON, Mitth. Nat. Ver. Neu-Vorpommern u. Rügen, vol. 10, 1878, p. 156, pl. 3, fig. 24.—FRANKE, Abhandl. geol. pal. Institut. Univ. Greifswald, vol. 6, 1925, p. 20, pl. 2, fig. 6.

The only American specimens of this species I have are from the Upper Cretaceous, Navarro formation, E. of Richland, Navarro Co., Texas. It is a small species and may easily be overlooked.

BOLIVINA WATERSI Cushman, new species.

Plate 12, fig. 6.

Test minute, tapering, broadest near the apertural end, thickest along the median line, periphery subacute; chambers very distinct, numerous, curved; sutures distinct, depressed, with broad depressions between the chambers; wall rather coarsely perforate; aperture narrow, elongate.

Length 0.25 mm., breadth 0.10 mm.

Holotype (Cushman Coll. No. 6119) from the Upper Cretaceous, Navarro formation, E. of Richland, Navarro Co., Texas.

This species is very small and easily overlooked but the characters are very distinctive. It is named for Mr. James A. Waters who discovered it.

GENUS PROROPORUS Ehrenberg, 1844.

Proroporus EHRENBURG, Ber. k. pr. Akad. Wiss. Berlin, 1844, p. 75.
(Genotype *P. lingua* EHRENBURG).

Test biserial and like *Bolivina* except that in the adult the chambers tend to extend clear across the test and the aperture becomes terminal.

The typical characters call for a biserial test with a terminal aperture. This is a stage toward *Bifarina* but may be a convenient one to recognize.

PROROPORUS PLAITA (Carsey)

Plate 12, figs. 7 a, b.

Bolivina plaita CARSEY, Univ. Texas Bull. 2612, 1926, p. 26, pl. 4, fig. 2.

The type specimens of this smooth species are from the Upper Cretaceous of Texas. Mrs. Carsey has kindly sent me typical specimens of this species. In my own collection I have the species from numerous localities especially from the Navarro of Texas and a form of it also occurs in the Taylor marl. Very excellent specimens were collected by Mrs. Helen J. Plummer from the Ripley formation of Owl Creek, Miss. The aperture in adult specimens becomes terminal which would place the species in the genus *Proroporus*. It is very close to *Bolivina reussi* Geinitz from the Upper Cretaceous of Europe and may prove to be the same.

GENUS BOLIVINOIDES Cushman, new genus.

The species taken for the genotype of this genus is *Bolivina draco* Marsson from the Upper Cretaceous of Europe. In this and related species from the Upper Cretaceous of Europe and America there is a generally rhomboid test with the thickest portion toward the aperture, this end of the test usually appearing like a thickened lip devoid of ornamentation. The sutures and chamber divisions are more or less obscured by the ornamentation which is in general at right angles to the sutures, and represented by costae or raised lobes of the test. Such species are widely distributed in the Upper Cretaceous of Europe and America but apparently did not persist into the Tertiary.

BOLIVINOIDES DECORATA (Jones).

Plate 12, fig. 9.

Bolivina decorata JONES in Wright, Proc. Belfast Nat. Field Club, Appendix, 1885-86, p. 330, pl. 27, figs. 7, 8.

Bolivina latticea CARSEY, Univ. Texas Bull. 2612, p. 27, pl. 4, fig. 9.

This species described by Jones from the Cretaceous of Keady

Hill, County Derry, Ireland, occurs also in the Upper Cretaceous of America. The apertural end of the test is thickened and the whole test generally rhomboid in front view, the sutures obscured by the surface ornamentation consisting of prominent oblong tubercles arranged so that there is an apparent crossing of two sets of broken ridges.

Mrs. Carsey has kindly sent me a specimen of her species which seems to be identical with that of Jones. Her specimens are from the Taylor marl, 4 miles SW. of Taylor, Texas. I have the species also from the Taylor, 1.8 miles NW. of Annona, Red River Co., and from the Annona Chalk, 10 miles N. by E. of DeKalb, Bowie Co., Texas.

BOLIVINOIDES DECORATA (Jones), var. DELICATULA Cushman, new variety.

Plate 12, fig. 8.

Bolivina decorata CUSHMAN, (not Jones), Bull. Amer. Assoc. Petr. Geol., vol. 10, 1926, p. 582, pl. 15, fig. 11.

Test differing from the typical in the much more slender test, the ornamentation being much less definitely marked, the wall thinner and fairly smooth toward the initial end.

Holotype (Cushman Coll. No. 5139) from the Upper Cretaceous, Velasco shale of Hacienda El Limon, Vera Cruz, Mexico. It also, occurs in the Navarro formation of Texas as well as in the upper part of the Taylor marl. It is closely related to *Bolivinoides strigillata* (Chapman) from the Upper Cretaceous of England.

BOLIVINOIDES RHOMBOIDEA (Cushman).

Plate 12, figs. 10 a, b.

Bolivina rhomboidea CUSHMAN, Contrib. Cushman Lab. Foram. Res., vol. 2, pt. 1, 1926, p. 19, pl. 2, figs. 3 a, b.

This species described from the Upper Cretaceous, Mendez shale, of Mexico does not seem to occur in the more northern localities. It is closely related to *B. decorata* (Jones) and even more closely to *B. draco* (Marsson). It is a shorter more rhomboid form than either and the ornamentation is much coarser and more definite.

GENUS BOLIVINITA, new genus.

The species taken as the genotype of this genus is *Bolivinita quadrilatera* (Schwager). A species, *Bolivinita eleyi* Cushman, new species, is known from the Cretaceous of Europe and Amer-

ica. There are probably other species including *Bolivinita rhomboidalis* (Millett). The chambers of the test are alternating, but the periphery is concave with strongly developed angles which are carinate, giving a quadrilateral or rhomboid form in section and end view. The aperture is broader than is usual in *Bolivina* being much more like that of *Guembelina* to which it is related. The general characters have persisted since the Upper Cretaceous and as might be suspected from other similar examples the living species are today most abundant and strongly developed in the Indo-Pacific.

BOLIVINITA ELEYI Cushman, new species.

Plate 12, figs. 11 a, b.

Textularia obsoleta ELEY (not Reuss), Geol. in the Garden, 1859, p. 202, pl. 8, fig. 11 C; (?) p. 195, pl. 2, fig. 11.—WRIGHT, Irish Nat., 1902, p. 179, List.—(?) CHAPMAN, Bull. Geol. Surv., W. Australia, No. 72, 1917, p. 16, pl. 12, fig. 116.

Test somewhat rhomboid, two or three times as long as broad, greatest width formed by the last two chambers, the periphery flattened as are the other two broader faces, angles very slightly keeled; sutures somewhat indistinct, limbate; surface finely perforate.

This species was originally described by Eley from the Cretaceous Chalk of England. It is not the same as the earlier described *Textularia obsoleta* Reuss and must have a new name. I have therefore named it *Bolivinita eleyi*.

Holotype (Cushman Coll. No. 5552) from the upper part of the Brownstown marl, Hollywood road, 8.1 miles W. of Arkadelphia, Clark Co., Arkansas collected by L. W. Stephenson. This is apparently identical with the English Chalk species. Chapman has recorded *Bolivina obsoleta* from the Cretaceous, Gingin Chalk of Australia, noting that the Cretaceous specimens are narrower than those of the Pliocene or Recent which have been referred to the same species.

36. THE SIGNIFICANCE OF RELATIVE MEASUREMENTS IN THE STUDY OF FORAMINIFERA.

BY JOSEPH A. CUSHMAN AND REGINALD W. HARRIS

The variation in size of foraminifera has long been a subject of note by many authors. Small forms are often referred to as "starved" forms or varieties without any data from an experimental point of view to prove the validity of this idea. To determine what might be shown over a wide range of distribution in a species where no doubt as to the specific identification would be involved, a study was made of several series of *Pulvinulina menardii* (d'Orbigny) from various depths and localities. Series from the Western Atlantic were used, care being taken to see that the material had not been previously sorted by sifting or other treatment. Also care was taken to use what appeared to be adult specimens in all cases. Five localities from *Albatross* dredgings were taken as follows: D 2763, off Southern Brazil 24° S., 42° W., 671 fathoms; D 2760 off Eastern Brazil, 12° S., 37° W., 1019 fathoms; H 165, Caribbean Sea, 15° 55' N., 71° 03' W., 2209 fathoms; D 2381, Gulf of Mexico, 28° 05' N., 87° 56' 15" W., 1330 fathoms; D 2041, off New England, 39° 22' N., 68° 25' W., 1608 fathoms. A series of specimens were measured for length and breadth as follows, the figure given being the average.

D 2763,	Length	.957	mm.,	breadth	.744	mm.
D 2760,	"	1.067	"	"	.873	"
H 165,	"	1.252	"	"	1.024	"
D 2381,	"	1.190	"	"	.984	"
D 2041,	"	1.139	"	"	.902	"

A study of the figures shows that the maximum size is reached in the Caribbean Sea, and a progressive decrease in size takes place both north and south. Due possibly to the effect of warm Gulf Stream water, size falls off less rapidly toward the north than toward the south. Several series were measured from various parts of the Pacific, but none of them approach the size attained in the Caribbean and Gulf of Mexico.

In the Miocene of Trinidad, specimens close to or identical with *Pulvinulina menardii* are common in the *Globigerina*-ooze. A series of these gives the following average measurements, length .565 mm.; breadth .492 mm. It will be noted that these are

very much smaller than the recent specimens, and indicate that the species has been growing larger in late Tertiary time.

To carry this idea further, a series of specimens of *Textularia* of various species all allied to d'Orbigny's *T. carinata* were measured with the following general results. Of these species, *Textularia mississippiensis* Cushman from the Upper Eocene and Lower Oligocene of America shows apparently that the size has increased somewhat from the Upper Eocene through the Red Bluff Clay to the Byram Marl of the Lower Oligocene where the largest specimens were found. In Europe in the Oligocene and Miocene, *Textularia carinata* d'Orbigny from the specimens measured, shows a progressive increase reaching its maximum in the Miocene. The recent *T. pseudocarinata* Cushman, while related to the Miocene species of d'Orbigny, is much smaller as well as differing in other characters. This particular group of related species which had its inception in the Early Tertiary, apparently reached the maximum size in the Miocene of Europe.

A series of *Pulvinulina mexicana* Cushman, *P. jacksonensis* Cushman and Applin, and *P. byramensis* Cushman from the Claiborne, Jackson and Byram Marl respectively were measured and compared. These species are closely related, and often difficult to distinguish, but the relative proportions with the other characters makes them readily identifiable. The following series were measured from large, well-preserved specimens:

P. byramensis (Byram, Miss.) Diameter .812 mm., thickness .462 mm.

P. jacksonensis (Bunker Hill, Ouachita River, La.) Diameter .812 mm., thickness .424 mm.

P. mexicana (Moctezuma River, Mexico.) Diameter .769 mm., thickness .482 mm.

It will be noted that the average diameter varies but little, yet *P. mexicana* consistently averaged less than the species from the horizons above. This was further checked by measurements of series of the *P. mexicana* from Louisiana, Texas, California and Mexico. The diameter of *P. jacksonensis* and *P. byramensis* averaged alike in these two series, yet the latter appears larger under the binocular, due to the greater thickness. The ventral side in the three species becomes more convex in relation to the total thickness as development in the geologic column takes place. Even the ratio of diameter and thickness shows this relation somewhat, although a further division of the thickness into dorsal and ventral would be much more striking. The following ratios of total thickness to total diameter were obtained.

- P. byramensis*, 1 : 1.75 or thickness 57.0% of diameter
P. jacksonensis, 1 : 1.92 or thickness 52.1% of diameter
P. mexicana, 1 : 1.60 or thickness 62.6% of diameter

Data on a small form of *Gyroidina soldani* d'Orbigny, common in the Eocene and Oligocene were obtained. Specimens were fairly abundant and only mature forms were used.

Zardo Creek, Mexico diameter .28 mm.

Gonzales Co., Texas (Cook Mt.) diameter .32 mm.

North Louisiana (Minden) diameter .387 mm.

Specimens from the Jackson and the Red Bluff Clay of the Lower Oligocene show that the maximum size is reached in the Lower Oligocene with an average diameter of .433 mm. These relative measurements checked over a series extending to the Eocene of California.

The suggestion is here made that with a long-lived species or series of related species, it may be possible by the simple method of measuring a series of adult specimens to place the sample containing them in its relative position in the geologic column. A series of measurements made on such species, especially where material can be obtained from continuous core samples, should give valuable data along this line. Other characters of course should be taken into account, but relative measurements seem to hold a distinct possibility if used with full discrimination as to selection of material.

37. SPORADOGENERINA, A DEGENERATE FORAMINIFERAL GENUS.

By JOSEPH A. CUSHMAN.

In the collection of slides of foraminifera made by the late Dr. James M. Flint is one containing several specimens of a very peculiar foraminifer from the Gulf of Mexico. Doctor Flint evidently recognized its unique character as the slide was labelled new but no name given. A study of the series shows that the specimens belong to a new species which cannot be placed in any described genus. For it a new genus is erected as follows:

GENUS SPORADOGENERINA Cushman, new genus

Test with the early chambers roughly uvigerine especially in the microspheric form, the later chambers becoming irregularly uniserial and much elongate, aperture changing from a regular terminal position to one or more indefinite openings at the side of the chamber. Genotype *Sporadogenerina flintii* new species.

SPORADOGENERINA FLINTII Cushman, new species.

Plate 11, figs. 6, 7.

Test elongate, early chambers globular arranged in an irregular spiral in the microspheric form, in the megalospheric form fewer and less regular; later chambers very irregular, elongate, subcylindrical, uniserial; sutures distinct, slightly depressed; wall thin, hyaline, finely perforate; aperture in the young simple, terminal, in the adult, one or more, often on the side of the chamber. Length up to 2 mm.

Holotype (U. S. Nat. Mus. No. 20283) from *Albatross* station D2377 in the Gulf of Mexico, 210 fathoms.

The early stages resemble those of species as *Uvigerina interrupta*. The smaller the proloculum the greater the number of the uvigerine chambers. This genus is probably derived from a smooth form of *Uvigerina* and is evidently a degenerate one.

EXPLANATION OF PLATE 10.

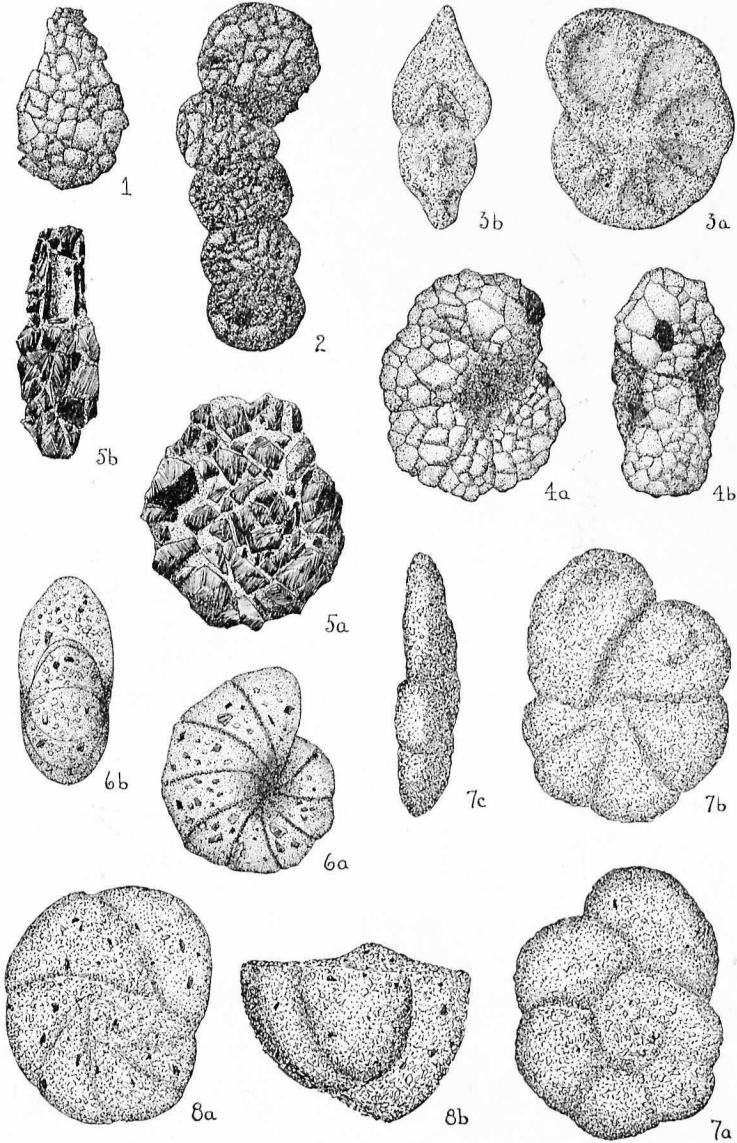
- FIG. 1. *Proteonina difflugiformis* (H. B. Brady). X 50.
 FIG. 2. *Reophax texana* Cushman and Waters, n. sp. X 50.
 FIGS. 3 a, b. *Haplophragmoides excavata* Cushman and Waters, n. sp. X 50.
 a, side view; b, peripheral view.
 FIGS. 4 a, b. *Haplophragmoides rugosa* Cushman and Waters, n. sp. X 50.
 a, side view; b, peripheral view.
 FIGS. 5 a, b. *Haplophragmoides calcula* Cushman and Waters, n. sp. X 50.
 a, side view; b, peripheral view.
 FIGS. 6 a, b. *Haplophragmoides glabra* Cushman and Waters, n. sp. X 50.
 a, side view; b, peripheral view.
 FIGS. 7 a-c. *Trochammina diagonis* (Carsey). X 50.
 a, dorsal view; b, ventral view; c, peripheral view.
 FIGS. 8 a, b. *Trochammina gyroides* Cushman and Waters, n. sp. X 50.
 a, dorsal view; b, peripheral view.

EXPLANATION OF PLATE 11.

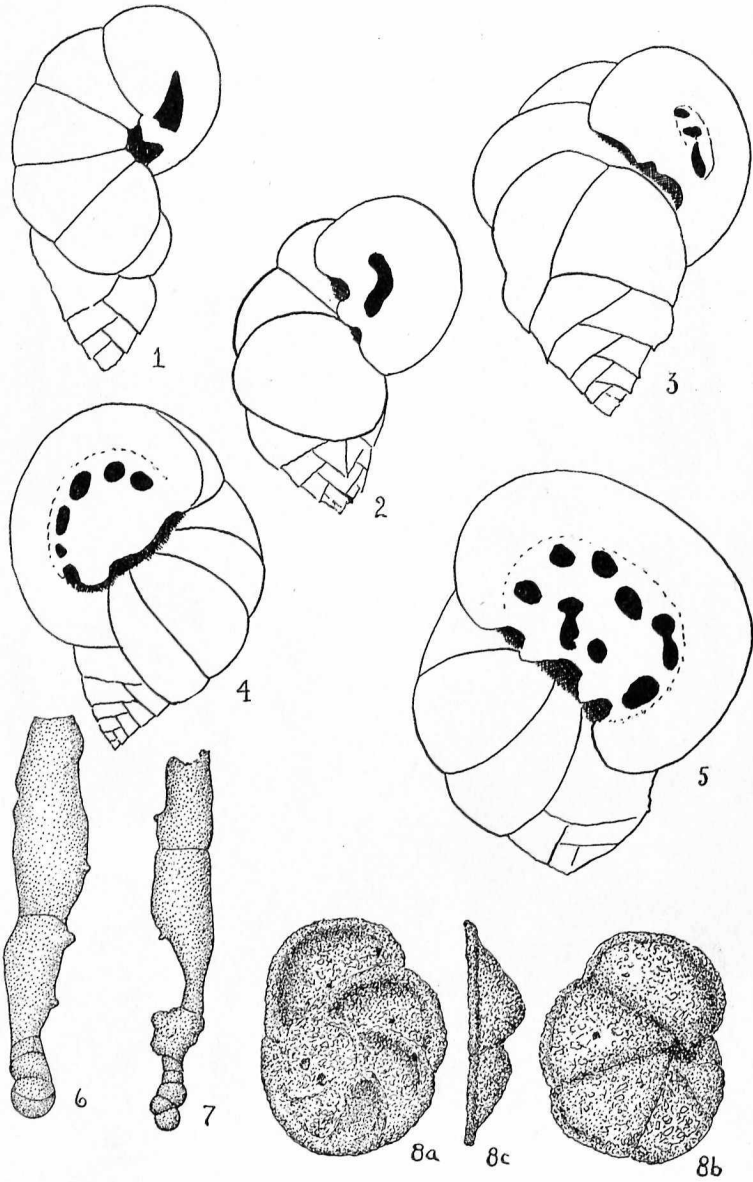
- FIGS. 1-5. *Cribrbulimina mixta* (Parker and Jones), X 30. Recent specimens from Australia. Fig. 1, apparently a megaspheric form with the later chambers loosely coiled, the aperture at the base of the chamber and another supplementary one in the face of the chamber; fig. 2, the secondary aperture enlarging and in fig. 3, divided into several openings. Fig. 4, a broad microspheric form with the secondary openings grouped in a semicircle. Fig. 5, a large adult specimen with the cribrate plate having numerous scattered, rounded openings.
 FIGS. 6, 7. *Sporadogenerina flintii* Cushman, n. sp. X 30.
 FIGS. 8 a-c. *Trochammina texana* Cushman and Waters, n. sp. X 50.
 a, dorsal view; b, ventral view; c, peripheral view.

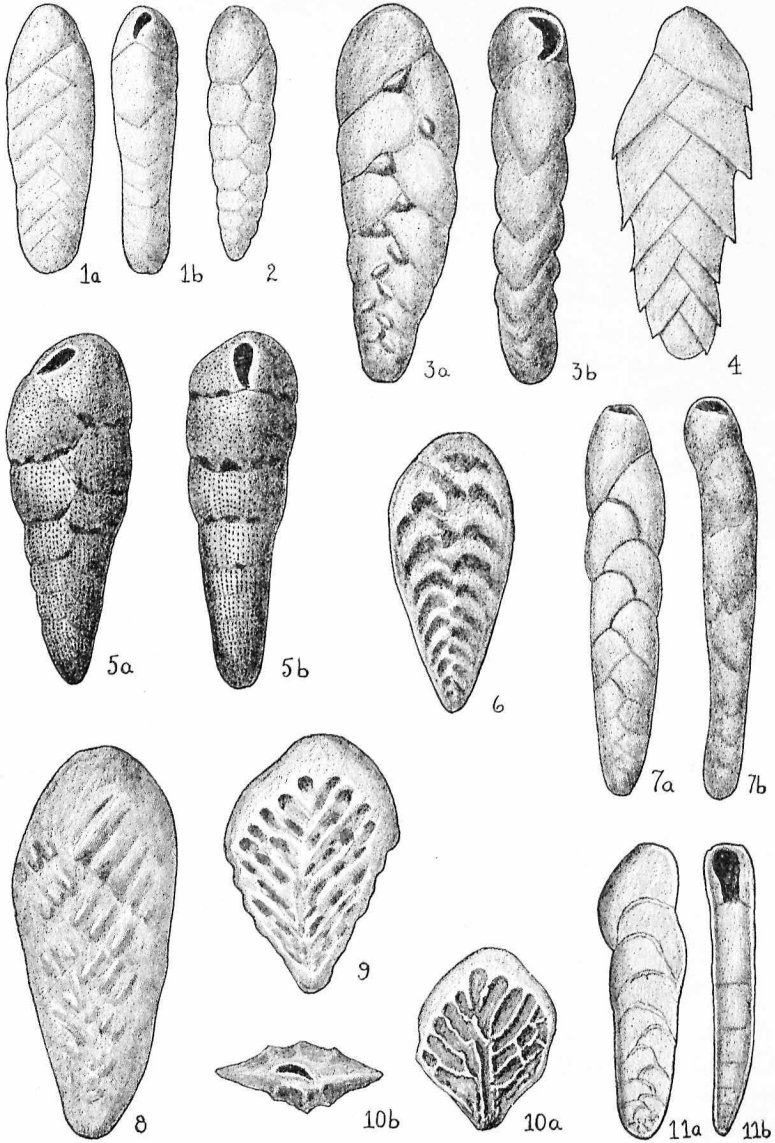
EXPLANATION OF PLATE 12.

- FIGS. 1 a, b. *Bolivina incrassata* Reuss. X 35.
 a, front view; b, side view.
 FIG. 2. *Bolivina tegulata* Reuss. X 65.
 FIGS. 3 a, b. *Bolivina gemma* Cushman, n. sp. X 65.
 a, front view; b, side view.
 FIG. 4. *Bolivina decurrens* (Ehrenberg). X 100.
 FIGS. 5 a, b. *Bolivina clavata* Cushman, n. sp. X 65.
 a, front view; b, side view.
 FIG. 6. *Bolivina watersi* Cushman n. sp. X 150.
 FIGS. 7 a, b. *Proroporus plaita* (Carsey). X 65.
 a, front view; b, side view.
 FIG. 8. *Bolivinoidea decorata* (Jones), var. *delicatula* Cushman, n. var. X 65.
 FIG. 9. *Bolivinoidea decorata* (Jones). X 65.
 FIGS. 10 a, b. *Bolivinoidea rhomboidea* (Cushman). X 65.
 a, front view; b, end view.
 FIGS. 11 a, b. *Bolivinita eleyi* Cushman, n. sp. X 65.
 a, front view; b, side view.



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RECENT LITERATURE ON THE FORAMINIFERA

Below are given some of the more recent works on the foraminifera that have come to hand.

Parr, Walter J.

Some Additional Microzoa from the Red Limestone at Grange Burn, Vic.

(Victorian Naturalist, vol. 43, May 1926, pp. 17-20.)

Melbourne.

A list of 58 species and varieties of foraminifera and 4 of ostracods are given with notes on the more interesting species.

Milner, Henry B.

The Stratigraphic Value of Micro-Organisms in Petroleum Exploration.

(Nature (London), vol. 117, April 17, 1926, pp. 558-560.)

London.

A summary of the work that has been done in America on the Cretaceous and Tertiary foraminifera and other groups, especially in connection with petroleum work on subsurface geology.

Douvillé, H.

La forme conique chez les Foraminifères, et le genre *Dictyoconus* Nuttall.

(Compte Rend. Sommaire Seances Soc. Geol. France, 1926, pt. 3, pp.19-21.)

Paris.

The conical form in the different groups of foraminifera is discussed and detailed notes on the genus *Dictyoconoides* are given.

Newton, R. Bullen.

On *Fusulina* and other Organisms in a partially Calcareous Quartzite from near the Malayan-Siamese Frontier.

(Ann. Mag. Nat. Hist., ser. 9, vol. 17, 1926, pp. 49-64, pls. 2, 3.)

London.

Foraminifera as well as other fossils are noted and an excellent bibliography of papers dealing with Palaeozoic foraminifera especially *Fusulina* and its allies is given.

Casasnovas, G. C.

Nota sobre las Amphistegina, Miogypsina y Lepidocyclina, del Burdigaliense de Malloica.

Bol. R. Soc. Espan. Hist. Nat., vol. 26, No. 5, 1926, pp. 287-291, 4 text figs.)

Madrid.

Numerous species are recorded by genera only.

Terra, H. de.

Ein neues Tertiärvoskommen im Kontinentalen Griechenland.

(Centralblatt für Min. Geol. u. Pal., abt. B. No. 8, 1926, pp. 265-271, 2 figures.)

Stuttgart.

A new formation in the Tertiary of Greece is noted and notes on several species of foraminifera are given.

Hodson, Helen K.

Names for the stellate "Orthophragmina".

(Amer. Journ. Sci., vol. 12, No. 70, October, 1926, pp. 353, 354.)

New Haven.

This paper shows that the name *Asteriacites* Schlotheim adopted for the stellate "Orthophragmina" cannot be used and that the first name that can be used is *Cisseis* Guppy, 1866.

Yabe, Hisakatsu and Shoshiro Hanzawa.

A foraminiferous limestone, with a questionable fauna, from Klias peninsula, British North Borneo.

(Sci. Rept. Tohoku Imp. Univ., sec. ser. (Geol.), vol. 9, No. 1, 1926, pp. 1-7, plate 1.)

Sendai.

Numerous species and genera are recorded and figured from a peculiar limestone which may represent a passage bed between the Eocene and Oligocene.

Yabe, Hisakatsu and Shoshiro Hanzawa.

Choffatella Schlumberger, and *Pseudocyclammina* a new genus of arenaceous foraminifera.

(Sci. Rept. Tohoku Imp. Univ., sec. ser. (Geol.), vol. 9, No. 1, 1926, pp. 9-11, plate 2, 1 text figure.)

Sendai.

This paper deals with *Cyclammina*-like forms from the lowermost Cretaceous or Upper Jurassic of Japan. A new genus, *Pseudocyclammina* is erected and a new species of *Choffatella* described.

Yabe, Hisakatsu and Shoshiro Hanzawa.

Geological age of *Orbitolina*-bearing rocks of Japan.

(Sci. Rept. Tohoku Imp. Univ., sec. ser. (Geol.), vol. 9, No. 1, 1926, pp. 13-20, pls. 3-6, 1 text figure.)

Sendai.

Five new species and varieties of *Orbitolina* are described and figured from the Lower Cretaceous formations of Japan.

Hofker, J.

Die Foraminiferen aus dem senon Limburgens. V.

(Nat. Maan., Nat. Gen. Limb^{er}g, Jaarg. 15, No. 7, July 30, 1926, pp. 79-82, 1 plate.)

Limburg.

A paper devoted to exhaustive descriptive details with numerous figures of *Amphistegina fleuriansi*.

Nuttall, W. L. F.

The Zonal Distribution and Description of the Larger Foraminifera of the Middle and Lower Kirthar Series (Middle Eocene) of Parts of Western India.

(Geol. Survey India, Records, vol. 59, 1926, pp. 115-164, pls. 1-8.)

Calcutta.

Many details of distribution and correlation are given, with descriptive details of many species of *Nummulites*, *Assilina*, *Discocyclina* and *Actinocyclina*, a number of them new. Ten pages of bibliography are given. The paper is illustrated by exceptionally clear photographic sections and exteriors.

Gee, F. R.

The Geology of the Andaman and Nicobar Islands, with special reference to Middle Andaman Island.

(Records. Geol. Survey India, vol. 59, pt. 2, 1926, pp. 208-232, pls. 11-15.)

Calcutta.

A very few genera of foraminifera are noted. The plates contain a figure of *Assilina granulosa* and some sections of unnamed *Lepidocyclinas* and *Nummulites*.

Davies, L. M.

Remarks on Carter's genus *Conulites-dictyoconoides* Nuttall with descriptions of some new species from the Eocene of North-West India.

(Rec. Geol. Survey India, vol. 59, pt. 2, 1926, pp. 237-253, 5 pls.)
Calcutta.

Detailed description of the genus and of several new species from India are given with excellent photographic figures.

Lacroix, E.

De l'emploi des coccoliths par les Foraminifères arénacés pour l'édification de leurs testes.

(Compt. Rend. Acad. Sci., vol. 183, pt. 7, 1926, pp. 430-431.)

Paris.

Numerous species from the Rockall Bank use coccoliths in the building of the test. Solution by acid shows the usual chitinous lining and chemical tests show the usual iron compounds present.

Gilard, P.

Recherche sur la constitution des craies du Limbourg.

(Acad. Roy. Belgique Cl. Sci. Mem. Coll. vol. 8, pt. 1, 1926, pp. 1-72, 4 pls, 8 text figs.)

Bruxelles.

A few foraminifera are recorded by genera from these Cretaceous sediments of Belgium.

Chapman, Frederick.

Cretaceous and Tertiary Foraminifera of New Zealand with an Appendix on the Ostracoda.

(New Zealand Dept. Mines, Geol. Surv. Palaeont. Bull. No. 11, 1926, pp. 1-120, 22 pls.)

Wellington.

This is an important paper taking in all the known Cretaceous and Tertiary Foraminifera of New Zealand. The original plates of Karrer and Stache on the *Novara*-Expedition collections from New Zealand are republished. There are 277 species and varieties of foraminifera, and 28 of ostracods. Eleven of the foraminifera are described as new, and five of the ostracods. The similarity of the Cretaceous to that of Europe and America is noted.

Nuttall, W. L. F.

The Zonal Distribution of the Larger Foraminifera of the Eocene of Western India.

(Geol. Mag., vol. 63, No. 749, Nov. 1926, pp. 495-504.)

London.

A summary of the species that have been recorded from this region and their stratigraphic significance with tables showing distribution.

J. A. C.