

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. Institut. 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. Institut. Univ. Greifswald, vol. 6, 1925, p. 21, pl. 2, fig. 7.

Bolivina textilarioides 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. Instit. 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.

EXPLANATION OF PLATE 10.

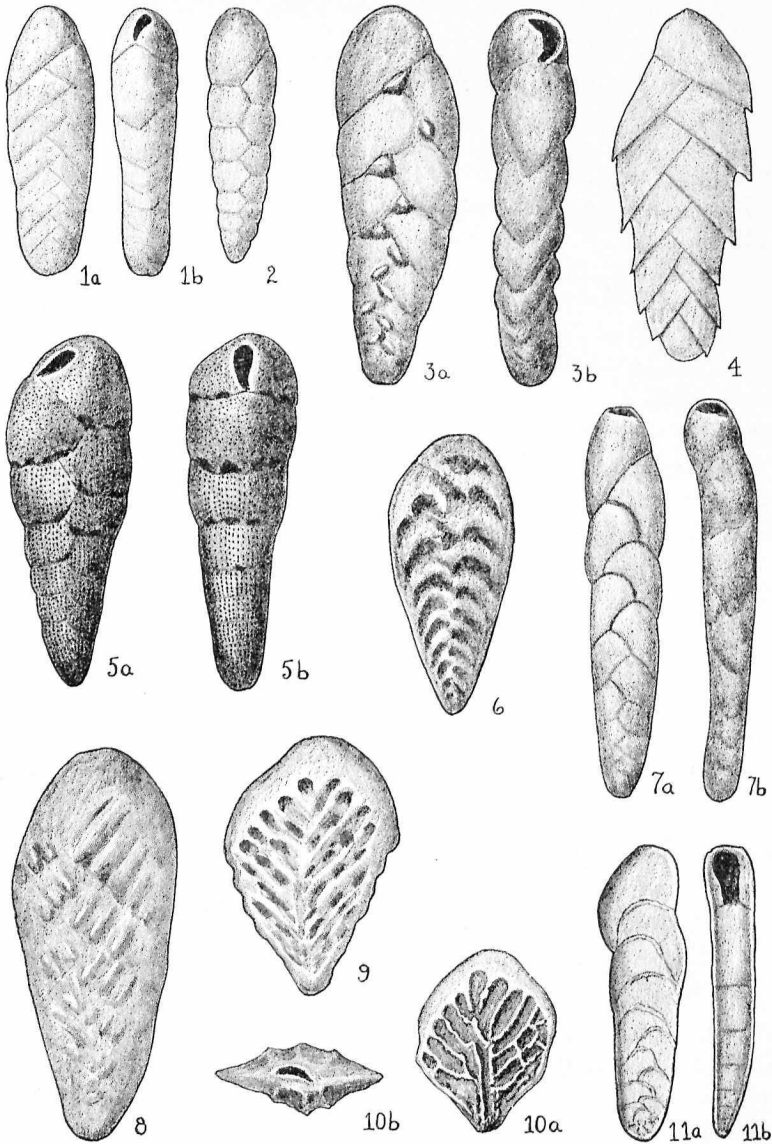
- FIG. 1. *Proteonina difflugiformis* (H. B. Brady). X 50.
 FIG. 2. *Reophax texana* Cushman and Waters, n. sp. X 50.
 FIGS. 3 a, b. *Haplophragmoides excavata* Cushman and Waters, n. sp. X 50.
 a, side view; b, peripheral view.
 FIGS. 4 a, b. *Haplophragmoides rugosa* Cushman and Waters, n. sp. X 50.
 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. *Criobulimina 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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