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CRETACEOUS FORAMINIFERA FROM THE  
SACRAMENTO VALLEY, CALIFORNIA

A Dissertation

Submitted to the Graduate Faculty of the  
Louisiana State University and  
Agricultural and Mechanical College  
in partial fulfillment of the  
requirements for the degree of  
Doctor of Philosophy

in

The Department of Geology

by  
Richard Paul Zingula  
B.S., Iowa State College, 1951  
M.S., Louisiana State University, 1953  
January, 1958

## ACKNOWLEDGMENTS

The author first became interested in this problem while working in California under the direction of Dr. Henry V. Howe of the Louisiana State University. His guidance and constructive criticism throughout the project have been of the utmost importance. I am deeply indebted to the Humble Oil & Refining Company for financial and technical assistance, particularly to such of the personnel as Mr. J. R. Jackson who was in charge of the Chico office when this project was initiated, Mr. John D. Frick the present district geologist, and to Mr. Andrew W. Marianos, my friend and co-worker from whom I received much manual and technical assistance as well as moral support. Mrs. Joyce Rodgers, who was employed by the Humble Company as an artist, made most of the drawings. Dr. Harold V. Andersen of the Louisiana State University gave me much assistance on the descriptive and taxonomic problems. Two weeks were spent at the Smithsonian Institution, where Dr. Alfred R. Loeblich, Jr. and Mrs. Helen Tappan Loeblich gave freely of their time and assistance.

To these people, and to many others who offered constructive criticism, the author is sincerely grateful.

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## ABSTRACT

The outcropping Mesozoic sediments of the northern Sacramento Valley, California comprise a sequence of more than 25,000 feet of interbedded graywackes and mudstones, with minor conglomerate. Since the lithology is of one type throughout the section, and since there are few, if any, persistent unconformities, workers in the field have been greatly retarded in their efforts to correlate units from one area to another. Megafossils are too rare to be of much use in detailed surface correlation, and are completely worthless to subsurface geologists. Very little has been published on the microfossils, and that only on part of the upper Cretaceous. Thus, there has arisen a complex problem of correlation and nomenclature which seems to have increased over the years, due to the lack of a standard to work from.

The Shasta group, set up by Whitney in 1869, is now considered to be lower Cretaceous, and to be made up of the lower Paskenta and upper Horsetown. The latter was originally defined by White as the "Horsetown beds." His type locality, rather than being Albian in age, is probably Cenomanian or Turonian. Also, the lithology at his type area is quite different from that of rocks generally considered to be 'Horsetown.' In 1938, Anderson redefined the Horsetown as a group, and changed the type locality to the North Fork of Cottonwood Creek. His unit there is a paleontologic rather than lithologic entity. This



prompted Murphy to change the unit to stage status in 1956.

Therefore, it is quite evident that the rich foraminiferal faunas should be studied and reported on as an aid to all who will work in that area in the future. This dissertation is an attempt to present the foraminifera of the Horsetown, in the sense of Anderson in 1938, as exposed along the course of Dry Creek in northern Tehama County.

The author has been engaged in a study of the foraminifera of the Sacramento Valley for the Humble Oil and Refining Company since the summer of 1952. During the summer of 1953, 38 bulk samples were collected along the Horsetown section of Dry Creek; from localities which the Humble Company samples showed to be richly fossiliferous. From these, 100 species and subspecies, representing 59 genera, are here presented. Of these, 3 genera, 45 species, and 3 subspecies are considered to be new.

The presence of certain species of *Rotalipora* indicates that the uppermost part of this section may be Cenomanian in age rather than late Albian. The lower portion is probably Aptian or older, although planktonic species are too rare to make accurate age determinations. More faunal affinity is shown to the faunas of the Gault of Europe and the Grayson formation of Texas than to those of any other suite of sediments.

## INTRODUCTION

### Location of the area.

The area is located on the west side of the Sacramento Valley in northern Tehama County, California (fig. 1 - inset). It can be reached by following state highway 36 from Red Bluff west toward Beegum. The region is covered by the southwest quarter of the 1952 edition of the Ono, California quadrangle (15 minute series) published by the United States Geological Survey.

This is the Yolla Bolly delta area of Anderson (1938), commonly known as the Beegum Basin. Here the Cretaceous strata dip to the east at from 15-30 degrees, becoming more horizontal to the east. Major streams flow in an easterly direction, exposing the sediments in almost continuous sections in the valleys.

Samples were collected from exposures on the streams that parallel highway 36. The section collected (fig. 1) extends from the thick, massive graywacke where Vestal Road joins the highway in Sec. 1, T28N, R8W, down Budden Canyon and Dry Creek, to the base of the thick conglomerate in Sec. 9, T28N, R7W.

### History of previous work.

The Mesozoic rocks of this region are predominantly interbedded gray, flaggy graywacke and black mudstone (fig. 2), with a few conglomerate beds of variable thickness.

The first reference to these sediments is by William Gabb, who, in 1869, introduced the terms Chico and Shasta for rocks now considered to be of Cretaceous age. In the preface to Gabb's report, J. D. Whitney defined the Shasta group, which he stated "is a provisional name, proposed to include a series of beds of different ages, but which, from our imperfect knowledge of the subject, cannot yet be separated; it includes all below the Chico Group." The fossils he listed were of Neocomian to Albian in age, with only a few of these species continuing on into the Chico.

In 1885, C. A. White further divided the Shasta group into the lower Knoxville beds and upper Horsetown beds. The type locality of the latter was given as the now non-existent mining camp of Horsetown on Clear Creek in Sec. 36, T31N, R6W, MDBM, Shasta County. There are two exposures in that area, one-half mile apart, with the area between covered by gravels. One consists of a few hundred feet of graywacke and sandy siltstone with a few fossils, presumably of Albian age. The other is a sandy ledge containing abundant ammonites, and surrounded by mudstone carrying Cenomanian or Turonian Globotruncanas. White does not indicate which of these two outcrops he meant to be the type of the Horsetown, but evidence would indicate the latter. Old residents of the area have stated that the town of Horsetown was located just across the creek from this ledge, and faunal lists of the type area read "at Horsetown." Certainly this was the more accessible and fossiliferous.

In 1902, F. M. Anderson introduced the term "Paskenta beds" for the upper part of the Knoxville beds of White, and placed them in the lower Cretaceous below the Horsetown. In 1933, he formally proposed the name Paskenta, and in 1938 redefined the Paskenta and Horsetown as groups. The type section of Anderson's redefined "Horsetown group" was chosen to be along the North Fork of Cottonwood Creek and its tributary, Huling Creek, in southern Shasta county, instead of at Horsetown. The North Fork - Huling Creek area includes 6400 feet of section, with graywacke at the base, grading up into graywacke and mudstone, and finally to an almost pure mudstone at the top. He considered the Paskenta to be Valanginian, and the Horsetown here to be of Hauterivian to upper middle Albian in age. In this area the boundary is purely arbitrary, and based on fossil evidence only; although farther to the south the contact is considered to be disconformable. The Horsetown-Chico boundary in this area is also gradational, and based entirely on fossil evidence. Thus, the Horsetown as defined by Anderson is entirely different from that of White.

M. A. Murphy, in 1956, proposed that the name Horsetown be used in a stage sense since Anderson's group included only one formation in much of the area, and since the divisions between the groups were based more on faunal than lithologic differences.

Purpose of this dissertation.

The author first became interested in this area while working for the Humble Oil & Refining Company in Chico, California, under the direction of Dr. Henry V. Howe, during the summer of 1952. At that time the company was interested in obtaining a zonation of the Mesozoic sediments in the Sacramento Valley. With this in mind, Dr. Howe had had numerous sections collected in detail along the creeks of the west side of the Valley. Dr. Howe, Mr. Andrew Marianos, and the author were engaged in examining these samples in Chico. Previous investigation had indicated, and our work that summer confirmed the conclusion, that the best area to study the microfauna of the Horsetown as defined by Anderson in 1938 was along Dry Creek and its tributaries. This creek had the least disturbed, most exposed section of those seen along the west side of the valley.

Here the basal Horsetown, a two hundred foot thick, massive graywacke, conformably overlies the mudstones and flaggy graywackes of the Paskenta. This grades rapidly up into 7200 feet of thin bedded (1 inch to 2 feet) mudstones and flaggy graywackes, with the mudstone making up 70-80% of the total. This is conformably overlain by a massive conglomerate which is generally considered to be the base of the Chico. It is this thick, predominantly mudstone section that was sampled for this dissertation. Lithologically the Horsetown here is a unit in that it is underlain and overlain by thick units of coarser and more massive

material. Faunally it is also distinct, most of the species being restricted to this part of the section.

Several papers have been written on the megafossils of this area and of sediments of comparable age at other places on the Pacific Coast. However, it has only been in recent years that the Cretaceous of northern California was considered to contain microfossils. A few papers have been written on the foraminifera of the upper Cretaceous, but none before on those of the lower units. Thus, this dissertation has as its purpose the presentation of the foraminifera of the Horsetown Stage as found along Dry Creek. Although not intended as a regional stratigraphic paper, I feel that a few remarks concerning the age of the sediments and the affinities of the fauna to those of comparable age elsewhere are certainly necessary.

#### Age and affinities of the fauna.

Although this unit has long been considered to be no younger than Albian, the presence of Rotalipora appenninica (O. Renz), R. roberti (Gandolfi), and R. ticinensis (Gandolfi) in the upper samples would indicate that at least part of the section may be upper Cretaceous. This assumption is further strengthened by the fact that some of the other species found in these samples are also found in sediments above the conglomerate, which are definitely of Cenomanian age. The material below sample # 30 is probably Aptian (or older), although planktonic forms of known species are too rare to lend much weight to this idea.

As is true of most of the Cretaceous in the Pacific Coast area, the fauna of this section is unique to the area; but it is more closely allied with that of Europe than with any of comparable age elsewhere in this country. The greatest affinities are with the Aptian and Albian of Germany and with the Gault of Folkestone, England. Some of the species of the Horsetown are found in the Grayson formation of Texas.

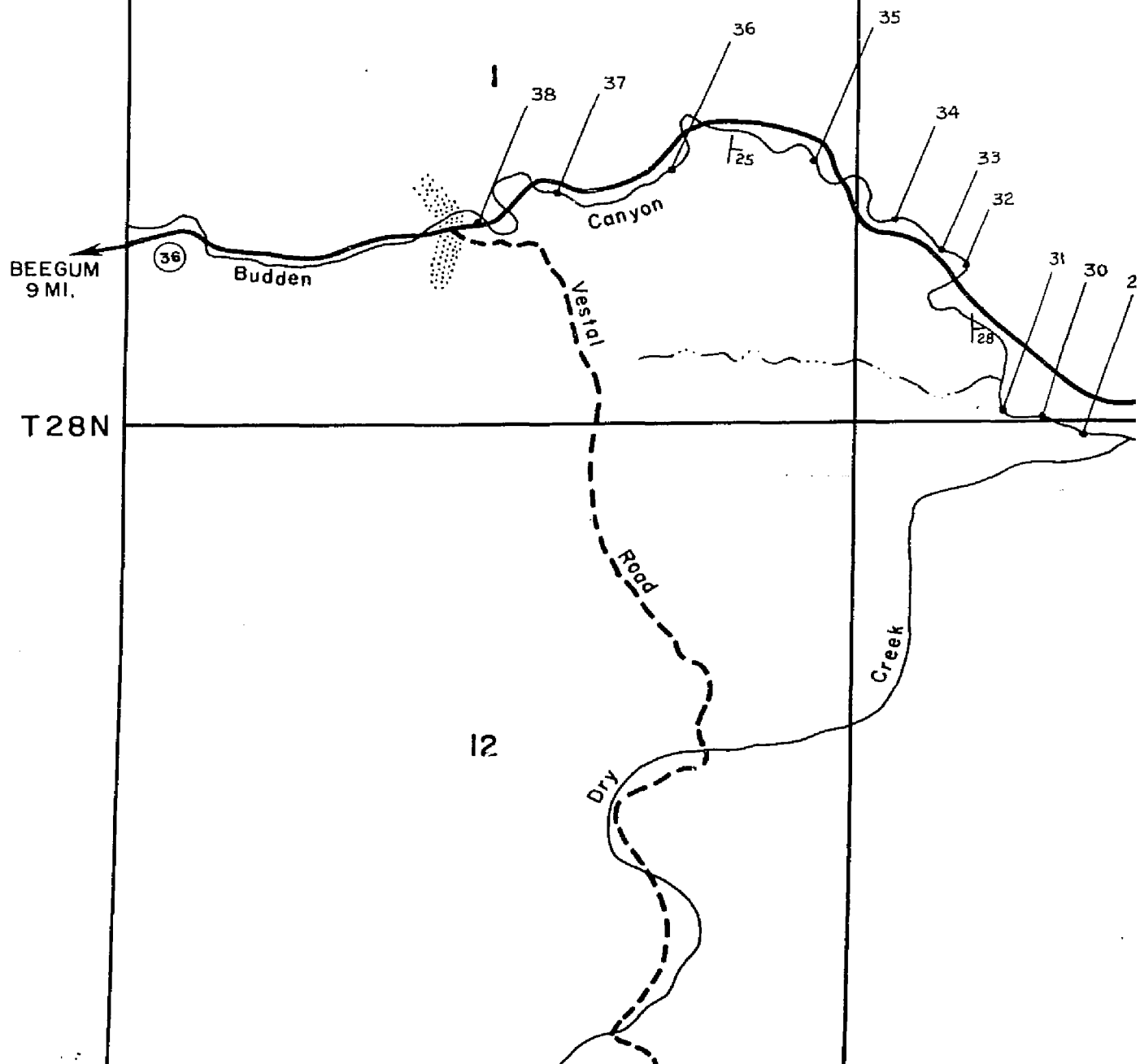
#### Procedure.

While working for the Humble Company in the summer of 1952, I had an opportunity to see microfaunas collected along many of the creeks which flow out of the Coast Ranges and Klamath Mountains. During the next school year I worked with small samples that had been collected at 25 foot intervals by the Humble Company from Dry Creek. The next summer, while again working in Chico, I collected 38 samples weighing approximately 20 pounds apiece. These were collected from below permanent water level on the creek to be certain that fresh material was obtained. Only fine grained, spheroidally weathering mudstones (fig. 3) carry good microfaunas, and care was taken to sample only the finest sediments. The locations were selected to give the most complete, abundant, and representative faunas. This material was washed down in Humble's laboratory in Chico. They were broken down in a Campbell washer and washed on a 200 mesh screen. During the next three years, while attending the Louisiana State University, and working for the Humble Company, picking and separation of species was

completed. Camera lucida drawings were made of all species by Mrs. Joyce Rodgers of Chico, who was employed by the Humble Company as an artist. Some of these were redrawn by me during the last year as better specimens were obtained. Two weeks were spent at the Smithsonian Institution in Washington, D. C. in the spring of 1957, where I had the opportunity to compare my specimens with types from many parts of the world. Over 150 books and articles have been perused in an attempt to place the correct names on the species, and to insure as complete and correct synonymy as possible.



R8W R7W



R8W R7W

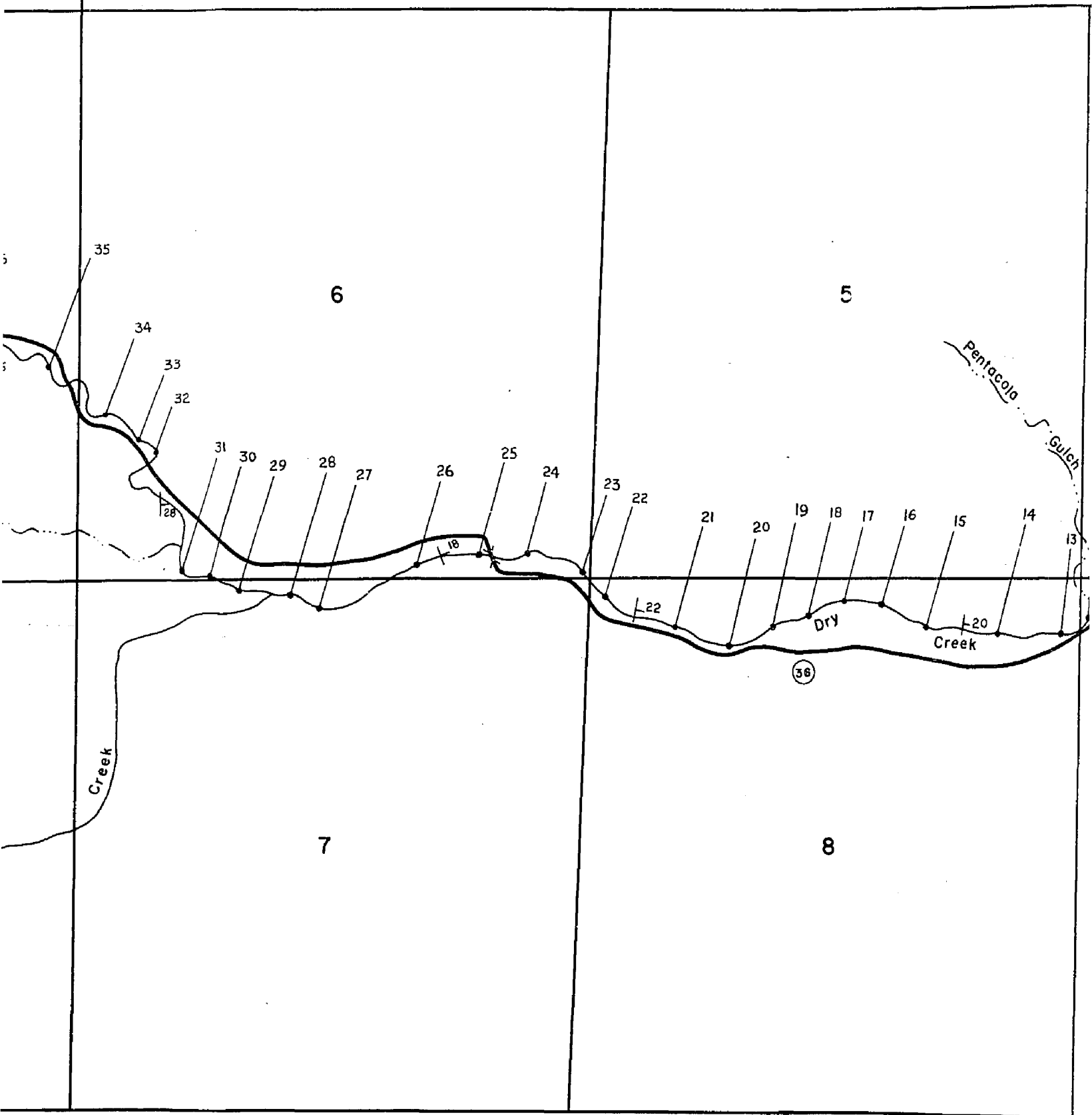
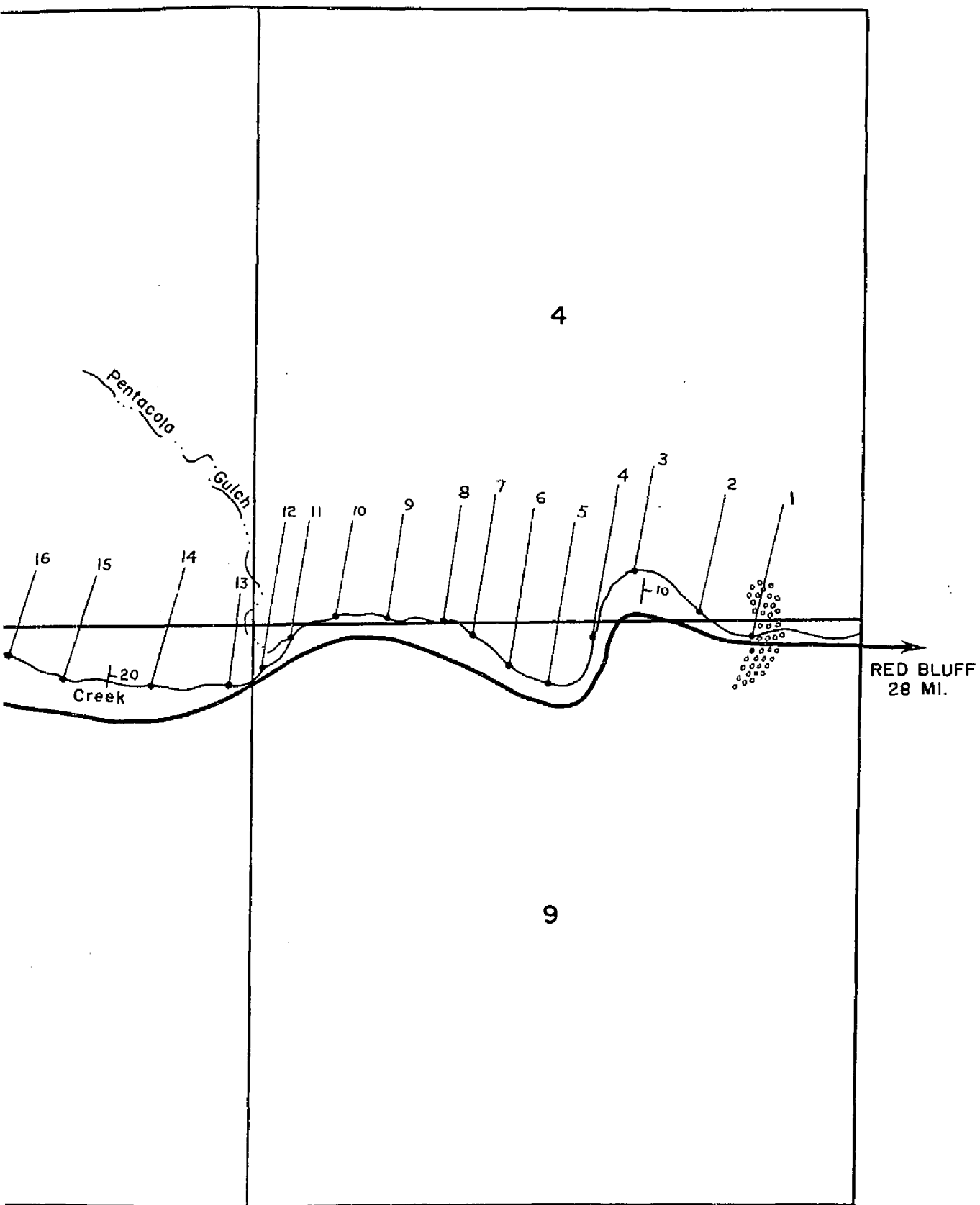


Figure 1 - Location Map



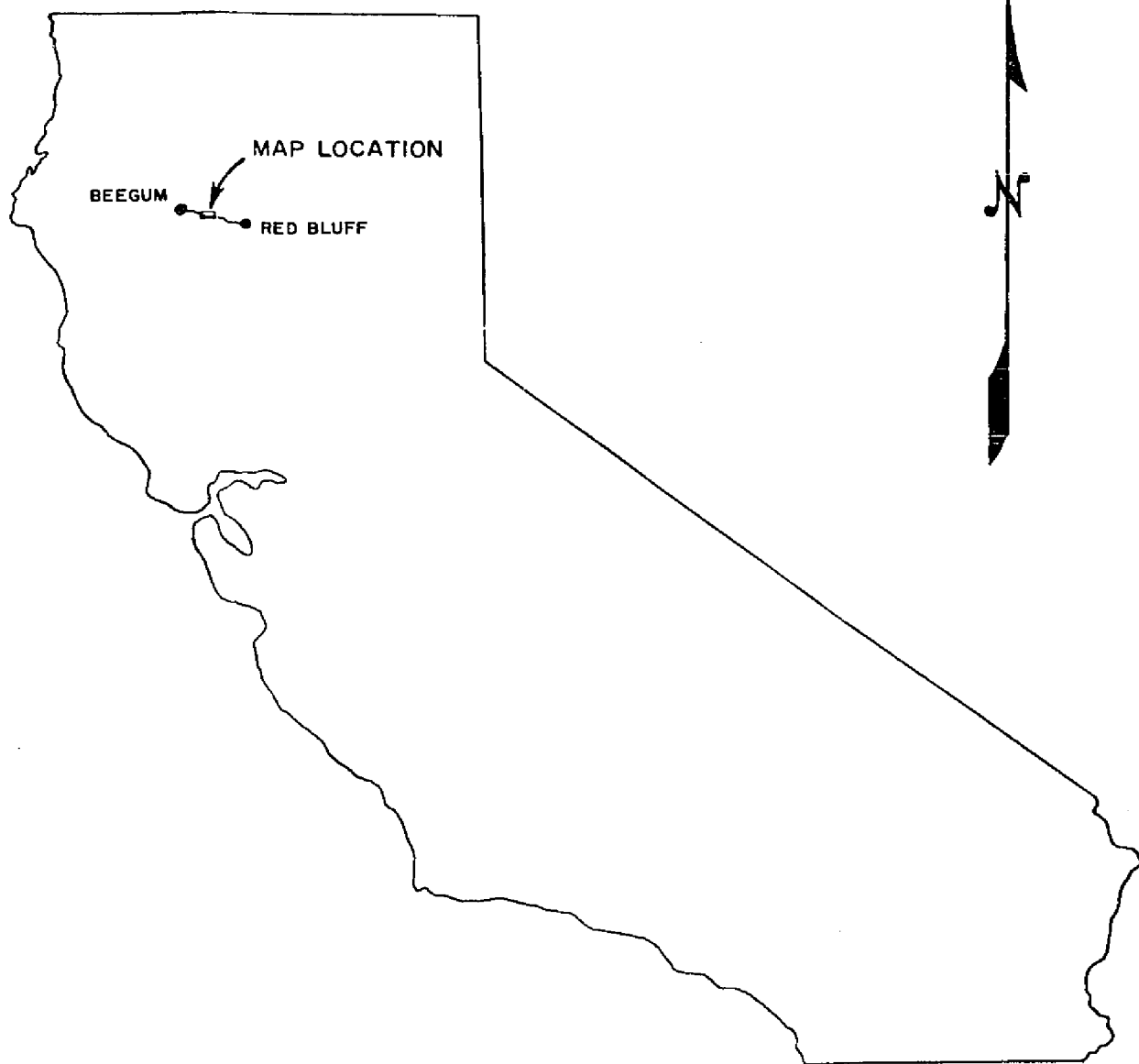




Figure 2. Interbedded Horsetown mudstone and graywacke along Dry Creek.



Figure 3. Spheroidally weathering Horsetown mudstone.

TAXONOMY OF FORAMINIFERA

Phylum PROTOZOA

Class SARCODINA

Order FORAMINIFERA

Family RHIZAMMINIDAE

Genus BATHYSIPHON Sars, 1872

BATHYSIPHON ANOMALOCOELIA Tappan

Plate I, figs. 1a, b

Bathysiphon anomalocoelia Tappan, 1955, U. S. Geol. Surv., Prof. Paper  
236-B, p. 35, figs. 1-3.

Test free, large; a straight tube open at both ends; test agglutinated, of fine fragments, small sponge spicules (?), and much siliceous cement, wall thick, translucent, smooth; test usually collapsed. Length of hypotype 1.14 mm., greatest diameter 0.53 mm.

This species has a much thicker wall than that of B. alexanderi Cushman from the upper Cretaceous of Texas, and generally does not have constrictions. It is much smaller than B. carapitanus Hedberg, and does not have constrictions.

BATHYSIPHON sp. "a"

Plate I, figs. 2a, b

Test free, large, agglutinated; a tube open at each end, with slight

constrictions at irregular intervals; wall thick, of coarse quartz grains with a small amount of siliceous cement. Length of figured specimen 1.00 mm., diameter 0.21 mm.

Described species of Mesozoic age that are this coarse are much larger. However, I am sure that so common looking a species must be similar enough to paratypes or topotypes of some already published form that it would be wise not to introduce a new name.

Family HYPERAMMINIDAE

Genus HYPERAMMINA Brady, 1878

HYPERAMMINA n. sp. "a"

Plate I, figs. 3a, b, 4a

Test free, glossy, translucent; a globular early portion followed by a long, straight tube, the globular portion usually broken off; wall thick, smooth, entirely of siliceous material, no apparent fragments; outer surface of wall often with weak constrictions; aperture the open end of the tube. Greatest diameter of bulb in fig. 4 is 0.28 mm., diameter of the tubular portion 0.09 mm.; length of tube in fig. 3 is 1.03 mm., diameter 0.14 mm.

All of the Mesozoic species of this genus that I have seen are either tapering with a small proloculum, or are composed of granular material.

## Family REOPHACIDAE

Genus REOPHAX Montfort, 1808

## REOPHAX CONSTRICTUS (Reuss)

Plate I, figs. 6a, b

Haplostiche constricta Reuss, 1874, in Geinitz, Palaeontographica, vol. 20, pt. 2, p. 121, pl. 24, figs. 9-12.

Reophax constrictus (Reuss) Cushman, 1944, Contr. Cushman Lab. Foram. Research, vol. 20, p. 1, pl. 1, fig. 1.

Test free, elongate, agglutinated, uniserial, rectilinear; wall of coarse sand grains with minor cement; chambers inflated, of constant size, usually only 2, rarely 3 or 4; sutures distinct, horizontal; aperture terminal, round, with a long neck. Length of hypotype 0.49 mm., greatest diameter 0.22 mm.

## REOPHAX TEXANUS Cushman and Waters

Plate I, figs. 5a, b

Reophax texana Cushman and Waters, 1927, Contr. Cushman Lab. Foram. Research, vol. 2, p. 82, pl. 10, fig. 2.

Test free, large, agglutinated, uniserial, rectilinear; wall composed of medium to coarse angular quartz grains with minor siliceous cement; initial end blunt, chambers rounded, increasing very gradually in size or not at all; sutures distinct, depressed; aperture terminal,



simple, flush or slightly produced. Length of hypotype 1.27 mm., greatest diameter 0.46 mm.

Family AMMODISCIDAE

Genus AMMODISCUS Reuss, 1861

AMMODISCUS GLABRATUS Cushman and Jarvis

Plate I, figs. 7a-c, 8a, b

Ammodiscus glabratus Cushman and Jarvis, 1928, Contr. Cushman Lab. Foram. Research, vol. 4, p. 86, pl. 12, figs. 6a, b.

Test free, agglutinated, biconcave, circular or oval in plan view, periphery rounded; wall finely arenaceous with much siliceous cement, glossy; test a small proloculum and long, undivided tube planispirally coiled or with the earliest portion somewhat irregular; tube increasing slightly in diameter toward aperture, somewhat impressed on the preceding coil, 5 to 8 whorls in the adult; aperture the open end of the tube, circular or slightly deformed. Hypotype in fig. 7 has a maximum diameter of 0.67 mm., least diameter 0.57 mm., maximum thickness 0.10 mm., diameter of the tube at the aperture 0.09 mm. The hypotype in fig. 8 has a maximum diameter of 0.44 mm., thickness 0.08 mm., diameter of the tube 0.08 mm.

Holotypes and paratypes of A. cheradospirus Loeblich and Tappan have been examined, and this species is probably synonymous.

## Genus GLOMOSPIRA Rzehak, 1888

## GLOMOSPIRA CHAROIDES (Jones and Parker) var. CORONA

Cushman and Jarvis

Plate I, figs. 9a-c

Trochammina squamata Jones and Parker var. charoides Jones and

Parker, 1860, Geol. Soc. London, Quart. Jour., vol. 16, p. 304,

(type figure not given).

Glomospira charoides (Jones and Parker) White, 1928, Jour. Pal., vol. 2,

p. 187, pl. 27, figs. 7a-c.

Glomospira charoides (Jones and Parker) var. corona Cushman and

Jarvis, 1928, Contr. Cushman Lab. Foram. Research, vol. 4,

p. 89, pl. 12, figs. 9-11.

Test free, siliceous, wall smooth; test a proloculum and long tubular second chamber; early portion of the test spherical, the tube spirally wound up and down the mass, later portion with the tube coiled more or less in one plane at one edge of the test; aperture the open end of the tube. Height of hypotype 0.26 mm., greatest diameter 0.32 mm., diameter of the tube 0.08 mm.

G. pattoni Tappan should probably be considered a junior synonym as the holotype and paratype match many of the specimens found in this section.

## GLOMOSPIRA sp. "a"

Plate I, figs. 10a-c

Test free, siliceous, wall smooth; test a proloculum and long, tubular second chamber coiled in a continuously changing direction, but near one plane, particularly in the latter portion, so that the test appears somewhat flat; test may be elongate or almost circular in plan view; aperture the open end of the tube. Greatest diameter of figured specimen 0.41 mm., least diameter 0.24 mm., greatest thickness 0.15 mm., diameter of the tube 0.06 mm.

Forms of this type have been called G. gordialis (Jones and Parker) by some authors, but the type specimen is much less planispiral, and becomes uncoiled in the adult.

## Family LITUOLIDAE

Genus TROCHAMMINOIDES Cushman, 1910

TROCHAMMINOIDES n. sp. "a"

Plate I, figs. 11a, b, 12a, b

Test free, agglutinated, planispiral; evolute to varying degrees, from a form with whorls not at all appressed and all three whorls visible to a rare stage where only the last whorl is visible; wall granular, of fine grains with a large amount of brown, siliceous cement; umbilical region depressed, periphery smooth, broadly rounded; chambers numerous, 14 to 20 in the last whorl, short, increasing very gradually

in size, not inflated; sutures distinct, flush or rarely slightly depressed, much thickened, straight, radial, spiral suture distinct, slightly depressed; aperture the open end of the last chamber. Greatest diameter of figured microspheric form 0.78 mm., least diameter 0.63 mm., thickness 0.29 mm.; greatest diameter of figured megalospheric form 0.52 mm., least diameter 0.43 mm., thickness 0.19 mm.

Previously named species all have longer chambers with fewer chambers per whorl, and usually have depressed sutures.

#### Genus HAPLOPHRAGMOIDES Cushman, 1910

#### HAPLOPHRAGMOIDES EGGERI Cushman

Plate II, figs. 1a, b, 2a-c

Haplophragmoides fontinense Egger (not Terquem), 1910. Naturwiss.,

Ver. Regensburg Ber., vol. 12, 1907-09, p. 10, pl. 3, figs. 16-18.

Haplophragmoides eggeri Cushman, 1926, Am. Assoc. Petroleum Geol.,

Bull., vol. 10, pl. 15, figs. 1a, b.

Test free, planispiral, involute; wall granular, of fine quartz grains with a large amount of siliceous cement; periphery broadly rounded, lobulate; only the 5 or 6 chambers of the last whorl visible, chambers increasing in size, inflated; sutures radial, straight or nearly so, depressed; umbilicus open; aperture indistinct; test often crushed and chambers flattened, particularly in large specimens. Greatest diameter of hypotype in fig. 2 is 0.31 mm., least diameter 0.27 mm., thickness

0.19 mm.; greatest diameter of hypotype in fig. 1 is 0.74 mm., least diameter 0.58 mm., thickness 0.20 mm.

Specimens of the flattened form of this species have been called H. excavata Cushman and Waters, by some authors.

#### HAPLOPHRAGMOIDES sp. "a"

Plate I, figs. 13a, b

Test free, agglutinated, planispiral, involute, massive; wall of fine quartz grains with a large amount of siliceous cement; test fat, periphery broadly rounded, smooth to slightly lobulate; chambers irregularly increasing in size, 6 to 8 in the last whorl, little if at all inflated; sutures radial, straight, indistinct, slightly depressed; umbilical region slightly depressed; aperture indistinct, probably a low slit at the base of the apertural face. Greatest diameter of figured specimen 0.52 mm., least diameter 0.46 mm., thickness 0.22 mm.

This form is quite variable as to overall size, ratio of thickness to diameter, and roundness of the periphery. Thus, it could be placed in any one of the species, too numerous to mention, of this type unless one could compare with type material. The species is quite similar to many specimens in the California Mesozoic that have been called Cribrostomoides trinitatis Cushman and Jarvis and C. cretacea Cushman and Goudkoff, where those specimens have been recemented or crushed in such a manner as to obscure the aperture. None of the

specimens in this section show any evidence of a Cribrostomoides type aperture.

New Genus "A"

New Genus "A" n. sp. "a"

Plate I, figs. 3a-c, 4a-c

Test free, agglutinated; wall smooth to granular, of fine to medium quartz grains with a variable amount of siliceous cement; chambers numerous, simple, not increasing much in size, little or not at all inflated; chambers irregularly coiled, direction and plane of coiling constantly changing, sometimes as much as 90 degrees, giving rise to a subglobular test; sutures distinct, thickened, flush; aperture a round opening in the face of the last chamber, obscured in most specimens. Due to compression and variability of chamber arrangement, general appearance is quite variable. Greatest diameter of figured specimen 0.41 mm., least diameter 0.29 mm. In figs. 3a-c, the chambers are numbered to show the order in which they were added.

The genus most closely resembles Recurvoides Earland from the Recent, which has a planispiral early stage.

## Genus AMMOBACULITES Cushman, 1910

## AMMOBACULITES cf. COPROLITHIFORMIS (Schwager)

Plate II, figs. 5a, b

Haplophragmium coprolithiforme Schwager, 1868, Benecke's Geogn. -  
paleont. Beiträge, vol. 1, p. 654, pl. 34, fig. 3.

Ammobaculites coprolithiforme Cushman, 1927, Royal Soc. Canada,  
Trans., 3d ser., vol. 21, sec. 4, p. 130, pl. 1, figs. 6, 7.

Test free, agglutinated; wall of coarse quartz grains and a few  
sponge spicules (?) and radiolaria, with minor cement, surface rough;  
early portion of test planispiral, flattened, last 2 or 3 chambers uni-  
serial, straight, round in section; chambers often indistinct, particularly  
in the planispiral portion; sutures slightly depressed, horizontal in the  
uniserial portion; aperture terminal, round, sometimes with a sugges-  
tion of a neck. Length of hypotype 1.09 mm., breadth of coil 0.58 mm.,  
diameter of uniserial portion 0.51 mm.

Size, shape, and chamber arrangement are the same as in A.  
coprolithiformis but the wall is coarser. The same is true for A. cobbani  
Loeblich and Tappan and A. humei Nauss.

## AMMOBACULITES LUECKEI Cushman and Hedberg

Plate II, figs. 6a, b

Ammobaculites lueckei Cushman and Hedberg, 1941, Contr. Cushman  
Lab. Foram. Research, vol. 17, p. 83, pl. 21, figs. 4a, b.

Test free, agglutinated; wall of fine to medium quartz grains, but

smoothly finished; early chambers irregularly coiled, the remainder rectilinear, uniserial; test robust, not compressed; chambers distinct, inflated; uniserial sutures horizontal, depressed; aperture terminal, round to somewhat elongate, with a short neck. Length of hypotype 1.33 mm., uniserial breadth 0.58 mm.

### Family TEXTULARIIDAE

Genus SPIROPLECTAMMINA Cushman, 1927

SPIROPLECTAMMINA LAEVIS (Roemer) var. CRETOSA Cushman

Plate II, figs. 9a, b

Spiroplectammina laevis (Roemer) var. cretosa Cushman, 1932, Contr.

Cushman Lab. Foram. Research, vol. 8, p. 87, pl. 11, figs. 3a, b.

Test free, biserial; wall agglutinated, smooth, of fine particles with minor cement, test usually tan or brown; apical end broadly rounded, first few chambers increasing rapidly in width, remaining chambers increasing more slowly, all chambers low and broad; test thickest at median line, edges sharp, presenting an elongate diamond in cross section, the long direction through the edges; edges of test not lobulate; chambers numerous, 18-24 in adult, overlapping at the median line; sutures arcuate, thin, and almost flush in early portion, rapidly becoming raised and thickened on surface, edges of last chambers raised and thickened so that the edges are high; aperture a low slit at the base of the last formed chamber, apertural face very low. Length of hypotype



0.38 mm., breadth 0.33 mm., thickness 0.23 mm.

Although this form has been placed in Spiroplectammina, this subspecies at least, is probably a Textularia since the coiled stage is rare and small. It differs from Spiroplectammina senonana Lalicker in not having spines on the ends of the chambers, and the median line is not as raised.

SPIROPLECTAMMINA n. sp. "a"

Plate II, figs. 8a, b

Test free, agglutinated; wall granular, of fine quartz grains; strongly compressed, 1 1/2 times as long as broad, edges acute to truncate; early chambers planispirally coiled, usually one whorl, remainder of test biserial; chambers increasing rapidly in breadth but not in height, last few may become narrower, not overlapping; sutures thickened, raised, oblique, curved near median line, becoming straight nearer the edge; median line raised and thickened; aperture a low slit at the base of the last formed chamber. Length of figured specimen 0.30 mm., breadth 0.20 mm., thickness 0.09 mm.

S. gandolfi Carbonnier is less compressed and has a more acute periphery. S. dentata (Alth) var. tenuisa Gauger has spines on the ends of the chambers.

## Genus TEXTULARIA Defrance, 1824

## TEXTULARIA n. sp. "a"

## Plate II, figs. 7a, b

Test free, agglutinated, biserial; wall of medium quartz grains with a minor amount of siliceous cement; sutures, and sometimes majority of test, typically stained black; apical end rounded, test gradually tapering, slightly compressed, elongate, periphery rounded, lobulate; as many as 20 chambers in adult, increasing gradually in size, overlapping slightly at the median line, inflated, early chambers usually broken off; sutures distinct, depressed, straight, nearly horizontal, median line depressed; aperture a round opening at the base of the apertural face. Length of figured specimen 0.65 mm., breadth 0.29 mm., thickness 0.19 mm.

The black coloration is constant and distinctive, and sets this species off from all others of this general shape.

## Genus SIPHOTEXTULARIA Finlay, 1939

## SIPHOTEXTULARIA n. sp. "a"

## Plate II, figs. 12a, b

Test free, agglutinated, biserial, compressed; wall of fine to medium sized particles with much siliceous cement; chambers inflated, particularly the last few, increasing in size as added, much more rapidly in breadth than height; sutures depressed, oblique, indistinct in early

portion; aperture in the apertural face, with a massive neck. Length of figured specimen 0.67 mm., breadth 0.54 mm., thickness 0.24 mm.

Family VERNEUILINIDAE

Genus VERNEUILINA d'Orbigny, 1840

VERNEUILINA n. sp. "a"

Plate II, figs. 11a, b

Test free, agglutinated, triserial; wall granular, of fine quartz grains with much siliceous cement; test triangular, with slightly concave sides, one narrower than the other two, edges sharp to narrowly rounded; initial end of test rounded, width increasing for  $2/3$  to  $3/4$  the length, then test becoming narrower; sutures indistinct, flush, inclined; chambers numerous, not inflated; axis straight or twisted; aperture indistinct. Length of figured specimen 0.53 mm., maximum breadth 0.26 mm.

This species is smaller, finer grained, and has sharper edges than most of the known Cretaceous species.

Genus GAUDRYNELLA Plummer, 1931

GAUDRYNELLA n. sp. "a"

Plate II, figs. 13a, b, 14a, b

Test free, medium to large, agglutinated; early chambers triangular, triserial, then low, compressed biserial, the last few chambers

nodose, rectilinear, uniserial; two definite forms, the small form has good triserial and biserial stages, with the uniserial stage rare, the large form has a very short triserial stage which is usually broken off, and the biserial and uniserial stages are well developed; wall smooth, of fine grains with much siliceous cement; sutures depressed, particularly in the uniserial portion, straight and oblique in the biserial portion, horizontal in the uniserial stage; edge of biserial stage round, more so in the small form than in the large, sides flat to slightly convex; adult aperture large, terminal, round, with a short neck. Length of the large figured form (figs. 14a, b) 1.25 mm., width biserial stage 0.31 mm., thickness biserial stage 0.16 mm.; length of the small figured form (figs. 13a, b) 0.44 mm., biserial width 0.20 mm., biserial thickness 0.13 mm.

This species has most of the characteristics of Spiroplectinata Cushman, as he considered it in his later work, but in his original description of the genus he stated that the early chambers were planispiral, not triserial. S. annectens (Parker and Jones) of the Gault and Grayson is similar to this species, but is narrower and more delicate; and is too small to determine the early chamber arrangement, in fact, this is usually only the proloculum which is at the side of the biserial portion.

Other species of Gaudryinella, from the Cretaceous of Texas, have the biserial chambers more inflated and somewhat irregular.

## Genus PSEUDOC LAVULINA Cushman, 1936

## PSEUDOC LAVULINA CALIFORNICA Cushman and Todd

Plate III, figs. 1a-c

Pseudoclavulina californica Cushman and Todd, 1948, Contr. Cushman

Lab. Foram. Research, vol. 24, p. 92, pl. 16, fig. 6.

Test free, elongate, agglutinated; wall smooth, of fine quartz grains with minor calcareous cement; first  $1/4$  to  $1/3$  of test triserial, triangular, with slightly concave sides and sharply angled edges, remainder of test uniserial, rectilinear, circular in cross section; uniserial portion slightly offset; triserial chambers indistinct in many specimens, not inflated, increasing in size as added, uniserial chambers distinct, inflated; triserial sutures oblique, those in the uniserial portion horizontal; aperture terminal, round, with a short, thick neck. Length of hypotype 0.77 mm., greatest triserial breadth 0.29 mm., greatest uniserial breadth 0.22 mm.

The type specimens of P. californica are poorly preserved, but this is undoubtedly the same species.

PSEUDOC LAVULINA CALIFORNICA Cushman and Todd n. subsp. "a"

Plate III, figs. 2a, b

Test free, elongate, agglutinated; wall of fine sand grains with minor calcareous cement; first  $1/3$  to  $2/3$  of test triserial, triangular,

with concave sides and sharply angled edges, remainder of test uniserial, rectilinear, triangular, sides flat to concave, edges not as sharp as in early part of test, the last chamber is often globular, and round in cross section; triserial chambers indistinct, increasing in size as added, sutures flush, oblique; uniserial chambers of constant size except last one or two which are smaller, chambers highest at center, sutures depressed; aperture terminal, round, with a short neck. Length of figured specimen 1.02 mm., greatest triserial breadth 0.28 mm., greatest uniserial breadth 0.14 mm.

This subspecies differs from the typical form in that most of the uniserial portion is triangular in cross section.

*PSEUDOCALAVULINA CALIFORNICA* Cushman and Todd n. subsp. "b"

Plate III, figs. 3a, b

Test free, elongate, agglutinated, wall of fine sand grains with minor calcareous cement; first 1/3 of test triserial, triangular, with concave sides and narrowly rounded edges, axis often twisted; next few chambers biserial, remainder of test irregularly uniserial; triserial chambers gradually increasing in size, not inflated, often indistinct, sutures flush or slightly depressed, oblique; biserial chambers distinct, of constant size, inflated, somewhat irregularly shaped, overlapping slightly, sutures oblique, depressed, median line depressed; uniserial chambers distinct, of constant size, inflated, irregularly shaped, not in

a straight line, sutures oblique; aperture terminal, round, with a short neck. Length of figured specimen 0.85 mm., maximum triserial breadth 0.24 mm., diameter of last chamber 0.21.

This subspecies differs from the other two forms in having a biserial stage and in having the uniserial chambers staggered and irregularly shaped.

### Family VALVULINIDAE

Genus ARENOBULIMINA Cushman, 1927

ARENOBULIMINA ? n. sp. "a"

Plate II, figs. 10a, b

Test free, agglutinated; wall of medium quartz grains with a variable amount of siliceous cement, wall rough to fairly smooth; first few chambers triserial, remainder of test high spired with  $4 \frac{1}{2}$  to  $5 \frac{1}{2}$  chambers per whorl, 4 to 6 whorls in adult; test tapering; chambers distinct, round, somewhat inflated, simple, not increasing much in size as added; sutures distinct, depressed, spiral suture distinguishable; aperture not apparent. Length of figured specimen 0.68 mm., greatest diameter 0.42 mm.

The species is here considered an Arenobulimina on the basis of chamber arrangement, even though the aperture is not distinguishable. The holotype and paratypes of A. chapmani Cushman are similar, even

though his description and type figure are quite different, but his species has higher chambers, and the spiral suture is more prominent.

Genus MARSSONELLA Cushman, 1933

MARSSONELLA OXYCONA (Reuss)

Plate III, figs. 4a, b

Gaudryina oxycona Reuss, 1860, Sitz. Akad. Wiss. Wien, vol. 40,  
p. 229, pl. 12, fig. 3.

Marssonella oxycona (Reuss) Cushman, 1933, Contr. Cushman Lab.  
Foram. Research, vol. 9, p. 36, pl. 4, figs. 13a, b.

Test free, agglutinated, conical; wall smooth, of fine arenaceous material; earliest whorl with 4 or 5 chambers, later triserial, adult biserial; test usually elliptical in transverse section; chambers distinct but not inflated, simple, overlapping, broader than high, increasing gradually in size as added; sutures distinct, thin, flush; aperture a low broad opening at the inner margin of the last formed chamber, in many specimens with a valvular, tooth-like projection in the middle; apertural end of test flat or concave. Length of hypotype 0.52 mm., greatest breadth 0.41 mm.

MARSSONELLA n. sp. "a"

Plate III, figs. 5a, b

Test free, agglutinated; wall rough, translucent, of medium to



coarse quartz grains with siliceous cement; test tapering, flaring, wider than high in adult, elliptical in section, slightly twisted; early chambers 4 or 5 per whorl, rapidly becoming biserial; chambers indistinct, simple, not inflated, low, increasing rapidly in breadth but not in height; sutures indistinct, flush; apertural end broad, flat to concave; aperture a low slit at the inner margin of the last chamber. Length of figured specimen 0.27 mm., width 0.42 mm., thickness 0.32 mm.

The flaring shape of this species sets it apart from all others.

#### Genus DOROTHIA Plummer, 1931

#### DOROTHIA ? ALMADENENSIS Cushman and Todd

#### Plate III, figs. 9a, b

Dorothia ? almadenensis Cushman and Todd, 1948, Contr. Cushman

Lab. Foram. Research, vol. 24, p. 94, pl. 16, figs. 11, 12a, b.

Test free, agglutinated, large, robust; wall granular, thick, of fine quartz grains with calcareous cement; first whorl with 4 or 5 chambers, rapidly reducing to biserial; multiserial portion of test rounded in section, biserial portion slightly compressed, edges broadly rounded; chambers simple, inflated, high, increasing in size as added, overlapping slightly; sutures depressed, oblique, median line depressed; aperture a round opening at the inner margin of the last chamber, extending up into the face of the chamber. Length of hypotype 1.27 mm., biserial width 0.71 mm., biserial thickness 0.50 mm.

This species should probably be placed in the genus Plectina due to the shape and position of the aperture.

### DOROTHIA FILIFORMIS (Berthelin)

Plate III, figs. 6a-c, 7a-c

Gaudryina filiformis Berthelin, 1880, Mém. Soc. Géol. France, ser. 3, vol. 1, p. 25, pl. 1 (24), figs. 8a-d.

Dorothia filiformis (Berthelin) Cushman, 1937, Cushman Lab. Foram. Research, Sp. Publ., no. 8, p. 73, pl. 8, figs. 1a-c, 2.

Test free, agglutinated, elongate, sides nearly parallel; wall smooth to somewhat rough, of fine to medium quartz grains with little or much siliceous cement; chamber arrangement quite variable, the first few 4 per whorl, rapidly becoming triserial, later biserial, axis slightly twisted, ratio of triserial to biserial stage greatly variable with triserial portion making up 1/5 to 4/5 of the test; triserial portion rounded or, less commonly, sub-triangular in section, biserial portion circular or elliptical in section; initial end of rounded forms blunt, more pointed when early portion is triangular; chambers numerous, increasing irregularly and very gradually in size, indistinct except in fine-walled specimens, may or may not be inflated, of irregular shape; sutures often indistinct, flush to slightly depressed; aperture indistinct, appears to be a low slit at the base of the last chamber. Length of hypotype in fig. 6 is 0.49 mm., greatest triserial diameter 0.17 mm.,

greatest biserial diameter 0.19 mm., least biserial diameter 0.11 mm.

Length of hypotype in fig. 7 is 0.73 mm., greatest diameter 0.21 mm.

The tests of this species are usually crushed, making chamber relationships and position and shape of aperture quite difficult to determine.

#### DOROTHIA n. sp. "a"

Plate III, figs. 8a, b

Test free, agglutinated; wall of fine to medium quartz grains with minor calcareous cement; early portion of test multiserial to triserial, rounded, later portion biserial, slightly compressed, elliptical in section; chambers distinct, inflated, low, increasing more rapidly in width than height, overlapping in the biserial portion; sutures indistinct, depressed, median line depressed; test tapering, apical end rounded, apertural end broad, almost flat; aperture a slit in a depression at the inner margin of the last chamber. Length of figured specimen 0.58 mm., breadth 0.29 mm., thickness at the base of the apertural face 0.38 mm.

D. conula (Reuss) is shorter and stouter, with higher chambers.

#### DOROTHIA n. sp. "b"

Plate III, figs. 12a, b

Test free, agglutinated; wall smooth, of fine grains with minor calcareous cement; first whorl with 4 chambers, then triserial, rapidly

becoming biserial, triserial stage sometimes absent; test slightly compressed, edges broadly rounded, initial end pointed, test tapering, chambers inflated, increasing steadily in size, only slightly overlapping; sutures distinct, depressed, median line depressed; aperture arched, at the base of the inner margin of the last formed chamber; apertural face rounded. Length of figured specimen 0.66 mm., width 0.37 mm., thickness 0.31 mm.

Some of the specimens called D. gradata (Berthelin) by various authors resemble this species, but D. gradata is more robust, has more multiserial chambers, is coarser, and the aperture often has a slight lip.

#### Genus KARRERIELLA Cushman, 1933

##### KARRERIELLA n. sp. "a"

##### Plate III, figs. 10a, b, 11a, b

Test free, agglutinated, compressed; wall typically smooth, of fine siliceous fragments with much siliceous cement, rarely coarse and rough; first whorl with 5 or more chambers, rapidly reducing in number, with more than half of the test biserial; chambers distinct, inflated, elongate, or rarely round, overlapping in biserial portion; sutures distinct, depressed, in biserial portion straight and oblique; aperture elongate, with a strong neck, arising high in the median face of the last chamber. Length of specimen in fig. 10 is 0.63 mm., width 0.33 mm.,

biserial thickness 0.16 mm.; length of specimen in fig. 11 is 0.82 mm., width 0.34 mm., thickness 0.21 mm.

Genus LISTERELLA Cushman, 1933

LISTERELLA n. sp. "a"

Plate IV, figs. 1a, b

Test free, agglutinated; wall of medium to coarse sand grains with a variable amount of siliceous cement; early portion multiserial, 4 or 5 chambers per whorl, rapidly becoming rectilinear, uniserial; coiled portion short, little more than one whorl, uniserial portion straight, straight sided, circular in section; multiserial chambers increasing rapidly in size, uniserial ones only slightly, chambers not inflated; sutures flush, distinct; aperture terminal, circular, with a short neck. Length of figured specimen 0.50 mm., diameter of coil 0.30 mm., diameter of uniserial portion 0.22 mm.

Cushman described Listerella as new on p. 36 of the Contr. Cushman Lab. Foram. Research, vol. 9, 1933, stating that it had a terminal aperture with a neck which his type figure shows to be circular. On page 37, he set up the genus Martinottiella with the aperture elongate with a tooth or lip. The type figure shows a short neck. On page 138, Cushman Lab. Foram. Research, Sp. Publ. 8, 1937, he places Martinottiella in synonymy with Listerella; and states that, "further study of type material of the species originally referred to Clavulina

communis d'Orbigny and C. primaeva Cushman seems to show that these should be included under one genus. As the genus Listerella preceded Martinottiella, the former is here used." On page 138 of the 1950 edition of "Foraminifera" he places Listerella in synonymy with Martinottiella. Since Listerella has priority, it is used here.

LISTERELLA n. sp. "b"

Plate IV, figs. 2a, b, 3a, b

Test free, agglutinated; wall smooth, of fine quartz grains with siliceous cement, with a chitinous lining; early portion of test multi-serial or triserial, rounded, rapidly becoming uniserial, rectilinear, rounded, uniserial portion straight sided to tapering; sutures slightly depressed, often indistinct in triserial stage; chambers slightly inflated, usually 3 or 4 in the uniserial stage; triserial portion with slightly greater diameter than early uniserial chambers, chambers increasing in size as added; aperture terminal round, with a long neck. Length of form in fig. 2 is 0.37 mm., greatest diameter 0.15 mm.; length of form in fig. 3 is 0.40 mm., greatest diameter 0.30 mm.

Specimens found low in the section are small, with the uniserial portion straight sided; these grade up into the larger form with a tapered uniserial stage.

## Family MILIOLIDAE

Genus QUINQUELOCULINA d'Orbigny, 1826

QUINQUELOCULINA n. sp. "a"

Plate IV, figs. 4a-c

Test free, calcareous, imperforate, porcelaneous, white; test fat, almost as broad as long; chambers arranged in a quinqueloculine manner, 5 visible from the exterior; chambers little inflated, increasing in size as added, edges broadly rounded; sutures distinct, little if at all depressed; wall smooth, or with faint longitudinal costae near the inner edge of the last chamber; aperture terminal, round to semicircular, with a narrow lip or short neck, no tooth present in any specimens observed. Length of figured specimen 0.40 mm., width 0.30 mm., thickness 0.20 mm.

Most Cretaceous species of this genus are ornamented or have chambers more separated, with narrower or truncate edges. Q. wadei Berry is smaller, and has a distinct tooth.

## Family OPHTHALMIDIIDAE

Genus CORNUSPIRA Schultze, 1854

CORNUSPIRA sp. "a"

Plate IV, figs. 5a, b

Test free, calcareous, biconcave; planispiral, a small proloculum followed by a long undivided tube, round in section; test circular in plan

view; tube thin in early portion, gradually increasing in diameter, faint growth lines visible in later portion; tube slightly impressed over the preceding whorl; spiral suture depressed; aperture the open end of the tube, a high arch; delicate early portion often broken out. Diameter of figured specimen 0.31 mm., thickness 0.03 mm.

I have not seen type material that is comparable to this species, but there are many species in the literature to which this form might belong. No species is here selected since many are quite similar, and without type material one could easily err.

#### Family TROCHAMMINIDAE

Genus TROCHAMMINA Parker and Jones, 1859

TROCHAMMINA n. sp. "a"

Plate IV, figs. 6a-c

Test free, large, agglutinated, trochoid; wall coarse, of angular quartz grains, with minor siliceous cement; all chambers of the 2 or 3 whorls visible dorsally, ventrally only the 5 to 7 of the last whorl; chambers inflated, increasing in size as added; test flat to convex dorsally, chambers in a very low spire, sutures radial, depressed, spiral suture depressed; ventral sutures radial, depressed, umbilicus depressed to open; aperture indistinct, probably ventral, a low slit at the base of the last formed chamber between the umbilicus and periphery. Greatest diameter of figured specimen 1.01 mm., least diameter 0.72 mm.,



thickness 0.35 mm.

The most similar species is T. böhmi Franke which usually has fewer chambers.

TROCHAMMINA n. sp. "b"

Plate IV, figs. 7a-c, 8a-c

Test free, trochoid; wall granular, apparently composed entirely of siliceous cement; usually 2 whorls in adult, all chambers visible dorsally, ventrally only the 5 of the last whorl; chambers globular, increasing in size as added, little if at all appressed; umbilicus open; aperture indistinct, probably a low slit at the base of the last chamber between the umbilicus and periphery. Greatest diameter of specimen in fig. 7 is 0.44 mm., least diameter 0.35 mm., thickness 0.14 mm.; greatest diameter of specimen in fig. 8 is 0.29 mm., least diameter 0.24 mm., thickness 0.17 mm. Specimens are usually mashed so that the true shape is almost impossible to determine.

Chambers of T. lattai Loeblich and Tappan are not so globular; T. neocomiana Myatliuk is higher spired and has more chambers per whorl.

## Family LAGENIDAE

Genus ROBULUS Montfort, 1808

ROBULUS MODESTUS Bandy

Plate IV, figs. 9a, b

Robulus modestus Bandy, 1951, Jour. Pal, vol. 25, p. 493, pl. 72,  
figs. 9a, b.

Test free, calcareous, perforate; planispiral, involute; periphery sharp to rounded, never with a keel; chambers not inflated, not reaching umbilicus, umbilicus with an area of clear shell material which is rarely slightly raised, 8 to 16 chambers in the adult whorl with an average of 10; sutures distinct, generally thin, curved in early portion, becoming straighter in some adults; aperture radiate, elongate, at the peripheral angle; apertural face convex to concave. Greatest diameter of hypotype 0.70 mm., least diameter 0.55 mm., thickness 0.33 mm.

As here considered, this species is probably equivalent to many others in the literature since there are no special distinguishing characteristics. The lack of ornamentation, varying number of chambers, and degree of thickness and curvature of the sutures makes it very similar to species of many ages. R. modestus was chosen since it is the one closest to this area geographically and timewise.

## ROBULUS n. sp. "a"

Plate IV, figs. 10a, b

Test free, calcareous, perforate; planispiral, involute, robust, thickest in the umbilical region, periphery with a narrow keel; chambers increasing in size as added, slightly inflated, 7 to 11 in last whorl, usually 9 or 10; sutures curved, thickened and raised, may or may not be beaded, join at the umbilicus in a raised ring, an umbo, or an irregularly shaped raised, nodose area, sutures often modified by low costae which parallel the periphery, generally in the umbilical area; aperture radial, elongate, at the peripheral angle; apertural face slightly rounded, the edges greatly thickened. Greatest diameter of figured specimen 0.73 mm., least diameter 0.55 mm., thickness 0.45 mm.

This species is similar to Lenticulina (Lenticulina) wisselmanni Bettenstaedt from the Barremian of Germany, but L. wisselmanni is more evolute, the aperture is circular, and the sutures are not beaded. Lenticulina (Lenticulina) eichenbergi Bartenstein and Brand from the Barremian is similar, but is thinner and more evolute, and does not have beads on the sutures.

## ROBULUS n. sp. "b"

Plate IV, figs. 11a, b

Test free, large, calcareous, perforate; planispiral, close coiled, degree of involuteness variable; 10 to 16 chambers in adult, chambers

not inflated, increasing in size as added; sutures thickened, raised, slightly curved; periphery keeled; test thickest at the center with a large, raised boss of clear shell material in the umbilical area; aperture radiate, slightly elongate, at the peripheral angle; apertural face short, generally concave with the edges thickened, rarely rounded with no distinct edges. Greatest diameter of figured specimen 2.00 mm., least diameter 1.46 mm., thickness 0.75 mm.

The tests are often deformed due to compression, with the result that the chambers are sunken.

R. stephensoni Cushman does not have raised sutures. The great size separates this species from most others of this genus.

#### Genus DARBYELLA Howe and Wallace, 1933

##### DARBYELLA ? n. sp. "a"

##### Plate V, figs. 1a-c

Test free, calcareous, perforate, biconvex; trochoid, all chambers of the 1 1/2 to 2 whorls visible dorsally, ventrally only the 6 or 7 of the last whorl; chambers smooth, not inflated, meeting at the umbilicus ventrally; dorsally the whorls are evolute, only slightly appressed, sutures flush, slightly thickened, curved to nearly straight; aperture indistinct, apparently a rounded opening at the peripheral margin; apertural face rounded. Greatest diameter of figured specimen 0.28 mm., least diameter 0.24 mm., thickness 0.16 mm.

The specimens are small and not too well preserved, but the aperture does appear to be at the periphery. It is interesting that the entire test is trochoid, and not just the last chamber or two.

Genus LENTICULINA Lamarck, 1804

LENTICULINA CIRCUMCIDANEA (Berthelin)

Plate V, figs. 2a, b

Cristellaria circumcidanea Berthelin 1880, Soc. Géol. France, Mém., Sér. 3, vol. 1, no. 5, p. 52, pl. 3, figs. 1a, b.

Test free, calcareous, perforate; planispiral, tending to uncoil; periphery narrowly rounded or with a narrow keel; chambers inflated, later ones more so than early ones, increasing in size as added, 5 to 7 in adult whorl; sutures curved, depressed; aperture radiate, at the peripheral angle; apertural face broad and rounded. Greatest diameter of hypotype 0.76 mm., least diameter 0.51 mm., thickness 0.34 mm.

Genus MARGINULINA d'Orbigny, 1826

MARGINULINA CLAVA Lalicker

Plate V, figs. 3a, b

Marginulina clava Lalicker, 1950, Univ. Kans., Pal. Contr., no. 5 (Protozoa, art. 2), p. 13, pl. 1, figs. 8a, b.

Test free, calcareous, perforate; planispiral to uniserial, compressed; periphery and ventral margin rounded, sides almost flat,

periphery arcuate; chambers little if at all inflated, increasing more rapidly in breadth than height, usually 9 in adult; sutures flush or rarely slightly depressed, thickened, nearly straight, oblique to the axis, those of the uniserial portion reaching back almost to the planispiral portion; aperture radiate, at the peripheral angle, often produced. Length of hypotype 0.60 mm., width 0.34 mm., thickness 0.12 mm.

This species probably is a Planularia since it is compressed. P. plana (Reuss) does not have as large a coiled stage. Astacolus petalus Loeblich and Tappan has a shorter coiled stage, and does not have thickened sutures.

#### MARGINULINA (PSECADIUM) HAMULOIDES Brotzen

Plate V, figs. 9a, b, 10a, b

Marginulina (Psecadium) hamuloides Brotzen, 1936, Sver. Geol. Unders. Avh., Ser. C, no. 396 (<sup>O</sup>Arsb. 30, no. 3); p. 68, pl. 4, figs. 10a-c, 11a-c.

Test free, calcareous, perforate; early portion planispiral or arcuate, later chambers uniserial, arcuate; planispiral or strongly curved portion short, less than one volution; chambers little to greatly inflated, most inflated in straightest forms, 5 to 7 chambers in adult, increasing in size as added, but not uniformly so; uniserial portion of test circular or ovoid in section; dorsal margin smooth to slightly oblate, ventral margin lobulate, particularly in forms with arcuate early portion;

sutures depressed to varying degrees, oblique to the periphery; aperture round, radiate, at the dorsal margin, sometimes with a short neck. Length of hypotype with coiled stage 0.36 mm., greatest uniserial diameter 0.15 mm.; length of hypotype without coiled stage 0.41 mm., greatest uniserial diameter 0.16 mm.

M. erromena Loeblich and Tappan should probably be included in this species since forms of the size of both species are found in this section. Smaller forms are figured here since they are usually better preserved. The more uniserial types found in this section form a continuous series with the true M. hamuloides, although Brotzen did not include such types in his description.

#### MARGINULINA n. sp. "a"

Plate V, figs. 4a, b

Test free, calcareous, perforate; early chambers arcuate to coiled, last chamber or two uniserial, degree of coiling variable; chambers spherical, increasing in size as added, each enclosing much of the next older, chambers few, usually 4 to 6; sutures distinct, depressed; aperture terminal, central or slightly eccentric toward the periphery, simple to slightly radiate. Length of figured specimen 0.39 mm., greatest diameter 0.33 mm.

The most coiled forms somewhat resemble Cristellaria oligostegia Reuss, but that species is more planispiral and the chambers are not as

appressed. The great degree to which each chamber encloses the preceding one is the most distinguishing characteristic.

MARGINULINA n. sp. "b"

Plate V, figs. 5a, b

Test free, calcareous, perforate; one planispiral whorl, the remainder of the test uniserial; uniserial portion elliptical in cross section, not increasing much in diameter; inner and outer margins slightly curved, outer margin smooth, inner margin slightly lobulate; coiled portion very small compared with uniserial portion; 6 to 10 chambers in adult, increasing in size as added, uniserial chambers inflated, those in the planispiral stage are not; sutures distinct, flush in planispiral stage, depressed in uniserial stage, oblique to the periphery, slightly curved; aperture radiate, at the peripheral angle. Length of figured specimen 0.57 mm., diameter of the uniserial portion 0.19 mm.

M. flaccida Schwager is more compressed, and later chambers are more globular.

Genus MARGINULINOPSIS Sylvestri, 1904

MARGINULINOPSIS PHRAGMITES Loeblich and Tappan

Plate V, figs. 7a, b

Marginulinopsis phragmites Loeblich and Tappan, 1950, Jour. Wash.

Acad. Sci., vol. 40, p. 9, pl. 1, figs. 22, 23a, b.



Test free, calcareous, perforate; planispiral to uniserial; uniserial portion straight, elliptical in section; chambers numerous, 5 to 9 in adult, increasing slowly in size as added; sutures depressed, often slightly thickened, horizontal or slightly oblique to the axis; numerous strong costae, parallel to the periphery, extend the length of the test; aperture radiate, at or near the peripheral angle, often with a short neck; length of hypotype 0.50 mm., greatest uniserial diameter 0.23 mm.

The type specimens of M. phragmites seem a little longer and thinner, with sharper costae, than the specimens from the Horsetown.

#### Genus DENTALINA d'Orbigny, 1826

##### DENTALINA CATENULA Reuss

Plate V, figs. 13a, b

Dentalina catenula Reuss, 1860, Akad. Wiss. Wien, Math. - naturwiss. Kl., vol. 40, p. 185, pl. 3, fig. 6.

Test free, calcareous, perforate, uniserial, arcuate; chambers inflated, circular in cross section, produced at the apertural end but overlapped by the next younger so that each appears almost as broad as long, degree of constriction at the sutures variable; chambers increasing in size as added, 5 to 7 in unbroken adults, specimens generally broken; sutures distinct, slightly oblique, higher on the concave side; convex margin more lobulate than concave; aperture coarsely radiate, terminal,

slightly eccentric toward the inner margin of the curved test. Length of hypotype 0.64 mm., greatest diameter 0.26 mm.

DENTALINA cf. COALVILLENIS Peterson

Plate V, figs. 11a, b

Dentalina coalvillensis Peterson, 1953, Utah Geol. Min. Surv., Bull., no. 47 (Contr. Micropal., no. 1), p. 38, pl. 2, figs. 1, 2.

Test free, calcareous, perforate; uniserial, elongate, slightly curved; apical end with a short spine; chambers round in section, very slightly inflated, longer than broad, increasing in size as added, more rapidly in height than breadth; proloculum rounded, somewhat longer than next chamber; sutures thickened, variably oblique, generally highest on the convex margin; aperture radiate, terminal, slightly eccentric toward the convex margin; length of hypotype 0.77 mm., greatest diameter 0.13 mm.

This species does not have sutures as constricted as in adult of D. coalvillensis.

DENTALINA COMMUNIS (d'Orbigny)

Plate V, figs. 12a, b

Nodosaria (Dentaline) communis d'Orbigny, 1826, Ann. Sci. Nat., Sér. 1, vol. 7, p. 254, (type figure not given).

Dentalina communis (d'Orbigny) Plummer, 1931, Univ. Tex. Bull.,  
no. 3101, p. 149, pl. 11, fig. 4.

Test free, calcareous, perforate; uniserial, arcuate, round to ovoid in cross section, initial end round to pointed; early chambers often slightly compressed, later ones round, inflated, chambers increasing more rapidly in height than breadth, 5 to 9 in adult; concave margin smooth, convex margin somewhat lobulate, particularly in later portion; sutures thin, nearly flush in early portion, later depressed, oblique, highest at the concave margin; aperture radiate, terminal, eccentric and nearer the concave margin. Length of hypotype 0.87 mm., maximum diameter 0.14 mm.

DENTALINA n. sp. "a"

Plate V, figs. 14a, b

Test free, large, calcareous, perforate, tan or brown; elongate, uniserial, slightly arcuate, circular in cross section; microspheric form pointed at apical end, increasing in diameter as the 9 to 12 chambers are added, initial few chambers arcuate, sutures very oblique, later chambers rectilinear, sutures less oblique; megalospheric form with a large, rounded proloculum, chambers increasing in height more rapidly than breadth, sides of test nearly straight and parallel, sutures almost perpendicular to the axis; chambers overlapping, not inflated in either form; sutures in both forms thin, distinct, flush or slightly

depressed; aperture terminal, radiate, eccentric toward the convex margin. Length of figured specimen 1.11 mm., greatest diameter 0.37 mm.

Test distinctive in being massive, and in having the chambers overlapping.

Genus NODOSARIA Lamarck, 1812

"NODOSARIA" ORTHOSTOECHA Loeblich and Tappan

Plate V, figs. 8a, b

Nodosaria orthostoecha Loeblich and Tappan, 1950, Jour. Wash. Acad. Sci., vol. 40, p. 11, pl. 1, figs. 33a, b.

Test free, calcareous, perforate; uniserial, composed of 3 to 5 globular chambers in a rectilinear series; sutures distinct, depressed, slightly inclined; all chambers of roughly equal size; numerous low to prominent costae which run the length of the test are continuous across the sutures, and are generally crooked or slightly spiral; aperture radiate, terminal, eccentric. Length of hypotype 0.71 mm., diameter of last chamber 0.17 mm.

This species should be placed in the genus Dentalina since the sutures are slightly inclined and the aperture is off center. D. porcatulata Loeblich and Tappan is very similar, but the ribs are more spiral.

## NODOSARIA sp. "a"

Plate V, figs. 15a, b

Test free, calcareous, perforate; uniserial, rectilinear, initial end rounded; the three inflated chambers increasing in size as added; sutures distinct, depressed; surface ornamented by numerous low, longitudinal costae which are continuous across the sutures, approximately 15 at the apical end, branching to make a total of approximately 25 on the adult chamber; aperture terminal, centered or nearly so, round, produced, in some specimens with an indication of a long, thin neck. Length of figured specimen 0.64 mm., greatest diameter 0.28 mm.

Genus RECTOGLANDULINA Loeblich and Tappan, 1955

RECTOGLANDULINA QUINQUECOSTATA (Bornemann)

Plate VI, figs. 1a, b

Glandulina quinquecostata Bornemann, 1854, <sup>II</sup>Über Liasformation

Umgegend Göttingen, p. 32, pl. 2, fig. 6.

Rectoglandulina quinquecostata (Bornemann) Tappan, 1955, U. S. Geol.

Surv., Prof. Paper 236-B, p. 75, pl. 26, figs. 17, 18.

Test free, calcareous, perforate; uniserial, circular in cross section, tapering, the initial end rounded to pointed; chambers inflated, 4 to 6 in adult, increasing in size as added; sutures may or may not be distinct, generally depressed, rarely flush, perpendicular to the axis; 8 to

10 heavy ribs extend from the initial chamber to the aperture, continuous across the sutures; aperture terminal, simple, round, with a short, thin neck. Length of hypotype 0.81 mm., greatest diameter 0.22 mm.

Specimens from low in the section are less pointed, the aperture is less drawn out, the sutures are less depressed, and the apertural end of the last chamber is less drawn out, than in specimens high in this section. These older specimens are more like Tappan's types than specimens higher in the section.

Genus TRISTIX Macfadyen, 1941

TRISTIX ALCIMA Loeblich and Tappan

Plate VI, figs. 2a, b

Tristix alcima Loeblich and Tappan, 1950, Jour. Pal., vol. 24, p. 52, pl. 14, figs. 6a, b.

Test free, white or pinkish, calcareous perforate; uniserial, rectilinear; test expanding rapidly from a bulbous proloculum of variable size, forms with a relatively small proloculum having sides parallel in latter half of length, those with a large proloculum generally increase in width throughout length; chambers short, triangular in cross section, with concave faces, concavity variable; edges of test rounded, not lobulate, straight, rarely somewhat sigmoid; sutures distinct, slightly depressed, arched in the middle of each side of the test; aperture terminal

rounded to triradiate, with a short neck. Length of hypotype 0.41 mm., greatest width 0.29 mm.

A few specimens that would be called T. reesidei Loeblich and Tappan are present, but they probably represent a variant of T. alcima. I have examined specimens of Rhabdogonium excavatum Reuss, and it appears to be the same as Tristix alcima, however those specimens were not primary types.

#### Genus PSEUDOGLANDULINA Cushman, 1929

##### PSEUDOGLANDULINA n. sp. "a"

Plate VI, figs. 3a, b

Test free, calcareous, perforate, tan or amber in color; uniserial, axis straight, chambers telescoped, embracing, 4 to 6 in adult, increasing in size as added; sutures indistinct, flush, at right angles to the axis; aperture terminal, centered, radiate. Length of figured specimen 0.60 mm., greatest diameter 0.38 mm.

P. marginuliformis Frizzell usually has a coiled or arcuate stage, and the sutures are slightly depressed. P. humilis (Roemer) has depressed sutures, and each chamber overhangs the previous one.

Glandulina pygmaea Terquem 1866 (not G. pygmaea Reuss, 1851) is much shorter.

## Genus SARACENARIA Defrance, 1824

## SARACENARIA BONONIENSIS (Berthelin) n. subsp. "a"

Plate VI, figs. 8a, b

Cristellaria bononiensis Berthelin, 1880, Soc. Géol. France, Mém., ser. 3, vol. 1, mèm. 5, p. 55, pl. 3 (26), figs. 23a-c.

Saracenaria bononiensis (Berthelin) Tappan, 1940, Jour. Pal., vol. 14, p. 105, pl. 16, figs. 16a, b.

Test free, calcareous, perforate, small, typically white with clear edges; early portion of test planispiral, major portion uniserial, triangular with acute edges and almost flat sides and ventral margin, uniserial portion somewhat arcuate, not increasing much in breadth; periphery with a strong keel which continues over the coiled portion up onto the ventral margin; edges likewise marked by ridges of clear shell material which join the peripheral keel at the bottom of the test; chambers gradually increasing in size as added, 8 to 10 in adult; sutures flush, thickening near the periphery, straight, oblique; aperture radiate, at the peripheral angle; apertural face strongly oblique to the periphery, blending in with the ventral margin. Length of figured specimen 0.37 mm., uniserial thickness 0.14 mm., width of ventral margin 0.15 mm.

The subspecies differs from the typical in not having the aperture elongate, the sutures not as oblique, and the ventral margin is not lobulate.



## SARACENARIA CYPHA Loeblich and Tappan

Plate VI, figs. 4a, b

Saracenaria cypha Loeblich and Tappan, 1950, Jour. Pal., vol. 24,  
p. 54, pl. 14, figs. 9, 10a, b, 11.

Test free, calcareous, perforate; planispiral to uniserial, uniserial portion triangular in section; sutures distinct, flush to slightly depressed on sides, depressed on ventral margin with chambers slightly overlapping, sutures strongly curved in planispiral portion, less so in uniserial chambers; planispiral portion with a minor keel which often dies out in the uniserial chambers; sides flat to rounded, apertural face flat to rounded, edges round or angled; 7 to 11 chambers in adult, increasing in size as added; aperture radiate, at the peripheral angle. Length of hypotype 0.65 mm., breadth 0.30 mm., width of ventral margin 0.25 mm.

## SARACENARIA sp. "a"

Plate VI, figs. 9a, b

Test free, calcareous, perforate; planispirally coiled in young, becoming uniserial in adult, with all chambers in most specimens reaching to the coiled portion; coiled portion of test small, thin, compressed, uniserial portion making up a large portion of the test, with inner margin inflated, test roughly triangular in cross section, periphery acute; chambers increasing in size as added, not inflated, 8 to

11 in adult; sutures indistinct, thin, curved to sigmoid, flush; aperture at the peripheral margin, round, radiate; apertural face a continuation of the ventral margin, convex. Length of figured specimen 0.46 mm., width 0.22 mm., thickness 0.17 mm.

Individual specimens of this species could be placed in many species of Saracenaria, Lenticulina, or Astacolus. It would be futile to attempt to pick out the one that would fit the most specimens.

SARACENARIA n. sp. "a"

Plate VI, figs. 5a, b, 6a, b

Test free, calcareous, perforate, elongate; planispiral to uniserial, planispiral portion very short, in some specimens early portion arcuate only; chambers not inflated, increasing in size as added, 5 to 9 in adult; uniserial portion of test triangular in cross section, edges angular, periphery slightly arcuate, inner margin straight to arcuate, slightly lobulate; sutures indistinct, flush or rarely slightly depressed, oblique to the axis; aperture radiate, at the peripheral angle; apertural face blends with inner margin. Length of specimen in fig. 5 is 1.05 mm., breadth 0.25 mm., width of inner margin 0.21 mm.; length of specimen in fig. 6 is 0.85 mm., breadth 0.30 mm., width of inner margin 0.25 mm.

The great length and general lack of an apertural face are characteristic of this species.

## Genus LINGULINA d'Orbigny, 1826

## LINGULINA n. sp. "a"

## Plate VI, figs. 7a, b

Test free, calcareous, perforate; uniserial, rectilinear, compressed, thickest at the median line, edges sharp to rounded, carinate in some specimens; chambers rounded chevron shaped, inflated, 6 to 8 in adult, slightly embracing; initial end rounded, with a large proloculum, next 2 or 3 chambers increasing rapidly in breadth, later chambers all of same breadth or very slightly increasing, no noticeable increase in thickness of test in later chambers; sutures depressed; aperture terminal, medial, elongate, with a neck. Length of figured specimen 0.58 mm., width 0.26 mm., thickness 0.11 mm.

This species differs from L. taylorana Cushman in being larger and more parallel sided; and from L. pygmaea Reuss in being smaller, sutures more curved, and in having flanges at the basal edge of each chamber.

## LINGULINA n. sp. "b"

## Plate VI, figs. 10a, b

Test free, calcareous, perforate; uniserial, rectilinear, compressed; only broken specimens available, 3 chambers in all specimens, chambers slightly inflated, chevron shaped, not increasing in size; sutures thickened, raised, but not to highest level of chambers; 6 costae,

not affected by sutures, extend the length of the test, one in the middle of each edge, and one at each corner of the test; aperture terminal, centered, round, not radiate on any specimens seen. Length of figured specimen 0.33 mm., width 0.18 mm., thickness 0.10 mm.

Differs from Frondicularia pupa Terquem and Berthelin in being parallel sided.

Genus VAGINULINA d'Orbigny, 1826

VAGINULINA NEOCOMIANA Chapman

Plate VII, figs. 6a-c

Vaginulina neocomiana Chapman, 1894, Geol. Soc. London, Quart.

Jour., vol. 50, p. 711, pl. 34, figs. 10a, b, 11.

Test free, calcareous perforate; elongate, slender, tapering, arcuate, uniserial (?), the initial portion always broken off; subtriangular in cross section; chambers increasing in size as added, becoming more inflated in adult, especially on convex margin; sutures strongly oblique, depressed, highest at the concave margin; concave margin narrow, ribbed, not lobulate; convex margin lobulate, edges angled to rounded; aperture terminal, at the concave edge, radiate, produced. Length of hypotype 1.24 mm., width 0.19 mm., thickness of last chamber at convex margin 0.15 mm.

Considerably more robust and angular than V. debilis (Berthelin) from the lower Cretaceous of Texas.

## VAGINULINA RECTA Reuss

Plate VII, figs. 1a-c, 2a-c

Vaginulina recta Reuss, 1863, Akad. Wiss. Wien., Sitz., vol. 46, p. 48, pl. 3, figs. 14, 15.

Test free, calcareous, perforate; megalospheric form uniserial, microspheric form planispiral to uniserial; proloculum of megalospheric form raised above the rest of the test, other chambers not inflated, 3 to 7 in adult; test compressed, sides parallel, rectangular in section, margins truncate, slightly concave, periphery usually straight, ventral margin slightly lobulate; sutures oblique, flush to depressed, or very rarely slightly raised; aperture radiate, at the peripheral angle. Length of microspheric hypotype 1.10 mm., width 0.23 mm., thickness 0.16 mm.; length of megalospheric hypotype 0.61 mm., width 0.19 mm., thickness 0.10 mm.

Although V. recta is supposed to have slightly raised sutures, many specimens from the lower Cretaceous of Texas have sutures flush or even slightly depressed. V. kochii Roemer has more strongly raised sutures, and is tapered. V. geisendorferi Franke as used by Tappan (1940) is the same as this species, in part, but the type has much more inflated chambers.

## VAGINULINA SUBROTUNDA ten Dam

Plate VI, figs. 12, 13a, b

Vaginulina subrotunda ten Dam, 1946, Jour. Pal., vol. 20, p. 574,  
pl. 88, figs. 3a, b.

Test free, calcareous, perforate; compressed, flat, planispiral to uniserial, coiled portion small; chambers increasing in size as added, 6 or 7 in adult, not inflated; uniserial portion of periphery straight to arcuate, thickened by three longitudinal costae; inner margin straight, truncate, edges slightly keeled by coalescing sutures; sutures distinct, raised to depressed, strongly oblique to the axis, slightly curved, generally reaching back almost to the coiled portion of the test; early portion of the test ornamented by numerous longitudinal costae, those near the periphery parallel to it, the inner ones converging on the periphery distally; later portion of test with costae, or only in the vicinity of the sutures; aperture radiate, at the peripheral angle. Length of hypotype in fig. 12 is 0.60 mm., width 0.23 mm., thickness 0.06 mm.; length of hypotype in fig. 23 is 0.55 mm., width 0.25 mm., thickness 0.12 mm.

The type specimens of V. subrotunda are slightly larger than the specimens from this section. V. complanata (Reuss) var. perstriata Tappan is probably a junior synonym; or, at most, a variety of this species.

## VAGINULINA n. sp. "a"

Plate VII, figs. 3a, b

Test free, calcareous, perforate, compressed, small; planispiral to uniserial, the planispiral stage very short; 5 to 7 chambers in adult, a bulbous proloculum followed by 2 or 3 coiled or strongly arcuate chambers, the remaining chambers uniserial but reaching back towards the proloculum, chambers may or may not continually increase in size as added; dorsal and ventral margins rounded, the chambers oval in cross section, ventral margin a smooth curve, each chamber making a definite angle on the dorsal margin; sutures slightly thickened, flush, rarely slightly depressed, curved in coiled portion, later becoming straight or sigmoid; aperture terminal, radiate, at the peripheral angle, with a neck. Length of figured specimen 0.31 mm., diameter of coil 0.30 mm., diameter of uniserial portion 0.12 mm.

The angles on the dorsal margin are distinctive of the species, and distinguish it from all others.

## VAGINULINA n. sp. "b"

Plate VI, figs. 11a, b

Test free, calcareous, perforate; planispiral in early stages, becoming uniserial in some adults; test compressed, edges round, smooth, periphery arcuate; chambers increasing in size as added, 8 to 11 in adult; sutures thickened, raised, slightly curved, the area posterior

to each depressed in the uniserial portion of the test, sutures in planispiral portion meet at the umbilicus to form a round bump of clear shell material in many specimens; aperture terminal radiate, at the peripheral angle. Length of figured specimen 0.60 mm., width 0.35 mm., thickness 0.17 mm.

Astacolus daintreei (Chapman) does not have the knob of shell material.

Genus ASTACOLUS Montfort, 1808

ASTACOLUS aff. PEDIACUS Tappan

Plate VI, figs. 14a, b, 15a, b

Astacolus pediacus Tappan, 1955, U. S. Geol. Surv., Prof. Paper 236-B, p. 57, pl. 17, figs. 1-10.

Test free, calcareous, perforate, compressed, elongate; planispiral or arcuate to uniserial, planispiral portion very small, hardly one full whorl, generally simple strongly arcuate; chambers increasing in size as added, 7 to 11 in adult, not inflated, reaching back toward the coiled portion, triangular; edges rounded, test thickened at the middle or near the ventral margin; width of test increasing slightly toward the apertural end, dorsal margin arcuate to almost straight, ventral margin straight or slightly arcuate; sutures flush or rarely slightly depressed, of variable thickness, thickest near the dorsal edge, strongly oblique, straight to slightly curved; aperture radiate, terminal, at the dorsal



angle; apertural face long, rounded, blending with the ventral margin. Length of "microspheric" hypotype 0.70 mm., width 0.22 mm., thickness 0.13 mm.; length of "megalospheric" hypotype 0.56 mm., width 0.20 mm., thickness 0.13 mm.

This species is quite variable as to length, thickness, and angle of sutures with no definite megalospheric and microspheric stages. It probably includes portions of A. arietus (Terquem), A. caliopsis (Reuss), A. varians recta (Franke), A. apyrastus Tappan, Vaginulinopsis epicharis Loeblich and Tappan, and Vaginulina tripleura (Reuss).

#### ASTACOLUS n. sp. "a"

Plate V, figs. 6a, b

Test free, calcareous, perforate; early portion planispiral and close coiled, later tending to uncoil, rarely with one or two uniserial chambers; planispiral portion robust, thickest in the umbonal area, later portion flattened; periphery thin but rounded, inner margin rounded, periphery almost straight in uncoiled portion; chambers increasing rapidly in size as added, not inflated; sutures flush, thickened, but thinner near the periphery in some specimens, sutures in adult portion strongly oblique to the periphery, reaching back toward the coiled portion of the test; aperture radiate, at the peripheral angle; apertural face narrow, rounded.

Length of figured specimen 0.83 mm., diameter of coiled portion 0.35 mm., thickness 0.21 mm.

This species is distinctive in being fat in the early portion, later compressed; and in the uncoiling stage.

Genus PALMULA Lea, 1833

PALMULA sp. "a"

Plate VII, figs. 4a, b

Test free, calcareous, perforate, compressed; early portion of test planispiral, evolute, last few chambers uniserial, chevron shaped; planispiral portion thickened at umbilical area, with an umbo on each side; periphery broadly rounded; uniserial portion flat, compressed, periphery becoming truncate; chambers increasing in size as added, 11 to 14 in adult, not inflated; sutures flush, thickened, curved in planispiral portion, chevron shaped in uniserial portion; aperture radiate, at the peripheral angle in the early chambers, becoming terminal in the uniserial portion. Length of figured specimen 0.57 mm., greatest uniserial width 0.31 mm., thickness 0.18 mm.

None of these specimens are definitely adults, nevertheless they are distinctive.

Genus FRONDICULARIA Defrance, 1824

FRONDICULARIA cf. CUSHMANI Loeblich and Tappan

Plate VII, figs. 5a, b

Fronidicularia cushmani Loeblich and Tappan, 1941, Bull. Amer. Pal.,  
vol. 26, no. 99, p. 14 (340), pl. 3 (49), fig. 4.

Test free, calcareous, perforate; uniserial, compressed, palmate in plan view, sides of test concave, edges truncate, lobulate, curved; succeeding chambers farther removed from the base of the test; proloculum globular, rising above the general level of the test, remainder of chambers chevron shaped, not inflated, 4 to 8 in adult; sutures distinct, thickened, flush in median portion of test, raised near the periphery, curved back there to form double keels along the edges; numerous low, discontinuous costae are present which may parallel or slightly diverge from the median line, some costae cross sutures, proloculum often with one low costa extending into the next chamber; aperture terminal, round, radiate, produced. Length of hypotype 0.65 mm., width 0.36 mm., thickness 0.11 mm. (not proloculum).

F. cushmani type specimens do not have the chambers as much removed from the base.

Genus LAGENA Walker and Jacob, 1798

LAGENA n. sp. "a"

Plate VII, figs. 7a, b

Test free, calcareous, perforate, very large for the genus; unilocular, ovate in side view, circular in cross section; surface smooth; apical end rounded or very slightly produced; aperture terminal, coarsely radiate. Length of figured specimen 0.62 mm., diameter 0.38 mm.

Differs from all other species in its large size and coarsely radiate aperture.

Family POLYMORPHINIDAE

Genus PALEOPOLYMORPHINA Cushman and Ozawa, 1930

PALEOPOLYMORPHINA n. sp. "a"

Plate VII, figs. 8a-c

Test free, calcareous, perforate; elongate, the initial end blunt, not increasing much in diameter; early chambers spiral, rapidly becoming biserial, test slightly twisted; chambers elongate, somewhat inflated, increasing rapidly in length; succeeding chambers further removed from the base; aperture terminal, round, radiate. Length of figured specimen 0.41 mm., diameter 0.11 mm.

The general shape of the test, and the degree to which the chambers are removed from the base makes this species quite distinctive.

## Genus GUTTULINA d'Orbigny, 1839

## GUTTULINA n. sp. "a"

Plate VII, figs. 9a-c

Test free, small, calcareous, perforate; bulbous, an irregular oval in cross section; chambers elongate, quinqueloculine, five visible, increasing in size as added, succeeding, chambers somewhat removed from base, inflated, but sutures not depressed; sutures thin, often indistinct; greatest diameter of test  $1/3$  of way from base; aperture terminal, elongate. Length of figured specimen 0.30 mm., greatest diameter 0.25 mm.

The general shape of the test distinguishes this species from others.

## Genus PYRULINA d'Orbigny, 1839

## PYRULINA CYLINDROIDES (Roemer)

Plate VII, figs. 13a, b

Polymorphina cylindroides Roemer, 1838, Neues Jahrb., p. 385, pl. 3, fig. 26.

Pyrulina cylindroides (Roemer) Cushman and Ozawa, 1930, U. S. Nat. Mus. Proc., vol. 77, art. 6, p. 56, pl. 14, figs. 1-5.

Test free, calcareous, perforate; elongate, fusiform, apical and pointed, greatest diameter near middle of test, early chambers triserial; chambers elongate, overlapping, increasing in size as added, each

further removed from the base than the preceding one, chambers very little inflated; sutures thin, indistinct, often slightly depressed in adult portion of test; aperture terminal, radiate. Length of hypotype 0.50 mm., greatest diameter 0.17 mm.

Specimens from the Horsetown have the chambers less inflated than those from the lower Cretaceous of Texas; however, Cushman (1946) shows a considerable amount of variation in P. cylindroides.

#### PYRULINA SHOALCREEKENSIS Bullard

Plate VII, figs. 10a-c

Pyrulina shoalcreekensis Bullard, 1953, Jour. Pal., vol. 27, no. 3, p. 344, pl. 46, figs. 9-12, syntypes.

Test free, calcareous, perforate; fat, acuminate, greatest diameter in the early half of the test; early chambers triloculine, possibly quinqueloculine in a few specimens, rapidly becoming biserial, succeeding chambers further removed from the base; chambers not inflated, increasing in size as added; sutures thin, flush, often indistinct; aperture terminal, round, radiate. Length of hypotype 0.39 mm., greatest diameter 0.20 mm.

## Family HETEROHELICIDAE

Genus GÜMBELITRIELLA Tappan, 1940

"GÜMBELITRIELLA" ? n. sp. "a"

Plate VIII, figs. 11a-c

Test free, calcareous, perforate; high trochospiral, subtriangular to subquadrate in cross section; chambers distinct, globose, smooth, increasing rapidly in size as added, 3 or 4 per whorl except sometimes adding extra chambers somewhat indiscriminately in the last whorl; spiral suture not apparent; umbilicus large, open, aperture indeterminate in available specimens, the umbilicus filled with debris. Height of figured specimen 0.20 mm., greatest diameter 0.27 mm., least diameter 0.26 mm.

This species is tentatively placed in Gümbelitrella on the basis of chamber arrangement in spite of the fact that the aperture is not visible.

Tappan (1940) erected the genus for forms with the early chambers triserial as in Gümbelitra, but with the later portion multiserial. On page 115 she set up Gümbelitra harrisi n. sp., a small, triangular, triserial form with globose chambers. The type species of Gümbelitrella, G. graysonensis, is erected and first described on page 116 for forms with "Test small, free in the early stage similar to Gümbelitra harrisi n. sp., later chambers added irregularly, generally with four or five exposed when viewed from above...." From

an examination of topotype material it would appear that Gumbelitriella graysonensis may be conspecific with Gumbelitria harrisi; that is, it covers those forms in which the later chambers are added in an irregular manner. Thus, Gumbelitriella may not even be a distinct and separate genus; in which case this species from the Horsetown may belong in Gumbelitria.

Family BULIMINIDAE

Genus BULIMINA d'Orbigny, 1826

BULIMINA ? sp. "a"

Plate VII, figs. 12a, b

Test free, calcareous, perforate; an elongate spiral, triserial, spiral suture not prominent; test robust, rounded in section, initial end blunt, broadest  $2/3$  the distance from the initial end; chambers inflated, increasing in size as added; aperture not discernible. Length of figured specimen 0.53 mm., greatest diameter 0.33 mm.

This species is larger than B. nannina Tappan from the Grayson, and has higher chambers.



## Family ELLIPSOIDINIDAE

Genus PLEUROSTOMELLA Reuss, 1860

PLEUROSTOMELLA OBTUSA Berthelin

Plate VIII, figs. 2a-c, 3a, b

Pleurostomella obtusa Berthelin, 1880, Soc. Géol. France, Mém., sér. 3, vol. 1, no. 5, p. 29, pl. 1, figs. 9a, b.

Test free, calcareous, perforate, elongate; trimorphic, one "megalospheric" and two "microspheric" forms; megalospheric form long, slender, initial end blunt, chambers increasing more rapidly in height than breadth, not much inflated, 7 or 8 in adult, early chambers almost uniserial, rectilinear, rapidly becoming loosely biserial with the chambers not much displaced from the median line; rare microspheric form differs from the megalospheric form in that the initial end is more pointed and is compressed, first 5 to 7 chambers regularly biserial, later chambers as in megalospheric form, early portion of test is twisted, 13 or 14 chambers in adult; common microspheric form is more pointed at the initial end than the megalospheric form, first 4 to 6 chambers slightly flattened, distinctly biserial, twisted, later chambers more rectilinear, but not as much as in other forms, chambers inflated, 8 to 11 in adult; rare microspheric form is long and slender, common microspheric form is short and tapering; the aperture in all forms is a depressed, high arched opening on the inner side of the chamber, with two sharp teeth. Length of the common microspheric hypotype

0.36 mm., greatest diameter 0.13 mm.; length of the megalospheric hypotype 0.62 mm., greatest diameter 0.15 mm.

These forms have been placed in several different species by other authors, but are here considered to be the same because of similarity of morphology and geologic range.

Genus ELLIPSOGLANDULINA Silvestri, 1900

ELLIPSOGLANDULINA n. sp. "a"

Plate VIII, figs. 1a-c

Test free, small, calcareous, perforate; slightly flattened, elliptical in cross section, oval in side view, the greatest diameter near the middle of the test; adult with 4 rectilinear uniserial, overlapping chambers increasing in size as added, last chamber making up  $2/3$  of test, chambers not much inflated; sutures indistinct, flush, horizontal; aperture terminal, an elongate slit parallel to the long axis of the ellipse. Length of figured specimen 0.27 mm., width 0.19 mm., thickness 0.17 mm.

The small size and somewhat flattened test serve to separate this species from all others of the genus.

## Family ROTALIIDAE

Genus VALVULINERIA Cushman, 1926

VALVULINERIA n. sp. "a"

Plate VIII, figs. 4a-c

Test free, calcareous, perforate; trochoid, convex dorsally, concave ventrally, periphery rounded, smooth to lobulate; chambers increasing in size as added, all those of the 3 whorls visible dorsally, ventrally only the 5 of the last whorl, chambers inflated, more so ventrally than dorsally, perforations coarser on the dorsal than the ventral side; ventral sutures straight, radial, depressed; dorsal sutures slightly curved and oblique, depressed, spiral suture depressed; umbilicus deep, partially covered by a flap of shell material extending in from the last formed chamber; aperture a low arched slit midway between the umbilicus and the periphery at the base of the last formed chamber, with a valvular lip, and extending into the umbilicus under the flap of shell material. Greatest diameter of figured specimen 0.29 mm., least diameter 0.24 mm., thickness 0.13 mm.

The relatively large size of the umbilicus distinguishes this species from others of comparable age.

Genus GYROIDINA d'Orbigny, 1826

GYROIDINA LOETTERLEI Tappan

Plate VIII, figs. 5a-c

Gyroidina loetterlei Tappan, 1940, Jour. Pal., vol. 14, p. 120, pl.

19, figs. 10a-c.

Test free, calcareous, perforate; trochoid, test plano-convex, the periphery broadly rounded, not lobulate; chambers increasing in size as added, all chambers of the 2 to 2 1/2 whorls visible dorsally, only the 7 or 8 of the last whorl ventrally; sutures distinct, radial, flush in early portion, becoming slightly depressed in later chambers; umbilicus closed or shallow; aperture a slit at the base of the last chamber, extending from the umbilicus almost to the periphery, with a narrow flap in well preserved specimens; apertural face high. Greatest diameter of hypotype 0.31 mm., least diameter 0.24 mm., thickness 0.16 mm.

GYROIDINA n. sp. "a"

Plate VIII, figs. 6a-c

Test free, calcareous, perforate; trochoid, subspherical to unequally biconvex; chambers increasing in size rapidly, dorsally all the chambers of the 2 to 3 whorls visible, ventrally only the 6 or 7 of the last whorl; periphery very broadly rounded, not lobulate, dorsal side little or strongly convex, ventral side highly convex but not pointed;

sutures radial, slightly curved, thin to slightly thickened, flush or a little depressed, spiral suture slightly depressed; umbilicus closed or with a slight depression; aperture a slit at the base of the last formed chamber, partially covered with a large lip, and either limited to an area halfway between the umbilicus and periphery or reaching almost to the umbilicus. Greatest diameter of figured specimen 0.51 mm., least diameter 0.44 mm., thickness 0.44 mm.

The globular shape and the large lip are distinctive.

#### Genus EPONIDES Montfort, 1808

EPONIDES ? sp. "a"

Plate VIII, figs. 7a-c

Test free, calcareous, perforate; strongly biconvex, more so ventrally than dorsally, thickest at the umbilicus; trochoid, all chambers of the 2 to 2 1/2 whorls visible dorsally, ventrally only the 6 or 7 of the last whorl; chambers increasing slowly in size, not inflated, reaching to the umbilicus ventrally; dorsal sutures radial, thickened, flush, spiral suture distinct; ventral sutures straight or slightly curved, thickened, flush to slightly depressed; aperture indefinite, possibly a low slit at the base of the apertural face between the umbilicus and periphery. Greatest diameter of figured specimen 0.30 mm., least diameter 0.27 mm., thickness 0.17 mm.

Since the position and shape of the aperture can not be determined, the generic determination is only provisional.

Genus OSANGULARIA Brotzen, 1940

OSANGULARIA n. sp. "a"

Plate VIII, figs. 8a-c

Test free, calcareous, perforate; trochoid, strongly and equally biconvex, thickest at the umbilicus, periphery sharp; all chambers of the  $2\frac{1}{2}$  to 3 whorls visible dorsally, ventrally only the 8 to 12 of the last whorl, chambers increasing in size as added, not inflated; ventral sutures radial, curved, thickened, slightly raised, but may be depressed in the last few chambers, meeting at the umbilicus in a large plug of clear shell material; dorsal sutures oblique, particularly in the adult, straight to curved, thickened, flush or raised, spiral suture definite but not much raised if at all; first  $1\frac{1}{2}$  whorls covered with a thick layer of shell material dorsally; aperture a straight slit extending from the base of the last chamber,  $\frac{2}{3}$  the distance from the umbilicus to the periphery, up into the apertural face, surrounded by a lip. Greatest diameter of figured specimen 0.32 mm., least diameter 0.27 mm., thickness 0.18 mm.

The test is usually larger and the sutures more raised in the lower part of the range of the species than in the upper portion.

## OSANGULARIA n. sp. "b"

Plate VIII, figs. 9a-c

Test free, calcareous, coarsely perforate; trochoid, all chambers of the 2 to 2 1/2 whorls visible dorsally, ventrally only the 9 to 12 of the last whorl, chambers increasing in size as added, not inflated; test biconvex, more so dorsally than ventrally; ventral sutures thickened, raised, often depressed in last few chambers, radial, curved, meeting at the umbilicus but not forming a distinct plug; dorsal sutures thickened, raised, somewhat oblique, curved, sutures join at the periphery to give test a thickened edge, spiral suture raised and distinct; aperture a slit, surrounded by a low lip, midway between the umbilicus and periphery, extending from the base of the last chamber up into the apertural face. Greatest diameter of figured specimen 0.27 mm., least diameter 0.21 mm., thickness 0.10 mm.

This species differs from O. n. sp. "a" in being flatter ventrally, not having a large umbilical plug, and in having the periphery thickened by the coalescing sutures.

## OSANGULARIA n. sp. "c"

Plate VIII, figs. 10a-c

Test free, calcareous, perforate; strongly and almost symmetrically biconvex; trochoid, a low spiral on the dorsal side, all chambers of the 2 whorls visible dorsally, ventrally only the 9 or 10 of the last whorl;

chambers increasing in size as added, not inflated; ventral sutures flush, thickened, nearly radial, but curved backward near the periphery, meeting and forming a large plug of clear shell material at the umbilicus, with a slight spiral depression in the plug; dorsal sutures strongly thickened, little if at all raised, oblique, bending strongly backward near the periphery, spiral suture thickened, raised in some specimens; chambers curved or triangular depending upon the individual specimen, aperture a narrow slit, extending from the base of the apertural face, near the periphery, into the apertural face, parallel to the axis of coiling, with a faint lip. Greatest diameter of figured specimen 0.31 mm., least diameter 0.26 mm., thickness 0.14 mm.

This species differs from the two above in having no more than two whorls, and in that the sutures are usually flush.

Genus EPISTOMINA Terquem, 1883

EPISTOMINA SUPRACRETACEA ten Dam

Plate IX, figs. 1a-c

Epistomina caracolla (Roemer) Franke, 1925, Abh, Geol. Pal. Inst.

Univ. Greifswald, vol. 6, p. 88, pl. 8, fig. 10.

Epistomina elegans (d'Orbigny) Cushman, 1927, Jour. Pal., vol. 1,

p. 166, pl. 26, figs. 3, 4.

Epistomina partschiana (d'Orbigny) Franke, 1928, Abh, Preuss. Geol.

Landesanst., N. F., heft 111, pp. 185-186, pl. 17, fig. 9.



Epistomina supracretacea ten Dam, 1948, Inst. Franc. Pétrole, Rev.,  
vol. 3, no. 6, p. 163.

Test free, calcareous, perforate; trochoid, the dorsal side somewhat convex, ventrally strongly so; all chambers of the 2 to 2 1/2 whorls visible dorsally; ventrally only the 7 or 8 of the last whorl, chambers increasing in size as added, reaching to the umbilicus ventrally; ventral sutures radiate, thickened, very slightly raised; dorsal sutures oblique, straight, thick and raised, curving backward at the periphery to give the test a thickened edge, spiral suture prominent; apertures several, an elongate opening in each chamber near the periphery on the ventral side, parallel to the periphery, usually all except the last one or two closed with clear shell material. Greatest diameter of hypotype 0.64 mm., least diameter 0.53 mm., thickness 0.32 mm.

Specimens from low in the section are often smaller than the hypotype. The tests are usually eroded to a point where the sutures are not raised.

#### EPISTOMINA sp. "a"

Plate VIII, figs. 12a-c

Test free, large, calcareous, perforate, white; biconvex, convexity variable, usually more so ventrally than dorsally; trochoid, all chambers of the 1 1/2 to 2 1/2 whorls visible dorsally, ventrally only the 7 or 8 of the last whorl, chambers meeting at the umbilicus;

chambers little if at all inflated, increasing in size as added; dorsal sutures very thick, raised curved, swept backward and meeting at the periphery to form a thick edge on test, spiral suture distinct; ventral sutures radial, very thick and raised, meeting at the umbilicus to form a large mass of thick shell material, ventral sutures often thicker near umbilicus than periphery; apertures several, ventral, near and parallel to the periphery, closed with clear shell material, commonly one per chamber, but often with a partition making two short slits per chamber, or the aperture in line with a suture. Greatest diameter of figured specimen 0.85 mm., least diameter 0.73 mm., thickness 0.50 mm.

Tests more convex ventrally lower in the section than near the top; figured specimen from near the top of the range of the species.

#### New Genus "B"

New Genus "B" n. sp. "a"

Plate VIII, figs. 11a-c

Test free, calcareous, perforate; trochoid, biconvex, compressed; all chambers of the  $2\frac{1}{2}$  to 3 whorls visible dorsally, only the 10 to 12 of the last whorl visible ventrally, chambers increasing in size as added, not inflated; periphery truncate, rarely narrowly rounded, slightly lobulate; ventral sutures raised, thickened, radial, but curving

posteriorly near the periphery, joining to form a rounded ventral keel, meeting in the umbilicus to form a slightly raised plug of clear shell material, in most specimens the last 2 or 3 sutures are depressed near the umbilicus; dorsal sutures thickened, raised, oblique, slightly curved, becoming more so near the periphery where they curve posteriorly and join to form a rounded dorsal keel, which becomes a raised spiral suture on older whorls, spiral suture forms a knob of clear shell material over the proloculum; apertural face depressed, oblique to the plane of coiling; aperture a slit, surrounded by a thin lip, in the middle of the apertural face, and perpendicular to the plane of coiling. Greatest diameter of figured specimen 0.50 mm., least diameter 0.38 mm., thickness 0.16 mm.

This genus differs from Osangularia Brotzen in having a truncate periphery, and being flatter. It differs from the Globotruncanidae in having thickened ventral sutures, the aperture single and extending into the apertural face, in having a lip completely surrounding the aperture, and in having the umbilicus closed with a plug.

New Genus "C"

New Genus "C" n. sp. "a"

Plate IX, figs. 3a-c

Test free, calcareous, perforate; trochoid, all chambers of the 2 1/2 to 3 1/2 whorls visible dorsally, ventrally only the 5 or 6 of the

last whorl, chambers increasing in size as added, slightly inflated ventrally, test biconvex, more so dorsally than ventrally, thickest at the umbilicus, periphery rounded, test subcircular in plan view; dorsal sutures arcuate, almost parallel to the periphery, thick, raised, making up most of the dorsal surface, spiral suture not prominent; ventral sutures radial, thin, depressed; dorsally the chambers are narrow, elongate, ventrally they are broad, reaching to the umbilicus; apertures several, ventral, primary aperture a low arch at the base of the last chamber near the umbilicus, secondary apertures elongate, near the umbilicus, extending anteriorly from a suture into the next chamber, early ones covered with thin shell material. Greatest diameter of figured specimen 0.33 mm., least diameter 0.30 mm., thickness 0.21 mm.

This genus differs from Buccella Andersen in that the secondary apertures are not confined to the sutures, the ventral side is not pustulose, the umbilicus is not open, and the dorsal sutures are almost parallel to the periphery.

#### Family GLOBIGERINIDAE

Genus GLOBIGERINA d'Orbigny, 1826

GLOBIGERINA sp. "a"

Plate IX, figs. 2a-c

Test free, calcareous, perforate; trochoid, 3 or 4 chambers in early whorls, usually 3 in the last whorl; chambers globular, increasing

rapidly in size, the last chamber almost equal in size to the two preceding; umbilicus small, usually filled with debris; aperture an arched slit extending from the umbilicus towards the periphery. Greatest diameter of figured specimen 0.31 mm., least diameter 0.24 mm., height 0.18 mm.

### Family GLOBOROTALIIDAE

Genus GLOBOROTALIA Cushman, 1927

GLOBOROTALIA CALIFORNICA Cushman and Todd

Plate IX, figs. 4a-c

Globorotalia californica Cushman and Todd, 1948, Contr. Cushman Lab.

Foram. Res., vol. 24, p. 96, pl. 16, figs. 22, 23.

Test free, calcareous, perforate; biconvex, more so ventrally than dorsally; low trochoid, all chambers of the 2 1/2 to 3 whorls visible dorsally, ventrally only the 6 or 7 of the last whorl; chambers globular, increasing in size as added, the periphery lobulate; early chambers pustulose to spinose, last 2 or 3 smooth; sutures radial, depressed, spiral suture sometimes slightly thickened and raised; umbilicus open, large; aperture a high arch, with a lip, at the base of the last chamber extending from the umbilicus toward the periphery but not opening into the umbilicus. Greatest diameter of hypotype 0.41 mm., least diameter 0.31 mm., thickness 0.20 mm.

Cushman and Todd's type specimens are badly eroded and

encrusted, thus much of the detail is lost from their specimens, and from their description.

Genus GLOBOROTALITES Brtozen, 1942

GLOBOROTALITES n. sp. "a"

Plate IX, figs. 5a-c

Test free, calcareous, perforate, trochoid; the dorsal side slightly convex, the ventral side greatly so, periphery narrow to sharp; all chambers of the 3 to 4 whorls visible dorsally, ventrally only the 6 to 8 of the last whorl; chambers increasing in size as added, particularly in depth, the proximal posterior region of the ultimate portion highest, tumid, chambers not inflated; dorsal sutures raised, thickened, oblique, curved, spiral suture slightly raised in some specimens; ventral sutures depressed, thickened, radial, curved; aperture a low arch at the base of the last formed chamber, extending from the umbilicus almost to the periphery, with a minute valvular lip, aperture generally hidden by highest portion of chamber, except when viewed in peripheral view. Greatest diameter of figured specimen 0.41 mm., least diameter 0.33 mm., thickness 0.29 mm.

## Genus ROTALIPORA Brotzen, 1942

## ROTALIPORA APPENNINICA (O. Renz)

Plate IX, figs. 6a-c

Globotruncana appenninica Gandolfi, 1942, Riv. Ital. Pal. vol. 48,  
pp. 116-123, figs. 40a-c, pl. 4, fig. 12.

Test free, calcareous, coarsely perforate; biconvex, subcircular in plan view, periphery lobulate; trochoid, all chambers of the  $2\frac{1}{2}$  to  $3\frac{1}{2}$  whorls visible dorsally, ventrally only the 7 or 8 of the last whorl, chambers slightly inflated dorsally and ventrally; dorsal sutures thickened, raised, rarely slightly beaded, curved or nearly straight, directed somewhat posteriorly, curving backward and often coalescing at the periphery to form a keel, spiral suture prominent; ventral sutures in early chambers raised and thickened, often depressed in last few chambers, nearly radial, often slightly curved toward the posterior; umbilicus large, open; primary aperture a high arched opening at the base of the last chamber near the umbilicus, another aperture at each suture in the umbilicus, apertures usually obscured by debris. Greatest diameter of hypotype 0.46 mm., least diameter 0.41 mm., thickness 0.22 mm.

Globorotalia decorata Cushman and Todd from the New Almaden limestone is probably the same species; however, the type specimens are too badly weathered to make identification absolute.

Thalmaninella brotzeni Sigal, from the middle Cenomanian of Algeria, may be the same.

# ROTALIPORA ROBERTI (Gandolfi)

Plate IX, figs. 8a-c

Anomalina roberti Gandolfi, 1942, Riv. Ital. Pal., vol. 48, Suppl.,

Mém. 4, pp. 100, 134, 150, pl. 2, figs. 2a-c.

Test free, calcareous, perforate; biconvex, more so ventrally than dorsally, the periphery broadly rounded, lobulate; test trochoid, low, all chambers of the 3 whorls visible dorsally, ventrally only the 7 to 9 of the last whorl; chambers inflated, increasing in size slowly, pustulose or spinose except the last 2 or 3 which are usually smooth; sutures depressed and radial both ventrally and dorsally, spiral suture distinct, depressed; umbilicus open, broad, deep, usually filled with fine detritus; primary aperture a high interiomarginal arch extending from the umbilicus toward the periphery, with a lip; secondary apertures probably present at the sutures in the umbilical region. Greatest diameter of hypotype 0.53 mm., least diameter 0.44 mm., thickness 0.23 mm.

# ROTALIPORA TICINENSIS TICINENSIS (Gandolfi)

Plate IX, figs. 7a-c

Globotruncana ticinensis Gandolfi, 1942, Riv. Ital. Pal., vol. 48, Suppl.,

Mém. 4, pp. 113, 135, pl. 2, figs. 3, 4.

Thalmaninella ticinensis ticinensis (Gandolfi) Reichel, 1949, Ecolog.

Geol. Helv., vol. 42, p. 603, pl. 16, fig. 6, pl. 17, fig. 6.

Test free, calcareous, perforate; biconvex, periphery slightly



lobulate; trochoid, high spired, all chambers of the 2 1/2 to 3 whorls visible dorsally, ventrally only the 7 or 8 of the last whorl, chambers flat dorsally, slightly inflated ventrally, particularly at their inner ends, wall not spinose; dorsal sutures raised, thickened, curved, coalescing to form both a keel and a raised spiral suture, ventral sutures thin, depressed, radial; umbilicus large, open, deep; aperture a high interiomarginal arch extending from the umbilicus toward the periphery, with a lip; probably a secondary aperture at each suture in the umbilicus; umbilicus usually filled with detrital material. Greatest diameter of hypotype 0.34 mm., least diameter 0.29 mm., thickness 0.17 mm.

#### Family ANOMALINIDAE

Genus PLANOMALINA Loeblich and Tappan, 1946

PLANOMALINA APSIDOSTROBA Loeblich and Tappan

Plate IX, figs. 9a-c

Planomalina apsidostroba Loeblich and Tappan, 1946, Jour. Pal., vol. 20, p. 258, pl. 37, figs. 22, 23a, b.

Test free, calcareous, perforate; planispirally coiled, partially evolute, biumbilicate, with the periphery keeled up to the last chamber; chambers increasing gradually in size, closely appressed, much curved, 8 to 10 in the last adult whorl; sutures strongly curved, bending posteriorly both at the periphery and the umbilicus, raised, and thickened;

fimbriate peripheral keel formed by the coalescing raised sutures; aperture a low arch at the base of the apertural face of the last formed chamber with a small but distinct lip, apertural face truncate. Greatest diameter of hypotype 0.38 mm., least diameter 0.28 mm., thickness 0.13 mm.

Genus CIBICIDES Montfort, 1808

CIBICIDES n. sp. "a"

Plate IX, figs. 10a-c

Test free, calcareous, perforate, trochoid; variably convex ventrally, flat to strongly convex dorsally, periphery angled to rounded; chambers increasing in size gradually, all chamber of the  $2\frac{1}{2}$  to 3 whorls visible dorsally, ventrally only the 11 to 13 of the last whorl, chambers not inflated; dorsal sutures thickened, raised, except occasionally depressed in last few chambers, oblique, curved, meeting to form a thickened spiral suture that may be either raised or depressed, thickened spiral suture often forming a low, clear boss in the small early whorls; ventral sutures thickened, flush, or depressed in the last few chambers, radial, but angled posteriorly  $\frac{1}{3}$  to  $\frac{2}{3}$  the distance to the periphery; chambers reaching to the umbilicus with a slight umbilical depression, or umbilicus filled with a flush or depressed plug of clear shell material formed by the junction of the sutures; aperture a slit with

a lip, at the base of the last formed chamber, extending from the dorsal side, across the periphery just to the ventral side. Greatest diameter of figured specimen 0.36 mm., least diameter 0.28 mm., thickness 0.15 mm.

The angularity of the ventral sutures, ventral convexity, and thickened and raised spiral suture distinguish this species from others of the genus.

Genus PLANULINA d'Orbigny, 1826

PLANULINA RUDIS (Reuss)

Plate IX, figs. 11a-c

Rosalina rudis Reuss, 1863, Sber. Math.-naturw. Cl. Akad. Wiss.,  
vol. 46, p. 87, taf. 11, fig. 7.

Anomalina D 11 Hecht, 1938, Abh. Senck. Naturf. Ges., abh. 443, pp.,  
taf. 9a, figs. 49-51.

Anomalina rudis (Reuss) ten Dam, 1950, Mém. Soc. Géol. France, n. S.,  
vol. 29, Mém. no. 63, p. 56, taf. 4, fig. 8.

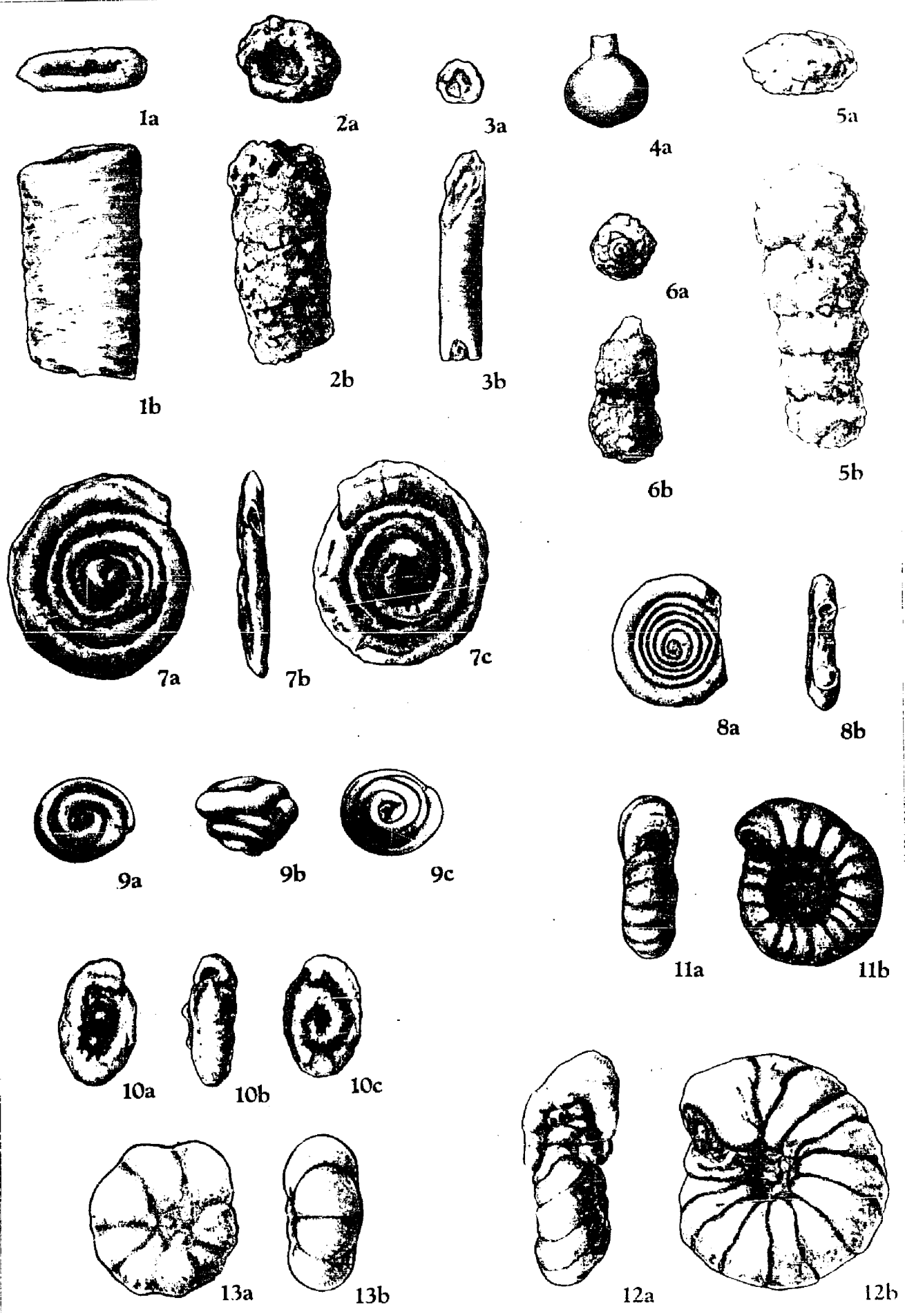
Gavelinella rudis (Reuss) Bettenstaedt, 1952, Senckenbergiana, vol. 33,  
p. 276, taf. 2, figs. 26a, b, 27a-c, 28a, b, 29a, b.

Test free, calcareous, coarsely perforate; convex ventrally, concave dorsally, the periphery narrowly rounded; trochoid, partially evolute, all chambers of the 2 to 3 whorls clearly visible dorsally, ventrally the 10 to 12 of the last whorl are somewhat appressed on the early whorls although the early whorls are visible; ventral and dorsal sutures curved,

thin to thick, and flush to raised in early chambers, usually thin and depressed in later chambers; chambers increasing gradually in size as added, little if at all inflated, not quite reaching the umbilicus ventrally; umbilicus open, shallow; dorsal side with early whorls lower than later ones; aperture a low slit, with a lip, at the base of the last formed chamber, extending from near the umbilicus across the periphery to the dorsal side. Greatest diameter of hypotype 0.52 mm., least diameter 0.41 mm., thickness 0.08 mm.

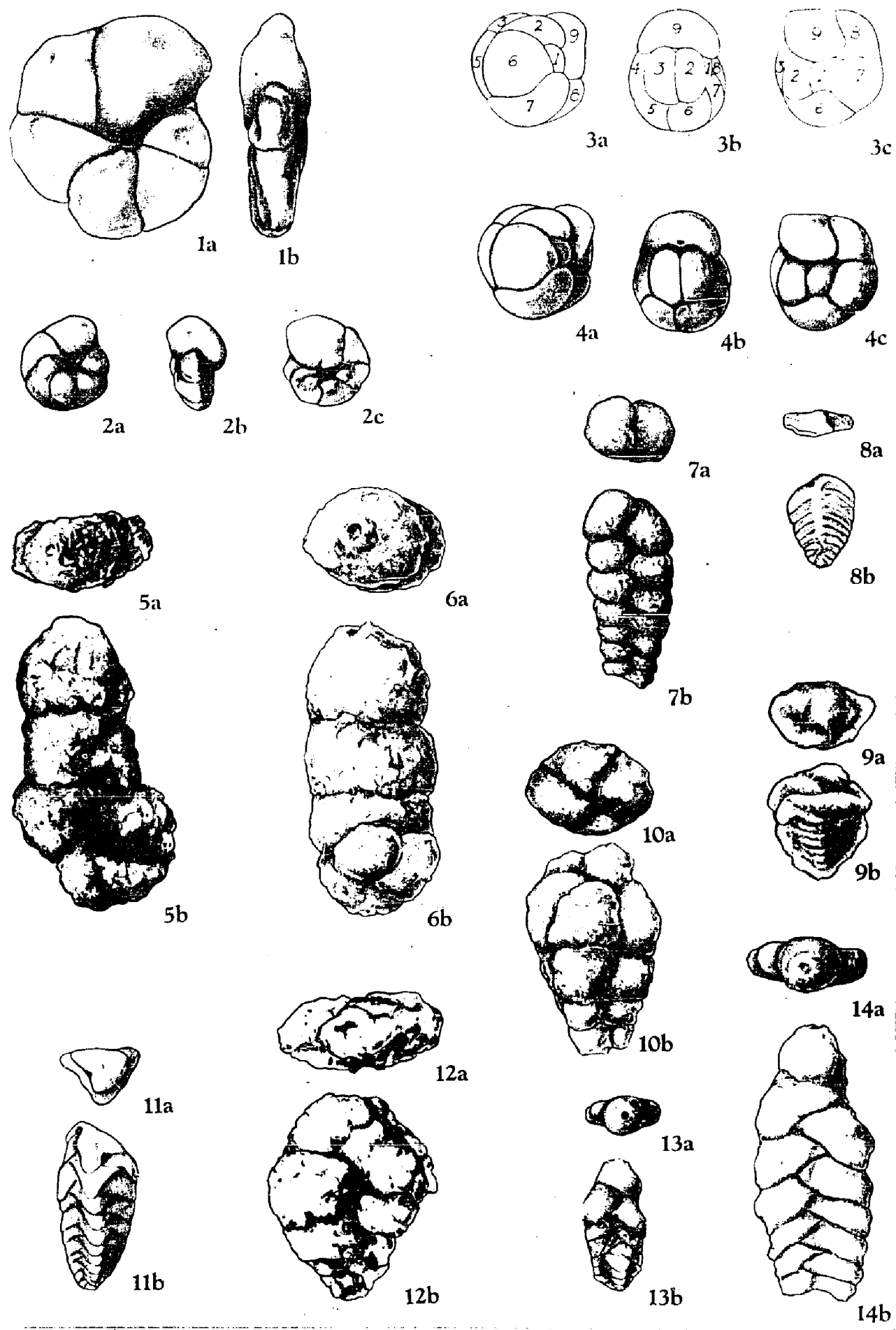
## EXPLANATION OF PLATE I

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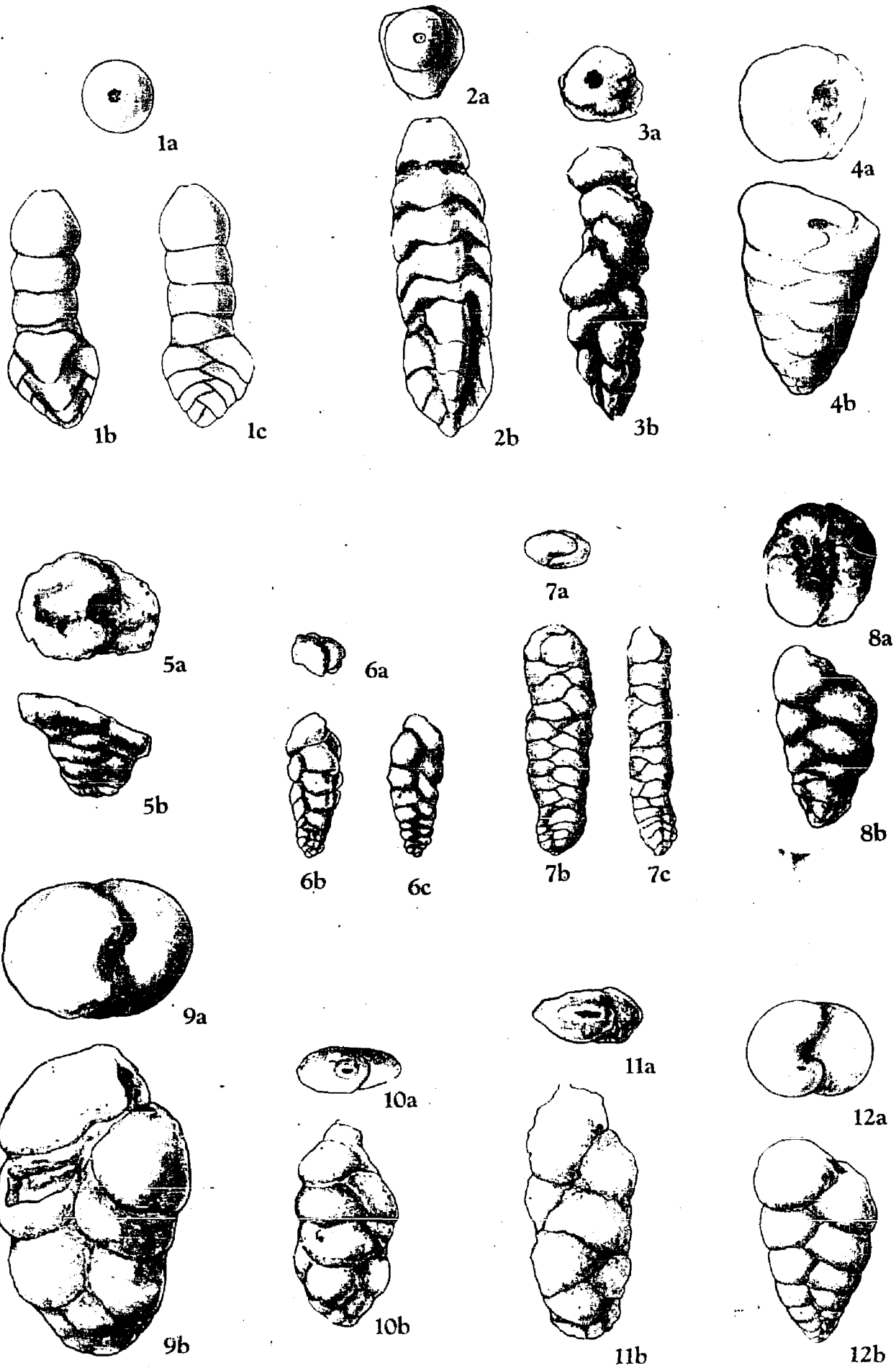
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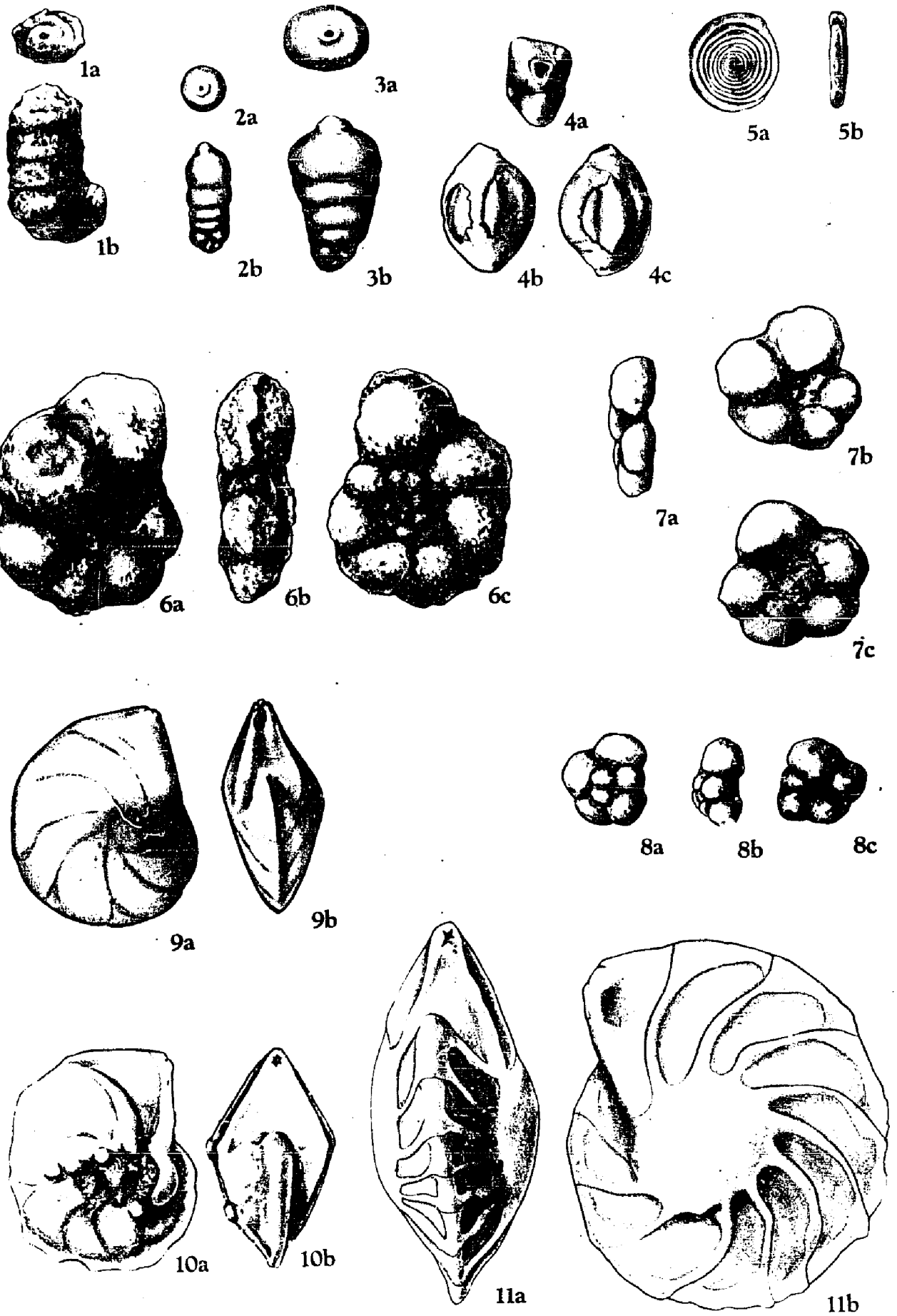
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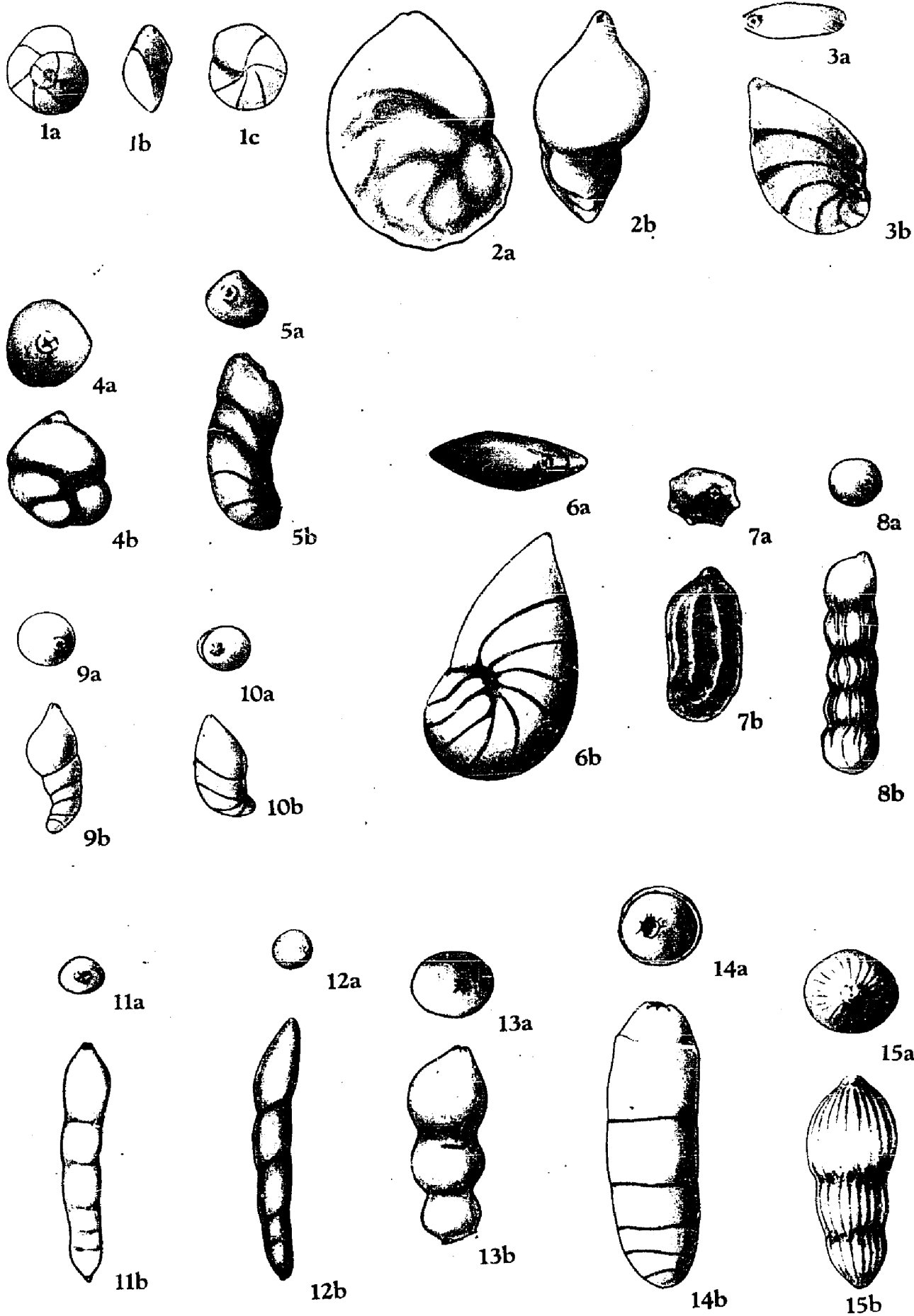
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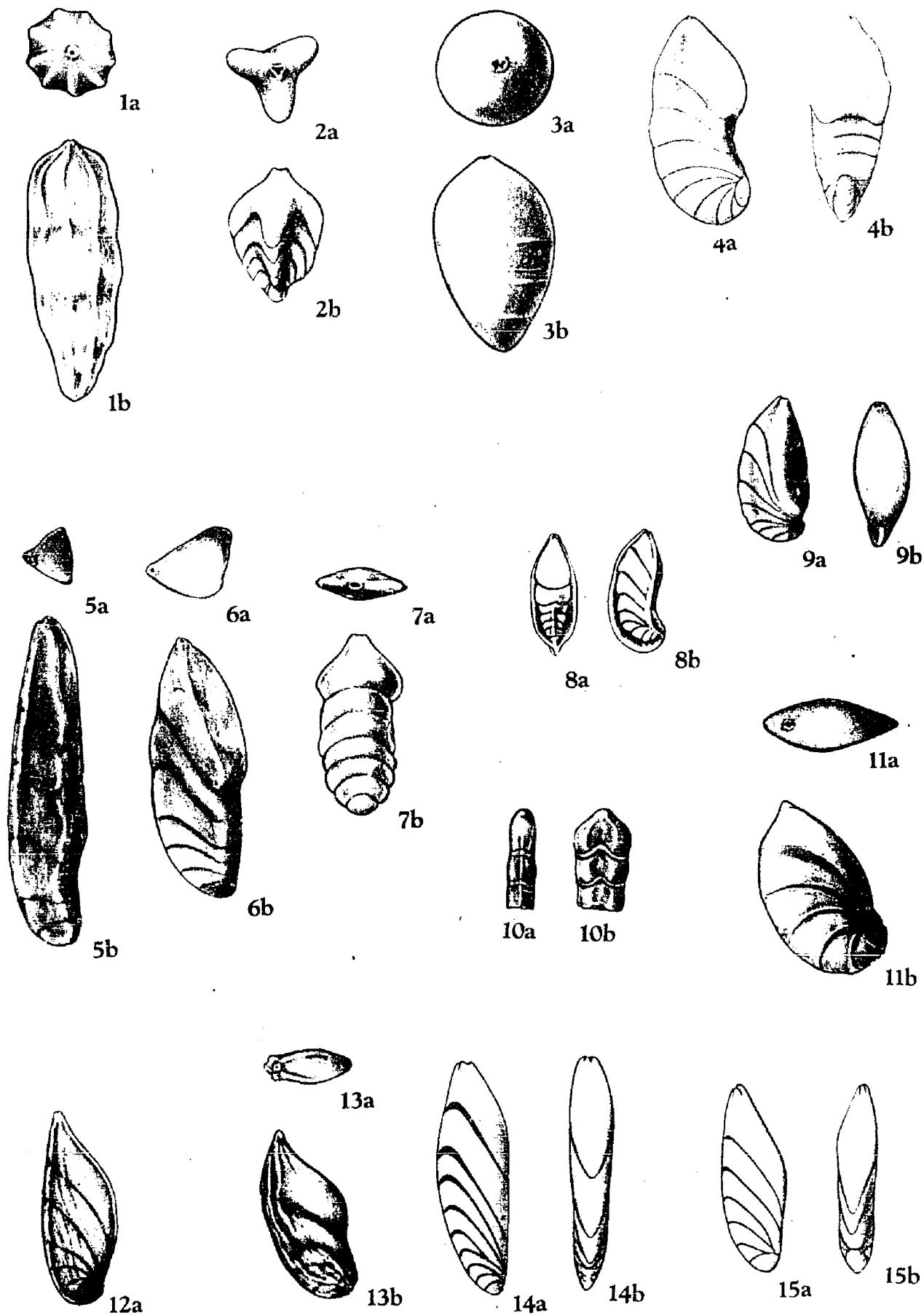
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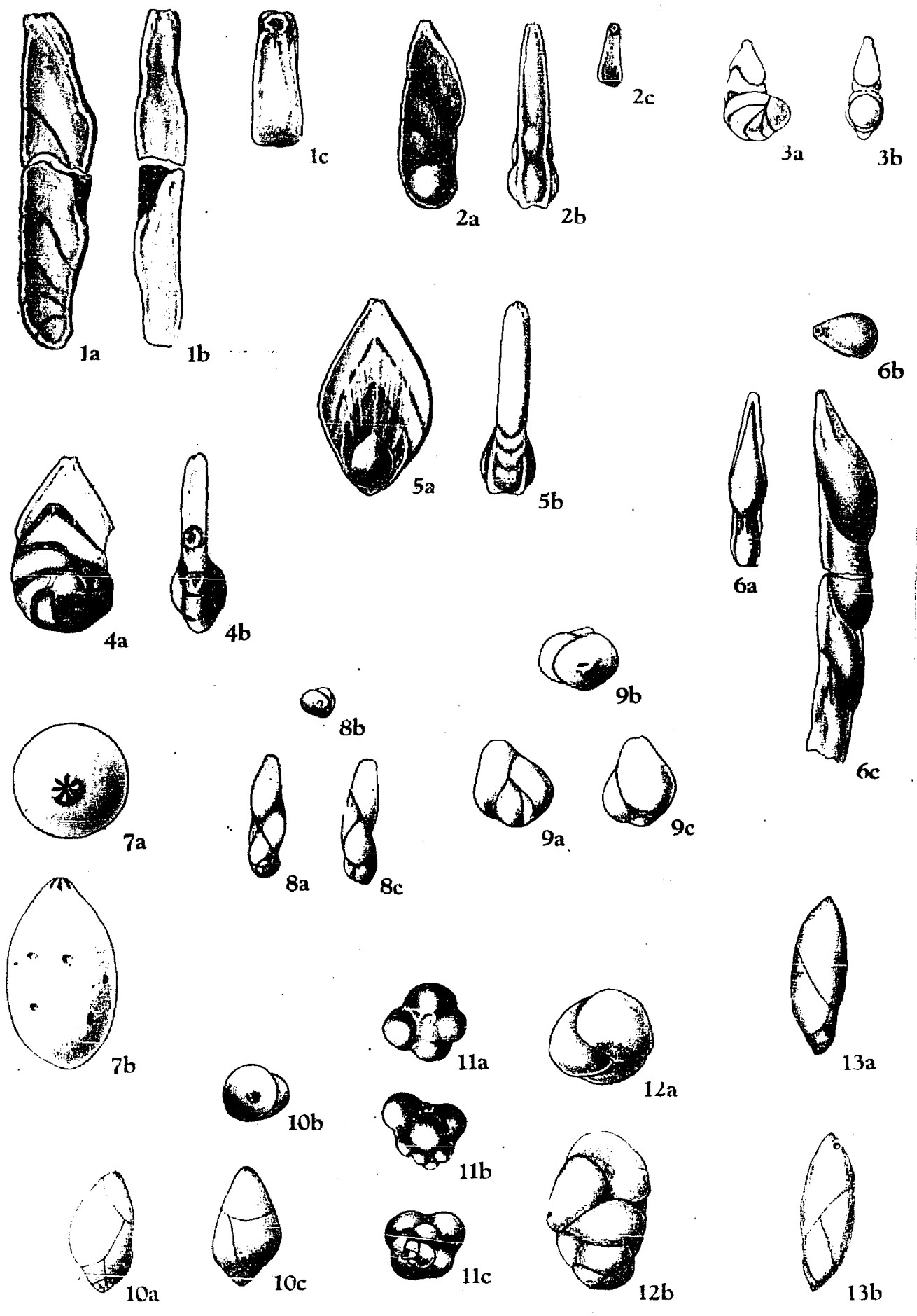
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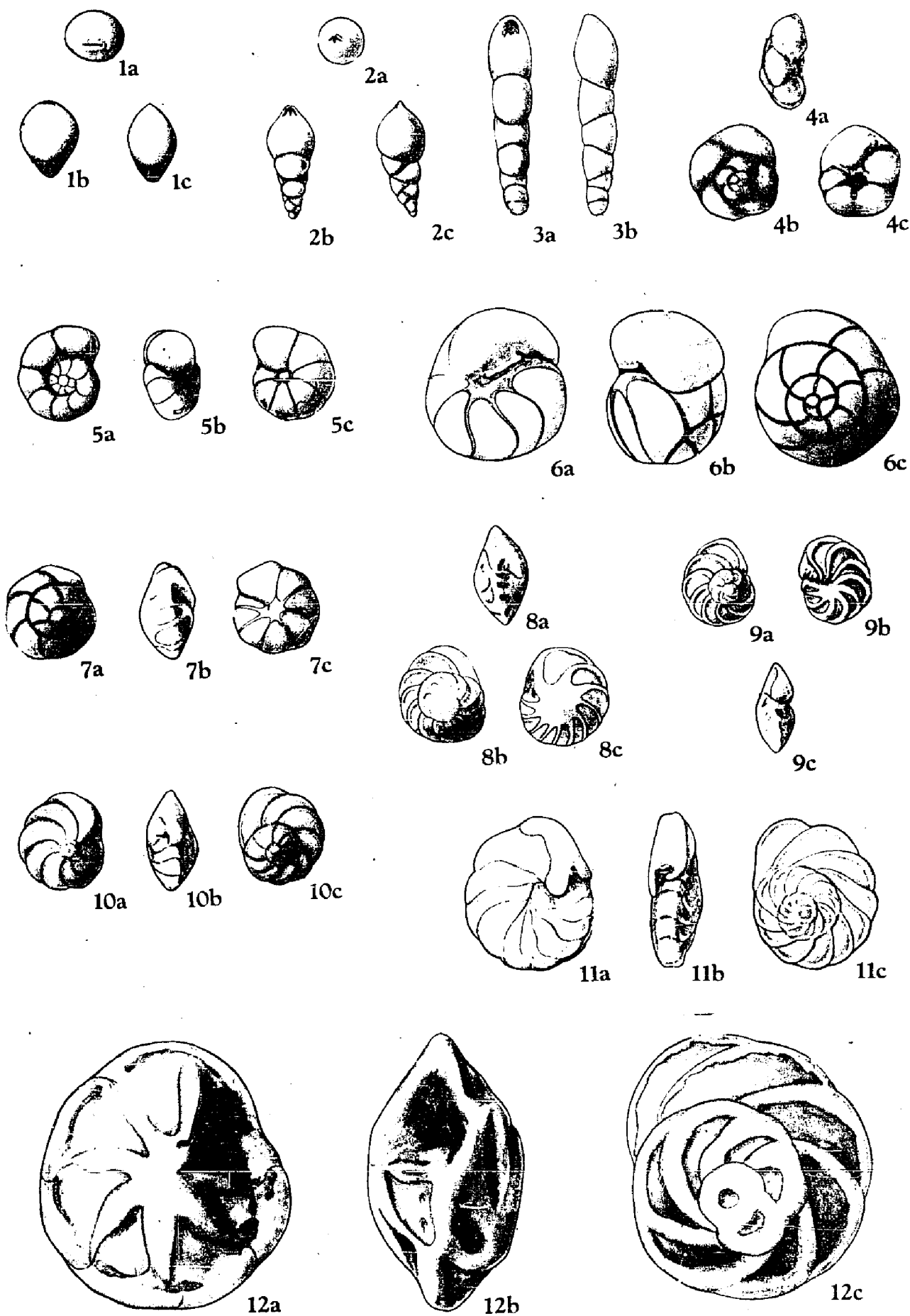
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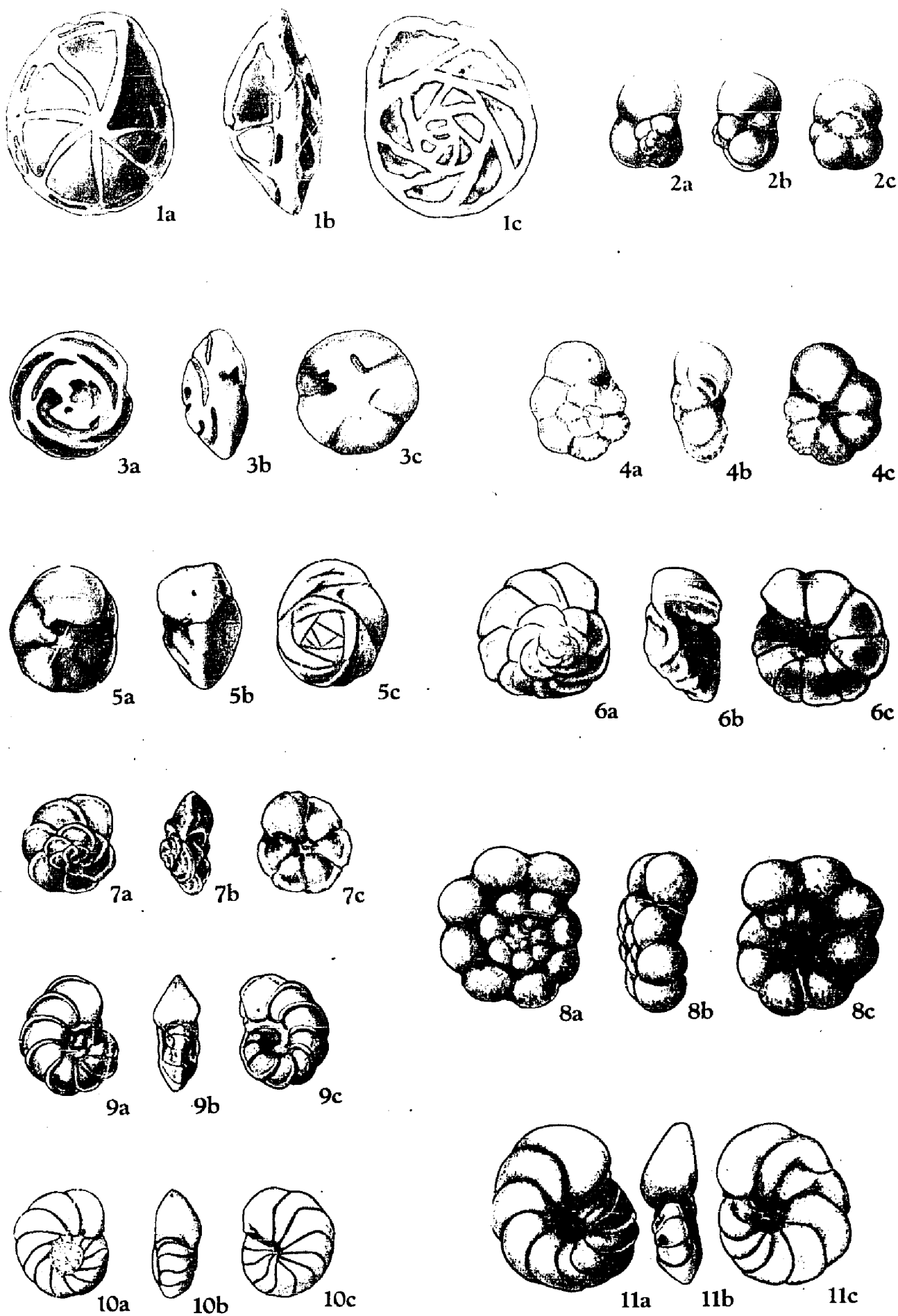
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# APPENDIX I

## LOCATIONS OF STATIONS

All stations are in Tehama County, California.

### Sta. No.

|     |                                       |      |     |      |
|-----|---------------------------------------|------|-----|------|
| 1.  | 140 ft. S, 925 ft. W, NE cor. Sec. 9  | T28N | R7W | MDBM |
| 2.  | 85 ft. N, 1105 ft. W, SE cor. Sec. 4  | "    | "   | "    |
| 3.  | 475 ft. N, 1945 ft. W, SE cor. Sec. 4 | "    | "   | "    |
| 4.  | 140 ft. S, 2295 ft. W, NE cor. Sec. 9 | "    | "   | "    |
| 5.  | 560 ft. S, 2675 ft. W, NE cor. Sec. 9 | "    | "   | "    |
| 6.  | 390 ft. S, 3000 ft. W, NE cor. Sec. 9 | "    | "   | "    |
| 7.  | 110 ft. S, 3320 ft. W, NE cor. Sec. 9 | "    | "   | "    |
| 8.  | 10 ft. N, 3575 ft. W, SE cor. Sec. 4  | "    | "   | "    |
| 9.  | 55 ft. N, 1190 ft. E, SW cor. Sec. 4  | "    | "   | "    |
| 10. | 85 ft. N, 730 ft. E, SW corn. Sec. 4  | "    | "   | "    |
| 11. | 110 ft. S, 325 ft. E, NW cor. Sec. 9  | "    | "   | "    |
| 12. | 390 ft. S, 80 ft. E, NW cor. Sec. 9   | "    | "   | "    |
| 13. | 560 ft. S, 350 ft. W, NE cor. Sec. 8  | "    | "   | "    |
| 14. | 560 ft. S, 865 ft. W, NE cor. Sec. 8  | "    | "   | "    |
| 15. | 505 ft. S, 1650 ft. W, NE cor. Sec. 8 | "    | "   | "    |
| 16. | 250 ft. S, 2105 ft. W, NE cor. Sec. 8 | "    | "   | "    |
| 17. | 225 ft. S, 2510 ft. W, NE cor. Sec. 8 | "    | "   | "    |
| 18. | 390 ft. S, 2295 ft. E, NW cor. Sec. 8 | "    | "   | "    |
| 19. | 505 ft. S, 1915 ft. E, NW cor. Sec. 8 | "    | "   | "    |

## LOCATIONS OF STATIONS (Cont.)

Sta. No.

|     |  |      |     |      |
|-----|--|------|-----|------|
| 20. | 670 ft. S, 1485 ft. E, NW cor. Sec. 8  | T28N | R7W | MDBM |
| 21. | 475 ft. S, 920 ft. E, NW cor. Sec. 8   | "    | "   | "    |
| 22. | 170 ft. S, 160 ft. E, NW cor. Sec. 8   | "    | "   | "    |
| 23. | 55 ft. N, 80 ft. W, SE cor. Sec. 6     | "    | "   | "    |
| 24. | 250 ft. N, 650 ft. W, SE cor. Sec. 6   | "    | "   | "    |
| 25. | 250 ft. N, 1160 ft. W, SE cor. Sec. 6  | "    | "   | "    |
| 26. | 140 ft. N, 1010 ft. W, SE cor. Sec. 6  | "    | "   | "    |
| 27. | 280 ft. S, 2810 ft. W, NE cor. Sec. 7  | "    | "   | "    |
| 28. | 170 ft. S, 3000 ft. W, NE cor. Sec. 7  | "    | "   | "    |
| 29. | 110 ft. S, 1730 ft. E, NW cor. Sec. 7  | "    | "   | "    |
| 30. | 30 ft. N, 1405 ft. E, SW cor. Sec. 6   | "    | "   | "    |
| 31. | 85 ft. N, 1110 ft. E, SW cor. Sec. 6   | "    | "   | "    |
| 32. | 1290 ft. N, 810 ft. E, SW cor. Sec. 6  | "    | "   | "    |
| 33. | 1430 ft. N, 620 ft. E, SW cor. Sec. 6  | "    | "   | "    |
| 34. | 1680 ft. N, 270 ft. E, SW cor. Sec. 6  | "    | "   | "    |
| 35. | 2155 ft. N, 325 ft. W, SE cor. Sec. 1  | T28N | R8W | MDBM |
| 36. | 2100 ft. N, 1350 ft. W, SE cor. Sec. 1 | "    | "   | "    |
| 37. | 1905 ft. N, 2185 ft. W, SE cor. Sec. 1 | "    | "   | "    |
| 38. | 1680 ft. N, 2780 ft. W, SE cor. Sec. 1 | "    | "   | "    |

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 |  |   |
|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|--|---|
|   |   |   | X |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  | Ammobaculites coprolitiformis<br>Ammobaculites lueckei<br>Ammodiscus glabratus<br>Arenobulimina ? n. sp. "a"<br>Astacolus aff. pediacus |
| X | X | X |   |   | X |   |   | X | X  | X  | X  |    |    |    | X  | X  | X  | X  | X  | X  | X  | X  | X  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  | Astacolus n. sp. "a"<br>Bathysiphon enomalocecia<br>Bathysiphon sp. "a"<br>Bulimina sp. "a"<br>Gibicides n. sp. "a"                     |
| X | X | X | X | X |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  | Cornuspira sp. "a"<br>Darbyella ? n. sp. "a"<br>Dentalina catenula<br>Dentalina cf. calvillensis<br>Dentalina communis                  |
| X | X | X | X | X | X | X | X | X | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | Dentalina n. sp. "a"<br>Dorothis ? almsdenensis<br>Dorothis filiformis<br>Dorothis n. sp. "a"<br>Dorothis n. sp. "b"                   |   |
| X | X | X | X | X | X | X | X | X | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | Ellipsoglendulina n. sp. "a"<br>Epistomina supracretacea<br>Epistomina sp. "a"<br>Eponides ? sp. "a"<br>Fronicularia cf. cushmani      |   |
| X | X | X | X | X | X | X | X | X | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | Gaudryinella n. sp. "a"<br>Globigerina sp. "a"<br>Globorotalia californica<br>Globorotalites n. sp. "a"<br>Glomospira charoides corona |   |
| X | X | X | X | X | X | X | X | X | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | Glomospira sp. "a"<br>"Climaceliella" n. sp. "a"<br>Guttulina n. sp. "a"<br>Cyroidina loetterli<br>Cyroidina n. sp. "a"                |   |
| X | X | X | X | X | X | X | X | X | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | Haplophragmoides eggeri<br>Haplophragmoides sp. "a"<br>Hyperammina n. sp. "a"<br>Karreriella n. sp. "a"<br>Lagena n. sp. "a"           |   |
| X | X | X | X | X | X | X | X | X | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | Lenticulina circumcidanea<br>Lingulina n. sp. "a"<br>Lingulina n. sp. "b"<br>Listerella n. sp. "a"<br>Listerella n. sp. "b"            |   |
| X | X | X | X | X | X | X | X | X | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | Marginulina clava<br>Marginulina hamuloides<br>Marginulina n. sp. "a"<br>Marginulina n. sp. "b"<br>Marginulinopsis phragmites          |   |
| X | X | X | X | X | X | X | X | X | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | Marssonella oxycona<br>Marssonella n. sp. "a"<br>New Genus "A" n. sp. "a"<br>New Genus "B" n. sp. "a"                                  |   |

|                             |                           |                           |                           |                           |   |                           |   |                           |                         |                           |     |   |
|-----------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---|---------------------------|---|---------------------------|-------------------------|---------------------------|-----|---|
| X<br>X                      | X                         | X X                       | X X                       | X X                       | X | X X X                     | X | X ?                       | X                       | X                         |     | Marginulina clava<br>Marginulina hamuloides<br>Marginulina n. sp. "a"<br>Marginulina n. sp. "b"<br>Marginulinopsis phragmites   |
| X X X X<br>X X X X<br>X     | X X X X<br>X X X X<br>X   | X X X X<br>X X X X<br>X   | X X X X<br>X X X X<br>X   | X X X X<br>X X X X<br>X   | X | X X X X<br>X X X X<br>X   | X | X X X X<br>X X X X<br>X   | X X X X<br>X X X X<br>X | X X X X<br>X X X X<br>X   |     | Marssonella oxycona<br>Marssonella n. sp. "a"<br>New Genus "A" n. sp. "a"<br>New Genus "B" n. sp. "a"<br>New Genus "C" n. sp. "a"   |
| X X<br>X<br>X X X X X       | X X<br>X X X X X<br>X     | X X X X<br>X X X X<br>X   | X X X X<br>X X X X<br>X   | X X X X<br>X X X X<br>X   | X | X X X X<br>X X X X<br>X   | X | X X X X<br>X X X X<br>X   | X                       | X                         |     | Nodosaria orthostoecha<br>Nodosaria sp. "a"<br>Osangularia n. sp. "a"<br>Osangularia n. sp. "b"<br>Osangularia n. sp. "c"   |
| X<br>X X X X<br>X X X X X   | X X X X<br>X X X X<br>X X | X X X X<br>X X X X<br>X X | X X X X<br>X X X X<br>X X | X X X X<br>X X X X<br>X X | X | X X X X<br>X X X X<br>X X | X | X X X X<br>X X X X<br>X X | X                       | X X X X<br>X X X X<br>X X |     | Paleopolymorphina n. sp. "a"<br>Palmula sp. "a"<br>Planomalina apsidostroba<br>Planulina rudis<br>Pleurostomella obtusa   |
| X X X X X<br>X              | X X X X<br>X X X X<br>X   | X X X X<br>X X X X<br>X   | X X X X<br>X X X X<br>X   | X X X X<br>X X X X<br>X   | X | X X X X<br>X X X X<br>X   | X | X X X X<br>X X X X<br>X   | X X X X<br>X X X X<br>X | X X X X<br>X X X X<br>X   |     | Pseudoclavulina californica<br>Pseudoclavulina californica n. subsp. "a"<br>Pseudoclavulina californica n. subsp. "b"<br>Pseudoglandulina n. sp. "a"<br>Pyralina cylindroides |
| X<br>X X X X X<br>X         | X X X X<br>X X X X<br>X   | X X X X<br>X X X X<br>X   | X X X X<br>X X X X<br>X   | X X X X<br>X X X X<br>X   | X | X X X X<br>X X X X<br>X   | X | X X X X<br>X X X X<br>X   | X X X X<br>X X X X<br>X | X X X X<br>X X X X<br>X   | X   | Pyralina shoalcreekensis<br>Quinqueloculina n. sp. "a"<br>Rectoglandulina quinquecostata<br>Reophax constrictus<br>Reophax texanus  |
| X X X X X<br>X X X X X<br>X | X X X X<br>X X X X<br>X   | X X X X<br>X X X X<br>X   | X X X X<br>X X X X<br>X   | X X X X<br>X X X X<br>X   | X | X X X X<br>X X X X<br>X   | X | X X X X<br>X X X X<br>X   | X X X X<br>X X X X<br>X | X X X X<br>X X X X<br>X   | X X | Robulus modestus<br>Robulus n. sp. "a"<br>Robulus n. sp. "b"<br>Rotalipora apenninica<br>Rotalipora roberti   |
| X X<br>X<br>X               | X X<br>X X<br>X           | X X<br>X X<br>X           | X X<br>X X<br>X           | X X<br>X X<br>X           | X | X X<br>X X<br>X           | X | X X<br>X X<br>X           | X X<br>X X<br>X         | X X<br>X X<br>X           | X   | Rotalipora ticinensis<br>Saracenaria bononiensis n. subsp. "a"<br>Saracenaria cypha<br>Saracenaria sp. "a"<br>Saracenaria n. sp. "a"  |
| X X X<br>X X<br>X<br>X X X  | X X<br>X X<br>X           | X X<br>X X<br>X           | X X<br>X X<br>X           | X X<br>X X<br>X           | X | X X<br>X X<br>X           | X | X X<br>X X<br>X           | X X<br>X X<br>X         | X X<br>X X<br>X           |     | Siphotextularia n. sp. "a"<br>Spiroplectammina laevis cretose<br>Spiroplectammina n. sp. "a"<br>Textularia n. sp. "a"<br>Tristix alcima                                       |
| X X X X X<br>X X X X<br>X   | X X X X<br>X X X X<br>X   | X X X X<br>X X X X<br>X   | X X X X<br>X X X X<br>X   | X X X X<br>X X X X<br>X   | X | X X X X<br>X X X X<br>X   | X | X X X X<br>X X X X<br>X   | X X X X<br>X X X X<br>X | X X X X<br>X X X X<br>X   | X   | Trochammina n. sp. "a"<br>Trochammina n. sp. "b"<br>Trochamminoides n. sp. "a"<br>Vaginulina neocomiana<br>Vaginulina recta   |
| X X X X<br>X                | X X X X<br>X X X X<br>X   | X X X X<br>X X X X<br>X   | X X X X<br>X X X X<br>X   | X X X X<br>X X X X<br>X   | X | X X X X<br>X X X X<br>X   | X | X X X X<br>X X X X<br>X   | X X X X<br>X X X X<br>X | X X X X<br>X X X X<br>X   |     | Vaginulina subrotunda<br>Vaginulina n. sp. "a"<br>Vaginulina n. sp. "b"<br>Velvulinaria n. sp. "a"<br>Verneuilina n. sp. "a"  |

Table I. Occurrences of Species

## AUTOBIOGRAPHY

Richard Paul Zingula was born in Cedar Rapids, Iowa on May 31, 1929. His elementary education was obtained at the one-room school-house in District #11, Main Township, Linn County, Iowa. He attended the high school at Alburnett, Iowa, and received his diploma there in 1947. The next four years were spent at Iowa State College, where he received a B. S. degree in 1951, with a major in geology and minors in chemistry and zoology. He was admitted to the graduate school of the Louisiana State University that autumn, and received his M. S., with a major in geology and a minor in zoology, in June, 1953. During his first year there he taught as a graduate assistant. In June of 1954 he left school to work as a paleontologist for the Humble Oil and Refining Company in Chico, California. He returned to school in September, 1956.

He married Patricia Ann Hargis at Monroe, Louisiana, May 28, 1953. A daughter, Paula Ann Zingula was born on March 15, 1955.

## EXAMINATION AND THESIS REPORT

Candidate: Richard Paul Zingula

Major Field: Geology

Title of Thesis: "Cretaceous Foraminifera from the Sacramento Valley, California"

Approved:

*H.V. Howe H.V. Andersen*

Major Professor and Chairman

*Richard J. Purcell*

Dean of the Graduate School

### EXAMINING COMMITTEE:

*Robert E. Murray*

*George H. Brown*

*A. B. Sandberg*

*James P. Morgan*

Date of Examination:

*December 2, 1957*