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UPPER CRETACEOUS FORAMINIFERA FROM SOUTHERN CALIFORNIA AND NORTHWESTERN BAJA CALIFORNIA, MEXICO

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CONTENTS

ABSTRACT

An Upper Cretaceous foraminiferal fauna from southern California and northwestern Baja California, Mexico, consists of 274 species ranging in age from late Campanian to early Maastrichtian. These species represent 106 genera belonging to 38 families; 38 species, 3 genera, and 1 subfamily are described as new.

Three proposed assemblage zones are traced 70 miles from southern California into northwestern Mexico. These are correlated regionally and interregionally primarily by the means of 32 planktonic species and 8 specialized benthonic species. The zones and their ages are: *Globotruncana rosetta* Zone—middle to late Campanian, *Globotruncana mariei* Zone—late Campanian, and *Rugoglobigerina rugosa* Zone—early Maastrichtian. These age determinations are in agreement with ammonite correlations from the west coast of North America.

Two biofacies indicate two different, but geographically related, areas of marine deposition. Comparison of the faunal assemblages with modern bathymetric distributions suggests an inner shelf biofacies (above 140 m.) at Carlsbad and bathyal depths at La Jolla, Point Loma, and Punta Descanso. Displaced faunas are recognized by a mixing of the two biofacies, an increase in relative species diversity, and relationship to lithology and sedimentary and biologic structures.

Four Late Cretaceous planktonic faunal zones are postulated along the northeastern Pacific margin: equatorial, south-central, north-central, and northern. The equatorial faunal zone contains a Tethyan or tropical foraminiferal assemblage and is here recognized north to near the tip of Baja California (lat. 23° N). The south-central faunal zone with strong Tethyan faunal affinities includes southern California and northwestern Baja California and is traced to at least lat. 35° N. The north-central faunal zone includes the central and northern California exposures and is here extended into northern Washington (about lat. 47° N). Finally, the northern faunal zone includes Vancouver Island and southern and northern Alaska (lat. 69° N); it seems to represent a northern temperature zone modified by paleobathymetry and possibly by increased runoff. The greatest faunal change occurs at the suggested north-central and northern water boundary (near lat. 47° N) and closely approximates the position of the modern faunal boundary near lat. 50° N.

Late Cretaceous northeastern Pacific foraminiferal zoogeography, latitudinal diversity gradients, and faunal zones suggest oceanic current patterns, continental positions, and axis of rotation were much as they are today.

INTRODUCTION

Upper Cretaceous foraminiferal assemblages from four localities in southern California and northwestern Baja California, Mexico, are large and diversified. The fauna occurs primarily in siltstone sequences that allow easy recovery and provide good preservation. Cretaceous foraminifers from this region have been described or illustrated previously from only a single locality.

The recovery of 274 benthonic and planktonic species, from strata ranging from late Campanian to early Maastrichtian, provides the basis for a series of studies on the taxonomy, biostratigraphy, and paleoecology of this fauna. The purpose of the present investigation is 1) to describe and illustrate the foraminiferal fauna, 2) to recognize the biostratigraphic zonation, 3) to date and correlate the fauna with other foraminiferal assemblages both within and without North America, and 4) to summarize the paleoecologic and paleozoogeographic data obtained from this fauna.

The numerous planktonic and specialized benthonic species in particular were utilized for local and interregional correlation. This fauna already has provided some insight as to its geographic distribution during the Cretaceous, both within California and elsewhere in North America. Special emphasis has been on the recognition of the Boreal, Tethyan, and Indo-Pacific provincial faunas (Douglas & Sliter, 1966).

The only previously described Cretaceous foraminiferal fauna from southern California or Baja California, Mexico, is a Campanian assemblage from Carlsbad (Bandy, 1951), although several references to Cretaceous foraminifers have been made (e.g., Hertlein & Grant, 1944, 1954; Shepard, Lankford, & Milow, 1957; Milow & Ennis, 1961).

The 152 samples used for this study were prepared by the solvent-boiling technique and sieved through a 200-mesh screen (0.074 mm). This method was satisfactory and did not require any mechanical reduction of the samples.

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STRATIGRAPHY

Cretaceous clastic sediments of southern California and northwestern Mexico are divided into two general categories: 1) the rather extensive inland deposits exposed by structural uplift such as in the Simi Hills, Santa Monica Mountains, and Santa Ana Mountains, and 2) the remaining small isolated inland outcrops and narrow coastal exposures. The latter category is characteristic of the Upper Cretaceous outcrops in San Diego County, California, and along the Pacific Coast of Baja California, Mexico (Fig. 1). Within this area, samples for the present investigation were collected from Carlsbad, La Jolla, and Point Loma in San Diego County, and from Punta Descanso, Arroyo Carmen, Punta Banda, Punta San José, and San Antonio del Mar, in northwestern Mexico. In several areas (e.g., Arroyo Carmen, Punta Banda, Punta San José, and San Antonio del Mar) faunas consist either of only a few diagnostic species or shells which have been leached; hence these materials were not used in the present investigation.

Because of the geographically restricted nature of Cretaceous deposits in this region, they previously have received little attention. Early authors extended usage of the northern California formational name "Chico" to include these strata (FAIRBANKS, 1893; HANNA, 1926; ANDERSON, 1958). Later, the Rosario Formation (BEAL, 1948) of Baja California was applied to the Upper Cretaceous clastic deposits of northwestern Mexico and southern California (DURHAM & ALLISON, 1960; ELLIOTT & MAYTUM, 1966). In the present report, strata exposed at La Jolla, Carlsbad, Point Loma, and Punta Descanso are referred to the Rosario Formation.

Carlsbad.—This section consists of 50 feet of flaggy, blue-gray siltstone. Thin, 1- to 2-inch sandstone beds and lenses occur throughout but are more common and resistant in the upper half of the sequence. The lower contact is obscured by alluvial deposits, and the upper contact lies at the base of the unconformably overlying basal pebble conglomerate of the Tertiary.

La Jolla.—About 850 feet of siltstone and sandstone referred to the Rosario Formation by MILOW & ENNIS (1961) were sampled at this locality. These authors differentiated four local units in this formation and three (siltstone, siltstone-sandstone, and sandstone members) were sampled in this investigation.

The siltstone member consists of almost 500 feet of predominantly massive, concretionary, blue-gray siltstone. Thin, 3- to 6-inch coarse sandstone lenses with shell fragments occur in the upper half, followed by 2- to 3-foot sandstone beds containing graded bedding, convolute laminations, siltstone inclusions, and flame structures interbedded in the siltstone.

The siltstone-sandstone member lies in fault contact with the underlying siltstone member and is in turn faulted against the overlying sandstone member. This unit consists of about 100 feet of olive-gray siltstone interbedded with tan sandstone. The sandstone beds are thicker and make up a greater proportion of the member than in the underlying siltstone member.

The sandstone member is approximately 250 feet thick and consists of massive 8- to 12-foot sandstone beds and interbedded siltstone at the base overlain by a repetitive sequence of thinner sandstone and blue-gray siltstone beds that represent the dominant rock type of this unit. Commonly, the upper sandstone beds are graded and include siltstone fragments near their upper contact. The overlying micaceous, olive-gray siltstone layers have a sequence of planar laminations, convolute laminations, current-ripple laminations, and an upper, thin, dark, lignitic layer. These in turn are overlain by another sandstone and the sequence is repeated. Numerous burrows in this member penetrate both the silty and sandy beds. Such sedimentary structures are indicative of turbidity-current deposition (BOUMA, 1962; KUENEN, 1964) including phases of turbulence, bottom traction, steady and plastic flow, and perhaps effects of loading.

Point Loma.—The Cretaceous exposures at the southern tip of Point Loma include about 130 feet of massive to flaggy blue-gray siltstone and interbedded sandstone. The strike of the beds roughly parallels the axis of the point with the youngest strata lying on the eastern side. The lower half of the section contains a repetitious siltstone-sandstone sequence much like the sandstone member at La Jolla. The upper half consists of massive blue-gray siltstone with local concretions.

Punta Descanso.—Cretaceous deposits are exposed in low seacliffs about midway between Tijuana and Ensenada in Baja California, Mexico, where two exposures were sampled. One, just south of Punta Descanso, consists of 100 feet of alternating siltstone and sandstone with internal structures much like those of the sandstone member at La Jolla. The sandstone units commonly are discontinuous and lenslike, contain coarse shell fragments, and locally are folded into structures termed "slump overfolds" by CROWELL (1957). The second series of samples, from exposures near the settlement of Descanso, are from 21 feet of massive blue-gray, carbonaceous siltstone with scattered concretions.

BIOSTRATIGRAPHIC ZONATION AND AGE

Three biostratigraphic zones are recognized primarily on the distribution of 32 planktonic species and 8 specialized benthonic species (Table 1). These zones are traced from southern California south to Punta Descanso,

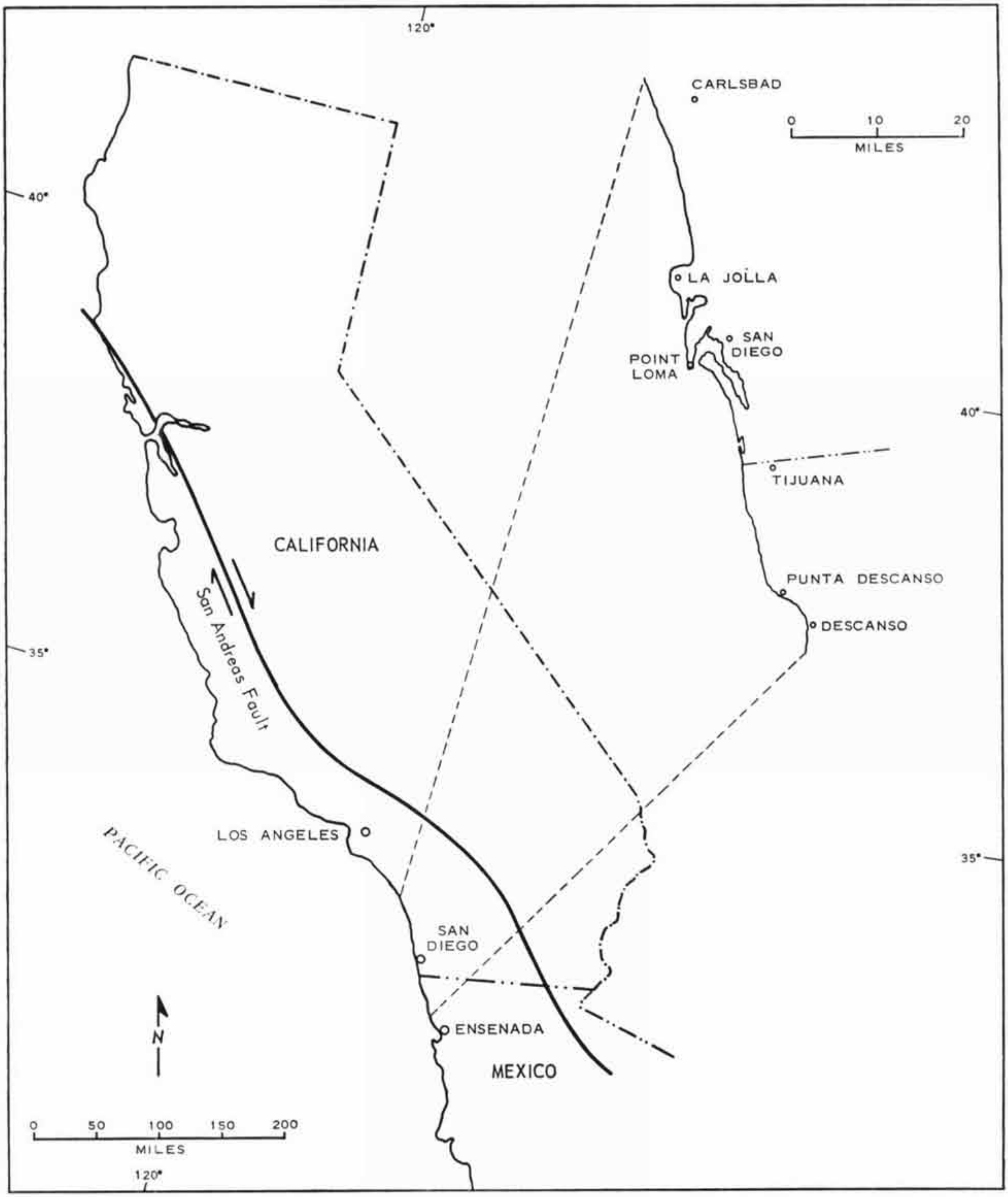
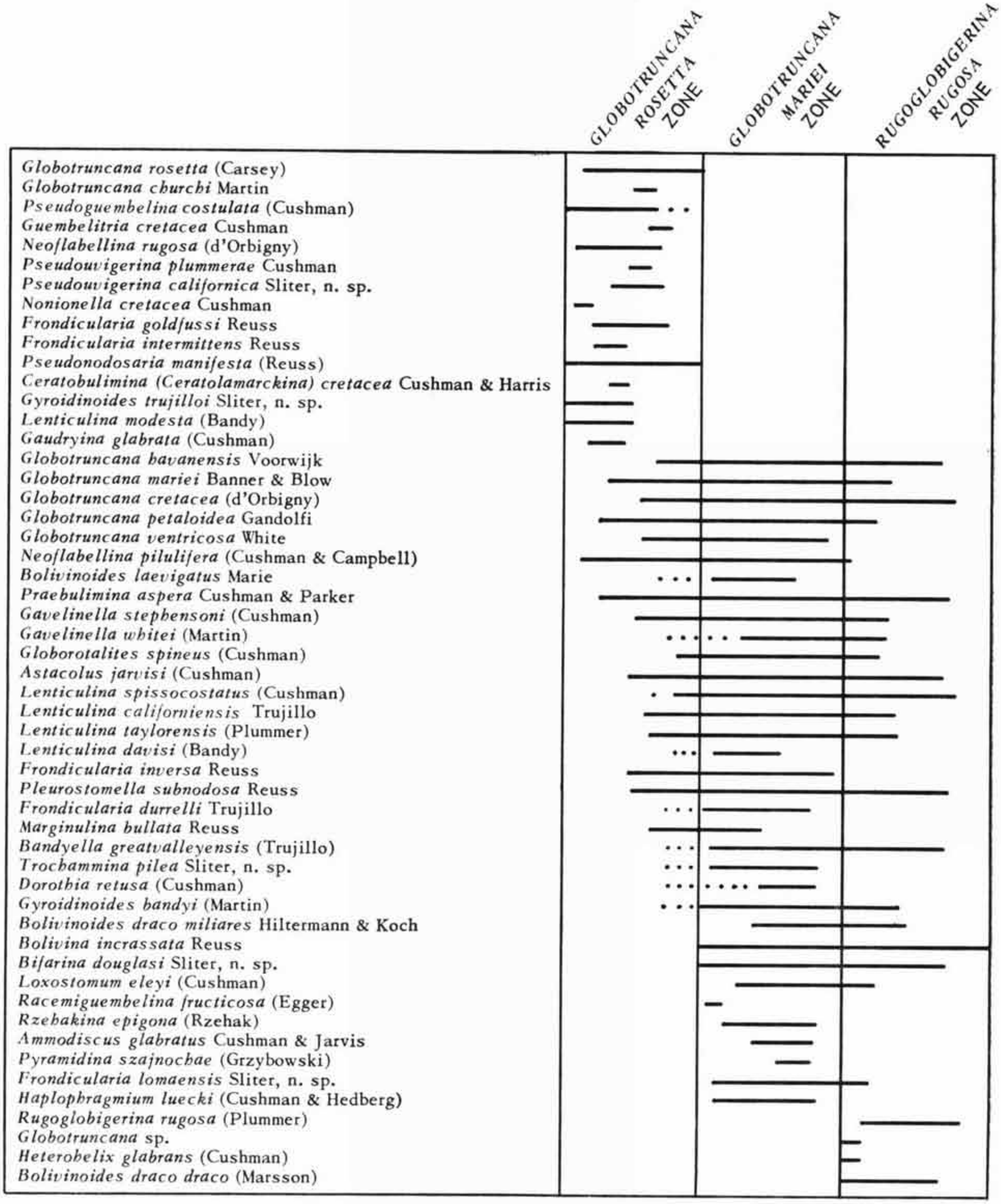


FIG. 1. Upper Cretaceous collecting localities in southern California and northwestern Baja California with respect to California and the San Andreas fault.

TABLE 1.—*Stratigraphic Range of Selected Zonal Species.*



a distance of 70 miles. Furthermore, some elements of these zones are found along the eastern Pacific margin in central California (MARTIN, 1964), northern California (DOUGLAS & SLITER, 1966; DOUGLAS, 1966), British Columbia (MCGUGAN, 1964) and southern Alaska (BERGQUIST, 1961), and are important in interregional correlation. The

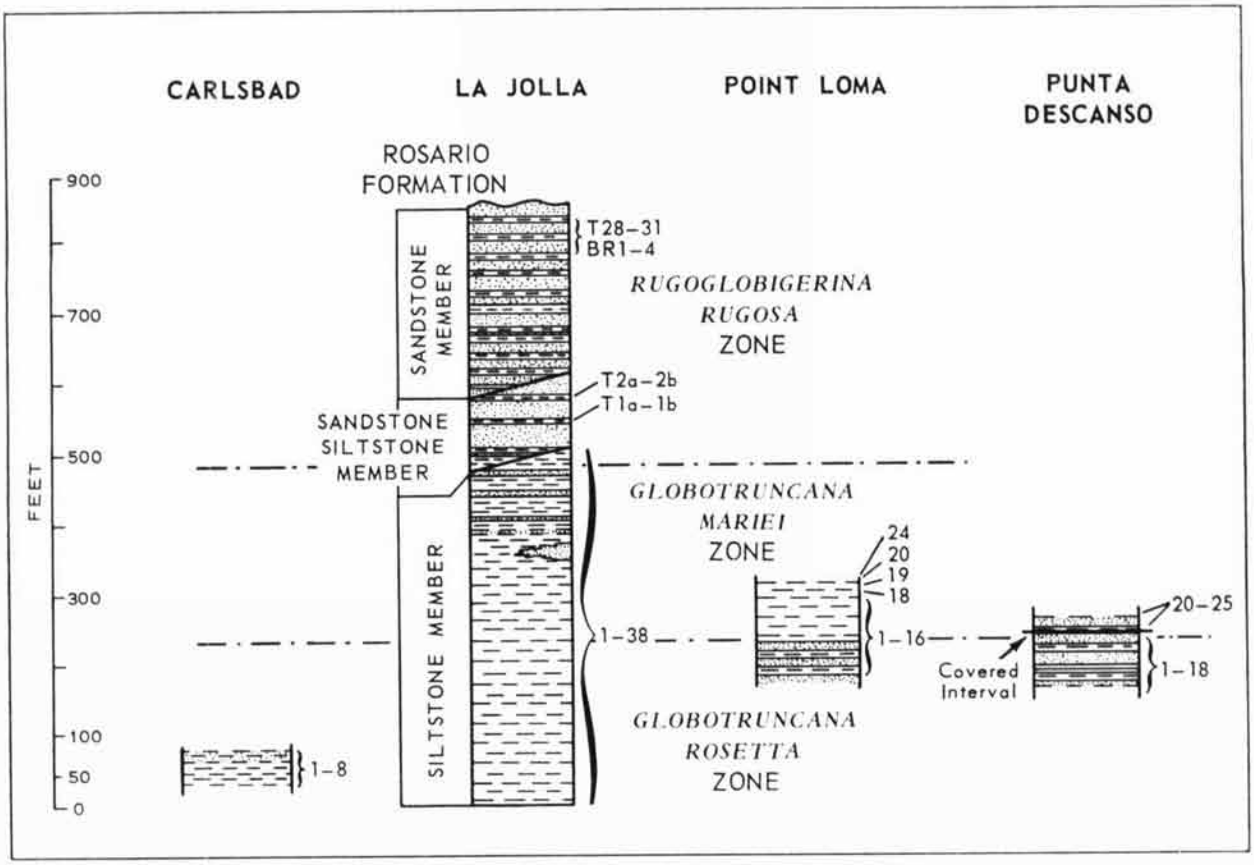


FIG. 2. Relative thicknesses and biostratigraphic zones of the Upper Cretaceous of southern California and northwestern Mexico.

three zones are concurrent-range zones as defined by the *Code of Stratigraphic Nomenclature* (1961, p. 656) and are best developed at La Jolla.

GLOBOTRUNCANA ROSETTA Zone

This zone is found in the lower 250 feet of the siltstone member at La Jolla (Fig. 2). The base of the zone is not determinable there because the siltstone overlies a lower massive sandstone member. Species locally restricted to this zone (Table 2a) include the following.

TABLE 2a.—*Species Locally Restricted to Globotruncana rosetta Zone.*

Globotruncana rosetta (CARSEY)
Globotruncana churchi MARTIN
Pseudoguembelina costulata (CUSHMAN)
Guembelitria cretacea CUSHMAN
Neoflabellina rugosa (D'ORBIGNY)
Pseudouvigerina plummerae CUSHMAN
Pseudouvigerina californica SLITER, n. sp.
Nonionella cretacea CUSHMAN
Frondicularia goldfussi REUSS
Frondicularia intermittens REUSS
Pseudonodosaria manifesta (REUSS)
Ceratobulimina (Ceratolamarckina) cretacea CUSHMAN & HARRIS
Gyroidinoides trujilloi SLITER, n. sp.
Lenticulina modesta (BANDY)
Gaudryina glabrata (CUSHMAN)

Other species first occurring in this zone (Table 2b) include the following.

TABLE 2b.—*Species First Occurring in Globotruncana rosetta Zone.*

Globotruncana havanensis VOORWIJK
Globotruncana mariei BANNER & BLOW
Globotruncana cretacea (D'ORBIGNY)
Globotruncana petaloidea GANDOLFI
Globotruncana ventricosa WHITE
Neoflabellina pilulifera (CUSHMAN & CAMPBELL)
Praebulimina aspera CUSHMAN & PARKER
Gavelinella stephensoni (CUSHMAN)
Globorotalites spineus (CUSHMAN)
Astacolus jarvisi (CUSHMAN)
Lenticulina spissocostatus (CUSHMAN)
Lenticulina californiensis TRUJILLO

Lenticulina taylorensis (PLUMMER)
Frondicularia inversa REUSS
Pleurostomella subnodosa REUSS
Marginulina bullata REUSS

The major faunal elements of this zone occur throughout the Carlsbad section and the lower 75 feet of strata at Punta Descanso.

The diagnostic foraminifers of this zone include *Globotruncana arca* (CUSHMAN), *G. rosetta* (CARSEY), *G. fornicata* PLUMMER, *G. marginata* (REUSS), and *G. churchi* MARTIN, which are indicative of an age no older than middle Campanian. European guide species include the Campanian *Neoflabellina rugosa* (D'ORBIGNY) and the characteristically late Campanian *Neoflabellina pilulifera* (CUSHMAN & CAMPBELL). Species which are restricted to this zone and characteristically to strata of Taylor age in the American Gulf Coast include *Pseudoguembelina costulata* (CUSHMAN), *Nonionella cretacea* CUSHMAN, *Frondicularia goldfussi* REUSS, and *F. intermittens* REUSS. Additional planktonic species beginning in this zone and ranging from the late Campanian to Maastrichtian include *Globotruncana havanensis* VOORWIJK and *G. petaloidea* GANDOLFI.

Megafossils from this portion of the Rosario Formation at La Jolla are inadequately described. Correlative strata throughout California, however, contain a middle to late Campanian *Metaplacenticeras* ammonite assemblage (POPENOE, IMLAY & MURPHY).

GLOBOTRUNCANA MARIEI Zone

The upper 250 feet of the siltstone member contains species of the *Globotruncana mariei* Zone. Locally restricted to this zone (Table 3a) are the following.

TABLE 3a.—*Species Locally Restricted to Globotruncana mariei Zone.*

Bolivinoides draco miliares HILTERMAN & KOCH
Rzehakina epigona (RZEHAK)
Ammodiscus glabratus CUSHMAN & JARVIS
Pyramidina szajnochae (GRZYBOWSKI)
Frondicularia lomaensis SLITER, n. sp.
Haplophragmium luecki (CUSHMAN & HEDBERG)
Racemiguembelina fructicosa (EGGER)

Characteristic species that occur most commonly in this zone (Table 3b) but may extend above, below, or both include the following.

TABLE 3b.—*Characteristic Species of Globotruncana mariei Zone.*

Bolivinoides laevigatus MARIE
Bandyella greatvalleyensis (TRUJILLO)
Bolivina incrassata REUSS
Bifarina douglasi SLITER, n. sp.
Trochammina pilea SLITER, n. sp.
Dorothia retusa (CUSHMAN)
Lenticulina davisi (BANDY)
Frondicularia durrelli TRUJILLO
Loxostomum eleyi (CUSHMAN)
Gyroidinoides bandyi (TRUJILLO)
Gavelinella whitei (MARTIN)

This zone also is recognized in the upper 100 feet exposed at Point Loma and the remaining 47 feet at Punta Descanso.

The *Globotruncana mariei* Zone is of latest Campanian age. The planktonic assemblage includes the common occurrences of *G. havanensis* VOORWIJK, *G. mariei* BANNER & BLOW, *G. arca* (CUSHMAN), and *G. petaloidea* GANDOLFI, and the uppermost occurrence of *G. ventricosa* WHITE. European guide species indicative of this age are *Bolivina incrassata* REUSS and *Bolivinoides draco miliares* HILTERMANN & KOCH. *Racemiguembelina fructicosa* (EGGER), which occurs rarely, is characteristic of the late Campanian-Maastrichtian in the American Gulf Coast, Mexico, Europe, and India. This zone also contains *Bolivinoides laevigatus* MARIE, which ranges from the late Campanian to early Maastrichtian in Israel and Europe.

Megafossils from this zone include the ammonites *Menuites* sp. cf. *M. menu* (FORBES) and *Baculites lomaensis* (ANDERSON), found at Point Loma, and suggest an age close to the Campanian-Maastrichtian boundary (MATSUMOTO, 1960). In addition, a smooth pachydiscid reported from Point Loma is correlated with the *Pachydiscus (Neodesmoceras)* association occurring in the Rosario Formation of Baja California, Mexico, and in the upper member of the Cretaceous sequence from the Simi Hills, California, also referred to the latest Campanian-Maastrichtian (MATSUMOTO, 1960). *Crassatella lomana* COOPER from Point Loma has been reported elsewhere from the Campanian Holz Shale Member of the Ladd Formation, Santa Ana Mountains (POPENOE, 1937).

RUGOGLOBIGERINA RUGOSA Zone

The *Rugoglobigerina rugosa* Zone is restricted to the La Jolla section where it occurs in the uppermost part of the siltstone member and throughout the siltstone-sandstone member and sandstone member. The meager fauna consists primarily of long-ranging calcareous species and a few agglutinated forms and is characterized by restricted occurrences of *Rugoglobigerina rugosa* (PLUMMER), *Globotruncana* sp., *Heterohelix glabrans* (CUSHMAN), and *Bolivinoides draco draco* (MARSSON).

The assemblage just noted, together with high-spired but noncrenulate specimens of *Globotruncana fornicata* PLUMMER, indicates an early Maastrichtian age.

Megafossils occur rarely in these beds. The strata are stratigraphically above those correlated with the Point Loma pachydiscid horizon and should, therefore, be within the Maastrichtian.

TABLE 4.—*Campanian-Maastrichtian Foraminiferal Biostratigraphic Zonation in California.*
[The subzone here termed *Globotruncana havanensis* Subzone was called *Globotruncanella havanensis* by DOUGLAS (1966).]

		THIS REPORT	DOUGLAS (1966)		TAKAYANAGI (1965)	GOUDKOFF (1945) MODIFIED
MAASTRICHTIAN	MIDDLE					C
	EARLY	*RUGOGLOBIGERINA RUGOSA* ZONE	*GLOBOTRUNCANA ARCA – PLANOGLOBULINA ORNATISSIMA* ZONE	*GLOBOTRUNCANA HAVANENSIS* SUBZONE		D_1, D_2
CAMPANIAN	LATE	*GLOBOTRUNCANA MARIEI* ZONE; *GLOBOTRUNCANA ROSETTA* ZONE		*GLOBOTRUNCANA CHURCHI* SUBZONE	*GLOBOTRUNCANA SUBCIRCUMNODIFER* ZONE	E, F_1
	MIDDLE	*GLOBOTRUNCANA ROSETTA* ZONE (lower part)		*GLOBOTRUNCANA CHURCHI* SUBZONE; *GLOBOTRUNCANA STUARTIFORMIS* SUBZONE		F_1, F_2
	EARLY			*GLOBOTRUNCANA STUARTIFORMIS* SUBZONE		F_2, G_1

PACIFIC COAST CORRELATION

Eastern Pacific coast correlations are shown in Tables 4 and 5. The following regional and interregional correlations are based primarily on planktonic species and specialized benthonic species of *Bolivina*, *Bolivinoides*, and *Neoflabellina*.

Southern California.—BANDY (1951) described an Upper Cretaceous foraminiferal fauna from Carlsbad containing 5 planktonic and 51 benthonic species. Most of these species have been recognized in the present study and augmented by an additional 16 planktonic and 91

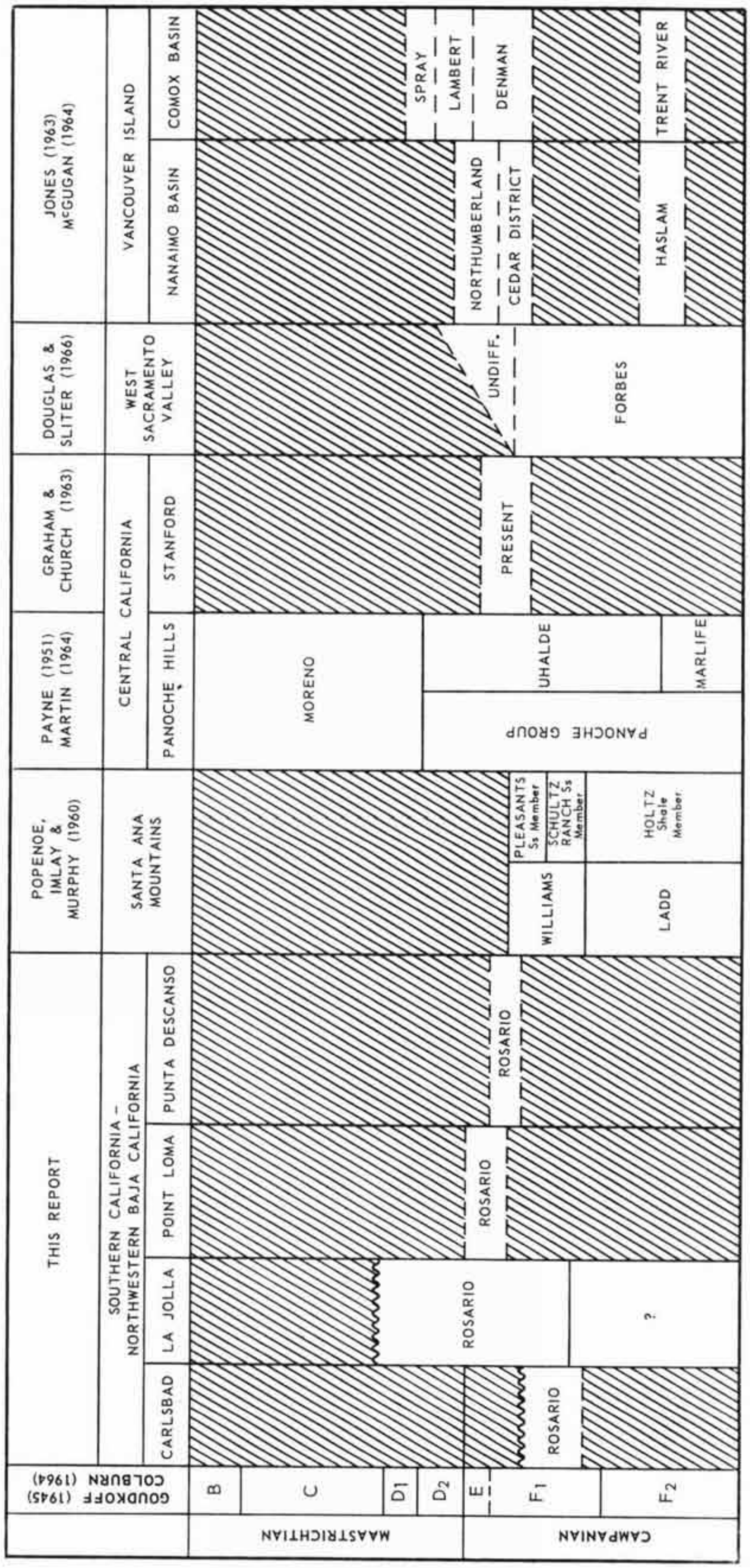


TABLE 5.—*Campanian-Maastrichtian Correlations along Pacific Coast.*

benthonic species. BANDY considered this fauna equivalent to the E zone of GOUDKOFF (1945) and the Taylor Marl of Texas, hence of Campanian age. As noted previously, the Carlsbad fauna represents the late Campanian *Globotruncana rosetta* Zone.

Central California.—CUSHMAN & CHURCH (1929) described a Cretaceous fauna from the Alcalde Hills of Fresno County, California. Twelve of the 43 species occur in southern California, including *Globotruncana churchi* MARTIN, *Planoglobulina ornatissima* (CUSHMAN & CHURCH), and *Gyroidinoides quadratus* (CUSHMAN & CHURCH). This assemblage also represents the late Campanian *Globotruncana rosetta* Zone.

CUSHMAN & CAMPBELL (1935) reported a fauna of 18 species in the subsurface Moreno Formation from a well near Tracy, San Joaquin County, California. Six of these species are common to southern California and include *Neoflabellina pilulifera* (CUSHMAN & CAMPBELL) and *Bolivina incrassata* REUSS. As noted by CUSHMAN & CAMPBELL, this fauna is younger than that described by CUSHMAN & CHURCH (1929) and is here correlated with the late Campanian *Globotruncana mariei* Zone.

The foraminifers from the Panoche Hills and Laguna Seca Hills of Fresno County, California, have been studied recently by MARTIN (1964). Of the 167 species described by him from the upper Marlife Formation, 67 occur in southern California and northwestern Mexico. The fauna generally is sparse, with few planktonic or specialized benthonic species. The upper portion of the upper Marlife Formation contains a few species common to the *Globotruncana rosetta* Zone, namely, *G. rosetta* (CARSEY), *G. churchi* MARTIN, *Lenticulina modesta* (BANDY), and *Gyroidinoides quadratus martini* SLITER. *Neoflabellina rugosa* (D'ORBIGNY) also occurs in this formation near the lower boundary. Fifty-seven percent of the species common to southern California and northwestern Mexico occur in this stratigraphic interval, and 68 percent of these are present in the *Globotruncana rosetta* and *G. mariei* Zones. In the overlying strata, 83 percent of the species in common are long-ranging and occur in all three southern California zones. The faunal assemblage of the upper portion of the upper Marlife Formation and the lower two-thirds of the Uhalde Formation thus is suggestive of middle to late Campanian, rather than early Campanian age. The upper Uhalde Formation contains long-ranging species that provide little aid for determination of the Maastrichtian boundary. *Rugoglobigerina rugosa* (PLUMMER) may be present, but the specimen illustrated by MARTIN (1964, pl. 10, fig. 6) is better referred to *Hedbergella*. The section at Laguna Seca Creek contains *Bolivina incrassata* REUSS, *Neoflabellina pilulifera* (CUSHMAN & CAMPBELL), and *Globulina subsphaerica* (BERTHELIN), suggestive of the *Globotruncana mariei* Zone; the last two species occur most characteristically in this zone. Species found above this assemblage are long-ranging and are not adequate for precise correlation.

The Campanian fauna described by GRAHAM & CHURCH (1963) from the Stanford University campus, California, contains 150 species, of which 58 are found in southern California and northwestern Mexico. Of correlative importance are *Bolivina incrassata* REUSS, *Neoflabellina pilulifera* (CUSHMAN & CAMPBELL), *Bolivinoides delicatulus* CUSHMAN (= *B. laevigatus* MARIE), and *Loxostomum eleyi* (CUSHMAN) which are indicative of the late Campanian *Globotruncana mariei* Zone.

Northern California.—TRUJILLO (1960) described 90 Upper Cretaceous foraminifers from the Redding area of Shasta County, California, that range from middle Turonian to Santonian. Thirty of these are found also in southern California. Members IV and VI of TRUJILLO contain 21 species in common, including the long-ranging benthonic species found in the *Globotruncana rosetta* and *G. mariei* Zones. Among the more restricted species are: *Bandyella greatvalleyensis* (TRUJILLO), *Pleurostomella subnodosa* REUSS, *Astacolus jarvisi* (CUSHMAN), *Ceratobulimina (Ceratolamarckina) cretacea* CUSHMAN & HARRIS, *Frondicularia durrelli* TRUJILLO, *Lenticulina californiensis* TRUJILLO, and *Gyroidinoides bandyi* (TRUJILLO). Members IV and VI are dated as Santonian to early Campanian on the basis of mollusks. The foraminiferal faunas also indicate an age older than the *Globotruncana rosetta* Zone.

Along the west side of the Sacramento Valley, planktonic foraminifers from the upper part of the Forbes Formation correlate with the *Globotruncana rosetta* and *G. mariei* Zones of southern California. TAKAYANAGI (1965) recognized six foraminiferal zones in strata exposed at Putah Creek, bordering Yolo and Solano Counties (Table 4). The youngest, or *Globotruncana subcircumnodifer* Zone, includes the upper Guinda Formation and all of the Forbes Formation. The latter formation contains *Globotruncana putahensis* TAKAYANAGI (= *G. stuartiformis* DALBIEZ) and *G. churchi* MARTIN [= *G. arca* (CUSHMAN) of TAKAYANAGI, 1965, pl. 22, fig. 6], the latter being restricted to the *G. rosetta* Zone in southern California.

Recently, DOUGLAS (1966) divided the Forbes Formation into one zone and two subzones based on the ranges of planktonic foraminifers (Table 4). The younger or *Globotruncana churchi* Subzone of DOUGLAS contains a planktonic fauna nearly identical to that in the *G. rosetta* and *G. mariei* Zones of southern California including *Globotruncana churchi* MARTIN, *G. ventricosa* WHITE, *G. fornicata* PLUMMER, *G. petaloidea* GANDOLFI and *Pseudoguembelina costulata* (CUSHMAN), all indicative of the late Campanian.

In the Marsh Creek Formation of Contra Costa County, California, DOUGLAS recognized the *Globotrun-*

cana churchi Subzone overlain by the younger *Globotruncanella havanensis* Subzone. This latter is correlated with the early Maastrichtian *Rugoglobigerina rugosa* Zone of southern California, based on the restricted occurrence of *R. rugosa* (PLUMMER) and the presence of *Globotruncanella (=Globotruncana) havanensis* (VOORWIJK), *G. petaloidea* (GANDOLFI), and *Globotruncana stuartiformis* DALBIEZ. DOUGLAS also reported this zone in unnamed Upper Cretaceous strata on San Miguel Island, Santa Barbara County, California.

The "zones" proposed by GOUDKOFF (1945) for the central valley of California are of interest for local subsurface correlation (Tables 4-5). These zones are defined by the stratigraphic ranges of 67 species, including 4 planktonic species. As the majority are benthonic forms, one might assume that they are facies-controlled and characterized by a different stratigraphic range outside the local geographic setting; in general this has been found to be true. The present fauna contains 24 species that occur in GOUDKOFF's zones G2 to A2, of Turonian to Danian age. *Bolivina incrassata* REUSS and *Neoflabellina pilulifera* (CUSHMAN & CAMPBELL), however, are of correlative value. In southern California, the latter first appears in the *Globotruncana rosetta* Zone and ranges into the *G. mariei* Zone. In the central valley, it ranges from the F1 to A2 zones. GOUDKOFF recognized the F1 zone in the Forbes Formation of Putah Creek which, as noted previously, contains a fauna correlating with the *Globotruncana rosetta* and *G. mariei* Zones. *Bolivina incrassata* REUSS first appears in the *Globotruncana mariei* Zone, and GOUDKOFF recorded it ranging from the D2 to A2 zones. The D2 zone was identified in the Ragged Valley Shale of the Alcalde Hills, Fresno County, and regarded as early Maastrichtian (POPENOE, IMLAY & MURPHY, 1960). Thus, the *Globotruncana rosetta* Zone correlates with a portion of the F1 zone, the *G. mariei* Zone with an interval including the remaining portion of the F1 zone and the E zone of later authors, and the *Rugoglobigerina rugosa* Zone tentatively including both the D2 and D1 zones.

Canada.—An Upper Cretaceous foraminiferal fauna of 44 species was described by MCGUGAN (1964) from Vancouver Island, British Columbia. Fourteen of these species are recorded in southern California and northwestern Mexico, all but one from the *Cibicides voltziana* and *Bolivina incrassata* Zones of MCGUGAN. In general, the species are long-ranging or confined to the *Globotruncana rosetta* and *G. mariei* Zones of southern California. The *Rugoglobigerina* Zone of MCGUGAN includes the lower Trent River Formation of the Comox basin and the major portion of the Haslam Formation in the Nanaimo basin. In Canada this zone contains *Ceratobulimina (Ceratolamarckina) cretacea* CUSHMAN & HARRIS, that in southern California is confined to the *Globotruncana rosetta* Zone. The *Cibicides voltziana* Zone includes the major portion of the Lambert Formation of the Comox basin and the Cedar district and Northumberland Formations of the Nanaimo basin. The fauna of this Canadian zone occurs in both the *Globotruncana rosetta* and *G. mariei* Zones in southern California. The *Bolivina incrassata* Zone includes the uppermost Lambert Formation and the younger Spray Formation. This zone contains the first appearance of *Bolivina incrassata* REUSS and correlates with the *Globotruncana mariei* Zone of southern California.

Alaska.—Alaskan faunas have been characterized as containing long-ranging, strongly facies-controlled species, the majority of which are agglutinated (BERGQUIST, 1961, 1966; TAPPAN, 1951, 1962). In southern Alaska, a foraminiferal zonation was based on some 78 species (BERGQUIST, 1961). Most are long-ranging, agglutinated or nodosariid species of little value for correlation. The B2 faunal zone, however, contains *Ceratobulimina (Ceratolamarckina) cretacea* CUSHMAN & HARRIS, *Pullenia cretacea* CUSHMAN, *Nodosaria septemcostata* GEINITZ, and *Neoflabellina* sp. aff. *N. rugosa* (D'ORBIGNY), suggesting correlation with the *Globotruncana rosetta* Zone or older strata in southern California. In northern Alaska, TAPPAN (1962) described a fauna of 155 species ranging in age from Valanginian to Campanian. Ten of these species occur in southern California and northwestern Mexico, including 4 Albian agglutinated species and 6 Turonian to Campanian species, all but one of which are calcareous. Of the latter, *Praebulimina cushmani* (SANDIDGE) and *P. venusae* (NAUSS) first appear in the *Globotruncana rosetta* Zone whereas *P. carseyae* (PLUMMER) is found only at Carlsbad.

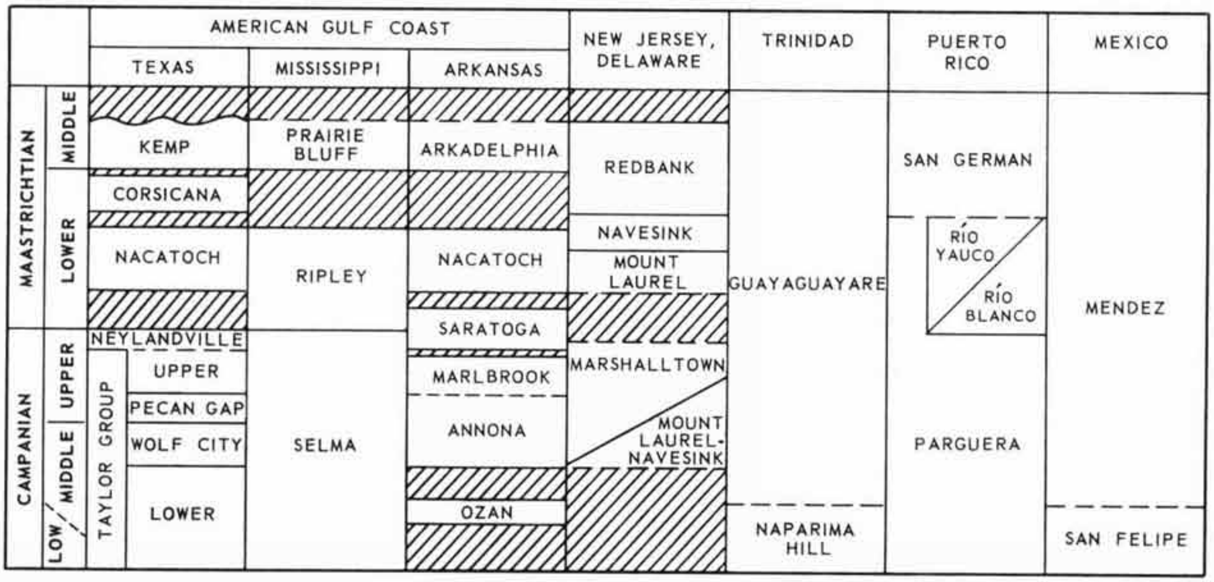
INTERREGIONAL CORRELATION

Interregional correlations are summarized on Tables 6 and 7. As noted previously, correlation is indicated primarily by planktonic and specialized benthonic species. The restricted Tethyan planktonic species also are correlated with the southern California zones. Thus, the local Campanian zones correlate with the occurrences of *Globotruncana calcarata* CUSHMAN whereas the early Maastrichtian assemblage correlates with the occurrences of *G. contusa* (CUSHMAN), *G. subcircumnodifer* GANDOLFI, *G. gagnebini* TILEV and *G. gansseri* BOLLI. As noted by DOUGLAS & SLITER (1966), these species, as well as other restricted Tethyan forms, are unreported from the eastern Pacific margin north of Central America. If in fact these species were excluded from the northern

Table 6.—*Interregional Campanian-Maastrichtian Foraminiferal Biostratigraphic Zonation.*

		CALIFORNIA THIS REPORT	TRINIDAD BOLLI (1966)	CUBA BRÖNNIMANN & RIGASSI (1963) MODIFIED	ATLANTIC COAST OLSSON (1964)		ALPS: REICHENHALL SALZBURG HERM (1962)	ALPS: CENTRAL SWISS MOHLER (1966)	FROM LITERATURE, VAN HINTE (1965)		NORTH AFRICA DALBIEZ (1955)
MAASTRICHTIAN	LATE		*ABATHOMPHALUS MAYAROENSIS*	*RUGOTRUNCANA MAYAROENSIS*			F E	*GLOBOTRUNCANA MAYAROENSIS*	*GLOBOTRUNCANA STUARTI*	*GLOBOTRUNCANA CONTUSA*	*GLOBOTRUNCANA CONTUSA*
	MIDDLE		*GLOBOTRUNCANA GANSSERI*	*RUGOTRUNCANA GANSSERI*	*GLOBOTRUNCANA CONTUSA* *HEDBERGELLA MONMOUTHENSIS*	*GLOBOTRUNCANA GAGNEBINI*	D	*GLOBOTRUNCANA CONTUSA CONTUSA*	*GLOBOTRUNCANA GANSSERI*	*GLOBOTRUNCANA CALICIFORMIS*	
	EARLY	*RUGOGLOBIGERINA RUGOSA*	*GLOBOTRUNCANA LAPPARENTI TRICARINATA*		*GLOBOTRUNCANA FORNICATA - TRICARINATA*	*HEDBERGELLA HOLMDELENSIS*					*GLOBOTRUNCANA ARCA*
CAMPANIAN	LATE	*GLOBOTRUNCANA MARIEI* *GLOBOTRUNCANA ROSETTA*		*GLOBOTRUNCANA LINNEIANA*		*GLOBOTRUNCANA LINNEIANA*	C	*GLOBOTRUNCANA CALCARATA*	*GLOBOTRUNCANA CALCARATA*		*GLOBOTRUNCANA ELEVATA*
	MIDDLE										
	EARLY		*GLOBOTRUNCANA STUARTI*				B	*GLOBOTRUNCANA THALMANNI - FLEXUOSA* GROUP	*GLOBOTRUNCANA STUARTIFORMIS*		

TABLE 7.—*Interregional Campanian-Maastrichtian Correlation.*



Pacific Basin, the strata may range into the middle Maastrichtian *Globotruncana gansseri* Zone of BOLLI (1957).

American Gulf Coast.—Upper Campanian equivalents in the American Gulf Coast include the Pecan Gap Chalk, upper Taylor Marl, and Neylandville Marl of Texas. These strata contain the restricted late Campanian species *Globotruncana calcarata* CUSHMAN (CUSHMAN, 1946; FRIZZELL, 1954). Reported occurrences of *Rugoglobigerina rugosa* (PLUMMER) *s.s.* from these strata are here referred to *Globotruncana subrugosa* (GANDOLFI) or *G. cretacea* (D'ORBIGNY). The Selma Chalk of Mississippi contains a correlative Campanian fauna including *Neoflabellina rugosa* (D'ORBIGNY) (CUSHMAN, 1946). In Arkansas, the Marlbrook Marl tentatively is correlated with the Campanian.

Maastrichtian correlatives in the American Gulf Coast include the Nacatoch Sand and Corsicana Marl of Texas and Saratoga Chalk of Arkansas.

Atlantic Coast.—The Upper Cretaceous planktonic foraminifers of New Jersey, Delaware, and New York recently have been studied (OLSSON, 1964; PERLMUTTER & TODD, 1965). A late Campanian assemblage occurs in the Mt. Laurel-Navesink Formation of Delaware, Marshalltown Formation of New Jersey, and Monmouth Group of New York. The early Maastrichtian is recognized in the Mt. Laurel and Navesink Formations of New Jersey by the appearance of *Rugoglobigerina rugosa* (PLUMMER) and *Hedbergella holmdelensis* OLSSON and the disappearance of *Globotruncana calcarata* CUSHMAN. OLSSON (1964) recorded the gradual evolution of the Maastrichtian species *G. gansseri* BOLLI in the early Maastrichtian. Species reported from the Maastrichtian *G. contusa-Hedbergella monmouthensis* Zone are suggestive of a middle, rather than late Maastrichtian age on the basis of the present correlation. It is significant to note that although *Globotruncana petaloidea* GANDOLFI is present, *G. havanensis* VOORWIJK has not been reported from the upper Atlantic Coast.

Caribbean area-Mexico.—Trinidad Cretaceous planktonic zonations by BOLLI (1951, 1957, 1966) have formed a major basis for interregional correlation. Many species reported by BOLLI from the *Globotruncana stuarti* and *G. lapparenti tricarinata* Zones of the Naparime Hill and Guayaguayare Formations are found in southern California. The *G. stuarti* Zone of Trinidad is correlated in part with the *G. rosetta* Zone of southern California and contains *G. arca* (CUSHMAN), *G. fornicata* PLUMMER, *G. lapparenti lapparenti* BROTZEN [= *G. linneiana* (D'ORBIGNY)], and the first occurrence of *Praeglobotruncana citae* (BOLLI) (= *Globotruncana havanensis* VOORWIJK). In southern California, the upper limit of *G. ventricosa* WHITE is in the overlying *G. mariei* Zone which occupies the hiatus found in Trinidad between the *G. stuarti* and *G. lapparenti tricarinata* Zones.

The early Maastrichtian *Globotruncana lapparenti tricarinata* Zone of Trinidad contains *G. tricarinata* (QUEREAU), and *G. arca* (CUSHMAN) and the last occurrences of *G. linneiana* (D'ORBIGNY) and *G. fornicata* PLUMMER. This zone correlates with the early Maastrichtian *Rugolobigerina rugosa* Zone of southern California.

In Cuba, BRÖNNIMANN & RIGASSI (1963) showed the Via Blanca Formation to range from the Campanian to the Maastrichtian. Three zones were erected, the Campanian *Globotruncana linneiana* Zone and the Maastrichtian *Rugotruncana gansseri* and *R. mayaroensis* Zones. The *Globotruncana linneiana* Zone correlates with the late Campanian-early Maastrichtian zones of southern

California. Campanian correlative species include *G. linneiana* (D'ORBIGNY), *G. fornicata* PLUMMER, *G. calcarata* CUSHMAN, *G. cretacea* (D'ORBIGNY), and several heterohelicid species. This zone also contains the first occurrence of *Rugoglobigerina rugosa* (PLUMMER) in the Tethyan area. The early Maastrichtian fauna from Cuba, occurring prior to the restricted middle Maastrichtian *Rugotruncana gansseri* Zone, contains *Globotruncana havanensis* VOORWIJK, *G. mariei* BANNER & BLOW, *G.* sp. cf. *G. tricarinata* (QUEREAU), *Rugoglobigerina rugosa* (PLUMMER), and *Heterohelix pulchra* (BROTZEN) in addition to other heterohelicids.

Mexican late Campanian-early Maastrichtian foraminifers have been studied by ETERNOD OLVERA (1959) from the Méndez Shale of the Tampico-Tuxpan Basin. The fauna includes the late Campanian species *Globotruncana calcarata* CUSHMAN and the Maastrichtian assemblage of *G. contusa* (CUSHMAN), *G. gansseri* BOLLI, *Rugoglobigerina rugosa* (PLUMMER) and *Plummerita hantkeninoides inflata* (BRÖNNIMANN). *Abathomphalus mayaroensis* (BOLLI) also is reported, although the figured specimen has a large, open umbilicus rather than the more characteristic small umbilicus. The presence of *Plummerita* in association with true abathomphalids would indicate a late Maastrichtian age for the upper portion of the Méndez Shale, equivalent to the *Abathomphalus mayaroensis* Zone of Trinidad.

South America.—GANDOLFI (1955) described the planktonic foraminifers from the Manaure Shale and the Colon Formation of Colombia. The lower portion of the Colon Formation contains the first appearance of *Globotruncana havanensis* VOORWIJK, *G. subcircumnodifer* GANDOLFI and high-spired, double-keeled specimens referred to *G. contusa patelliformis* GANDOLFI and regarded as intermediate between *G. fornicata* PLUMMER and *G. contusa* CUSHMAN *s.s.* The assemblage is recognized in the upper portion of the *G. mariei* Zone of southern California. The specimens resembling *G. contusa patelliformis* GANDOLFI are here referred to *G. fornicata* PLUMMER. *Globotruncana havanensis* VOORWIJK, *G. contusa* (CUSHMAN), and *G. stuarti* (DE LAPPARENT) were reported by GANDOLFI to range into the uppermost portion of the Campanian *Pullenia cretacea* Zone. In addition, *G. gansseri* BOLLI and *Rugoglobigerina rugosa* (PLUMMER), having the same range, were shown to begin at the Campanian-Maastrichtian boundary. The present correlation suggests that GANDOLFI's Maastrichtian boundary is too high and should be lowered within the *Pullenia cretacea* Zone to include the occurrences of *G. contusa.* A Maastrichtian age for the uppermost portion of the *Pullenia cretacea* Zone was suggested by GANDOLFI (1955, p. 86, 97). It includes the ranges of *Rugoglobigerina rugosa* (PLUMMER) and the characteristic Maastrichtian species *G. gansseri* BOLLI. The earlier specimens of *Rugoglobigerina* were reported to be weakly keeled and poorly ornamented and thus indicative of *Globotruncana subrugosa* (GANDOLFI). These transitional forms disappear entirely in the uppermost *Pullenia cretacea* Zone.

Europe.—Planktonic foraminifers of the type Campanian section of southwest France recently were described by VAN HINTE (1965). The assemblage includes *Globotruncana arca* (CUSHMAN), *G. fornicata* PLUMMER, *G. linneiana* (D'ORBIGNY), *G. marginata* (REUSS), *G. tricarinata* (QUEREAU), and *Pseudotextularia elegans* (RZEHAK). VAN HINTE referred this assemblage to the *Globotruncana stuartiformis* Zone, of middle Campanian age or prior to the first occurrance of *G. calcarata* CUSHMAN. This fauna correlates with the *Globotruncana rosetta* Zone of southern California.

In southwestern Germany-Austria, HERM (1962) described planktonic foraminifers from an Upper Cretaceous section in the Reichenhall-Salzburg basin. The correlative Campanian assemblage of his zones B and C includes *Globotruncana arca* (CUSHMAN), *G. fornicata* PLUMMER, *G. ventricosa* WHITE, and *G. calcarata* CUSHMAN. This is overlain by the early Maastrichtian zone D containing *G. contusa* (CUSHMAN) and *G. havanensis* VOORWIJK.

VAN HINTE (1963) zoned a similar sequence from southern Austria by means of planktonic and specialized benthonic foraminifers. The Pemberger Folge was shown to contain a late Campanian-early Maastrichtian assemblage, ranging from the upper part of the *Globotruncana elevata subspinosa* through the *G. calcarata* Zones and into the lower part of the *G. gansseri* Zone. Correlative foraminifers in this formation include *G. arca* (CUSHMAN), *G. fornicata* PLUMMER, *G. calcarata* CUSHMAN, *G. linneiana* (D'ORBIGNY), *G. havanensis* VOORWIJK, *Bolivinoides draco miliares* HILTERMANN & KOCH, and *B. draco draco* (MARSSON).

In northern Spain, HERM (1965) recently reported a similar Upper Cretaceous sequence containing late Campanian-early Maastrichtian planktonic and benthonic foraminifers. Upper Campanian-lower Maastrichtian southern California strata are correlated with this sequence by the occurrence of *Globotruncana linneiana* (D'ORBIGNY), *G. tricarinata* (QUEREAU), *G. arca* (CUSHMAN), *G. rosetta* (CARSEY), and *G. havanensis* VOORWIJK prior to the first appearance of the Maastrichtian species *G. gansseri* BOLLI. Restricted Tethyan correlative planktonics include *G. calcarata* CUSHMAN and *G. contusa* (CUSHMAN).

CATI (1964) described foraminifers from the *scaglia rossa* of northern Italy and dated them as Campanian. Several species, however, are indicative of the late Campanian *Globotruncana calcarata* Zone (e.g., *Globotruncana calcarata* CUSHMAN, *Pseudoguembelina costulata* (CUSHMAN), *Pseudotextularia elegans* (RZEHAK), and *Bolivinoides draco miliares* HILTERMANN & KOCK).

Japan.—Japanese Upper Cretaceous foraminiferal faunas are of interest because of the similarity of latitudinal distribution and geographic position, and the Indo-

Pacific character of the North American Pacific Coast Cretaceous foraminiferal and molluscan faunas. Foraminiferal studies of equivalent strata from Hokkaido, Japan, by FUKUTA (1957), TAKAYANAGI (1960), and YOSHIDA (1963) point out the dominantly agglutinated character of the fauna that, with its subordinate calcareous assemblage, strongly resembles the fauna described from northern Alaska by TAPPAN (1962). Correlation of these faunas is difficult, as few cosmopolitan planktonic or specialized benthonic species are present, the majority of the calcareous species belonging to the Nodosariidae (ASANO & TAKAYANAGI, 1965). YOSHIDA (1963) reported, however, *Bolivina incrassata* REUSS and *B.* sp. cf. *B. decurrens* (EHRENBERG) from eastern Hokkaido. On the basis of the micro- and megafossil assemblage and stratigraphy, he regarded the lower part of the Namuro Group as Maastrichtian in age. ASANO & TAKAYANAGI (1965) recently pointed out the provincial nature of the Japanese Late Cretaceous planktonic foraminifers from Hokkaido and the difficulty in interregional correlation. The faunal pecularities were suggested to be due to cold-water influences or a deterioration of local oceanic circulation.

Australia.—The basins of western Australia contain equivalent Campanian-Maastrichtian foraminiferal assemblages (EDGELL, 1957; BELFORD, 1959, 1960). The Toolonga Calcilutite, believed to be lower Campanian (BELFORD, 1960), contains planktonic species common to southern California and northwestern Mexico, corresponding to the basal *Globotruncana rosetta* Zone. The Korojon Calcarenite is equivalent to the *G. havanensis* Zone and includes *Neoflabellina pilulifera* (CUSHMAN & CAMPBELL) and *Bolivina incrassata* REUSS. The overlying Miria Marl has a Maastrichtian assemblage, including *Globotruncana havanensis* VOORWIJK, *G. lugeoni* TILEV (= *G. gansseri* BOLLI), *G. contusa* (CUSHMAN), *G. planata* EDGELL (= *Abathomphalus* sp.), and *Bolivinoides draco draco* (MARSSON). This assemblage correlates in part with the youngest strata in southern California; *however,* the presence of *Abathomphalus* indicates a still younger age for the upper portion of the formation.

BIOFACIES AND PALEOECOLOGY

Two distinct biofacies are recognized in the Upper Cretaceous of southern California. These transgress zonal boundaries and indicate two different, but geographically related areas of marine deposition—the inner shelf at Carlsbad and bathyal at La Jolla, Point Loma, and Punta Descanso.

SHELF ASSEMBLAGE

Comparison of data on the Carlsbad fauna with depth ranges and distributional patterns of Recent foraminifers (NORTON, 1930; PHLEGER, 1960; UCHIO, 1960; SMITH, 1964; WILCOXSON, 1964; SAIDOVA, 1965) reveals a distinct inner-shelf assemblage (above 140 meters). This biofacies is characterized by species of *Quinqueloculina, Spiroloculina, Globulina, Guttulina, Vaginulinopsis, Ramulina, Planorbulina, Pararotalia, Pyrulina,* and *Polymorphina* and by encrusting genera such as *Placopsilina, Carpenteria,* and *Epithemella,* n. gen.

The Carlsbad agglutinated foraminiferal fauna includes only 5 of the 40 species occurring at La Jolla, Point Loma, and Punta Descanso; i.e., *Silicosigmoilina californica* CUSHMAN & CHURCH, *Gaudryina glabrata* (CUSHMAN), *Dorothia oxycona* (REUSS), *Spiroplectammina laevis* (ROEMER), and *Dorothia pupa* (REUSS).

A paucity of Recent agglutinated foraminifers is generally true for shelf areas which commonly contain small, simple species. This pattern is modified, however, by local environmental conditions such as decreased salinity, depth, or turbidity. Nevertheless, the relative scarcity of agglutinated foraminifers at Carlsbad suggests a shelf environment.

The Carlsbad planktonic assemblage includes all but two of the species occurring in the equivalent zone at La Jolla. *Globotruncana stuartiformis* DALBIEZ and *G. mariei* BANNER & BLOW are lacking. Their absence may reflect a different planktonic environment at Carlsbad.

Recent planktonic foraminifers are characteristic of offshore, oceanic water and occur less commonly in continental shelf water, depending generally on the amount of runoff and geographic configuration. Thus, the reduced planktonic assemblage at Carlsbad may represent a more shoreward depositional environment than that at La Jolla, Point Loma, and Punta Descanso.

Additional mega- and microfossils at Carlsbad include the rudist *Coralliochama orcutti* WHITE, *Ostrea* sp., *Spondylus* sp., other small pelecypods, small gastropods, echinoid spines and plates, bryozoans, and ostracodes. HOLDEN (1964) examined the ostracode fauna and suggested a depth range of "middle to outer neritic" in a small coastal basin.

The Carlsbad foraminiferal fauna is divided into two assemblages. One is composed of species restricted to this locality (Table 8) and the second of species occurring both at Carlsbad and in portions of the other three localities. The latter assemblage is again divided into two groups. The first comprises species whose disjunct occurrences at La Jolla, Point Loma, and Punta Descanso are interpreted to indicate faunal displacement (Table 9) and the second comprises species found in the siltstone-sandstone facies of the three localities and representing either displaced species or merely rare occurrences of environmentally tolerant forms (Table 10). Many of the species in the latter category are tabular or minute and, as such, are highly susceptible to dispersal by currents.

BATHYAL ASSEMBLAGE

At La Jolla, Point Loma, and Punta Descanso, the foraminiferal fauna is again divided into two assemblages; one representing the indigenous fauna (Table 11) and the second, a displaced Carlsbad fauna (see Tables 9-10). Both of these assemblages are related closely to the lithologic facies. The indigenous fauna occurs in the siltstone sequence whereas a mixed indigenous-displaced fauna occurs in the siltstone-sandstone facies.

The indigenous fauna includes numerous agglutinated forms and an increase in species of the families Nonionidae, Osangulariidae, and Anomalinidae.

TABLE 8.—*Late Cretaceous Foraminifers Restricted to Carlsbad, California.*

Placopsilina sp.
Spiroloculina cretacea REUSS
Dentalina sp.
Palmula primitiva CUSHMAN
Pseudonodosaria obesa (LOEBLICH & TAPPAN)
Saracenaria jarvisi (BROTZEN)
Vaginulina olssoni SLITER, n. sp.
Berthelinopsis carlsbadensis SLITER, n. sp.
Guttulina adhaerens (OLSZEWSKI)
Pyrulina apiculata (MARIE)
Pyrulina sp. cf. *P. cylindroides* (ROEMER)
Seabrookia cretacica BERMÚDEZ
Oolina apiculata REUSS
Oolina delicata SLITER, n. sp.
Fissurina oblonga REUSS
Fissurina laticarinata SLITER, n. sp.
Fissurina akpatii SLITER, n. sp.
Fissurina bandyi SLITER, n. sp.
Fissurina simulata SLITER, n. sp.
Praebulimina carseyi (PLUMMER)
Epithemella martini (BROTZEN)
Planorbulina pacifica SLITER, n. sp.
Ellipsoidella gracillima (CUSHMAN)
Quadrimorphina spirata SLITER, n. sp.
Gavelinella henbesti (PLUMMER)
Heterolepa carlsbadensis SLITER, n. sp.
Pseudopatelinella cretacea TAKAYANAGI
Pseudopatelinella minuta SLITER, n. sp.

TABLE 9.—*Displaced Late Cretaceous Shelf Foraminifers Occurring in Bathyal Assemblages at La Jolla, Point Loma, and Punta Descanso.*

Gaudryina glabrata (CUSHMAN)
Cyclogyra sp.
Spiroloculina truncata SLITER, n. sp.
Quinqueloculina sp. cf. *Q. harrisi* HOWE & ROBERTS
Quinqueloculina sandiegoensis SLITER, n. sp.
Nodosaria proboscidea REUSS
Nodosaria sp.
Astacolus mundus (CUSHMAN)
Lagena semiinterrupta BERRY
Lenticulina revoluta (ISRAELSKY)
Saracenaria triangularis (D'ORBIGNY)
Vaginulina plummerae (CUSHMAN)
Vaginulinopsis directa (CUSHMAN)
Globulina lacrima (REUSS)
Ramulina globotubulosa CUSHMAN
Ramulina pseudoaculeata (OLSSON)
Bolivina decurrens (EHRENBERG)
Bolivina incrassata gigantea WICHER
Eouvigerina hispida CUSHMAN
Pararotalia praenaheolensis (OLSSON)
Fursenkoina nederi SLITER, n. sp.
Coryphostoma plaitum (CARSEY)
Nonionella austinana CUSHMAN
Pullenia sp. cf. *P. minuta* CUSHMAN
Gyroidina nonionoides (BANDY)
Globorotalites michelinianus (D'ORBIGNY)
Ceratobulimina (Ceratolamarckina) cretacea CUSHMAN & HARRIS

TABLE 10.—*Displaced or Environmentally Tolerant Late Cretaceous Foraminifers from Carlsbad, La Jolla, Point Loma, and Punta Descanso.*

Dorothia pupa (REUSS)
Nodosaria amphioxys REUSS
Astacolus sp. cf. *A. richteri* (BROTZEN)
Dentalina basiplanata CUSHMAN
Dentalina solvata CUSHMAN
Dentalina stephensoni (CUSHMAN)
Lagena acuticosta REUSS
Lenticulina sp. cf. *L. williamsoni* (REUSS)
Marginulina bullata REUSS
Saracenaria saratogana HOWE & WALLACE
Tristix sp. cf. *T. excavata* (REUSS)
Tristix sp.
Pyramidina prolixa (CUSHMAN & PARKER)
Pyramidina triangularis (CUSHMAN & PARKER)
Tappanina tuberosa SLITER, n. sp.
Serovaina orbicella (BANDY)
Alabamina dorsoplana (BROTZEN)
Colomia californica BANDY

TABLE 11.—*Late Cretaceous Bathyal Foraminifers from Globotruncana rosetta Zone at La Jolla.*

Bathysiphon brosegei TAPPAN
Bathysiphon vitta NAUSS
Bathysiphon varans SLITER, n. sp.
Hyperammina erugata SLITER, n. sp.
Ammodiscus cretaceus (REUSS)
Reophax globosus SLITER, n. sp.
Reophax prolatus SLITER, n. sp.
Haplophragmoides excavatus CUSHMAN & WATERS
Cribrostomoides cretacea CUSHMAN
Spiroplectammina chicoana LALICKER
Spiroplectammina sigmoidina LALICKER
Trochammina boehmi FRANKE
Trochammina texana CUSHMAN & WATERS
Trochammina triformis SLITER, n. sp.
Gaudryina bentonensis (CARMAN)
Gaudryina laevigata FRANKE
Gaudryina tailleuri (TAPPAN)
Dorothia bulletta (CARSEY)

Dorothia ellisorae (CUSHMAN)
Nodosaria velascoensis CUSHMAN
Dentalina catenula REUSS
Frondicularia frankei CUSHMAN
Lagena hispida REUSS
Lagena grahami SLITER, n. sp.
Lenticulina californiensis TRUJILLO
Lenticulina ovalis (REUSS)
Lenticulina pondi (CUSHMAN)
Lenticulina spissocostata (CUSHMAN)
Marginulina armata REUSS
Marginulinopsis striatocarinata (CUSHMAN & WATERS)
Saracenaria californica SLITER, n. sp.
Oolina globulosa (MONTAGU)
Fissurina orbignyana SEGUENZA
Praebulimina cushmani (SANDIDGE)
Praebulimina spinata (CUSHMAN & CAMPBELL)
Praebulimina venusae (NAUSS)
Praebulimina lajollaensis SLITER, n. sp.
Patellina subcretacea CUSHMAN & ALEXANDER
Falsocibicides beaumontianus (D'ORBIGNY)
Chilostomella trinitatensis CUSHMAN & TODD
Quadrimorphina camerata (BROTZEN)
Pullenia cretacea CUSHMAN
Osangularia cordieriana (D'ORBIGNY)
Gyroidinoides goudkoffi (TRUJILLO)
Gyroidinoides quadratus martini SLITER, n. subsp.
Gavelinella eriksdalensis (BROTZEN)
Gavelinella stephensoni (CUSHMAN)
Gavelinella velascoensis (CUSHMAN)
Gavelinella compressa SLITER, n. sp.
Heterolepa minuta SLITER, n. sp.

Currently little qualitative information is available on the distribution of lower shelf and bathyal Recent foraminifers; however, some trends and distributions may be utilized to suggest a Cretaceous depth zonation.

A dominance of agglutinated foraminifers generally is characteristic of two diverse depth environments in modern seas: 1) the inshore areas and lagoons, and 2) the bathyal to abyssal depths. As noted previously, these distribution patterns are modified by several environmental factors.

Among the Nonionidae, several species of *Pullenia* and *Chilostomella* characteristically occur between 200 and 3,000 m. (PARKER, 1954). In the Osangulariidae, *Osangularia culter* (PARKER & JONES) commonly occurs between 500 and 2,000 m. whereas *Hoeglundina elegans* (D'ORBIGNY) of the Ceratobuliminidae is characteristic of depths greater than 100 m. (PHLEGER, 1960). Members of the family Anomalinidae range widely from the inner shelf to bathyal; maximum numbers, however, are found on the continental shelf at bathyal depths.

Additional fossils include *Inoceramus* sp., *Baculites* sp., *Acila* sp., ostracodes, and numerous fish teeth.

The above faunal assemblage at La Jolla, Point Loma, and Punta Descanso and the uniform lithology of the siltstone sequence are suggestive of bathyal deposition far from the source area of coarse clastics.

The second or mixed foraminiferal assemblage is associated with the sandy facies at La Jolla, Point Loma, and Punta Descanso. These deposits commonly contain slump or turbidity-current structures in addition to transported shallow-water megafossils.

The turbidity-current structures are particularly well developed in the siltstone-sandstone member of the Rosario Formation at La Jolla. The foraminiferal fauna recovered from the micaceous siltstone containing planar and convolute laminations resembles that described by NATLAND (1963) from Tertiary sediments of the Ventura Basin, California. Elongate species commonly are broken, heavier agglutinated forms are missing, and the assemblage as a whole is size-graded. The random examples shown in Table 12 illustrate the size gradation. The uppermost lignitic layer, when present, contains a sparse indigenous fauna and an increased number of planktonics. The assemblage contains 15 species that are restricted to a bathyal environment, and only two species restricted to the upper shelf group.

The numerous burrows in the siltstone-sandstone facies also suggest a bathyal environment. SEILACHER (1964) correlated the presence of branching, facies transgressing, complex burrows of endobiotic deposit-feeders with bathyal, turbidity-current deposits.

The presence of displaced sublittoral foraminifers mixed with bathyal species within a lithologic sequence containing graded bedding, planar and cross laminations, and disturbed bedding strongly favors displacement by turbidity-current flows from the shelf to the deeper-basin floor.

Foraminifers from the two biofacies also are recognized at Point Loma and Punta Descanso. Comparison of these biofacies in the same biostratigraphic zone aids in identifying the paleoenvironment. At Point Loma the massive siltstone in the upper part of the section contains an indigenous bathyal fauna. The lower siltstone-sandstone sequence contains transported sublittoral species in addition to the indigenous bathyal fauna. The total fauna at this location includes 86 percent of the restricted bathyal species and 15 percent of the upper shelf species.

TABLE 12.—*Examples of Size Gradation in Different Lithologic Facies at La Jolla.*

FACIES	SAMPLE	LARGEST GLOBULAR SPECIMEN	AVERAGE SPECIMEN SIZE
SILTSTONE-SANDSTONE	T-28	0.35 mm	0.18 mm
	BR-1	0.49 mm	0.28 mm
SILTSTONE	LJ-9	1.40 mm	0.42 mm
	LJ-26	1.29 mm	0.49 mm

The Punta Descanso section is essentially the same; transported species occur in the sandy facies and rarely in the massive siltstone beds. Analysis of the total fauna shows it to contain 76 percent of the restricted bathyal species and 36 percent representing the sublittoral assemblage.

FAUNAL DIVERSITY

The occurrence of foraminifers in the Upper Cretaceous sections studied in southern California and northwestern Baja California, Mexico, is summarized in Table 15. Species diversity curves for the four locations (Fig. 3-6) support the biofacies analysis as evidence of an influx of transported species. The curves which depict the number of species in each sample for each of the four locations are discussed briefly below. In each case the sample size, method of preparation, and recovery technique were essentially uniform.

At La Jolla (Fig. 3), samples 1 to 20 show regular fluctuations in the number of species, ranging from 40 to 70 species per sample. The fluctuations seem to result from a combination of biologic factors affecting the distribution of the faunas and postdepositional solution of calcareous tests. The effect of population dilution by detrital sediment seems minimal in this massive siltstone sequence. Beginning at sample 20, transported sublittoral species appear in increasing numbers and continue throughout the rest of the section. The advent of displaced species coincides with an increase in the number of species, the highest numbers occurring in samples adjacent to sandstone beds (e.g., samples 27, 31, 34, and 36). Of interest is the increased number of species in samples 20 to 26 prior to the first discontinuous sandstone that lies just below sample 27. This increase reflects a local movement of sediment of insufficient magnitude to transport coarser detrital material. The peaks in species numbers in the earlier samples (e.g., 3, 14) may also, in part, be due to downslope movement.

The faunal diversity in samples of the T and BR series reveals the effects of transportation and detrital dilution. This fauna is composed largely of a fragmented and size-graded bathyal association.

At Point Loma (Fig. 4), samples 20 and 24 have a low species number because of post-depositional alteration. Samples 10 to 19 occur in the siltstone-sandstone facies and both species numbers and the displaced elements indicate sediment transportation. Samples 8 to 10 following the final sandstone show a diminishing of displaced species and faunal diversity.

The Punta Descanso fauna (Fig. 5) is much like that at Point Loma. Samples 6 to 18 occur in the siltstone-sandstone facies and have large diversity fluctuations. Several samples are couplets and so exaggerate the curves, however the remaining samples are of the same magnitude. Samples 25 to 21, from the siltstone facies, show a more uniform level of fluctuation, but sample 20, containing slump structures and pelecypod fragments, contains a higher diversity.

At Carlsbad (Fig. 6), the species diversity fluctuations in samples 1 to 7 seem due to downslope displacement of sediment. Sample 8, lying just below the Tertiary unconformity, has been affected by post-depositional alteration.

Recent foraminiferal species diversity shows a decrease in numbers both shoreward and off the continental shelf (Uchio, 1960; Walton, 1964). This information can be used to compare the depositional environments of the four southern California localities.

Averaging the stable fluctuations of species shows La Jolla and Point Loma to be closely similar in number with 58 and 56 species, respectively. Punta Descanso is lowest, with 24 species and Carlsbad highest, with 94 species. The higher number of species at Carlsbad is indicative of a shelf environment, whereas the lower numbers at La Jolla and Point Loma, in association with the bathyal faunal assemblage, suggest bathyal depths.

The reduction of species diversity associated with the sandy facies at La Jolla and Point Loma probably is due primarily to sediment dilution. These samples retain a bathyal faunal association in addition to the introduction of a shelf assemblage. This suggests a temporal change in the sediment source area rather than a variation in depth. Little is known, however, of the present depth ranges of bathyal foraminiferal species much less the Cretaceous association. Hence, the possibility of basin shoaling cannot be dismissed.

PALEOZOOGEOGRAPHY

Recent planktonic organisms occur in discrete faunas that are associated with analogous water masses (Bradshaw, 1959; Bieri, 1959; Brinton, 1962; Johnson & Brinton, 1963). These water masses of roughly latitudinal distribution, are recognized by their characteristic temperature and salinity curves (Sverdrup, Johnson & Flemming, 1942; Stepanov, 1964). Bradshaw (1959) delineated three planktonic foraminiferal assemblages in the northern and equatorial Pacific: a northern subarctic fauna, a southern warm-water fauna, and middle transition fauna (Fig. 7). The warm-water fauna was subdivided into a tropical equatorial west-central fauna and a subtropical central fauna. These more or less latitudinal faunas, controlled by climates and currents, provide a basis for the analysis of past distributions.

Late Cretaceous planktonic foraminifers generally are referred to two realms or provinces, that were defined by molluscan distributions: a northern Boreal province and an equatorial Tethyan province (Uhlig, 1911; Arkell, 1956). Pacific Coast Cretaceous molluscan faunas are differentiated from both the Boreal and Tethyal associations and define a third or Indo-Pacific province (Matsumoto, 1960; Popenoe, Imlay & Murphy, 1960; Jones, 1963; Sohl, 1964). This Indo-Pacific fauna is unlike that

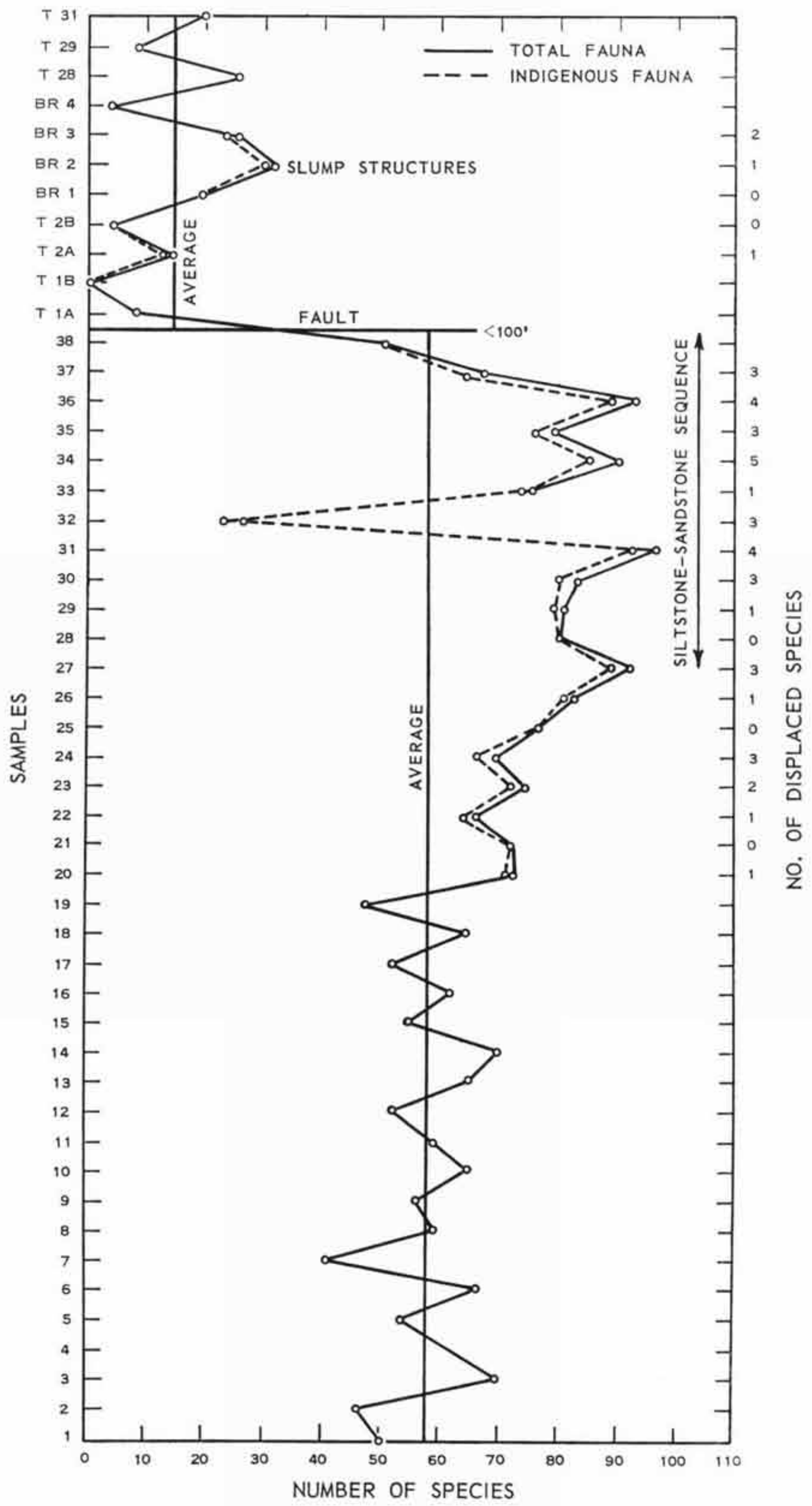


FIG. 3. Species diversity at La Jolla, California.

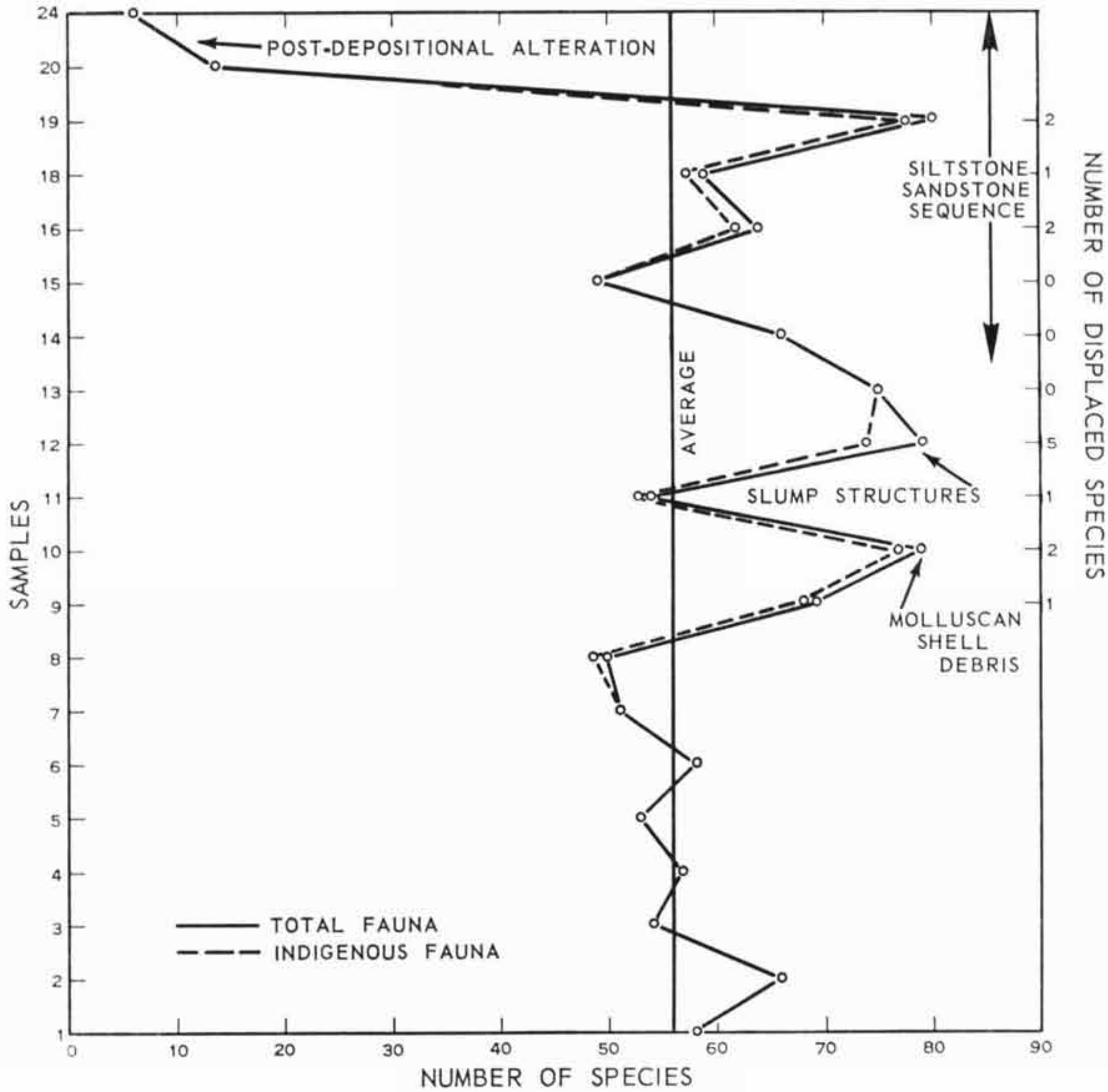


FIG. 4. Species diversity at Point Loma, California.

found in the American Gulf Coast and eastern Mexico, although the latitude of the lower Baja California occurrence (30° N.) is comparable to the northern limit of the Gulf Coast rudist faunas. Likewise, Late Cretaceous foraminiferal faunas from the eastern Pacific lack the usual Tethyan late Campanian-Maastrichtian species (DOUGLAS & SLITER, 1966).

The diagnostic Maastrichtian planktonic genera *Abathomphalus*, *Plummerita*, and *Trinitella* and species *Globotruncana contusa* (CUSHMAN) *s.s.*, *G. gansseri* BOLLI, *G. gagnebini* TILEV, and *G. stuarti* (DE LAPPARENT) are unknown from the northeastern Pacific. Their absence may be due to various factors: 1) strata of this age may be missing along the Pacific margin, 2) planktonic foraminifers may be missing from the youngest strata, or 3) these Tethyan species did not migrate into the northeastern Pacific.

Maastrichtian strata are recognized in this region, however, by the joint occurrence of *Globotruncana havanensis* VOORWIJK, *G. petaloidea* GANDOLFI, *Heterohelix glabrans* (CUSHMAN), *Racemiguembelina fructicosa* (EGGER), *Rugoglobigerina rugosa* (PLUMMER), and *Bolivinoides draco draco* (MARSSON) in southern California and the same globotruncanids plus *Globotruncana nothi* BRÖNNIMANN & BROWN in northern California (DOUGLAS & SLITER, 1966).

In southern California, the presence or absence of a preservable fauna is strongly facies-controlled, especially in the youngest strata. The Maastrichtian section consists of a repetitive series of sandstone and siltstone beds. The

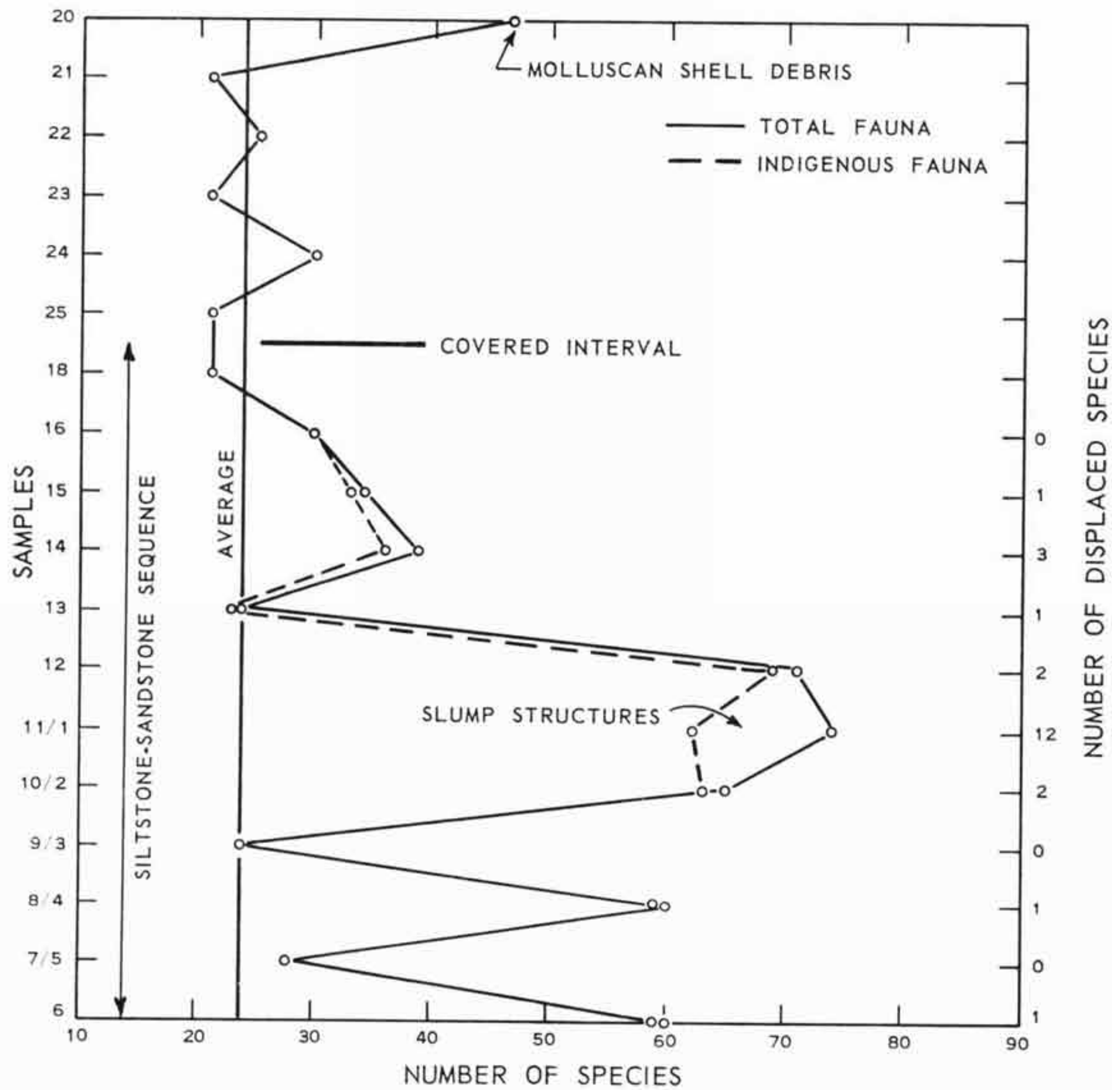


FIG. 5. Species diversity at Punta Descanso, Baja California.

most abundant fauna occurs in the upper lignitic layers of the siltstone beds. This lignitic layer may be 1 to 4 cm. thick, but is commonly lacking, apparently due to post-depositional current action. Hence, the planktonic fauna of these deposits is only sporadically recovered. Elsewhere, as in the Moreno Formation of central California, apparently unbroken (or disconformable) sequences of Cretaceous strata can be found extending into the Tertiary, but, the planktonic foraminifers disappear several hundred feet below the Tertiary contact (POPENOE, IMLAY & MURPHY, 1960; MARTIN, 1964). The disappearance of planktonic foraminifers may be due to local lithologic or paleoecologic conditions, or both. Tethyan species are also absent in comparable strata throughout northeastern Mexico, California, Vancouver Island, and Alaska suggesting that they failed to migrate into the eastern North Pacific.

That the Tethyan Maastrichtian assemblage had access to the Pacific Basin is demonstrated by the presence of *Globotruncana gansseri* BOLLI and *G. contusa* (CUSHMAN) associated with a coral-rudist fauna on seamounts in the mid-Pacific (HAMILTON, 1963). Furthermore, the joint occurrence of *Globotruncana havanensis* VOORWIJK, *G. gansseri, G. contusa,* and *Abathomphalus* in the Mira Marl of western Australia (EDGELL, 1957) also implies access to the Pacific.

The effects of isolation upon the northeastern Pacific Cretaceous foraminiferal population are noted in several ways, including 1) the absence of Tethyan species, 2) the presence of endemic planktonic and benthonic species, and 3) the presence of morphovariants of cosmopolitan species.

The effects of oceanic temperature variation have been interpreted as preventing the northward migration of the Tethyan *Abathomphalus* and *Plummerita.* Neither have been recorded north of lat. 25° in North America (DOUGLAS & SLITER, 1966). *Trinitella, Globotruncana contusa* (CUSHMAN), *G. gagnebini* TILEV, *G. gansseri* BOLLI, and *G. stuarti* (DE LAPPARENT) range northward along the Atlantic Coast to about lat. 39° N (OLSSON, 1964), but none has been recovered from Pacific Coast strata extending south to 31° N.

Faunal isolation is also indicated by the following assemblage (Table 13).

TABLE 13.—*Endemic Late Cretaceous Foraminifers of Northeastern Pacific.*

Globotruncana churchi MARTIN
Planoglobulina ornatissima (CUSHMAN & CHURCH)
Bifarina douglasi SLITER, n. sp.
Spiroplectammina chicoana LALICKER
Spiroplectammina sigmoidina LALICKER
Frondicularia durrelli TRUJILLO
Lenticulina californiensis TRUJILLO
Praebulimina spinata (CUSHMAN & CAMPBELL)
Bandyella greatvalleyensis (TRUJILLO)
Gyroidinoides quadrata (CUSHMAN & CHURCH)

The endemism may, in part, be nomenclatural, and these species elsewhere differently identified or as yet unrecorded. For example, several specimens from Russia, resembling *Globotruncana churchi* MARTIN, are referred by SUBBOTINA (1963) to *G. arca* (CUSHMAN).

Isolation or paleoecologic variation also resulted in morphologic variation of several cosmopolitan Globotruncanidae, including *Globotruncana rosetta* (CARSEY), *G. stuartiformis* DALBIEZ, and high-spired *G. fornicata* PLUMMER. Specimens closely resembling the California variants of *G. stuartiformis* DALBIEZ also are present in western Australia (EDGELL, 1957).

Faunal diversity gradients of Recent and Late Cretaceous planktonic foraminifers recently were compared by DOUGLAS & SLITER (1966). In the present Pacific Ocean, 9 genera and 24 species occur in the equatorial west central fauna and 3 genera and 6 species in the subarctic fauna. In the late Campanian, 10 genera and 25 species occurred in the Tethyan province, whereas north of 50° lat., 5 genera and 6 species have been reported.

A closer examination reveals 23 species of planktonic foraminifers in the late Campanian of northern California whereas 28 species occur in correlative strata in southern California (DOUGLAS & SLITER, 1966; DOUGLAS, 1966). The early Maastrichtian also shows an increase of 21 to 24 species from north to south.

In addition, the planktonic assemblage differs in its composition from northern to southern California. In southern California *Heterohelix pulchra* (BROTZEN) and *Pseudotextularia elegans* (RZEHAK) are more abundant and more variable. Five heterohelicids also are found only in southern California (Table 14).

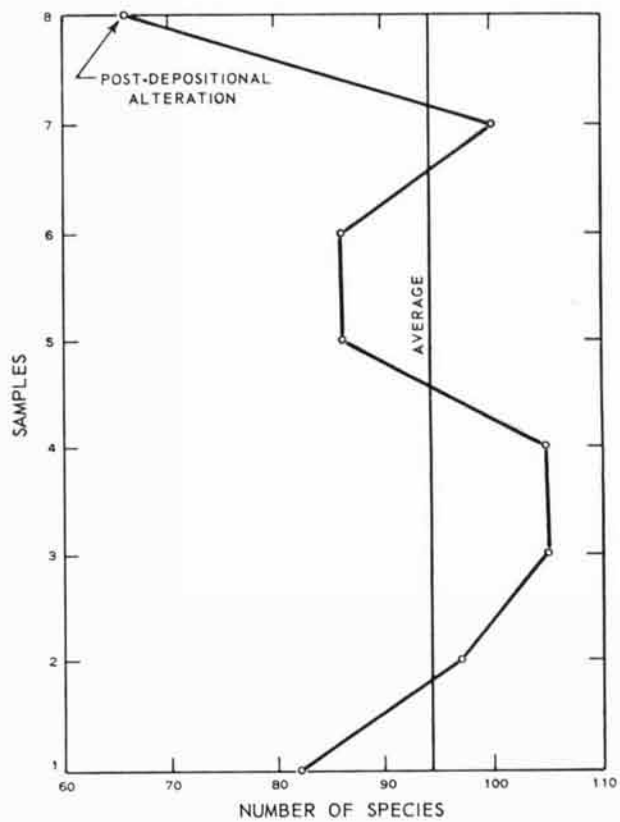


FIG. 6. Species diversity at Carlsbad, California.

TABLE 14.—*Heterohelicid Foraminifers Confined to Southern California.*

Heterohelix glabrans (CUSHMAN)
Heterohelix punctulata (CUSHMAN)
Guembelitria cretacea CUSHMAN
Racemiguembelina fructiocosa (EGGER)
Bifarina douglasi SLITER, n. sp.

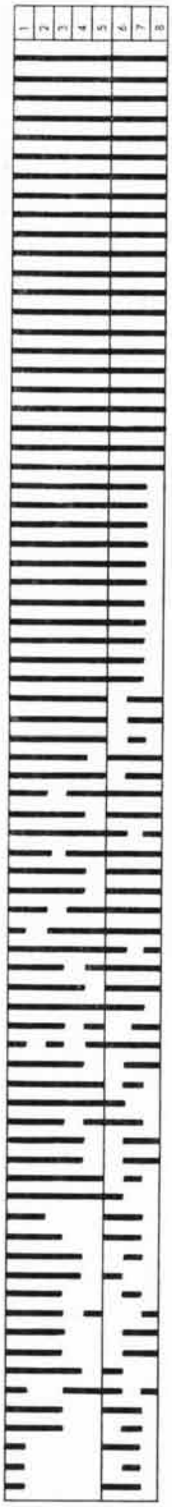
Northern California populations contain a greater abundance and diversity of hedbergellid species, and fewer Globotruncanidae. *Globotruncana nothi* BRÖNNIMANN & BROWN is not present in southern California, and *G. havanensis* VOORWIJK and other single-keeled species have not been reported above lat. 40° N along the Pacific Coast.

These Late Cretaceous foraminiferal diversity gradients, and the composition of the assemblages themselves suggest the presence of Cretaceous north-south climatic zones and latitudinal water masses along the eastern margin of the North Pacific as today.

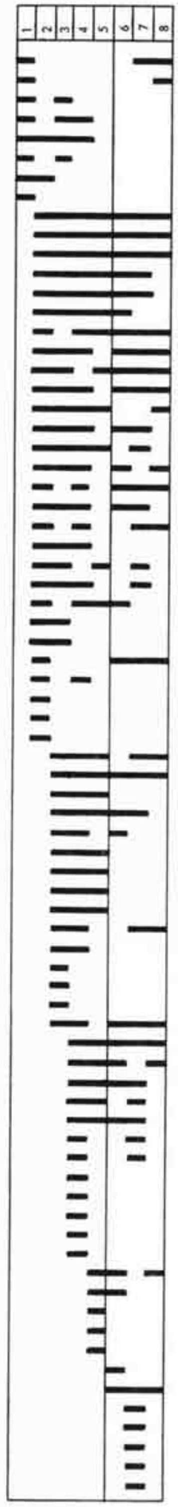
The planktonic distributions of the northern hemisphere during the Late Cretaceous indicate that the present clockwise circulation of oceanic currents had already become established. This circulation shifts cooler water southward along the eastern Pacific margin, as by

Table 15.—*Stratigraphic Distribution of Foraminifers in Upper Cretaceous Deposits of Southern California and Northwestern Baja California, Mexico.*

CARLSBAD



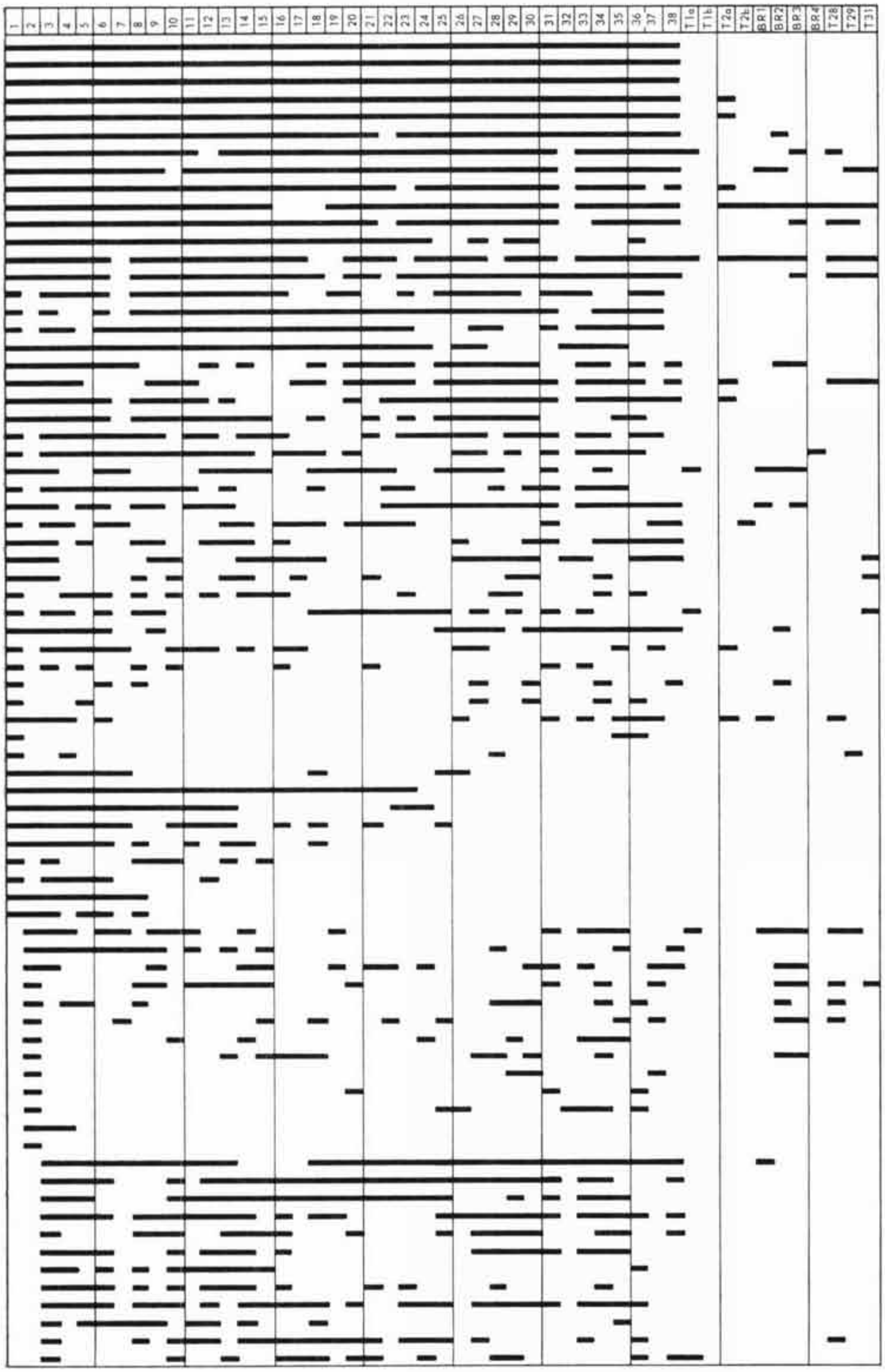
1 *Gaudryina glabrata*
2 *Praebulimina angulata*, n. sp.
3 *Neobulimina canadensis*
4 *Pseudouvigerina plummerae*
5 *Pyramidina prolixa*
6 *Praebulimina carseyae*
7 *Globotruncana arca*
8 *Globotruncana rosetta*
9 *Globigerinelloides messinae*
10 *Heterohelix globulosa*
11 *Gavelinella nacatochensis*
12 *Gavelinella sandidgei*
13 *Serovaina orbicella*
14 *Hoeglundina supracretacea*
15 *Gyroidina cretacea*
16 *Quinqueloculina sandiegoensis*, n. sp.
17 *Lenticulina carlsbadensis*, n. sp.
18 *Fissurina meyeriana*
19 *Lagena seminterrupta*
20 *Vaginulina olssoni*, n. sp.
21 *Bolivina incrassata gigantea*
22 *Coryphostoma plaitum*
23 *Praebulimina reussi*
24 *Planoglobulina ornatissima*
25 *Heterohelix striata*
26 *Colomia californica*
27 *Dentalina basiplanata*
28 *Dentalina legumen*
29 *Fissurina sandiegoensis*, n. sp.
30 *Fissurina simulata*, n. sp.
31 *Citharina suturalis*
32 *Dentalina marcki*
33 *Nodosaria proboscidea*
34 *Dorothia oxycona*
35 *Fissurina bandyi*, n. sp.
36 *Pyramidina rudita*
37 *Globotruncana linneiana*
38 *Globotruncana marginata*
39 *Heterohelix pulchra*
40 *Pseudoguembelina costulata*
41 *Saracenaria navicula*
42 *Citharina multicostata*
43 *Nodosaria septemcostata*
44 *Dentalina stephensoni*
45 *Lagena stavensis*
46 *Frondicularia intermittens*
47 *Marginulina bullata*
48 *Lenticulina revoluta*
49 *Palmula primitiva*
50 *Fursenkoina nederi* n. sp.
51 *Globotruncana cretacea*
52 *Pseudotextularia elegans*
53 *Gavelinella henbesti*
54 *Pseudopatellinella minuta*, n. sp.
55 *Frondicularia verneuiliana*
56 *Lenticulina modesta*
57 *Vaginulina plummerae*
58 *Vitriwebbina biosculata*
59 *Oolina delicata*, n. sp.
60 *Fissurina akpatii*, n. sp.
61 *Placopsilina* sp.
62 *Nonionella cretacea*
63 *Spiroloculina cretacea*
64 *Epithemella martini*
65 *Nonionella austinana*
66 *Pararotalia praenabeolensis*
67 *Saracenaria triangularis*
68 *Frondicularia goldfussi*
69 *Astacolus jarvisi*
70 *Nodosaria amphioxys*
71 *Astacolus mundus*
72 *Ellipsoidella gracillima*
73 *Globotruncana tricarinata*
74 *Globotruncana ventricosa*
75 *Allomorphina cretacea*



76 *Gyroidinoides nitidus*
77 *Lagena paucicosta*
78 *Globotruncana petaloidea*
79 *Globorotalites michelinianus*
80 *Quadrimorphina spirata*, n. sp.
81 *Saracenaria jarvisi*
82 *Neoflabellina rugosa*
83 *Lenticulina* sp. cf *L. williamsoni*
84 *Dentalina vistulae*
85 *Saracenaria saratogana*
86 *Eouvigerina hispida*
87 *Gyroidina nonionoides*
88 *Lagena acuticosta*
89 *Guttulina adhaerens*
90 *Pseudouvigerina californica*, n. sp.
91 *Globotruncana fornicata*
92 *Hedbergella monmouthensis*
93 *Heterohelix punctulata*
94 *Hedbergella holmdelensis*
95 *Ceratobulimina (Ceratolamarckina) cretacea*
96 *Spiroloculina truncata*, n. sp.
97 *Heterolepa carlsbadensis*, n. sp.
98 *Ramulina pseudoaculeata*
99 *Oolina apiculata*
100 *Dorothia pupa*
101 *Eouvigerina rosarioensis*, n. sp.
102 *Globigerinelloides alvarezi*
103 *Pseudopatellinella cretacea*
104 *Fissurina oblonga*
105 *Tappanina selmensis*
106 *Fissurina laticarinata*, n. sp.
107 *Lenticulina spissocostata*
108 *Dentalina solvata*
109 *Alabamina dorsoplana*
110 *Dentalina* sp.
111 *Seabrookia cretacica*
112 *Marginulinopsis texasensis*
113 *Pseudonodosaria obesa*
114 *Pyramidina triangularis*
115 *Allomorphina halli*
116 *Planorbulina pacifica*, n. sp.
117 *Stilostomella pseudoscripta*
118 *Berthelinopsis carlsbadensis*, n. sp.
119 *Dentalina alternata*
120 *Pyrulina apiculata*
121 *Vaginulinopsis directa*
122 *Globotruncana churchi*
123 *Quinqueloculina* sp. cf. *Q. harrisi*
124 *Pleurostomella subnodosa*
125 *Astacolus* sp. cf. *A. richteri*
126 *Bolivina decurrens*
127 *Globulina lacrima*
128 *Lenticulina spachholtzi*
129 *Lenticulina taylorensis*
130 *Pseudonodosaria manifesta*
131 *Praebulimina kickapooensis*
132 *Spiroplectammina laevis*
133 *Nodosaria* sp.
134 *Silicosigmoilina californica*
135 *Stilostomella impensia*
136 *Tristix* sp. cf. *T. excavata*
137 *Tristix* sp.
138 *Pseudonodosaria* sp.
139 *Dentalina gracilis*
140 *Pullenia jarvisi*
141 *Pullenia* sp. cf. *P. minuta*
142 *Frondicularia archiaciana*
143 *Pyrulina* sp. cf. *P. cylindroides*
144 *Allomorphina subtriangularis*
145 *Ramulina globotubulosa*
146 *Globorotalites spineus*
147 *Cyclogyra* sp.
148 *Lenticulina muensteri*
149 *Frondicularia inversa*
150 *Frondicularia* sp. D.

TABLE 15 *(Continued)*.

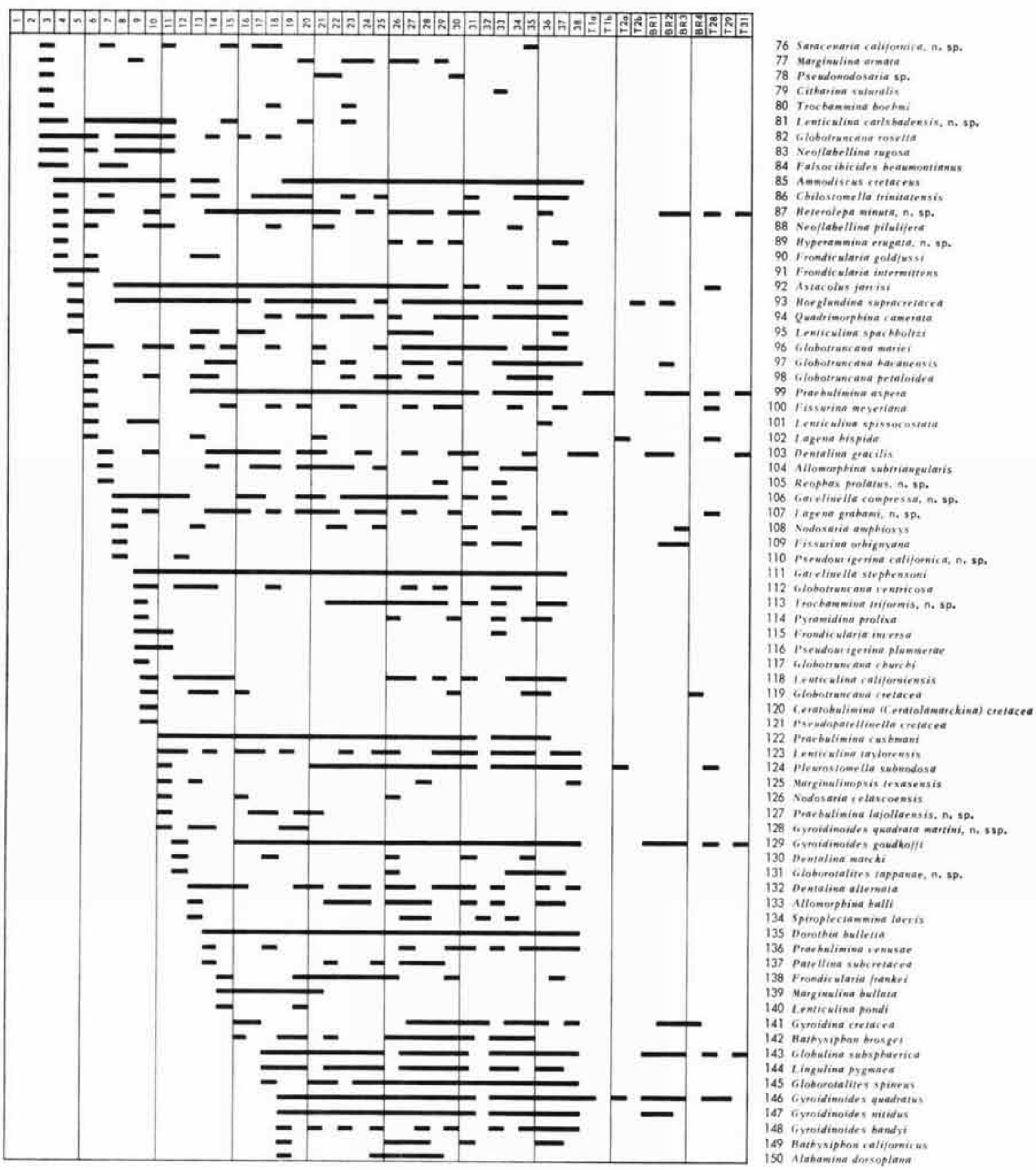
LA JOLLA



1 *Bathysiphon vitta*
2 *Spiroplectammina sigmoidina*
3 *Silicosigmoilina californica*
4 *Gaudryina laevigata*
5 *Cribrostomoides cretaceous*
6 *Globotruncana arca*
7 *Pyramidina rudita*
8 *Osangularia cordieriana*
9 *Lenticulina muensteri*
10 *Stilostomella impensia*
11 *Globigerinelloides messinae*
12 *Dorothia ellisorae*
13 *Dentalina vistulae*
14 *Heterohelix pulchra*
15 *Gavelinella eriksdalensis*
16 *Gaudryina bentonensis*
17 *Haplophragmoides excavatus*
18 *Praebulimina spinata*
19 *Saracenaria navicula*
20 *Praebulimina angulata*, n. sp.
21 *Gavelinella velascoensis*
22 *Heterohelix striata*
23 *Citharina multicostata*
24 *Globotruncana stuartiformis*
25 *Stilostomella pseudoscripta*
26 *Marginulina* sp. cf. *M. curvatura*
27 *Gavelinella nacatochensis*
28 *Allomorphina cretacea*
29 *Neobulimina canadensis*
30 *Globigerinelloides alvarezi*
31 *Heterohelix globulosa*
32 *Pseudotextularia elegans*
33 *Lagena paucicosta*
34 *Gavelinella sandidgei*
35 *Dentalina basiplanata*
36 *Frondicularia archiaciana*
37 *Pyramidina triangularis*
38 *Hedbergella holmdelensis*
39 *Dentalina solvata*
40 *Saracenaria triangularis*
41 *Saracenaria saratogana*
42 *Reophax globosus*, n. sp.
43 *Praebulimina kickapooensis*
44 *Pullenia cretacea*
45 *Frondicularia verneuiliana*
46 *Pseudonodosaria manifesta*
47 *Pseudoguembelina costulata*
48 *Nodosaria septemcostata*
49 *Gyroidinoides trujilloi*, n. sp.
50 *Lenticulina modesta*
51 *Serovaina orbicella*
52 *Marginulinopsis striatocarinata*
53 *Oolina globulosa*
54 *Lagena stavensis*
55 *Dentalina stephensoni*
56 *Dentalina legumen*
57 *Bathysiphon varans*, n. sp.
58 *Fissurina sandiegoensis*, n. sp.
59 *Lagena acuticosta*
60 *Lenticulina ovalis*
61 *Trochammina texana*
62 *Gaudryina glabrata*
63 *Nonionella cretacea*
64 *Sprioplectammina chicoana*
65 *Dorothia oxycona*
66 *Gaudryina tailleuri*
67 *Globotruncana linneiana*
68 *Globotruncana tricarinata*
69 *Globotruncana marginata*
70 *Globotruncana fornicata*
71 *Heterohelix punctulata*
72 *Planoglobulina ornatissima*
73 *Hedbergella monmouthensis*
74 *Dentalina catenula*
75 *Praebulimina reussi*

TABLE 15 *(Continued)*.

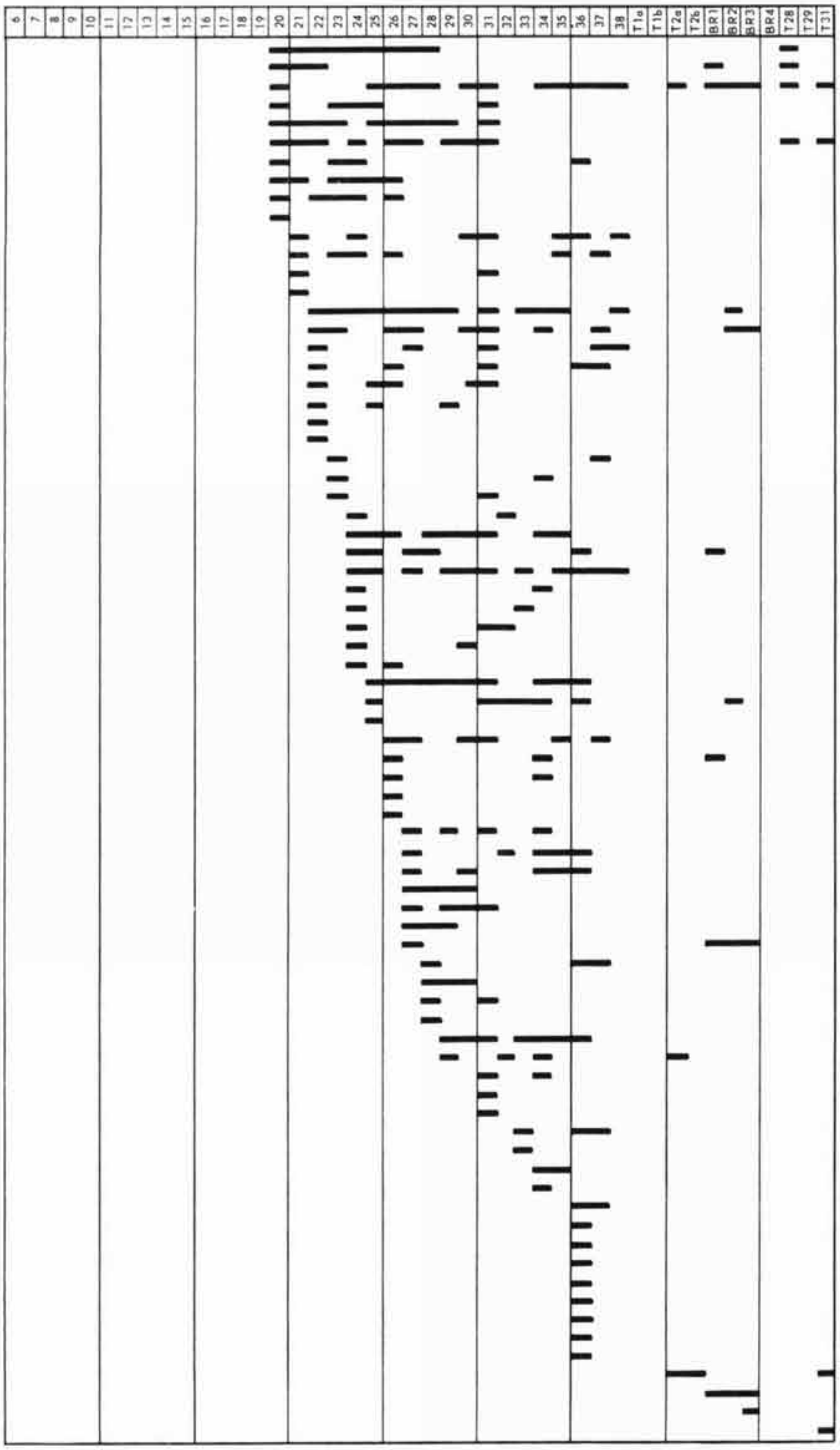
LA JOLLA (continued)



the present California Current, and sends tropical water farther northward along the Atlantic Coast, as by the present Gulf Stream. Tethyan planktonic species thus were transported farther along the American Atlantic Coast than on the Pacific. Their northward migration on the Pacific Coast would be dependent upon smaller countercurrents. Evidence of this current system are seen in the New Jersey-Delaware (lat. 39° N) occurrences of Tethyan planktonics (OLSSON, 1964) that, as yet, have not been reported along the Pacific Coast north of 31° lat. A North Pacific oceanic temperature and current barrier to the northward migration of warm-water planktonic species is further indicated by the delayed migration of species such as *Rugoglobigerina rugosa* (PLUMMER). This species occurs in Campanian Gulf Coast strata but is absent from the eastern Pacific prior to the Maastrichtian.

TABLE 15 *(Continued)*.

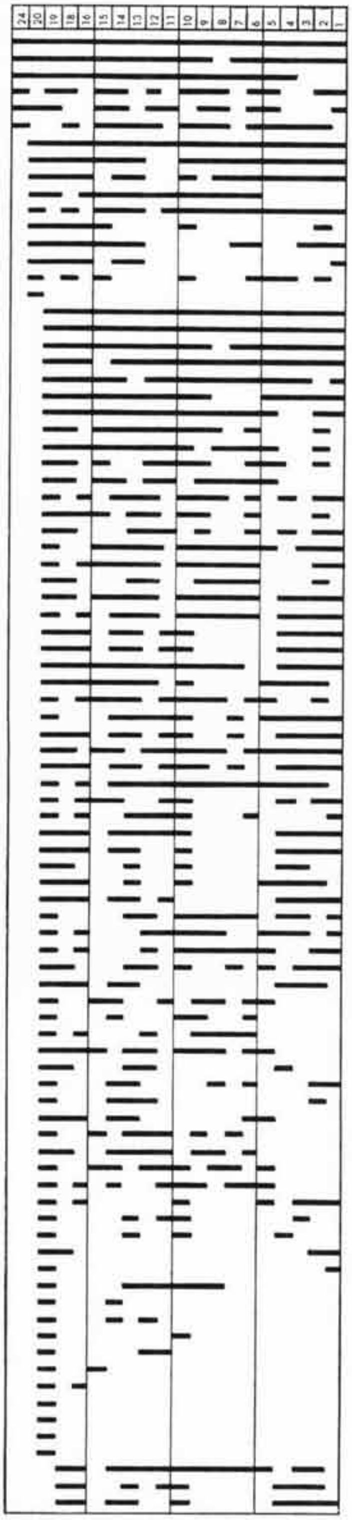
LA JOLLA (continued)



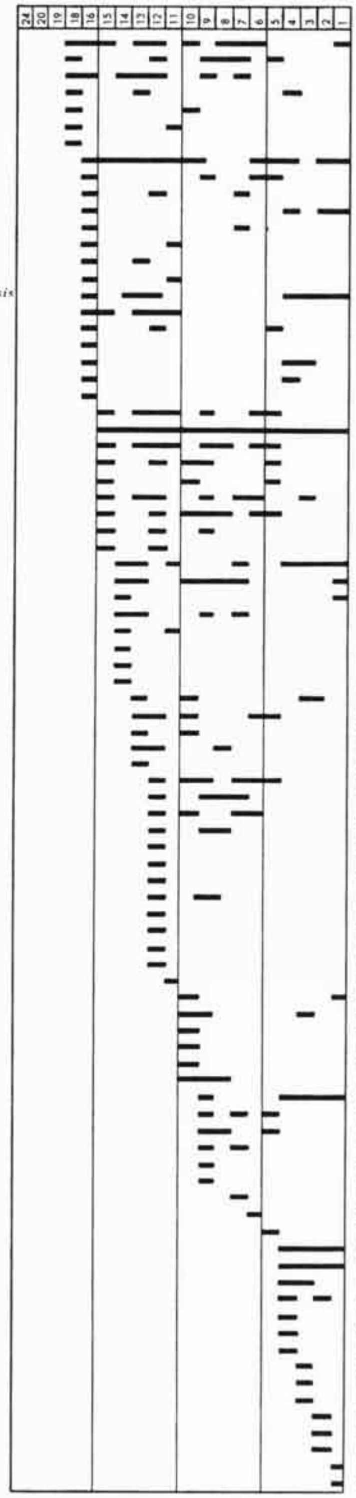
151 *Eouvigerina rosarioensis*, n. sp.
152 *Bifarina douglasi*, n. sp.
153 *Bolivina incrassata*
154 *Trochammina pilea*, n. sp.
155 *Frondicularia durrelli*
156 *Bandyella greatvalleyensis*
157 *Nodosaria distans*
158 *Lenticulina davisi*
159 *Bolivinoides laevigatus*
160 *Lenticulina revoluta*
161 *Haplophragmoides kirki*
162 *Frondicularia lomaensis*, n. sp.
163 *Haplophragnoides* sp. cf. *H. famosus*
164 *Frondicularia* sp. C.
165 *Nodosaria limbata*
166 *Ramulina pseudoaculeata*
167 *Oolina* sp. cf. *O. tokaoi*
168 *Ammodiscoides lajollaensis*, n. sp.
169 *Guttulina cuspidata*
170 *Haplophragmium lueckei*
171 *Svratkina lajollaensis*, n. sp.
172 *Ellipsocristellaria* sp.
173 *Globulina lacrima*
174 *Marginulina navarroana*
175 *Rzehakina epigona*
176 *Bolivinoides draco miliares*
177 *Nodosaria aspera*
178 *Berthelinella minuta*
179 *Gavelinella whitei*
180 *Astacolus* sp.
181 *Vaginulinopsis directa*
182 *Globorotalites michelinianus*
183 *Astacolus mundus*
184 *Quadrimorphina allomorphinoides*
185 *Colomia californica*
186 *Dentalina mariei*, n. sp.
187 *Gyroidina nonionoides*
188 *Loxostomum eleyi*
189 *Tristix* sp.
190 *Astacolus* sp. cf. *A. richteri*
191 *Tristix* sp. cf. *T. excavata*
192 *Tribrachia* sp.
193 *Dorothia pupa*
194 *Quinqueloculina sandiegoensis*, n. sp.
195 *Lagena semiinterrupta*
196 *Ammodiscus glabratus*
197 *Nodophthalmidium obscurum*
198 *Ellipsoidella kugleri*
199 *Ellipsopolymorphina* sp.
200 *Lenticulina* sp. cf. *L. williamsoni*
201 *Dorothia retusa*
202 *Saccammina complanata*
203 *Hippocrepina* sp. cf. *H. barksdalei*
204 *Tappanina tuberosa*, n. sp.
205 *Pararotalia praenaheolensis*
206 *Quinqueloculina* sp. cf. *Q. harrisi*
207 *Pyramidina szajnochae*
208 *Bolivina decurrens*
209 *Cribrostomoides trifolium*
210 *Ammobaculites alexanderi*
211 *Pullenia jarvisi*
212 *Guadryina pyramidata*
213 *Lenticulina* sp.
214 *Sigmomorphina* sp.
215 *Haplophragmoides fraseri*
216 *Globotruncana* sp.
217 *Globotruncana elevata*
218 *Heterohelix glabrans*
219 *Eouvigerina hispida*
220 *Frondicularia mucronata*
221 *Nodosaria navarroana*
222 *Rugoglobigerina rugosa*
223 *Bolivinoides draco draco*
224 *Ramulina globotubulosa*
225 *Nodosaria* sp.

TABLE 15 (*Continued*).

POINT LOMA



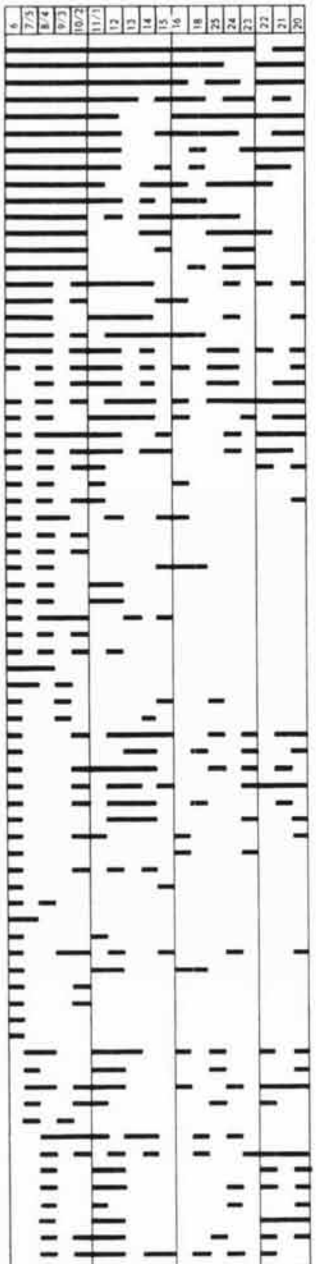
1 *Silicosigmoilina californica*
2 *Dorothia oxycona*
3 *Bathysiphon vitta*
4 *Praebulimina kickapooensis*
5 *Allomorphina cretacea*
6 *Chilostomella trinitatensis*
7 *Gaudryina laevigata*
8 *Cribrostomoides cretaceus*
9 *Gaudryina bentonensis*
10 *Spiroplectammina sigmoidina*
11 *Haplophragmoides excavatus*
12 *Trochammina texana*
13 *Bathysiphon brosgei*
14 *Haplophragmoides kirki*
15 *Gaudryina tailleuri*
16 *Trochammina* sp. cf. *T. ribstonensis*
17 *Lenticulina muensteri*
18 *Lenticulina taylorensis*
19 *Dentalina vistulae*
20 *Stilostomella impensia*
21 *Dentalina catenula*
22 *Gavelinella stephensoni*
23 *Globotruncana arca*
24 *Globotruncana stuartiformis*
25 *Praebulimina spinata*
26 *Praebulimina angulata*, n. sp.
27 *Pyramidina rudita*
28 *Globotruncana tricarinata*
29 *Globotruncana marginata*
30 *Globotruncana bavanensis*
31 *Globigerinelloides messinae*
32 *Planoglobulina ornatissima*
33 *Heterohelix striata*
34 *Heterohelix pulchra*
35 *Gavelinella nacatochensis*
36 *Gyroidinoides goudkoffi*
37 *Gyroidinoides quadratus*
38 *Dorothia ellisorae*
39 *Dorothia bulletta*
40 *Dentalina mariei*, n. sp.
41 *Globulina subsphaerica*
42 *Pleurostomella subnodosa*
43 *Astacolus jarvisi*
44 *Oolina globosa*
45 *Saracenaria navicula*
46 *Praebulimina aspera*
47 *Globotruncana ventricosa*
48 *Spiroplectammina chicoana*
49 *Trochammina triformis*, n. sp.
50 *Trochammina pilea*, n. sp.
51 *Frondicularia durrelli*
52 *Dentalina alternata*
53 *Lagena grahami*, n. sp.
54 *Lagena stavensis*
55 *Marginulina* sp. cf. *M. curvatura*
56 *Dentalina soleata*
57 *Ammodiscus cretaceus*
58 *Heterolepa minuta*, n. sp.
59 *Quadrimorphina camerata*
60 *Allomorphina halli*
61 *Globotruncana mariei*
62 *Globotruncana petaloidea*
63 *Globotruncana elevata*
64 *Hedbergella holmdelensis*
65 *Praebulimina cushmani*
66 *Globotruncana cretacea*
67 *Pseudotextularia elegans*
68 *Stilostomella pseudoscripta*
69 *Citharina multicostata*
70 *Frondicularia frankei*
71 *Lenticulina davisi*
72 *Nodosaria distans*
73 *Lenticulina ovalis*
74 *Dorothia retusa*
75 *Globotruncana linneiana*
76 *Globotruncana rosetta*
77 *Praebulimina reussi*
78 *Nodosaria* sp.
79 *Lagena paucicosta*
80 *Lagena hispida*
81 *Berthelinella minuta*, n. sp.
82 *Globulina lacrima*
83 *Ramulina pseudoaculeata*
84 *Patellina subcretacea*
85 *Lenticulina spissocostata*
86 *Hoeglundina supracretacea*
87 *Globorotalites spineus*
88 *Gyroidinoides nitidus*



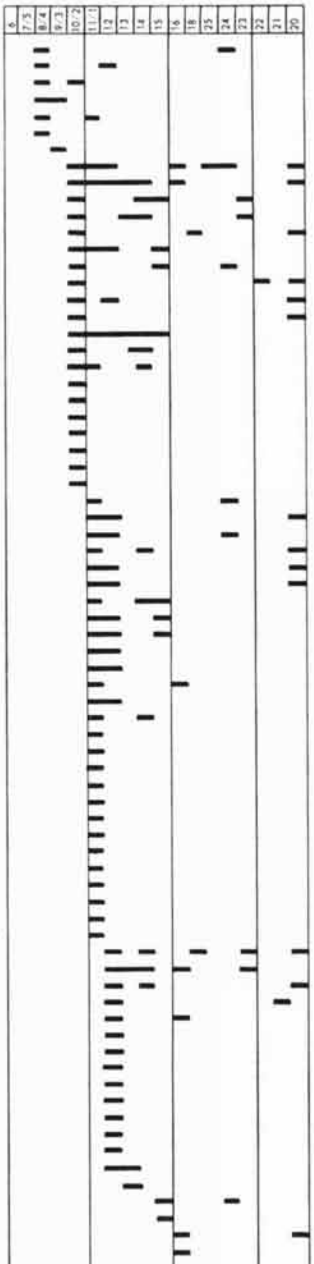
89 *Heterohelix punctulata*
90 *Frondicularia archiaciana*
91 *Lenticulina spachholtzi*
92 *Nodosaria amphioxys*
93 *Globorotalites michelinianus*
94 *Dentalina stephensoni*
95 *Bolivinoides laevigatus*
96 *Osangularia cordieriana*
97 *Gyroidina cretacea*
98 *Saracenaria saratogana*
99 *Nodosaria limbata*
100 *Marginulinopsis texasensis*
101 *Astacolus mundus*
102 *Ellipsoidella kugleri*
103 *Pullenia cretacea*
104 *Gavelinella whitei*
105 *Gyroidinoides bandyi*
106 *Pyramidina triangularis*
107 *Quinqueloculina* sp. cf. *Q. harrisi*
108 *Bathysiphon varans*, n. sp.
109 *Haplophragmoides* sp. cf. *H. famosus*
110 *Pseudonodosaria obesa*
111 *Hedbergella monmouthensis*
112 *Gavelinella velascoensis*
113 *Allomorphina subtriangularis*
114 *Globorotalites tappanae*, n. sp.
115 *Serovaina orbicella*
116 *Marginulina bullata*
117 *Saracenaria californica*, n. sp.
118 *Dentalina legumen*
119 *Falsocibicides beaumontianus*
120 *Gavelinella eriksdalensis*
121 *Pullenia jarvisi*
122 *Astacolus* sp. cf. *A. richteri*
123 *Globotruncana fornicata*
124 *Lenticulina californiensis*
125 *Alabamina dorsoplana*
126 *Pyramidina prolixa*
127 *Karreria* sp.
128 *Marginulina armata*
129 *Gavelinella compressa*, n. sp.
130 *Bifarina douglasi*, n. sp.
131 *Neoflabellina pilulifera*
132 *Lingulinopsis* sp.
133 *Gavelinella sandidgei*
134 *Spiroplectammina laevis*
135 *Dentalina basiplanata*
136 *Saracenaria triangularis*
137 *Fissurina meyeriana*
138 *Nodosaria proboscidea*
139 *Racemiguembelina fructicosa*
140 *Praebulimina lajollaensis*, n. sp.
141 *Neobulimina canadensis*
142 *Cyclogyra* sp.
143 *Spiroloculina truncata*, n. sp.
144 *Pararotalia praenabeolensis*
145 *Frondicularia* sp. C
146 *Ellipsopolymorphina* sp.
147 *Lenticulina* sp. cf. *L. williamsoni*
148 *Fursenkoina nederi*, n. sp.
149 *Frondicularia* sp. B
150 *Gaudryina glabrata*
151 *Bandyella greatvalleyensis*
152 *Frondicularia lomaensis*, n. sp.
153 *Citharina suturalis*
154 *Frondicularia verneuiliana*
155 *Frondicularia* sp. A
156 *Nodophthalmidium obscurum*
157 *Globigerinelloides alvarezi*
158 *Marginulinopsis striatocarinata*
159 *Heterohelix globulosa*
160 *Praebulimina venusae*
161 *Rzehakina epigona*
162 *Bolivina incrassata*
163 *Gaudryina pyramidata*
164 *Haplophragmium lueckei*
165 *Reophax globosus*, n. sp.
166 *Dorothia pupa*
167 *Lingulina pygmaea*
168 *Ammodiscus glabratus*
169 *Guttulina cuspidata*
170 *Nodosaria aspera*
171 *Dentalina gracilis*
172 *Reophax prolatus*, n. sp.
173 *Trochammina boehmi*
174 *Bathysiphon californicus*
175 *Svratkina lajollaensis*, n. sp.

TABLE 15 *(Concluded).*

PUNTA DESCANSO



1 *Cribrostomoides cretaceus*
2 *Gyroidinoides goudkoffi*
3 *Lenticulina muensteri*
4 *Gavelinella stephensoni*
5 *Silicosigmoilina californica*
6 *Gaudryina laevigata*
7 *Spiroplectammina sigmoidina*
8 *Dorothia ellisorae*
9 *Bathysiphon vitta*
10 *Dorothia oxycona*
11 *Dorothia bulletta*
12 *Haplophragmoides excavatus*
13 *Gaudryina bentonensis*
14 *Trochammina triformis* n. sp.
15 *Lenticulina taylorensis*
16 *Pleurostomella subnodosa*
17 *Osangularia cordieriana*
18 *Hoeglundina supracretacea*
19 *Praebulimina aspera*
20 *Pyramidina rudita*
21 *Praebulimina spinata*
22 *Globotruncana arca*
23 *Heterohelix pulchra*
24 *Dentalina cistulae*
25 *Astacolus jarvisi*
26 *Lagena grahami*, n. sp.
27 *Stilostomella impensia*
28 *Marginulina* sp. cf. *M. curvatura*
29 *Saracenaria navicula*
30 *Oolina globosa*
31 *Globulina subsphaerica*
32 *Frondicularia durrelli*
33 *Heterolepa minuta*, n. sp.
34 *Quadrimorphina camerata*
35 *Gyroidinoides quadratus*
36 *Patellina subcretacea*
37 *Neobulimina canadensis*
38 *Spiroplectammina chicoana*
39 *Bathysiphon brosgei*
40 *Haplophragmoides kirki*
41 *Trochammina texana*
42 *Globotruncana linneiana*
43 *Globotruncana havanensis*
44 *Globotruncana petaloidea*
45 *Heterohelix striata*
46 *Heterohelix punctulata*
47 *Pseudotextularia elegans*
48 *Hedbergella holmdelensis*
49 *Heterohelix globulosa*
50 *Globotruncana stuartiformis*
51 *Globotruncana tricarinata*
52 *Praebulimina reussi*
53 *Reophax globosus*, n. sp.
54 *Haplophragmoides* sp. cf. *H. famosus*
55 *Dentalina catenula*
56 *Lenticulina carlsbadensis*, n. sp.
57 *Berthelinella minuta*, n. sp.
58 *Astacolus mundus*
59 *Trochammina pilea*, n. sp.
60 *Lenticulina spachholtzi*
61 *Chilostomella trinitatensis*
62 *Falsocibicides beaumontianus*
63 *Praebulimina kickapooensis*
64 *Gaudryina tailleuri*
65 *Bathysiphon varans*, n. sp.
66 *Gavelinella sandidgei*
67 *Planoglobulina ornatissima*
68 *Dentalina basiplanata*
69 *Stilostomella pseudoscripta*
70 *Lagena paucicosta*
71 *Dentalina solvata*
72 *Dentalina gracilis*
73 *Allomorphina cretacea*
74 *Praebulimina angulata*, n. sp.
75 *Allomorphina subtriangularis*
76 *Gyroidina cretacea*
77 *Globorotalites tappanae*, n. sp.
78 *Gavelinella eriksdalensis*



79 *Lenticulina* sp.
80 *Nodosaria* sp.
81 *Globorotalites spineus*
82 *Ammodiscus cretaceus*
83 *Saracenaria triangularis*
84 *Nodosaria amphioxys*
85 *Loxostomum eleyi*
86 *Praebulimina cushmani*
87 *Globigerinelloides messinae*
88 *Globotruncana fornicata*
89 *Globotruncana marginata*
90 *Globigerinelloides alvarezi*
91 *Gavelinella nacatochensis*
92 *Dentalina stephensoni*
93 *Dentalina mariei*, n. sp.
94 *Saracenaria californica*, n. sp.
95 *Dentalina legumen*
96 *Globotruncana mariei*
97 *Hedbergella monmouthensis*
98 *Bolivina incrassata gigantea*
99 *Globotruncana rosetta*
100 *Globotruncana churchi*
101 *Guembelitria cretacea*
102 *Schackoina multispinata*
103 *Bathysiphon californicus*
104 *Fissurina orbignyana*
105 *Bandyella greatvalleyensis*
106 *Pyramidina triangularis*
107 *Serovaina orbicella*
108 *Allomorphina halli*
109 *Spiroplectammina laevis*
110 *Marginulina armata*
111 *Marginulina bullata*
112 *Vaginulina plummerae*
113 *Gyroidinoides nitidus*
114 *Coleites californica*
115 *Quinqueloculina sandiegoensis*, n. sp.
116 *Pullenia jarvisi*
117 *Nodosaria septemcostata*
118 *Nodophthalmidium obscurum*
119 *Bolivina decurrens*
120 *Ceratobulimina (Ceratolamarckina) cretacea*
121 *Cyclogyra* sp.
122 *Spiroloculina truncata*, n. sp.
123 *Pullenia* sp. cf. *P. minuta*
124 *Nonionella austinana*
125 *Gaudryina glabrata*
126 *Frondicularia verneuiliana*
127 *Fissurina sandiegoensis*, n. sp.
128 *Lenticulina ovalis*
129 *Fissurina mexicana*
130 *Oolina* sp. cf. *O. tokaoi*
131 *Lagena semiinterrupta*
132 *Conorboides platium*
133 *Globotruncana ventricosa*
134 *Globotruncana cretacea*
135 *Gavelinella velascoensis*
136 *Citharina multicostata*
137 *Nodosaria velascoensis*
138 *Lagena acuticosta*
139 *Citharina suturalis*
140 *Frondicularia frankei*
141 *Neoflabellina rugosa*
142 *Lingulina* sp.
143 *Neoflabellina pilulifera*
144 *Gyroidinoides bandyi*
145 *Quinqueloculina* sp. cf. *Q. harrisi*
146 *Pseudoguembelina costulata*
147 *Globorotalites michelinianus*
148 *Lenticulina davisi*
149 *Haplophragmoides fraseri*
150 *Dentalina marcki*
151 *Lenticulina spissocostata*
152 *Saccammina complanata*
153 *Carpenteria* sp.
154 *Lenticulina californiensis*
155 *Pseudonodosaria manifesta*

The selective limitation of northward planktonic migration by the Pacific current system need not have applied to benthonic foraminifers, lacking pelagic gametes, unless their migration was limited by other hostile ecologic conditions. The large number of Gulf Coast benthonic species present in the Pacific-margin Cretaceous strata may support this hypothesis of selective restriction or indicate increased tolerance to cooler water.

The Late Cretaceous faunal boundaries and their associated hydroclimates are postulated by examining the faunal distributions, paleotemperatures and paleogeography.

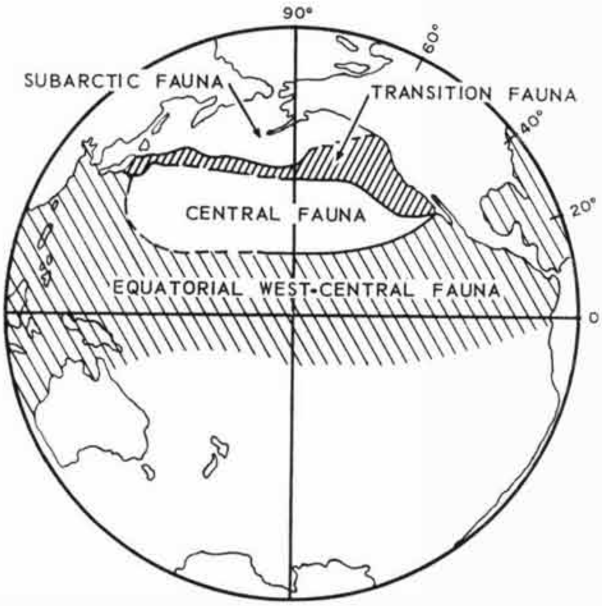


FIG. 7. Distribution of Recent planktonic foraminiferal assemblages in the North Pacific (after BRADSHAW, 1959).

The northern boundary of the Cretaceous Tethyan or tropical province with its characteristic fossil and lithologic associations is traced from southern Texas through central Mexico to the Pacific Ocean. The discovery of a Tethyan foraminiferal and molluscan fauna in the central Pacific (HAMILTON, 1953) extends the province east-west across the Pacific and northward to at least lat. 19° N. As noted previously, this fauna is unrecorded along the eastern Pacific margin north of 31° lat.

Although lacking restricted Tethyan globotruncanids, the Late Cretaceous southern California foraminiferal fauna contains a large and diversified heterohelicid fauna with Tethyan affinities. This fauna extends from Baja California (lat. 31° N) to La Jalama and San Miguel Island, California (lat. 35° N).

A second fauna is recognized from the Panoche Hills of central California (lat. 36° 30′ N) to northern California (lat. 40° N). It differs from southern California in lacking elements of the heterohelicid assemblage and having a progressively lower faunal diversity. In contrast, *Hedbergella* becomes increasingly more common and diversified northward.

North of California a third faunal assemblage is recognized. The Vancouver Island (lat. 49° N) fauna differs markedly from that of northern California and is characterized by low species diversity and numbers. Agglutinated benthonic species constitute the dominant element of the fauna whereas planktonic species are rare. Single-keeled globotruncanids have not been reported from the eastern north Pacific north of 40° lat. In southern Alaska (lat. 62° N), a remarkably similar fauna contains nearly an identical planktonic assemblage: *Globotruncana arca* (CUSHMAN), *Heterohelix globulosa* (EHRENBERG), *Planoglobulina* sp. cf. *P. austinana* (CUSHMAN), and *Rugoglobigerina pilulifera* BELFORD. TAPPAN (1960, 1962) described an Upper Cretaceous foraminiferal assemblage from northern Alaska (lat. 69° N) which likewise is distinguished from California faunas by a dominance of benthonic species and a paucity of planktonic forms.

These four faunal assemblages are sufficient in magnitude to imply a degree of ecologic control greater than that imposed by local geographic conditions. This is especially true of the planktonic foraminifers, present distributions of which generally coincide with oceanic water masses. The faunal differentiation may thus be attributed to various factors such as temperature, oceanic current patterns, depth of water, amount of runoff from adjacent land masses, and their geographic configuration.

Late Cretaceous floras and faunas indicate a lessened thermal gradient between the equator and poles than at present, and hence, broader latitudinal temperature zones. BELL (1957) regarded the flora from the Nanaimo Group of Vancouver Island as representing a warm temperate climate. Latest Cretaceous floras from Wyoming, described by DORF (1942) indicate a humid, warm temperate climate approaching subtropical. BARGHOORN (1953) reported Cretaceous to Eocene broad-leaf hardwood forests in high latitudes as indicating humid warm temperate or temperate climates in the polar region. Likewise, faunal data from the Pacific margin suggests a warmer climate than at present. DURHAM (1950) reviewed the Late Cretaceous molluscan and coral data from along the northeastern Pacific margin and suggested the 18.5° C. isotherm extended north to near 53° lat. Ammonites from the Nanaimo Group of Vancouver Island and the wide distribution of Indo-Pacific species, were believed by USHER (1952) to indicate a more uniform climate. Oxygen-isotope determinations for the Cretaceous also suggest a lower thermal gradient (LOWENSTAM & EPSTEIN, 1954; EMILIANI, 1961; BOWEN, 1961 a-c).

The four Late Cretaceous zones are remarkably similar to those of the present (Fig. 7-9). This may be purely fortuitous, or perhaps related to some combination of climatic and geographic conditions which would produce a similar zonation. Present indications of Late Cretaceous oceanic current patterns is speculative at best. The configuration of Cretaceous land masses bordering the Pacific Basin has been inferred by DURHAM & ALLISON (1960), EARDLEY (1962), WEYL (1964) and others (Fig. 9). Oceanic currents and faunal migration routes were affected by seaways then open through the present Bering Strait and parts of eastern Siberia and the isthmus of Latin America. Climatic conditions postulated by BROOKS (1951) for the middle latitudes were of mild winters and hot summers and an absence of cyclonic

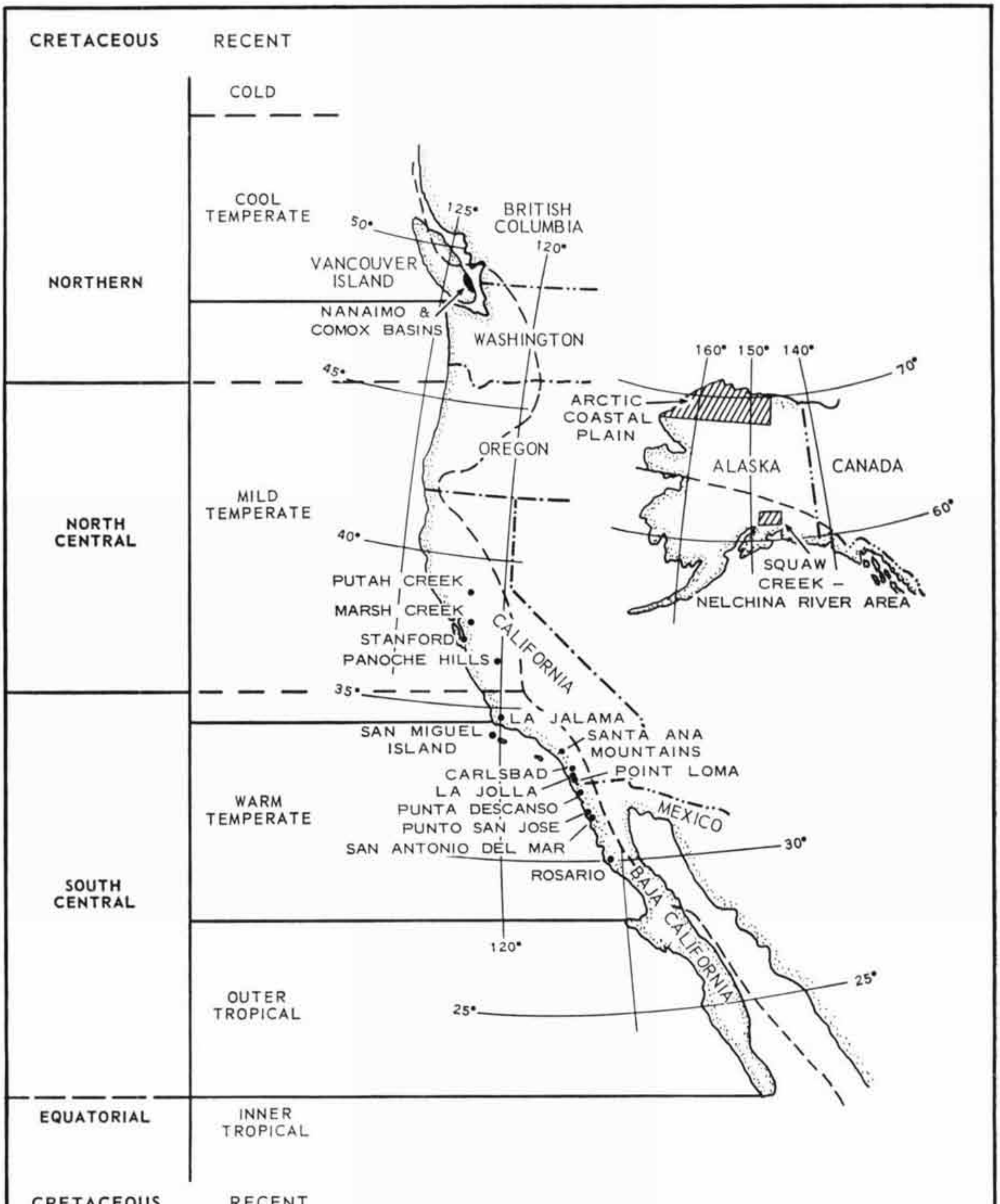


FIG. 8. Position of Recent and postulated position of late Cretaceous marine climatic boundaries along the northeastern margin of the Pacific and Upper Cretaceous sample localities. Postulated late Cretaceous shoreline after DURHAM & ALLISON (1960) and EARDLEY (1962). Recent marine climatic boundaries after HALL (1964) and VALENTINE (1966).

depressions. The polar front did not exist or lay far to the north. The subtropical anticyclones occurred farther north than now. The Arctic basin and prevailing west or southwest winds and a mild humid climate with high rainfall, and warm ocean currents extended into the high latitudes. One would expect these conditions to produce

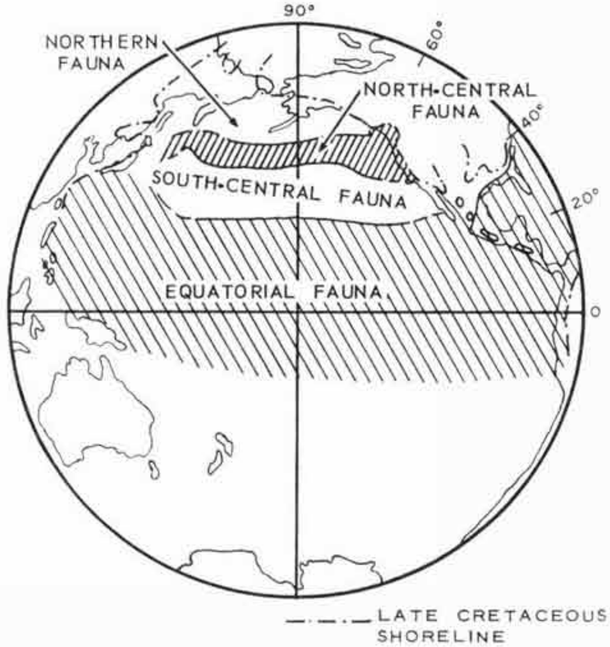


FIG. 9. Postulated distribution of planktonic foraminiferal assemblages in the North Pacific during the late Cretaceous. Inferred position of the late Cretaceous shoreline is after DURHAM & ALLISON (1960), EARDLEY (1962), and WEYL (1964).

different boundary locations and water-mass distributions than at the present unless the overall continental outline resulted in current divergencies and eddy systems similar to present ones.

The greatest Late Cretaceous faunal change recognized along the eastern Pacific margin occurs at the boundary between north-central and northern areas, here suggested to be near lat. 47° N. This boundary approximates the inferred position of the 18.5° C. isotherm. Recent planktonic species also show a distinctive faunal change near lat. 50° N. This change is most pronounced at the junction of the western North Pacific Kuroshio and Oyashio Currents and corresponds to the Subarctic Convergence. Along the eastern Pacific margin the transition zone is broader and less well defined, lying somewhere between 12° C. and 18° C. (BRADSHAW, 1959). BRINTON (1962, p. 199), however, recognized Arctic boundary species of euphausiids extending south to lat. 50° N and four subarctic species concentrated between lat. 45° N and lat. 55° N. JOHNSON & BRINTON (1963, p. 386, fig. 1) reported two forms of the subarctic euphausiid *Thysanoessa longipes* BRANDT distributed parallel to a belt of low faunal density near lat. 50° N in the eastern North Pacific. The similarity in position of this boundary during the Late Cretaceous and the Recent may be due to a like convergence of oceanic currents or the effects of unknown additional Cretaceous paleoenvironmental conditions. Late Cretaceous foraminiferal faunas occurring above lat. 49° N resemble one another in faunal character and content. In northern Alaska, TAPPAN (1960, 1962) recognized a strong facies control of the fauna occurring in an intertonguing sequence of nonmarine and marine strata. Southern Alaska and Vancouver Island faunas may likewise reflect fluctuating water depths and rates of sedimentation. Ammonites from Vancouver Island, however, were regarded by USHER (1952) as indicative, in part, of deep-water neritic facies in a basin having open connections with the Pacific Ocean. Likewise, JONES (1963) considered that much of the Matanuska Formation of southern Alaska was deposited below wave base. A probable outer neritic zone was suggested by the lack of current-produced sedimentary structures and heavy-shelled, shallow-water pelecypods and gastropods and an abundance of ammonites and Inocerami. The Chignit Formation of the Alaskan Peninsula, however, was probably deposited in shallower water as evidenced by the coarser-grained deposits, intercalated nonmarine and marine beds and a somewhat greater percentage of thick-shelled pelecypods (JONES, 1963). The foraminiferal fauna of deposits north of lat. 49° N resembles Recent boreal faunas in their low planktonic diversity and the abundance of agglutinated species (BRADSHAW, 1959; SAIDOVA, 1962; BELYAEVA & SAIDOVA, 1965). In addition, TAPPAN (1960, p. 285) noted the local abundance of the characteristic cold-water radiolarian *Dictyomitra* in the Campanian of northern Alaska. The similarity of faunas occurring above lat. 49° N, their low planktonic diversity, and the presence of certain cool-water indicators, together suggest a Late Cretaceous temperate northern temperature zone, as well as the effects of paleobathymetry and possibly increased runoff.

Figure 9 shows the postulated distribution of the four Late Cretaceous ecologic zones within the North Pacific. These distributions are constructed from the faunal data of BRADSHAW (1959), MCGOWAN (1960, 1963), BRINTON (1962), JOHNSON & BRINTON (1963), and FAGER & MCGOWAN (1963) and the hydroclimactic data of SVERDRUP, JOHNSON & FLEMING (1942) and the NORPAC Committee (1960), and modified by the inferred Late Cretaceous paleotemperatures and paleogeography.

The northern boundary of the equatorial zone is drawn near lat. 25° N to include the central Pacific Tethyan assemblage described by HAMILTON (1953). Along the Atlantic Coast this fauna extends to New Jersey, apparently due to the effect of the Late Cretaceous Gulf Stream. The suggested northern south-central boundary reflects the suggested oceanic circulation, i.e., it is extended northward along the Asiatic Coast due to the combined effects of clockwise circulation and the open Siberian straits, and is depressed along the eastern margin much as it is today. The northern north-central boundary is suggested to have been somewhat south of the 18.5° C. isotherm, or about lat. 47° N, and also is modified by the current pattern.

The Late Cretaceous foraminiferal paleozoogeography in the northern hemisphere further supports continental stability since the end of the Cretaceous. The north-south faunal diversity gradients, suggested latitudinal ecological zones, and inferred major oceanic currents during the Late Cretaceous indicate that climatic zones, continental positions, and the location of the axis of rotation were then much as they are today.

LOCALITIES

Carlsbad collections (UCLA locality 2412) from dry tributary to Letterbox Canyon, San Luis Rey Quadrangle, San Diego County, lat. 33°08′17″ N, long. 117°17′10″ W.
- C-1, Basal sample
- C-2, 10 feet stratigraphically higher
- C-3, 10 feet stratigraphically higher
- C-4, 8 feet stratigraphically higher
- C-5, 5.5 feet stratigraphically higher
- C-6, 5.5 feet stratigraphically higher
- C-7, 5.5 feet stratigraphically higher
- C-8, 5.5 feet stratigraphically higher

La Jolla collections (UCLA locality 5241) siltstone member of Rosario Formation in sea cliffs bordering eastern side of La Jolla Bay, at foot of Princess Street, La Jolla Quadrangle, San Diego County, California, lat. 32°51′ N, long. 117°16′ W.
- S-1 to S-27, composite channel samples starting at base of exposed section and extending south. Sample S-27 approximately 358 feet stratigraphically above sample S-1.
- S-28 to S-33, composite channel samples along southern side of La Jolla Bay. Sample S-33 is approximately 25 feet stratigraphically higher than sample S-27.
- S-34 to S-38, composite channel samples along southern side of La Jolla Bay. Sample S-38 is approximately 126 feet stratigraphically higher than sample S-33.

UCLA locality 5237, siltstone-sandstone and sandstone members of Rosario Formation exposed in sea cliffs extending from La Jolla Bay to contact with Tertiary stratigraphically about 1,000 feet south of Bird Rock, La Jolla Quadrangle, San Diego County, California.
- T-1a, -1b, -2a, -2b, composite samples near base of siltstone-sandstone member, along south side of La Jolla Bay. Sample T-2b is 15 feet stratigraphically higher than T-1a.
- T-28, in sandstone member at first point about 200 feet north of Bird Rock. Sample T-28 is approximately 200 feet stratigraphically above lower contact of this member.
- T-29, 25 feet stratigraphically higher than T-28.
- T-31, 10 feet stratigraphically higher than T-29.

UCLA locality 5224, sandstone member of Rosario Formation at La Jolla, at foot of Bird Rock Ave., La Jolla Quadrangle, San Diego County, California.
- BR-1, lee side of Bird Rock exposed at low tide.
- BR-2, seaward side of Bird Rock.
- BR-3, in small cove 100 feet south of Bird Rock, about 15 feet stratigraphically higher than BR-1.
- BR-4, 4 feet stratigraphically higher than BR-3.

Point Loma (UCLA locality 5225)—sea cliffs at southern tip of Point Loma, Point Loma Quadrangle, San Diego County, California, lat. 32°39′54″ N, long. 117°14′30″ W.
- L-1 to L-19, composite channel samples extending from lighthouse northeast around end of point. Sample L-1 approximately 100 feet stratigraphically higher than sample L-19.
- L-20, on western side of point 225 feet northwest of sample L-19 and about 6 feet stratigraphically lower.
- L-24, 800 feet northwest of sample L-20, approximately 30 feet stratigraphically lower.

Punta Descanso (UCLA locality 5226)—sea cliffs between Punta Descanso and Descanso, about 40 km. south of Tijuana in northwestern Baja California, Mexico, lat. 32°18′ N, long. 117°00′ W.
- E-1 to E-18, composite samples extending from Arroyo Médano to 1.5 miles north of Don Pancho. Section approximately 100 feet thick.
- E-20, 1,155 feet south of Descanso.
- E-21, 8 feet stratigraphically lower than E-20.
- E-22, nearly along strike with E-21.
- E-23, 4 feet stratigraphically lower than E-22.
- E-24, 5 feet stratigraphically lower than E-23.
- E-25, 4 feet stratigraphically lower than E-24.

SYSTEMATIC PALEONTOLOGY

The classification followed here is that of Loeblich & Tappan (1964). Large populations have been studied whenever possible to determine the intraspecific variation and the dimorphism.

All illustrated specimens are deposited in the foraminiferal collection of the University of California, Los Angeles.

Citations of dates following authors of generic and supergeneric taxa are to indicate priority only and are not necessarily cited in the references. Justification for these terms is given in Loeblich & Tappan (1964). Numerals in parentheses following types and occurrence refer to the position on the range charts; letters indicate chart locality, i.e., C–Carlsbad, J–La Jolla, L–Point Loma, and D–Punta Descanso.

Superfamily AMMODISCACEA Reuss, 1862

Family ASTRORHIZIDAE Brady, 1881

Subfamily RHIZAMMININAE Rhumbler, 1895

Genus BATHYSIPHON M. Sars in G. O. Sars, 1872

BATHYSIPHON BROSGEI Tappan

Plate 1, figure 1

Bathysiphon brosgei Tappan, 1957, p. 202, pl. 65, fig. 1-5.—— Tappan, 1962, p. 128, pl. 29, fig. 1-5.

Test free, elongate, cylindrical, nonseptate, tube commonly irregularly bent or with minor surface constrictions. Wall finely agglutinated with considerable cement, nonlabyrinthic, surface smoothly finished. Aperture at open end of tube.

Maximum length of figured hypotype, 1.02 mm.; diameter, 0.21 mm.

Discussion.—The present specimens compare well with the original illustrations of specimens from the Upper Cretaceous of Alaska. *Bathysiphon brosgei* is distinguished readily from associated species by the commonly distorted tube and the smoothly finished, characteristically white wall. The smooth surface, grain size, and color of the wall closely resemble that of *Hyperammina erugata* SLITER, n. sp., and the specimens described here may represent broken extensions of the tubular chamber of the latter species. As none of the specimens of *H. erugata* has a contorted chamber and as the stratigraphic ranges of these species are not strictly comparable, they are at present considered distinct. *Bathysiphon brosgei* ranges from the Albian into the Maastrichtian.

Types and occurrence.—Figured hypotype (UCLA 44000) from sample S-26, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (J142, L13, D39).

BATHYSIPHON CALIFORNICUS Martin

Plate 1, figure 2

Bathysiphon californicus MARTIN, 1964, p. 43, pl. 1, fig. 2.

Test free, elongate, cylindrical. Wall coarsely agglutinated, little cement, surface rough. Aperture consists of open end of tube.

Maximum length of figured hypotype, 2.24 mm.; breadth, 0.32 mm.

Discussion.—This species is distinguished by the narrow tube, coarse-textured agglutinated material, and relatively thin wall. *Bathysiphon californicus* was originally described from Santonian to Maastrichtian strata in Fresno County, California.

Types and occurrence.—Figured hypotype (UCLA 44001) from sample S-27, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (J149, L174, D103).

BATHYSIPHON VARANS Sliter, n. sp.

Plate 1, figure 4

Test free, large, elongate, tubular, with numerous transverse constrictions. Wall coarsely agglutinated, surface rough. Aperture at open end of tube.

Maximum length of holotype, 2.87 mm.; breadth, 0.74 mm.

Discussion.—This species is distinguished from *Bathysiphon vitta* NAUSS (1947), by its smaller diameter, numerous constrictions, coarser agglutinated material, and rougher surface. It differs from *B. dubia* (WHITE, 1928a) and *B. alexanderi* CUSHMAN (1933b), in having more numerous constrictions and a rougher surface texture. The recorded stratigraphic range of *B. varans* is Campanian to Maastrichtian.

Types and occurrence.—Holotype (UCLA 44003) and paratype (UCLA 44004) from sample S-2, Rosario Formation at La Jolla. Unfigured paratypes from Rosario Formation at Point Loma and Punta Descanso (J57, L108, D65).

BATHYSIPHON VITTA Nauss

Plate 1, figure 3

Bathysiphon vitta NAUSS, 1947, p. 334, pl. 48, fig. 4.——TRUJILLO, 1960, p. 302, pl. 43, fig. 2.——TAKAYANAGI, 1960, p. 64, pl. 1, fig. 4.——TAPPAN, 1962, p. 128, pl. 29, fig. 6-8.——GRAHAM & CHURCH, 1963, p. 17, pl. 1, fig. 1-2.

Bathysiphon sp. MARTIN, 1964, p. 43, pl. 1, fig. 3.

Test free, large, elongate, tubular, compressed. Wall finely agglutinated, surface smooth, characteristically white. Aperture at open end of tube.

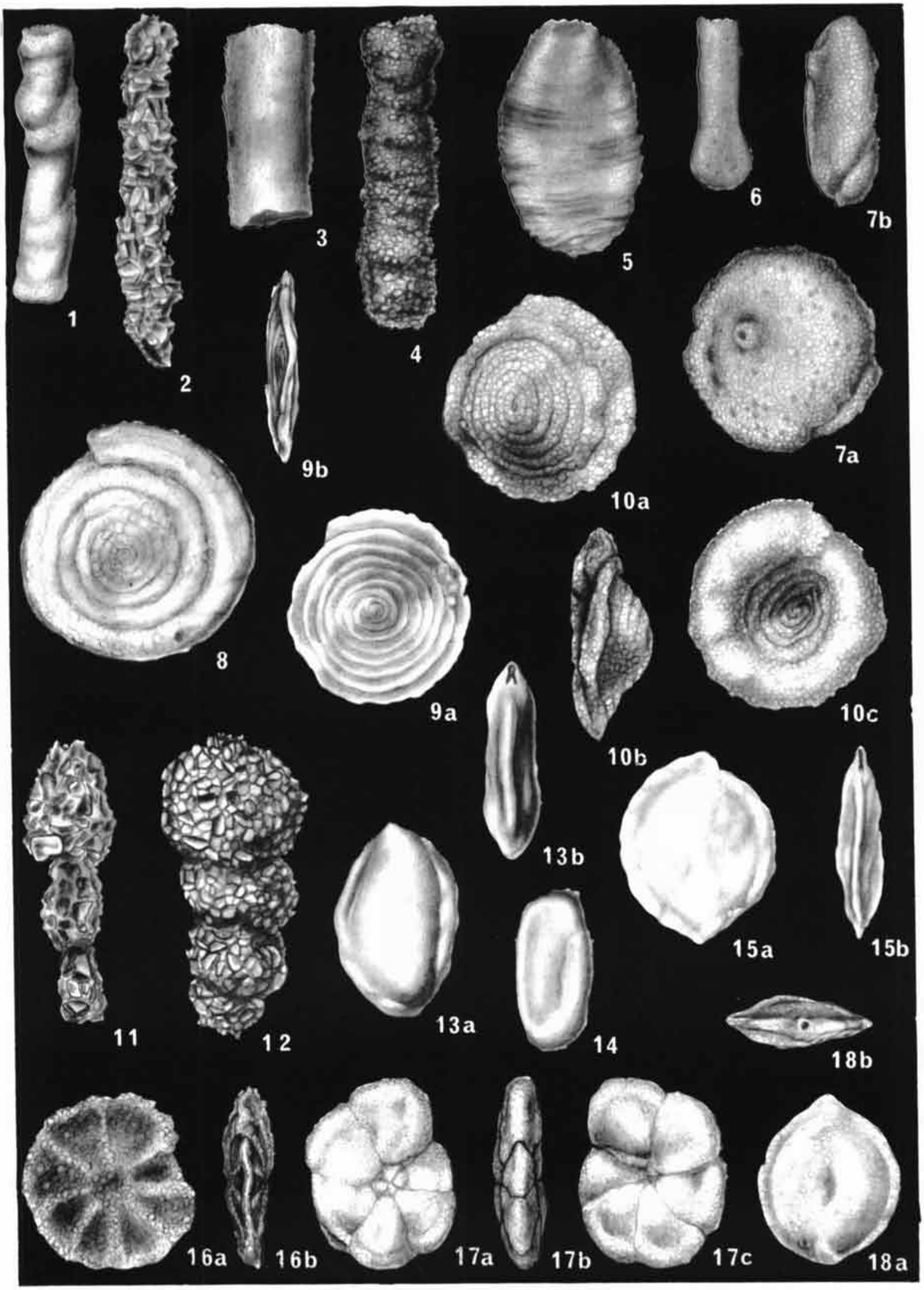
EXPLANATION OF PLATE 1

FIGURE

1. *Bathysiphon brosgei* TAPPAN, ×52 (p. 39).
2. *Bathysiphon californicus* MARTIN, ×25 (p. 40).
3. *Bathysiphon vitta* NAUSS, ×11 (p. 40).
4. *Bathysiphon varans* SLITER, n. sp., ×17 (p. 40).
5. *Hippocrepina* sp. cf. *H. barksdalei* (TAPPAN), ×33 (p. 41).
6. *Hyperammina erugata* SLITER, n. sp., ×23 (p. 41).
7. *Saccammina complanata* (FRANKE); 7a,b, apertural and side views, ×52 (p. 42).
8. *Ammodiscus cretaceus* (REUSS), ×52 (p. 42).
9. *Ammodiscus glabratus* CUSHMAN & JARVIS; 9a,b, side and edge views, ×98 (p. 42).
10. *Ammodiscoides lajollaensis* SLITER, n. sp.; 10a-c, side and edge views, ×89 (p. 42).
11. *Reophax prolatus* SLITER, n. sp., ×52 (p. 43).
12. *Reophax globosus* SLITER, n. sp., ×25 (p. 43).

13-15. *Silicosigmoilina californica* CUSHMAN & CHURCH; 13a,b, 15a,b, side and edge views showing morphologic variations, ×33; 14, side view, ×52 (p. 43).

16. *Haplophragmoides excavatus* CUSHMAN & WATERS; 16a,b, side and edge views, ×97 (p. 44).
17. *Haplophragmoides* sp. cf. *H. famosus* TAKAYANAGI; 17a-c, side and edge views, ×97 (p. 44).
18. *Rzehakina epigona* (RZEHAK); 18a,b, side and apertural views, ×52 (p. 43).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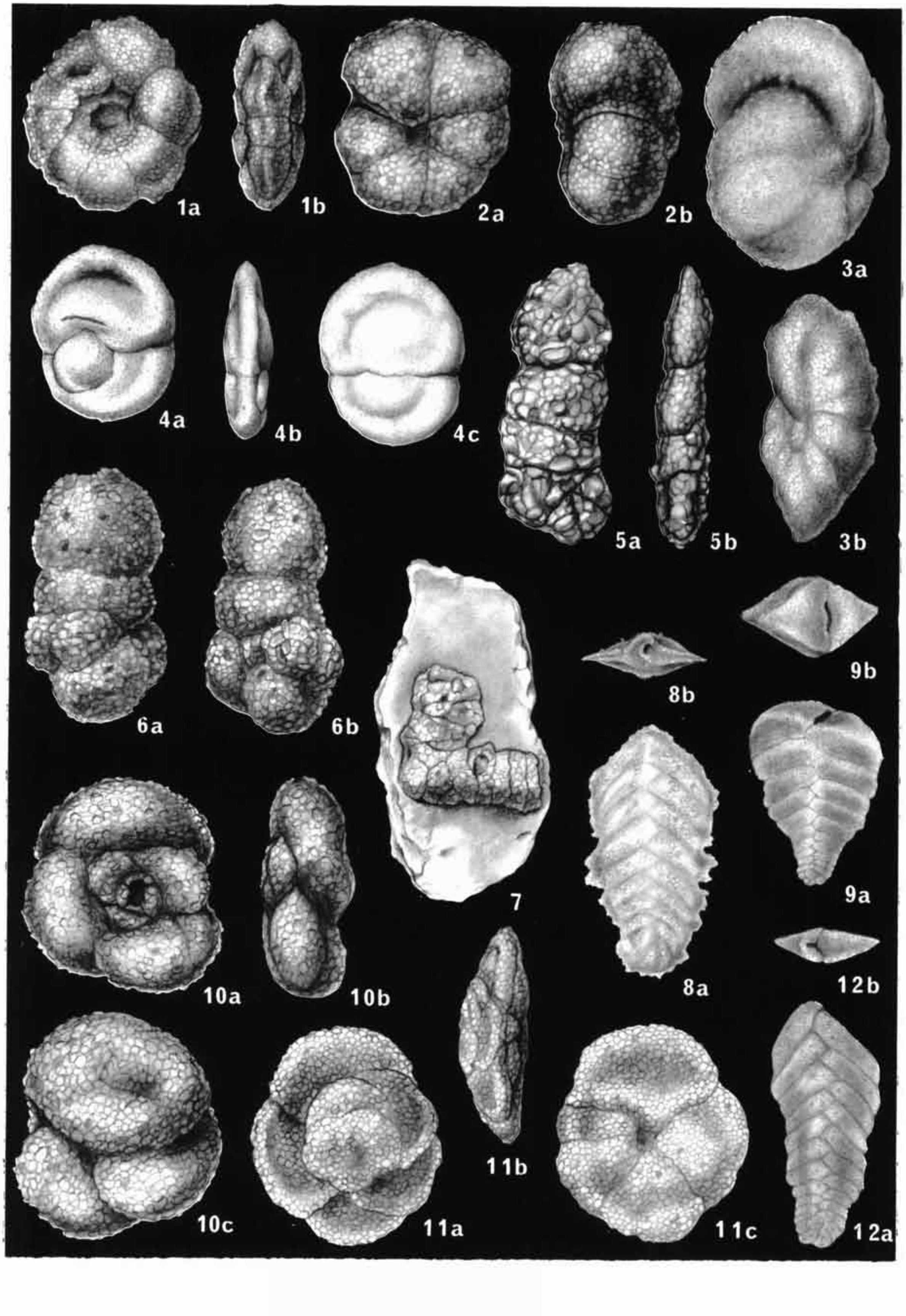
Sliter — Upper Cretaceous Foraminifera, Southern California and Northwestern Mexico.



Maximum length of figured hypotype, 2.80 mm.; breadth, 1.23 mm.

Discussion.—*Bathysiphon vitta* is characterized by its large size, nonconstricted and parallel-sided chamber, and finely agglutinated smooth wall. It is presently differentiated from *B. perampla* CUSHMAN & GOUDKOFF (1944), from the Cretaceous of Yolo County, California, by its much smaller size and smoother wall; future work, however, may show that these two species are synonymous. *Bathysiphon* sp. MARTIN (1964), from the Campanian-Maastrichtian of Fresno County, California, probably belongs to this species. *Bathysiphon vitta* has been recorded from California, Canada, Alaska, and Japan. It ranges from Albian to Maastrichtian.

Types and occurrence.—Figured hypotype (UCLA 44002) from sample S-37, Rosario Formation at La Jolla. Unfigured hypotypes from the Rosario Formation at Point Loma and Punta Descanso (J1, L3, D9).

Subfamily HIPPOCREPININAE Rhumbler, 1895

Genus HIPPOCREPINA Parker in G. M. Dawson, 1870

HIPPOCREPINA sp. cf. H. BARKSDALEI (Tappan)

Plate 1, figure 5

Hyperamminoides barksdalei TAPPAN, 1962, p. 129, pl. 29, fig. 21-27.

Test free, elongate, compressed, somewhat tapering. Chamber with transverse constrictions. Wall finely agglutinated, smoothly finished. Aperture terminal, rounded.

Maximum length of figured hypotype, 1.12 mm.; breadth, 0.67 mm.

Discussion.—The specimen here figured, although somewhat deformed, appears similar to the forms originally described from the Albian of Alaska.

Type and occurrence.—Figured hypotype (UCLA 44005) from sample S-28, Rosario Formation at La Jolla (J203).

Genus HYPERAMMINA Brady, 1878

HYPERAMMINA ERUGATA Sliter, n. sp.

Plate 1, figure 6

Hyperammina elongata Brady, NOTH, 1951, p. 24, pl. 6, fig. 6.
Hyperammina sp. cf. *H. elongata* Brady, TAKAYANAGI, 1960, p. 65, pl. 1, fig. 7-8.——MARTIN, 1964, p. 44, pl. 1, fig. 7.

Test free, elongate, cylindrical, initial bulbous proloculus followed by tubular chamber of smaller diameter. Wall finely agglutinated, surface smooth. Aperture at open end of chamber.

Maximum length of holotype, 1.23 mm.; chamber diameter, 0.32 mm.

Discussion.—The present species differs from *Hyperammina elongata* BRADY (1878), described from the Recent of the Arctic sea, in being much smaller and in having a more bulbous proloculus, nearly parallel sides, and smoothly textured, finely agglutinated wall. *Hyperammina erugata* ranges throughout the Senonian.

Types and occurrence.—Holotype (UCLA 44006) from sample S-4; paratype (UCLA 44007) from sample S-26; both from Rosario Formation at La Jolla (J89).

Family SACCAMMINIDAE Brady, 1884

Subfamily SACCAMMININAE Brady, 1884

EXPLANATION OF PLATE 2

FIGURE

1. *Haplophragmoides fraseri* WICKENDEN; 1a,b, side and edge views, ×66 (p. 44).
2. *Haplophragmoides kirki* WICKENDEN; 2a,b, side and edge views, ×89 (p. 44).
3. *Cribrostomoides cretaceus* CUSHMAN & GOUDKOFF; 3a,b, side and edge views, ×45 (p. 44).
4. *Cribrostomoides trifolium* (EGGER); 4a-c, side and edge views, ×23 (p. 45).
5. *Ammobaculites alexanderi* CUSHMAN; 5a,b, side and edge views, ×66 (p. 45).
6. *Haplophragmium lueckei* (CUSHMAN & HEDBERG); 6a,b, side views, ×33 (p. 45).
7. *Placopsilina* sp., ×25 (p. 45).
8. *Spiroplectammina chicoana* LALICKER; 8a,b, side and apertural views, ×66 (p. 46).
9. *Spiroplectammina laevis* (ROEMER); 9a,b, side and apertural views, ×66 (p. 46).
10. *Trochammina boehmi* FRANKE; 10a-c, spiral, edge, and umbilical views, ×66 (p. 46).
11. *Trochammina texana* CUSHMAN & WATERS; 11a-c, spiral, edge, and umbilical views, ×66 (p. 47).
12. *Spiroplectammina sigmoidina* LALICKER; 12a,b, side and apertural views, ×66 (p. 46).

Genus SACCAMMINA M. Sars in Carpenter, 1869

SACCAMMINA COMPLANATA (Franke)

Plate 1, figure 7

Pelosina complanata FRANKE, 1912, p. 107, pl. 3, fig. 1.——TAKAYANAGI, 1960, p. 65, pl. 1, fig. 6.——MARTIN, 1964, p. 44, pl. 1, fig. 6.

Test free, subspherical, commonly distorted, nonseptate. Wall finely agglutinated, surface smoothly finished. Aperture terminal, rounded, at end of distinct neck.

Maximum length of figured hypotype, 0.50 mm.; breadth, 0.25 mm.

Discussion.—TAPPAN (1962) recommended differentiation of *Pelosina* and *Saccammina* based on the test shape. Thus elongate, subcylindrical forms are referred to *Pelosina* and subspherical ones to *Saccammina*. Following this classification, *P. complanata* is assigned to the genus *Saccamina*. *S. lathrami* TAPPAN (1960), a similar form from the upper Albian to Cenomanian of Alaska, was distinguished from *S. complanata* on the basis of its smaller size and less distinct neck. The specimen of *S. complanata* illustrated by MARTIN (1964), from Fresno County, California, is comparable in size to *S. lathrami* but has a distinct neck. Likewise, the present specimens, although quite distorted, appear to have a distinct neck. More information is needed on morphologic variability within *Saccammina* in order to clarify the taxonomic position of these stratigraphically separated but similar species. *S. complanata* has been reported from the upper Santonian of California (MARTIN, 1964), Austin Chalk and Taylor Marl of the Gulf Coast, and lower Cenomanian-Turonian of Hokkaido, Japan (TAKAYANAGI, 1960).

Types and occurrence.—Figured hypotype (UCLA 44008) from sample S-31, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Punta Descanso (J202, D152).

Family AMMODISCIDAE Reuss, 1862

Subfamily AMMODISCINAE Reuss, 1862

Genus AMMODISCUS Reuss, 1862

AMMODISCUS CRETACEUS (Reuss)

Plate 1, figure 8

Operculina cretacea REUSS, 1845, p. 35, pl. 13, fig. 64-65.
Involutina cretacea (Reuss), TAKAYANAGI, 1960, p. 67, pl. 1, fig. 10-12.
Ammodiscus cretaceus (Reuss), TAPPAN, 1962, p. 130, pl. 30, fig. 1-2.——GRAHAM & CHURCH, 1963, p. 12, pl. 1, fig. 17.

Test free; discoidal, globular proloculus followed by an undivided, planispiral, tubular chamber, partially overlapping preceding whorl. Sutures distinct, depressed. Wall finely agglutinated, may or may not be soluble in acid, surface smooth. Aperture at open end of chamber.

Maximum diameter of figured hypotype, 0.81 mm.; thickness, 0.11 mm.

Discussion.—*Ammodiscus cretaceus* is distinguished by its relatively wide chamber, few whorls, and large size. Specimens in the present samples commonly show post-depositional distortion. Within California, this species has been observed in Campanian strata on Stanford University campus (GRAHAM & CHURCH, 1963). Other occurrences include the Campanian of Alaska (TAPPAN, 1962) and the Albian to lower Campanian of Hokkaido, Japan (TAKAYANAGI, 1960).

Types and occurrence.—Figured hypotype (UCLA 44009) from sample S-4, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (J85, L57, D82).

AMMODISCUS GLABRATUS Cushman & Jarvis

Plate 1, figure 9

Ammodiscus glabratus CUSHMAN & JARVIS, 1928, p. 86, pl. 12, fig. 6.
Involutina glabratus (Cushman & Jarvis), MARTIN, 1964, p. 45, pl. 1, fig. 10-11.

Test free, planispiral, compressed, consisting of small proloculus and nonsegmented tubular chamber, increasing gradually in size. Sutures distinct, depressed. Wall finely agglutinated, surface smoothly finished. Aperture at open end of tube.

Maximum diameter of figured hypotype, 0.36 mm.; thickness, 0.03 mm.

Discussion.—The present rare specimens are compressed and somewhat smaller than the typical forms, but otherwise similar in appearance. *Ammodiscus glabratus* is separated from *A. cretaceus* by its smaller diameter, greater number of whorls, and smaller proloculus. Juvenile forms of *A. cretaceus* have a larger chamber diameter and fewer whorls, making them distinct from the present species. Within California, *A. glabratus* ranges from the upper Santonian to the Maastrichtian.

Types and occurrence.—Figured hypotype from sample S-27, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma (J196, L168).

Genus AMMODISCOIDES Cushman, 1909

AMMODISCOIDES LAJOLLAENSIS Sliter, n. sp.

Plate 1, figure 10

Test free, small, consisting of proloculus followed by compressed tubular chamber that is trochospiral in early stage, and later becomes planispiral. Sutures distinct, depressed. Wall finely agglutinated, surface smoothly finished. Aperture at open end of tubular chamber.

Maximum diameter of holotype, 0.43 mm.; thickness, 0.17 mm.

Discussion.—*Ammodiscoides lajollaensis* SLITER, n. sp., differs from the Cretaceous species referred to the Recent *A. turbinatus* CUSHMAN (1909) in being much smaller and having a relatively larger chamber diameter. *A. lajollaensis* is rare and occurs only in the upper samples (Maastrichtian) of the La Jolla section.

Types and occurrence.—Holotype (UCLA 44011) from sample S-36; paratype (UCLA 44012) from sample S-37; both from Rosario Formation at La Jolla (J168).

Superfamily LITUOLACEA de Blainville, 1825

Family HORMOSINIDAE Haeckel, 1894

Subfamily HORMOSININAE Haeckel, 1894

Genus REOPHAX de Montfort, 1808

REOPHAX GLOBOSUS Sliter, n. sp.
Plate 1, figure 12

Reophax sp. MARTIN, 1964, p. 46, pl. 1, fig. 17.

Test free, elongate, uniserial, slightly arcuate. Chambers globular, somewhat overlapping, increasing moderately in size. Sutures distinct, constricted. Wall coarsely agglutinated, surface rough. Aperture terminal, at end of slight neck.

Maximum length of holotype, 2.17 mm.; diameter, 0.95 mm.

Discussion.—*Reophax globosus* SLITER, n. sp., is characterized by its large size, globular chambers and slight apertural neck. This species differs from *R. texanus* CUSHMAN & WATERS (1927) in larger size and more rapid increase in chamber size. *R. globosus* is similar to *R. troyeri* TAPPAN (1960) but is larger and also has a more rapid increase of chamber size. The specimen illustrated by MARTIN (1964) as *Reophax* sp. is believed to be synonymous although it is smaller in size. *R. globosus* extends from the Campanian into the Maastrichtian.

Types and occurrence.—Holotype (UCLA 44015) from sample S-1, Rosario Formation at La Jolla. Paratype (UCLA 44016) from sample E-5, Rosario Formation at Punta Descanso. Unfigured paratypes from Rosario Formation at Point Loma (J42, L165, D53).

REOPHAX PROLATUS Sliter, n. sp.
Plate 1, figure 11

Test free, elongate, uniserial, rectilinear. Chambers elongate parallel to axis, inflated. Sutures indistinct, constricted. Wall coarsely agglutinated, little cement, surface roughly finished. Aperture terminal, rounded, produced on short neck.

Maximum length of holotype, 1.05 mm.; diameter, 0.35 mm.

Discussion.—*Reophax prolatus* SLITER, n. sp., is distinguished from *R. globosus* SLITER, n. sp., by its elongate chambers and smaller size. *R. prolatus* ranges from the Campanian into the Maastrichtian.

Types and occurrence.—Holotype (UCLA 44013) from sample S-35. Paratype (UCLA 44014) from sample S-7. Both from the Rosario Formation at La Jolla. Unfigured paratypes from Rosario Formation at Point Loma (J105, L172).

Family RZEHAKINIDAE Cushman, 1933

Genus RZEHAKINA Cushman, 1927

RZEHAKINA EPIGONA (Rzehak)
Plate 1, figure 18

Silicina epigona RZEHAK, 1895, p. 214, pl. 6, fig. 1.
Rzehakina epigona (Rzehak), LOEBLICH & TAPPAN, 1964, p. C220, fig. 133,*1-3*.

Test free, ovate to subcircular in outline, compressed, periphery subacute. Chambers 2 per whorl, planispiral, involute, leaving central depression. Sutures indistinct. Wall finely agglutinated, insoluble in acid. Aperture a rounded opening at end of chamber, slightly produced.

Maximum length of figured hypotype, 0.63 mm.; breadth, 0.53 mm.; thickness, 0.21 mm.

Discussion.—The present specimens compare well with the original illustrations of RZEHAK and those given by LOEBLICH & TAPPAN (1964). *Rzehakina epigona* differs from *R. epigona lata* CUSHMAN & JARVIS (1928) in lacking prominent rounded peripheral carina. The test outline of the present form ranges from oval to nearly spherical.

Types and occurrence.—Figured hypotype (UCLA 44017) from sample L-1, Rosario Formation at Point Loma. Unfigured hypotypes from the Rosario Formation at La Jolla (J175, L161).

Genus SILICOSIGMOILINA Cushman & Church, 1929

SILICOSIGMOILINA CALIFORNICA Cushman & Church
Plate 1, figure 13-15

Silicosigmoilina californica CUSHMAN & CHURCH, 1929, p. 502, pl. 36, fig. 10-12.——GRAHAM & CHURCH, 1963, p. 23, pl. 1, fig. 20.——MARTIN, 1964, p. 57, pl. 4, fig. 4.

Test free, oval, compressed. Chambers initially planispiral, later sigmoidal. Sutures generally indistinct on all but last chamber, slightly depressed. Wall finely agglutinated, with siliceous cement, surface smooth. Aperture terminal, oval, with small tooth.

Maximum length of figured hypotypes, 0.53 to 0.95 mm.; breadth, 0.26 to 0.70 mm.; thickness, 0.15 to 0.25 mm.

Discussion.—This species is easily distinguished by its oval outline, sigmoidal chambers, and characteristically white siliceous wall. It differs from *Rzehakina epigona* (RZEHAK, 1895) in being larger, less circular in outline, and in having sigmoidal chambers and an apertural tooth. The original description refers to the lack of an apertural tooth as a disgnostic characteristic; LOEBLICH & TAPPAN (1964), however, reexamined the holotype and showed the presence of such a tooth. In the present samples this tooth is observed commonly in well-preserved specimens. *Silicosigmoilina californica* extends from the Coniacian into the lower Tertiary.

Types and occurrence.—Figured hypotype (Fig. 14, UCLA 44018) from sample S-34; figured hypotype (Fig. 13, UCLA 44063) from sample S-35; figured hypotype (Fig. 15, UCLA 44064) from sample S-36; all from the Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Carlsbad, Point Loma, and Punta Descanso (C134, J3, L1, D4).

Family LITUOLIDAE de Blainville, 1825

Subfamily HAPLOPHARAGMOIDINAE Maync, 1952

Genus HAPLOPHRAGMOIDES Cushman, 1910

HAPLOPHRAGMOIDES EXCAVATUS Cushman & Waters
Plate 1, figure 16

Haplophragmoides excavata CUSHMAN & WATERS, 1927, p. 82, pl. 10, fig. 3.——CUSHMAN, 1946, p. 21, pl. 2, fig. 13-15.——TRUJILLO, 1960, p. 305, pl. 43, fig. 5.——MARTIN, 1964, p. 48, pl. 2, fig. 8.

Test free, planispiral, involute, compressed periphery acute. Chambers 9 to 10 in final whorl, increasing gradually in size, commonly depressed in central portion. Sutures indistinct, flush. Wall finely agglutinated, surface smoothly finished. Aperture a narrow equatorial interiomarginal slit.

Maximum diameter of figured hypotype, 0.27 mm.; thickness, 0.09 mm. Unfigured hypotypes range to 1.65 mm. in diameter and 0.35 mm. in thickness.

Discussion.—*Haplophragmoides excavatus* is a common element at all localities except Carlsbad. Specimens are commonly distorted and compressed; thus the degree of chamber depression is a variable characteristic. This species is distinguished easily by its acute periphery and numerous chambers. *H. rota* NAUSS (1947), from the Upper Cretaceous of Alberta, Canada, may be synonymous with *H. excavatus,* as the characters listed in the description (i.e., size of test, concavity of chambers, size of umbilicus, and degree of final evolution) are seen as variable characters in the present populations. Originally described from the Gulf Coast area, *H. excavatus* is reported from the Taylor and Navarro Groups. California occurrences include the Coniacian to Santonian of Shasta County (TRUJILLO, 1960) and the Campanian to Maastrichtian of Fresno County (MARTIN, 1964).

Types and occurrence.—Figured hypotype (UCLA 44019) from sample S-31, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (J17, L11, D12).

HAPLOPHRAGMOIDES sp. cf. H. FAMOSUS Takayanagi
Plate 1, figure 17

Haplophragmoides famosus TAKAYANAGI, 1960, p. 71, pl. 1, fig. 22.

Test free, planispiral, compressed, not completely involute, periphery subacute. Chambers 6 to 7 in final whorl, increasing moderately in size. Sutures distinct, slightly depressed, radial to gently curved. Wall finely agglutinated, surface smooth. Aperture a low arch at base of final chamber.

Maximum diameter of figured hypotype, 0.39 mm.; other hypotypes range to 0.52 mm., thickness 0.10 mm.

Discussion.—A few specimens are referred tentatively to this species. Although they appear very similar to the illustrations given by TAKAYANAGI, the original description does not include information as to the type of planispiral coiling. *Haplophragmoides rota* NAUSS (1947), another similar species from the Upper Cretaceous of Canada, differs in being involute throughout and in having more chambers in the final whorl.

Types and occurrence.—Figured hypotype (UCLA 44020) from sample E-2, Rosario Formation at Punta Descanso. Unfigured hypotypes from Rosario Formation at La Jolla and Point Loma (J163, L109, D54).

HAPLOPHRAGMOIDES FRASERI Wickenden
Plate 2, figure 1

Haplophragmoides fraseri WICKENDEN, 1932, p. 86, pl. 1, fig. 2. ——TRUJILLO, 1960, p. 305, pl. 43, fig. 6.

Test free, planispiral, partially evolute, biumbilicate, periphery lobulate and rounded. Chambers 7 to 8 in final whorl, increasing gradually in size, globular, inflated. Sutures distinct, slightly curved, depressed. Wall finely agglutinated, surface smoothly finished. Aperture obscure on available specimens.

Maximum diameter of figured hypotype, 0.53 mm.; thickness, 0.25 mm.

Discussion.—This species is distinguished easily by its partially evolute, biumbilicate test, numerous chambers, and rounded axial periphery. The present specimens differ from that in the original illustration in being more compressed and more coarsely agglutinated. The coarser wall material also is present in the specimens described by TRUJILLO from northern California. Originally described from the Upper Cretaceous of Canada, *Haplophragmoides fraseri* is also reported from the middle Turonian of Shasta County, California.

Types and occurrence.—Figured hypotype (UCLA 44021) from sample S-36, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Punta Descanso (J215, D149).

HAPLOPHRAGMOIDES KIRKI Wickenden
Plate 2, figure 2

Haplophragmoides kirki WICKENDEN, 1932, p. 85, pl. 1, fig. 1.——MARTIN, 1964, p. 49, pl. 2, fig. 9.

Test free, planispiral, involute, periphery rounded. Chambers 5 to 6 in final whorl, increasing moderately in size, inflated. Sutures distinct, depressed, straight. Wall finely agglutinated, surface smoothly finished. Aperture a low equatorial interiomarginal arch at base of final chamber.

Maximum diameter of figured hypotype, 0.42 mm.; thickness, 0.28 mm.

Discussion.—*Haplophragmoides kirki* differs from *H. excavatus* in the rounded periphery and the less numerous, more inflated chambers. Originally described from the Upper Cretaceous of Canada, *H. kirki* also has been described from the Panoche Group of central California (MARTIN, 1964).

Types and occurrence.—Figured hypotype (UCLA 44022) from sample L-19, Rosario Formation at Point Loma. Unfigured hypotypes from the Rosario Formation at La Jolla and Punta Descanso (J161, L14, D40).

Genus CRIBROSTOMOIDES Cushman, 1910

CRIBROSTOMOIDES CRETACEUS Cushman & Goudkoff
Plate 2, figure 3

Cribrostomoides cretacea CUSHMAN & GOUDKOFF, 1944, p. 54, pl. 9, fig. 4.——TRUJILLO, 1960, p. 306, pl. 43, fig. 7, 8.——MARTIN, 1964, p. 50, pl. 2, fig. 11.

Test free, planispiral, involute. Chambers 8 to 10 in final whorl, gradually increasing in size, inflated. Sutures distinct, depressed. Wall finely agglutinated, surface smooth, characteristically white. Aperture an areal dentate slit, commonly obscured.

Maximum diameter of figured hypotype, 0.91 mm.; thickness, 0.63 mm.

Discussion.—Specimens of this species commonly are deformed, obscuring the apertural characteristics. Random specimens are sufficiently well preserved to show the dentate aperture. *Cribrostomoides cretaceus* originally was described by CUSHMAN & GOUDKOFF (1944) from the Upper Cretaceous of central California. Additional California references to this species include those of TRUJILLO (1960) from Shasta County with a reported range of Coniacian to Santonian and MARTIN (1964) from Fresno County giving a range of Santonian to Maastrichtian.

Types and occurrence.—Figured hypotype (UCLA 44023) from sample S-14, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (J5, L8, D1).

CRIBROSTOMOIDES TRIFOLIUM (Egger)
Plate 2, figure 4

Haplophragmium trifolium EGGER, 1899 [1902], p. 137, pl. 1, fig. 10, 32, 53.
Trochammina trifolia (Egger), TAKAYANAGI, 1960, p. 86, pl. 4, fig. 3.
Haplophragmoides trifolium (Egger), MARTIN, 1964, p. 49, pl. 2, fig. 10.

Test free, planispiral, involute, few (generally 3) chambers per whorl, increasing rapidly in size, test commonly distorted. Sutures distinct, depressed. Wall finely agglutinated, surface smooth. Aperture an areal slit.

Maximum diameter of figured hypotype, 1.40 mm.; thickness, 0.35 mm.

Discussion.—This species, originally described from the Upper Cretaceous of Germany, is rare in the present material and occurs only at La Jolla. Specimens commonly are distorted as shown by the figured hypotype. Within California, *Cribrostomoides trifolium* has been described from the Santonian of Fresno County (MARTIN, 1964). TAKAYANAGI (1960) reported this species from Hokkaido, Japan, as ranging from Turonian to upper Campanian.

Types and occurrence.—Figured hypotype (UCLA 44024) from sample S-37, Rosario Formation at La Jolla (J209).

Subfamily LITUOLINAE de Blainville, 1825

Genus AMMOBACULITES Cushman, 1910

AMMOBACULITES ALEXANDERI Cushman
Plate 2, figure 5

Ammobaculites alexanderi CUSHMAN, 1933b, p. 51, pl. 5, fig. 5.

Test free, elongate, compressed; initially planispiral, later becoming rectilinear. Chambers increasing moderately in size, becoming longer than broad, ultimate chamber produced. Sutures indistinct, slightly depressed. Wall coarsely agglutinated, little cement, surface rough. Aperture terminal, rounded.

Maximum length of figured hypotype, 0.77 mm.; breadth, 0.26 mm.; thickness, 0.14 mm.

Discussion.—Originally described from strata of early Taylor age, this species is a rare element in the present agglutinated fauna. It is distinguished by the initial planispiral coil, relatively high chambers, and produced ultimate chamber.

Types and occurrence.—Figured hypotype (UCLA 44025) from sample S-33, Rosario Formation at La Jolla (J210).

Genus HAPLOPHRAGMIUM Reuss, 1860

HAPLOPHRAGMIUM LUECKEI (Cushman & Hedberg)
Plate 2, figure 6

Ammobaculites lueckei CUSHMAN & HEDBERG, 1941, p. 83, pl. 21, fig. 4.
Haplophragmium lueckei (Cushman & Hedberg), LOEBLICH & TAPPAN, 1964, p. C244, fig. 155, *4*.

Test free, large; initial portion streptospirally coiled, later rectilinear. Chambers inflated, globular, increasing gradually in size, slightly overlapping. Sutures distinct, depressed. Wall coarsely agglutinated, surface moderately smooth. Aperture terminal, rounded.

Maximum length of figured hypotype, 1.23 mm.; diameter, 0.81 mm.

Discussion.—Originally described from the Upper Cretaceous of Colombia, this species occurs rarely in the present samples. The form illustrated as *Ammobaculites* sp. by MARTIN (1964) is similar in test size and shape but differs in having an initial planispiral coil.

Types and occurrence.—Figured hypotype (UCLA 44026) from sample S-23, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma (J170, L164).

Subfamily PLACOPSILININAE Rhumbler, 1913

Genus PLACOPSILINA d'Orbigny, 1850

PLACOPSILINA sp.
Plate 2, figure 7

Test attached, initially planispiral, later rectilinear, nearly parallel sided. Chambers generally 7 to 10 in planispiral stage, broad and low. Sutures gently curved, somewhat depressed. Wall coarsely agglutinated, surface somewhat roughly finished. Aperture terminal, simple, usually obscured.

Maximum length of figured hypotype, 1.58 mm.; breadth, 0.52 mm.

Discussion.—The morphologic development of this species ranges from forms that are entirely planispiral to uncoiled predominately rectilinear ones with reduced initial coils. The present specimens occur only in the Carlsbad section and most commonly are attached to pelecypod fragments, although a few specimens are encrusted on rock debris. This species resembles *Placopsilina cenomana* D'ORBIGNY of REUSS (1854) but differs in having a more coarsely agglutinated wall, less inflated chambers and a more irregular periphery.

Types and occurrence.—Figured hypotype (UCLA 44027) from sample C-2, Rosario Formation at Carlsbad (C61).

Family TEXTULARIIDAE Ehrenberg, 1838

Subfamily SPIROPLECTAMMININAE Cushman, 1927

Genus SPIROPLECTAMMINA Cushman, 1927

SPIROPLECTAMMINA CHICOANA Lalicker

Plate 2, figure 8

Spiroplectammina anceps (Reuss), CUSHMAN & CHURCH, 1929, p. 500, pl. 36, fig. 1-2.
Spiroplectammina chicoana LALICKER, 1935, p. 7, pl. 1, fig. 8-9. ——TRUJILLO, 1960, p. 310, pl. 44, fig. 6.——MARTIN, 1964, p. 51, pl. 2, fig. 13.
Spiroplectammina semicomplanata (Carsey), GRAHAM & CHURCH, 1963, p. 23, pl. 1, fig. 10-11.

Test free, elongate, tapering, compressed, initially planispiral, later biserial, periphery irregular in outline, acute in transverse section. Chambers numerous, low, broad. Sutures somewhat obscure, flush to slightly elevated, nearly straight. Wall coarsely agglutinated, surface moderately rough. Aperture an arched opening at base of final chamber.

Maximum length of figured hypotype, 0.60 mm.; breadth, 0.29 mm.; thickness, 0.12 mm.

Discussion.—*Spiroplectammina chicoana* is distinguished by the test shape and irregular periphery. The species seems distinct from *S. jarvisi* CUSHMAN, which differs in having an even periphery, smooth surface, and larger size. *S. semicomplanata* (CARSEY, 1926) from the Corsicana Marl, differs in being thicker more rapidly tapering and in having a more even periphery.

Types and occurrence.—Figured hypotype (UCLA 44028) from sample S-14, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (J64, L48, D38).

SPIROPLECTAMMINA LAEVIS (Roemer)

Plate 2, figure 9

Textularia laevis ROEMER, 1841, p. 97, pl. 15, fig. 17.
Spiroplectammina laevis (Roemer), CUSHMAN, 1932b, p. 87, pl. 11, fig. 2.——HOFKER, 1957, p. 61, fig. 58.
Spiroplectammina laevis (Roemer) var. *cretosa* CUSHMAN, 1932b, p. 87, pl. 11, fig. 3.——CUSHMAN, 1946, p. 27, pl. 6, fig. 1-3.

Test free, tapering; initially planispiral, later biserial; periphery subacute; apertural face broad, flat. Chambers numerous, low and broad, slightly inflated. Sutures distinct, gently curved to horizontal. Wall finely agglutinated, surface smoothly finished. Aperture an arched opening at inner margin of last chamber.

Maximum length of figured hypotype, 0.49 mm.; breadth, 0.35 mm.; thickness, 0.21 mm.

Discussion.—The present specimens of this species, which originally was described from the Cretaceous of Germany, are identical to forms from the upper Taylor Group (loc. 226-T-8 of Texas Bur. Econ. Geol., PLUMMER loc. no. 347) in my collection. These specimens show variation in chamber dimensions, test thickness, and degree of tapering. CUSHMAN's *Spiroplectammina laevis cretosa* falls within this range of variation and hence is here placed in synonymy.

Types and occurrence.—Figured hypotype (UCLA 44029) from sample C-4, Rosario Formation at Carlsbad. Unfigured hypotypes from Rosario Formation at La Jolla, Point Loma and Punta Descanso (C132, J134, L134, D109).

SPIROPLECTAMMINA SIGMOIDINA Lalicker

Plate 2, figure 12

Spiroplectammina sigmoidina LALICKER, 1935, p. 7, pl. 1, fig. 10-11.

Test free, elongate, tapering, compressed; initially planispiral, later biserial; periphery acute. Chambers numerous, low, broad. Sutures distinct, flush, gently curving. Wall finely agglutinated, surface smoothly finished. Aperture an elongate loop at inner margin of final chamber.

Maximum length of figured hypotype, 0.60 mm.; breadth, 0.26 mm.; thickness, 0.10 mm.

Discussion.—This species, described from the Upper Cretaceous near Coalinga, California, differs from *Spiroplectammina chicoana* in its narrower test, more regular periphery, and smoother surface. The "sigmoid sutures" described by LALICKER as a diagnostic characteristic are a variable feature in this species, whereas the test proportions and surface texture offer a more positive means of identification.

Types and occurrence.—Figured hypotype (UCLA 44030) from sample S-16, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (J2, L10, D7).

Family TROCHAMMINIDAE Schwager, 1877

Subfamily TROCHAMMININAE Schwager, 1877

Genus TROCHAMMINA Parker & Jones, 1859

TROCHAMMINA BOEHMI Franke

Plate 2, figure 10

Trochammina böhmi FRANKE, 1928, p. 174, pl. 15, fig. 24.——TRUJILLO, 1960, p. 304, pl. 44, fig. 1.
Trochammina sp. GRAHAM & CHURCH, 1963, p. 24, pl. 1, fig. 18.

Test free, trochoid, low-spired, compressed with lobate, rounded periphery. Chambers 4 per whorl, increasing rapidly in size, inflated. Sutures distinct, slightly curved, depressed. Wall coarsely agglutinated, surface smooth. Aperture at base of final chamber.

Maximum diameter of figured hypotype, 0.53 mm.; thickness, 0.21 mm.

Discussion.—*Trochammina boehmi* is recognized by the 4 inflated chambers in the final whorl, compressed test, and lobate periphery. The present specimens closely resemble the original illustrations of FRANKE but differ in being somewhat smaller. A similar size variation is noted in California where *T. boehmi* of TRUJILLO (1960) is larger than the present material, whereas *Trochammina* sp. GRAHAM & CHURCH (1963), here regarded as synonymous, is of similar size. Because size is the only morphologic variation in these occurrences, this probably is a reflection of local ecologic conditions. *T. bulloides* TAKAYANAGI (1960) appears to be a closely related species that differs in having a thicker, more compact test, and a smoother surface texture.

Types and occurrence.—Figured hypotype (UCLA 44031) from sample S-3, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma (J80, L173).

TROCHAMMINA PILEA Sliter, n. sp.
Plate 3, figure 3

Test free, trochoid, relatively high-spired, peripheral outline nearly circular, margin subacute. Chambers numerous, 6 to 8 in final whorl, increasing gradually in size. Sutures indistinct, curved, slightly depressed on spiral side; distinct, radial, and depressed on umbilical side. Wall moderately coarsely agglutinated, surface somewhat roughly finished. Aperture a low interiomarginal, extraumbilical arch.

Maximum diameter of holotype, 0.77 mm.; thickness, 0.42 mm.

Discussion.—This species is similar to *Trochammina albertensis* WICKENDEN (1932), from the Upper Cretaceous of Canada, but differs in being larger and higher-spired and having more chambers per whorl. Specimens are commonly crushed and distorted and superficially may resemble *T. texana* CUSHMAN & WATERS; they can be distinguished by the more numerous chambers and greater number of whorls in the test. *T. pilea* ranges from Campanian to Maastrichtian.

Types and occurrence.—Holotype (UCLA 44036) from sample L-3, Rosario Formation at Point Loma. Paratype (UCLA 44037) from sample S-24, Rosario Formation at La Jolla. Unfigured paratypes from Rosario Formation at Punta Descanso (J154, L50, D59).

TROCHAMMINA sp. cf. T. RIBSTONENSIS Wickenden
Plate 3, figure 1

Trochammina ribstonensis WICKENDEN, 1932, p. 90, pl. 1, fig. 12.——NAUSS, 1947, p. 340, pl. 49, fig. 6.——TAPPAN, 1962, p. 154, pl. 39, fig. 15-17.——MARTIN, 1964, p. 56, pl. 4, fig. 1.

Test free, small, trochospiral, compressed, spiral side gently convex with 3 whorls visible, umbilical side concave with only last whorl showing, axial periphery subangular. Seven chambers in final whorl, slightly inflated, increasing gradually in size. Sutures distinct, depressed, curved on spiral side, radial on umbilical side. Wall finely agglutinated, smooth. Aperture a low interiomarginal arch.

Maximum diameter of figured hypotype, 0.46 mm.; thickness, 0.11 mm.

Discussion.—The specimen here illustrated is similar to the original illustration but differs in larger size and compressed chambers. The compression of the test seems caused by postdepositional deformation.

Type and occurrence.—Figured hypotype (UCLA 44032) from sample L-20, Rosario Formation at Point Loma (L16).

TROCHAMMINA TEXANA Cushman & Waters
Plate 2, figure 11

Trochammina texana CUSHMAN & WATERS, 1927, p. 85, pl. 11, fig. 8.——TRUJILLO, 1960, p. 304, pl. 44, fig. 3.
Trochammina sp. cf. *T. texana* Cushman & Waters, GRAHAM & CHURCH, 1963, p. 24, pl. 1, fig. 16.

Test free, low trochospiral, compressed, generally planoconvex; spiral side flattened, umbilical side convex; umbilicate, periphery acute. Six chambers in final whorl, spiral chambers petaloid, generally concave centrally, umbilical chambers subpetaloid. Sutures curved; flush on spiral side; radial, depressed on umbilical side. Wall finely agglutinated, smoothly finished. Aperture a low interiomarginal extraumbilical-umbilical arch.

Maximum diameter of figured hypotype, 0.63 mm.; thickness, 0.21 mm.

Discussion.—Originally described from beds of Navarro age in Texas, this species differs from *Trochammina boehmi* in its more numerous, compressed chambers, umbilicate test, and more angular periphery. The present specimens are identical to those described by TRUJILLO (1960) from the Santonian of northern California and by GRAHAM & CHURCH (1963) from the Campanian of Stanford University campus.

Types and occurrence.—Figured hypotype (UCLA 44033) from sample S-25, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (J61, L12, D41).

TROCHAMMINA TRIFORMIS Sliter, n. sp.
Plate 3, figure 2

Test free, trochospiral, high-spired, periphery rounded. Chambers 3 per whorl, increasing rapidly in size, globular, inflated. Sutures distinct, depressed. Wall finely agglutinated, surface generally smoothly finished. Aperture a low arch at base of final chamber.

Maximum diameter of holotype, 0.56 mm.; length, 0.74 mm.

Discussion.—*Trochammina triformis* differs from *T. globigeriniformis* (PARKER & JONES, 1865) in having a higher spire, more inflated chambers, and larger size. It differs from *T. umiatensis* TAPPAN (1957) in being higher-spired and having 3 chambers per whorl, rather than 4. *T. triformis* ranges from the Campanian into the Maastrichtian.

Types and occurrence.—Holotype (UCLA 44034) from sample S-22; paratype (UCLA 44035) from sample S-37; both from Rosario Formation at La Jolla. Unfigured paratypes from Rosario Formation at Point Loma and Punta Descanso (J113, L44, D14).

Family ATAXOPHRAGMIIDAE Schwager, 1877

Subfamily VERNEUILININAE Cushman, 1911

Genus GAUDRYINA d'Orbigny, 1839

GAUDRYINA BENTONENSIS (Carman)

Plate 3, figure 10

Spiroplectammina bentonensis CARMAN, 1929, p. 311, pl. 34, fig. 8-9.

Gaudryina bentonensis (Carman), CUSHMAN, 1946, p. 33, pl. 7, fig. 15-16.——GRAHAM & CHURCH, 1963, p. 19, pl. 1, fig. 3.

Test free, elongate, triserial in early stage, later biserial, in many becoming nearly uniserial. Chambers indistinct, slightly inflated in later stages. Sutures indistinct, slightly constricted. Wall agglutinated, moderately rough. Aperture a low interiomarginal arch, usually obscured by distortion.

Maximum length of figured hypotype, 1.09 mm.; diameter, 0.32 mm.

Discussion.—This species is a consistent element of the fauna at all localities studied except Carlsbad. Specimens generally are compressed or distorted, commonly so as to obscure apertural details and chamber arrangement. A few specimens are sufficiently well preserved to show the initial triserial portion, a biserial mid-section, and the 1 or 2 nearly uniserial ultimate chambers. The last stage is developed from cuneate biserial chambers and only occurs in adult specimens. As this species thus has a loose biserial arrangement, the species is retained in *Gaudryina*. Initially described from the Cenomanian-Turonian Benton Shale of Wyoming, *G. bentonensis* also is recorded from the Campanian of Stanford University campus, California, and the Eagle Ford, Austin, and Taylor Groups of Texas. A species that may prove to be synonymous has been illustrated by TAKAYANAGI (1960) as *Gaudryinella teshioensis* ASANO, from the Turonian Saku Formation of Hokkaido, Japan.

Types and occurrence.—Figured hypotype (UCLA 44038) from sample S-8, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (J16, L9, D13).

GAUDRYINA GLABRATA (Cushman)

Plate 3, figure 4-5

Dorothia glabrata CUSHMAN, 1933b, p. 56, pl. 6, fig. 10.

Test free, elongate, tapering, somewhat laterally compressed; early stage triserial, subtriangular; later becoming biserial. Chambers increasing in thickness more rapidly than in height, moderately inflated, overlapping. Sutures distinct, depressed. Wall finely agglutinated, surface smoothly finished. Aperture an interiomarginal arched opening.

Maximum length of figured hypotypes, 0.46 to 0.56 mm.; breadth, 0.27 to 0.31 mm.; thickness, 0.20 to 0.26 mm.

Discussion.—Examination of Corsicana Clay samples (locs. 26-28 of CUSHMAN, 1946) in my collection reveals that, although the present specimens are shorter than the holotype, they nevertheless fall within the size range of the Texas material. In all other aspects they are nearly identical. The specimen illustrated as *Bermudezina extans* BANDY (1951) may represent an aberrant form or broken specimen of *Gaudryina glabrata*, inasmuch as the latter species is a common element in the Carlsbad section and true examples of *Bermudezina* were not encountered during the present study. Gulf Coast occurrences of *G. glabrata* are from strata ranging from upper Taylor to Navarro age.

Types and occurrence.—Figured hypotype (fig. 5, UCLA 44039) from sample S-14, Rosario Formation at La Jolla. Figured hypotype (fig. 4, UCLA 44040) from sample C-4, Rosario Formation at Carlsbad. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (C1, J62, L150, D125).

GAUDRYINA LAEVIGATA Franke

Plate 3, figure 8

Gaudryina laevigata FRANKE, 1914, p. 431, pl. 27, fig. 1-2.——CUSHMAN, 1946, p. 33, pl. 8, fig. 4.——TAKAYANAGI, 1960, p. 79, pl. 3, fig. 1.——GRAHAM & CHURCH, 1963, p. 20, pl. 1, fig. 12.——MCGUGAN, 1964, p. 940, pl. 150, fig. 6-8.——MARTIN, 1964, p. 52, pl. 3, fig. 2.

Gaudryina pyramidata Cushman, TRUJILLO, 1960, p. 308, pl. 44, fig. 9.——MARTIN, 1964, p. 52, pl. 3, fig. 3.

Test free, elongate, initially triserial, triangular in transverse section, becoming biserial and subrectangular in section. Chambers in early stages low and indistinct, becoming distinct, inflated and overlapping in biserial stage. Sutures in triserial portion flush, later depressed. Wall finely agglutinated, surface slightly granular. Aperture a low arch at inner margin of final chamber.

Maximum length of figured hypotype, 1.54 mm.; breadth, 0.77 mm.; thickness, 0.77 mm.

Discussion.—This common species is distinguished easily by the triangular initial portion and subrectangular biserial stage. The stratigraphic range of *Gaudryina laevigata* within California extends from the Santonian to the lower Maastrichtian.

Types and occurrence.—Figured hypotype (UCLA 44041) from sample S-30, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (J4, L7, D6).

GAUDRYINA PYRAMIDATA Cushman

Plate 3, figure 9

Gaudryina laevigata FRANKE, var. *pyramidata* CUSHMAN, 1926b, p. 587, pl. 16, fig. 8.

Gaudryina (Pseudogaudryina) pyramidata Cushman, CUSHMAN & GOUDKOFF, 1944, p. 56, pl. 9, fig. 7-8.——ETERNOD OLVERA, 1959, p. 65, pl. 1, fig. 1-2.

Gaudryina pyramidata Cushman, GRAHAM & CLARK, 1961, p. 109, fig. 2,*1*.

Test free, elongate, triangular in transverse section, early stage triserial, later biserial. Chambers low, broad, becoming slightly inflated in biserial portion. Sutures distinct, depressed. Wall finely agglutinated, surface smoothly finished. Aperture a low interiomarginal arch.

Maximum length of figured hypotype, 0.81 mm.; breadth, 0.77 mm.; thickness, 0.49 mm.

Discussion.—The original description of this species notes the triangular section, acute test angles, and somewhat longer length than breadth. These criteria clearly separate this species from *Gaudryina laevigata,* a more elongate species with a subrectangular adult stage. Within California, some confusion still exists over the distinction between these two species. Based on the characteristics just noted, the forms illustrated by TRUJILLO (1960) and MARTIN (1964) as *G. pyramidata* rightly belong to *G. laevigata.* Also, *Verneuilina muensteri* REUSS of MARTIN appears to be biserial in the adult stage and may represent *G. pyramidata.* The Cretaceous foraminiferal assemblage from Hokkaido, Japan, contains a species referred to *Gaudryina* sp. A by TAKAYANAGI (1960), that closely resembles *G. pyramidata.* This foraminifer was described as particularly characteristic of GOUDKOFF's G-1 zone and within California extends from the upper Turonian to the lowest Maastrichtian. Occurrences in the Gulf-Caribbean area range from the Campanian into the Maastrichtian.

Types and occurrence.—Figured hypotype (UCLA 44042) from sample L-4, Rosario Formation at Point Loma. Unfigured hypotypes from the Rosario Formation at La Jolla (J212, L163).

GAUDRYINA TAILLEURI (Tappan)

Plate 3, figure 6-7

Verneuilinoides tailleuri TAPPAN, 1957, p. 208, pl. 66, fig. 19-22.
Dorothia chandlerensis TAPPAN, 1957, p. 208, pl. 66, fig. 29-30.
Gaudryina tailleuri (Tappan), TAPPAN, 1962, p. 149, pl. 35, fig. 8-16.

Test free, elongate, narrow, nearly parallel-sided. Chambers numerous, nearly equal in size, becoming somewhat inflated, initially triserial, later biserial for one-third to two-thirds test length, rarely nearly becoming uniserial. Sutures generally distinct, depressed, horizontal. Wall finely agglutinated, surface commonly roughly finished. Aperture an arched opening at base of final chamber, rarely preserved.

Maximum length of figured hypotypes, 0.49 to 1.12 mm.; breadth, 0.18 to 0.19 mm.; thickness, 0.11 mm.

Discussion.—Originally described as two species from the Alaskan Cretaceous, TAPPAN (1962) showed these forms to be conspecific, possibly representing different stages in the life cycle. The present specimens are very similar to paratypes of *Gaudryina tailleuri* but differ in having a greater initial taper and being more compressed and less cylindrical. These differences are not regarded as sufficient to warrant specific differentiation. The relative abundance of the two forms is the reverse of that found in Alaskan material. The elongate, principally biserial form, rarer in Alaska, is the more common form in the present samples. *Dorothia hokkaidoana* TAKAYANAGI (1960) from the Cenomanian to upper Campanian of Japan is similar in appearance and may be synonymous, depending on the presence or absence of the initial trochospiral coil. The previous records of *G. tailleuri* indicates its occurrence in the Albian of northern Alaska.

Types and occurrence.—Figured hypotype (fig. 7, UCLA 44044) from sample S-35, figured hypotype (fig. 6, UCLA 44043) from sample S-13, both from the Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (J66, L15, D64).

Subfamily GLOBOTEXTULARIINAE Cushman, 1927

Genus DOROTHIA Plummer, 1931

DOROTHIA BULLETTA (Carsey)

Plate 3, figure 11

Gaudryina bulletta CARSEY, 1926, p. 28, pl. 4, fig. 4.
Dorothia bulletta (Carsey), BANDY, 1951, p. 491, pl. 72, fig. 4.——ETERNOD OLVERA, 1959, p. 67, pl. 1, fig. 6-7.——GRAHAM & CHURCH, 1963, p. 18, pl. 1, fig. 9.——MARTIN, 1964, p. 55, pl. 3, fig. 12.

Test free, elongate, subcylindrical, early portion conical to rounded. Chambers initially trochospiral, 4 to 5 per whorl, later biserial, becoming more inflated and cuneate. Sutures distinct, initially flush, later becoming depressed. Wall finely agglutinated, surface smooth. Aperture a low arch at base of final chamber, with small lip.

Maximum length of figured hypotype, 1.23 mm.; breadth, 0.46 mm.; thickness, 0.49 mm.

Discussion.—This species is characterized by its subcylindrical test, inflated chambers, and well-developed biserial stage. California occurrences range from Santonian to Maastrichtian in age, whereas in the Gulf Coast the species extends from the Austin to the Navarro Groups.

Types and occurrence.—Figured hypotype (UCLA 44045) from sample S-28, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (J135, L39, D11).

DOROTHIA ELLISORAE (Cushman)

Plate 3, figure 12

Marssonella ellisorae CUSHMAN, 1936d, p. 44, pl. 4, fig. 11.——McGUGAN, 1964, p. 940, pl. 150, fig. 9.
Dorothia ellisorae (Cushman), TRUJILLO, 1960, p. 309, pl. 44, fig. 4.

Test free, elongate, conical; initial and acute, becoming nearly parallel-sided; last 1 to 2 chambers may be reduced. Chambers initially trochospiral with 4 to 5 chambers per whorl, later biserial. Sutures initially flush, later depressed. Wall finely agglutinated, surface smoothly finished. Aperture a low arch at base of final chamber.

Maximum length of figured hypotype, 0.58 mm.; diameter, 0.25 mm.

Discussion.—This species differs from *Dorothia oxycona* (REUSS) in being smaller and nearly parallel sided in the adult stage. Specimens from the present material are identical to those in samples of Pecan Gap in my collection. California occurrences of *D. ellisorae* range from the upper Turonian to the Maastrichtian.

Types and occurrence.—Figured hypotype (UCLA 44046) from sample S-1, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (J12, L38, D8).

DOROTHIA OXYCONA (Reuss)

Plate 3, figure 13

Gaudryina oxycona Reuss, 1860, p. 229, pl. 12, fig. 3.——Cushman & Church, 1929, p. 501, pl. 36, fig. 3-4.

Marssonella oxycona (Reuss), Bandy, 1951, p. 492, pl. 72, fig. 8. ——Martin, 1964, p. 56, pl. 3, fig. 14.

Dorothia oxycona (Reuss), Trujillo, 1960, p. 309, pl. 44, fig. 5. ——Loeblich & Tappan, 1964, p. C275, fig. 184,5.

Marssonella trochus (d'Orbigny), Graham & Church, 1963, p. 21, pl. 1, fig. 6.

Test free, conical, initially trochospiral with 4 to 5 chambers per whorl, later biserial, apertural end slightly concave. Chambers narrow, somewhat overlapping. Sutures distinct, flush. Wall finely agglutinated, surface smooth. Aperture a low slit at inner margin of last chamber.

Maximum length of figured hypotype, 0.62 mm.; diameter, 0.46 mm.

Discussion.—This species is characterized by its conical shape, large size, and smooth to undulating surface. As described by Cushman (1946, p. 43) specimens of *Dorothia oxycona* grade from broadly flaring forms to those tapering more slowly and becoming elongated. Within the present samples some specimens show a chamber indentation probably resulting from postdepositional deformation. These specimens are similar to those described as *D. indentata* Cushman & Jarvis (1928) from Trinidad and Mexico but are intergradational to the present species. Until the relationship of these two similar species is determined, the present specimens are referred to *D. oxycona*. Within California, *D. oxycona* has been recorded from the Coniacian to the Maastrichtian.

Types and occurrence.—Figured hypotype (UCLA 44047) from sample S-25, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Carlsbad, Point Loma and Punta Descanso (C34, J65, L2, D10).

DOROTHIA PUPA (Reuss)

Plate 4, figure 1

Textularia pupa Reuss, 1860, p. 232, pl. 13, fig. 4.

Dorothia pupa (Reuss), Graham & Church, 1963, p. 18, pl. 1, fig. 7.——McGugan, 1964, p. 941, pl. 150, fig. 15-16.

Test free, large, stout, initially trochospiral with 4 to 5 chambers per whorl, later biserial. Chambers slightly inflated, becoming more inflated toward apertural end. Sutures distinct, slightly depressed. Wall finely agglutinated, surface smooth. Aperture a low arch at inner margin of last chamber.

Maximum length of figured hypotype, 1.16 mm.; breadth, 0.70 mm.; thickness, 0.60 mm.

Discussion.—*Dorothia pupa* differs from *D. bulletta* in having a shorter, thicker test and a reduced biserial stage. The present forms agree well with the original illustration of Reuss from the Senonian of Germany. American West Coast occurrences include the Campanian of Vancouver Island, Canada, and the Stanford University campus, California. Elsewhere, this species occurs in the Campanian of England, Egypt, and Australia.

Types and occurrence.—Figured hypotype (UCLA 44048) from sample S-28, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Carlsbad and Point Loma (C100, J193, L166).

DOROTHIA RETUSA (Cushman)

Plate 4, figure 2

Gaudryina retusa Cushman, 1926b, p. 588, pl. 16, fig. 10.——White, 1928b, p. 313, pl. 42, fig. 8-9.

Dorothia retusa (Cushman), Graham & Church, 1963, p. 19, pl. 1, fig. 8.

Test free, stout, early stage trochospiral with 4 to 5 chambers per whorl, later stage biserial. Chambers slightly inflated. Sutures distinct, depressed, oblique. Wall finely agglutinated, surface smoothly finished. Aperture a low arch at inner margin of final chamber.

Maximum length of figured hypotype, 0.67 mm.; breadth, 0.53 mm.; thickness, 0.53 mm.

Discussion.—*Dorothia retusa* is separated from *D. pupa* by the shorter, stouter test, larger chambers, and oblique sutures, and has been recorded from the Campanian of Stanford University campus, California, and the Upper Cretaceous of Mexico and Trinidad.

Types and occurrence.—Figured hypotype (UCLA 44049) from sample S-28, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma (J201, L74).

Superfamily MILIOLACEA Ehrenberg, 1839

Family FISCHERINIDAE Millett, 1898

Subfamily CYCLOGYRINAE Loeblich & Tappan, 1961

Genus CYCLOGYRA Wood, 1842

CYCLOGYRA sp.

Plate 4, figure 3

Test free, small discoidal, consisting of small proloculus followed by planispirally coiled tubular chamber. Wall calcareous, imperforate, porcelaneous, surface smooth with sporadic growth constrictions. Aperture at open end of chamber.

Maximum diameter of figured specimen, 0.34 mm.; thickness, 0.09 mm. Other specimens range to 1.0 mm. in diameter.

Discussion.—Only a few rare specimens of this species were found, the majority being fragmental or distorted. The form is easily distinguished, however, by its opaque, porcelaneous wall.

Types and occurrence.—Figured specimen (UCLA 44050) from sample L-3, Rosario Formation at Point Loma. Unfigured specimens from Rosario Formation at Carlsbad and Punta Descanso (C147, L142, D121).

Family NUBECULARIIDAE Jones, 1875

Subfamily SPIROLOCULININAE Wiesner, 1920

Genus SPIROLOCULINA d'Orbigny, 1826

SPIROLOCULINA CRETACEA Reuss

Plate 4, figure 4

Spiroloculina cretacea REUSS, 1854, p. 72, pl. 26, fig. 9.——CUSHMAN, 1946, p. 49, pl. 14, fig. 19-23.

Test free, compressed, fusiform in outline, periphery rounded to truncate. Chambers distinct, 2 per whorl, increasing gradually in size. Sutures distinct, slightly depressed. Wall calcareous, porcelaneous, imperforate, surface smooth. Aperture terminal, rounded, at end of short neck.

Maximum length of figured hypotype, 0.28 mm.; breadth, 0.15 mm.; thickness, 0.05 mm.

Discussion.—The majority of the present specimens have a rounded to subacute periphery, but random ones have the truncate periphery shown in the original illustrations. Both types are included within this species as other morphologic features are identical. Forms illustrated by CUSHMAN (1946) also include both specimens having a truncate and a rounded periphery. The present occurrences are limited to Carlsbad, where the species ranges throughout the section.

Types and occurrence.—Figured hypotype (UCLA 44051) from sample C-3, Rosario Formation at Carlsbad (C63).

SPIROLOCULINA TRUNCATA Sliter, n. sp.

Plate 4, figure 8

Test free, compressed, fusiform in outline, periphery squarely truncate, broad, both sides concave. Chambers 2 per whorl, increasing rather rapidly in size, with subacute peripheral shoulders. Sutures distinct, depressed. Wall calcareous, porcelaneous, imperforate, surface smoothly finished. Aperture terminal, rounded, at end of distinct neck, no tooth visible.

Maximum length of holotype, 0.31 mm.; breadth, 0.19 mm.; thickness, 0.09 mm.

Discussion.—This species is separated from *Spiroloculina cretacea* by the broad, truncate periphery, concave sides, and somewhat larger size. The specimen illustrated by EGGER (1899) as *S. cretacea* may be synonymous but differs in being much larger, relatively longer, and not as thick as the present specimens. *S. truncata* occurs rarely throughout the Carlsbad section and in single samples at both Point Loma and Punta Descanso. The present stratigraphic range is middle to upper Campanian.

Types and occurrence.—Holotype (UCLA 44052) from sample C-5; paratype (UCLA 44053) from sample C-5; both from Rosario Formation at Carlsbad (C96, L143, D122).

Subfamily NODOBACULARIINAE Cushman, 1927

Genus NODOPHTHALMIDIUM Macfadyen, 1939

NODOPHTHALMIDIUM OBSCURUM (Bogdanovich)

Plate 4, figure 5

Foraminella obscurum BOGDANOVICH, 1960, p. 19, pl. 1, fig. 1-5.
Nodophthalmidium obscurum (Bogdanovich), LOEBLICH & TAPPAN, 1964, p. C456, fig. 345,*11*.

Test free or attached, uniserial, rectilinear. Globular proloculus followed by planispiral second chamber and pyriform chambers in ultimate stage, connected to preceding chamber by tubular neck. Sutures indistinct. Wall calcareous, porcelaneous, imperforate, surface smooth to irregular. Aperture terminal, generally rounded.

Maximum length of figured hypotype, 0.48 mm.; diameter, 0.17.

Discussion.—The present specimens are nearly identical to those described by BOGDANOVICH (1960) from the Paleogene of Russia but differ in being smaller. They also have the same slitlike openings and rounded protuberances shown in the original illustration. LOEBLICH & TAPPAN (1964) suggested that these openings were the work of boring predators. As the bases of the protuberances are raised and the surface of most specimens show irregular outlines of attached objects, these may represent the bases of tubular spines used for attachment or some other purpose. This species differs from *Nodophthalmidium pyriforme* (TAPPAN) from the Lower Cretaceous of Texas in being smaller, lacking agglutinated coating, and having distinct protuberances. *N. obscurum* presently is found in the upper samples at La Jolla and the mid-section at both Point Loma and Punta Descanso.

Types and occurrence.—Figured hypotype (UCLA 44054) from sample S-26, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (J197, L156, E118).

Family MILIOLIDAE Ehrenberg, 1839

Subfamily QUINQUELOCULININAE Cushman, 1917

Genus QUINQUELOCULINA d'Orbigny, 1826

QUINQUELOCULINA sp. cf. Q. HARRISI Howe & Roberts

Plate 4, figure 6

Quinqueloculina harrisi HOWE & ROBERTS *in* HOWE, 1939, p. 35, pl. 2, fig. 13-15.

Test free, ovate in outline, axial periphery rounded, quinqueloculine coiling throughout. Chambers distinct, each a half coil in length, narrow. Sutures distinct, depressed. Wall calcareous, porcelaneous, imperforate, surface smooth. Aperture terminal, rounded, with small tooth.

Maximum length of hypotype, 0.44 mm.; breadth, 0.31 mm.; thickness, 0.22 mm.

Discussion.—This species occurs rarely in all the locations examined for this study. The specimens are very similar to *Quinqueloculina harrisi* originally described from the Eocene of Louisiana, and thus may represent a long-ranging or homeomorphic form.

Types and occurrence.—Figured hypotype (UCLA 44055) from sample E-12, Rosario Formation at Punta Descanso. Unfigured hypotypes from Rosario Formation at La Jolla, Carlsbad and Point Loma (C123, J206, L107, D145).

QUINQUELOCULINA SANDIEGOENSIS Sliter, n. sp.
Plate 4, figure 7

Test free, elongate, ovate in outline, axial periphery subacute to truncate, quinqueloculine coiling throughout. Chambers distinct, narrow, each a half coil in length. Sutures distinct, depressed. Wall calcareous, porcelaneous, imperforate, surface smoothly finished. Aperture terminal, rounded with small, simple tooth.

Maximum length of holotype, 0.48 mm.; breadth, 0.29 mm.; thickness, 0.20 mm.

Discussion.—*Quinqueloculina sandiegoensis* differs from *Q. moremani* CUSHMAN (1937) in having truncate or less strongly developed chamber angles and more inflated chambers. This species occurs in the upper portion of the La Jolla section, throughout the Carlsbad locality, and rarely at Punta Descanso. The stratigraphic range is Campanian to Maastrichtian.

Types and occurrence.—Holotype (UCLA 44056) from sample C-3; paratype (UCLA 44057) from sample C-3; both from Rosario Formation at Carlsbad (C16, J194, D115).

Superfamily NODOSARIACEA Ehrenberg, 1838

Family NODOSARIIDAE Ehrenberg, 1838

Subfamily NODOSARIINAE Ehrenberg, 1838

Genus NODOSARIA Lamarck, 1812

NODOSARIA AMPHIOXYS Reuss
Plate 4, figure 9

Nodosaria amphioxys REUSS, 1875, p. 82, pl. 2 (20), fig. 8.——CUSHMAN, 1946, p. 72, pl. 26, fig. 14.——BANDY, 1951, p. 501, pl. 73, fig. 15.

Test free, uniserial, elongate, tapering, both ends pointed. Chambers inflated, becoming elongate, increasing rapidly in size. Sutures distinct, depressed. Wall calcareous, finely perforate, surface costate, aperture terminal.

Maximum length of figured hypotype, 0.66 mm.; diameter, 0.17 mm.

Discussion.—*Nodosaria amphioxys* occurs rarely at La Jolla and Punta Descanso and somewhat more commonly at Carlsbad. The species is easily distinguished by the pointed ends, tapering test, and elongate chambers. Originally described from the Upper Cretaceous of Germany, this species ranges from the Campanian to the Maastrichtian.

Types and occurrence.—Figured hypotype (UCLA 44058) from sample C-4, Rosario Formation at Carlsbad. Unfigured hypotypes from Rosario Formation at La Jolla, Point Loma and Punta Descanso (C70, J108, L92, D84).

NODOSARIA ASPERA Reuss
Plate 4, figure 11

Nodosaria (Nodosaria) aspera REUSS, 1845, p. 26, pl. 13, fig. 14-15.
Nodosaria aspera Reuss, CUSHMAN, 1946, p. 72, pl. 26, fig. 6.——HAGN, 1953, p. 49, pl. 4, fig. 28.——POŻARYSKA, 1957, p. 65, pl. 7, fig. 3.——TRUJILLO, 1960, p. 328, pl. 47, fig. 10.——GRAHAM & CHURCH, 1963, p. 41, pl. 4, fig. 17-18.
Stilostomella aspera (Reuss), BELFORD, 1960, p. 69, pl. 19, fig. 1-2.

Test free, elongate, slightly tapering. Chambers inflated, subglobular, increasing uniformly in size, final chamber may be enlarged. Sutures distinct, depressed. Wall calcareous, finely perforate, radial in structure, surface spinose. Aperture terminal, at end of slender neck.

EXPLANATION OF PLATE 3

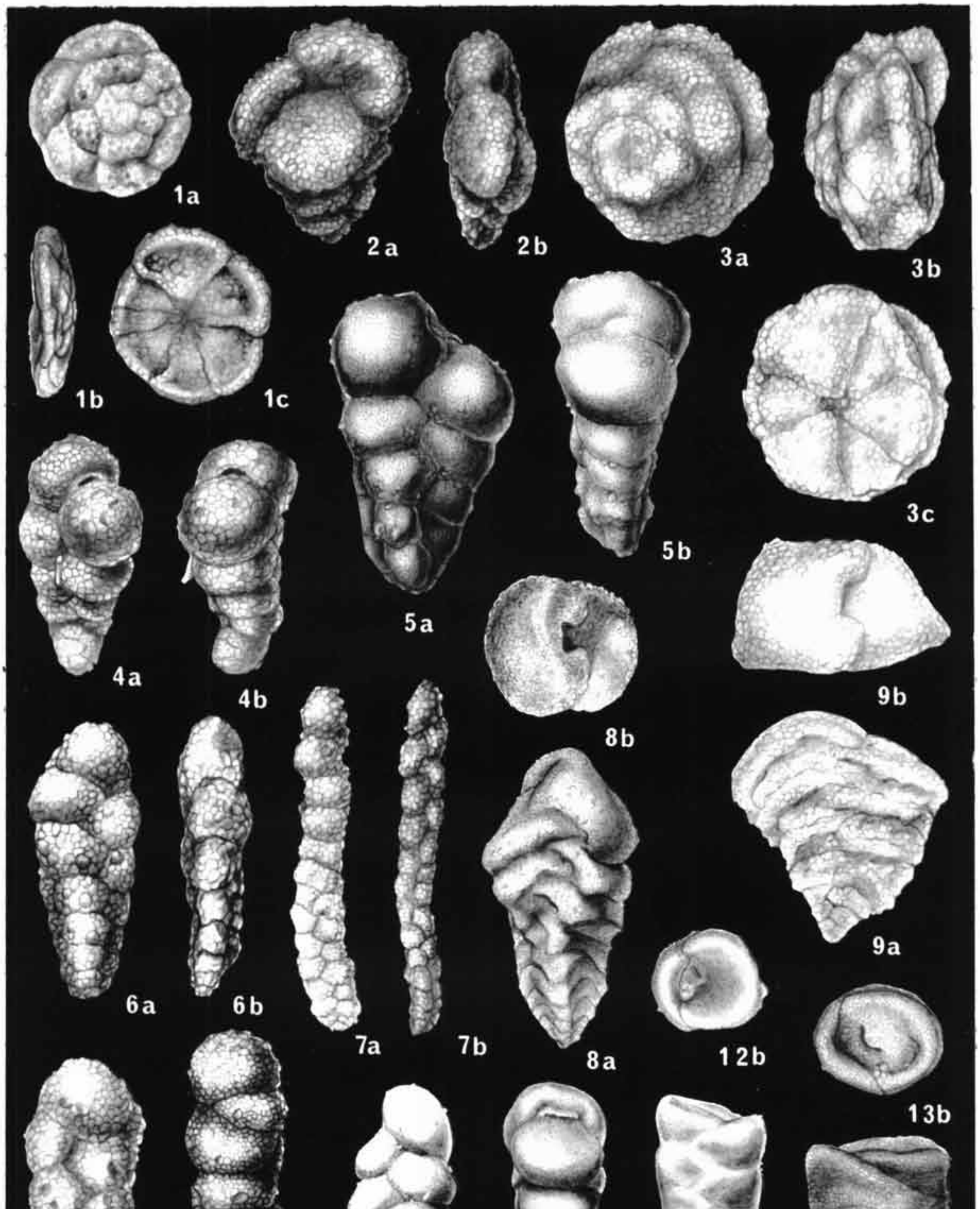
FIGURE

1. *Trochammina* sp. cf. *T. ribstonensis* WICKENDEN; 1a-c, spiral, edge, and umbilical views, ×66 (p. 47).
2. *Trochammina triformis* SLITER, n. sp.; 2a,b, side views, ×45 (p. 47).
3. *Trochammina pilea* SLITER, n. sp.; 3a-c, spiral, edge, and umbilical views, ×52 (p. 47).

4-5. *Gaudryina glabrata* (CUSHMAN); 4a,b, side views, ×66; 5, side view, ×97 (p. 48).

6-7. *Gaudryina tailleuri* (TAPPAN); 6a-c, side views, ×97; 7a,b, side views, ×52 (p. 49).

8. *Gaudryina laevigata* FRANKE; 8a,b, side and apertural views, ×33 (p. 48).
9. *Gaudryina pyramidata* CUSHMAN; 9a,b, side and apertural views, ×52 (p. 48).
10. *Gaudryina bentonensis* (CARMAN), side view, ×52 (p. 48).
11. *Dorothia bulletta* (CARSEY); 11a,b, side views, ×33 (p. 49).
12. *Dorothia ellisorae* (CUSHMAN); 12a,b, side and apertural views, ×70 (p. 49).
13. *Dorothia oxycona* (REUSS); 13a,b, side and apertural views, ×52 (p. 50).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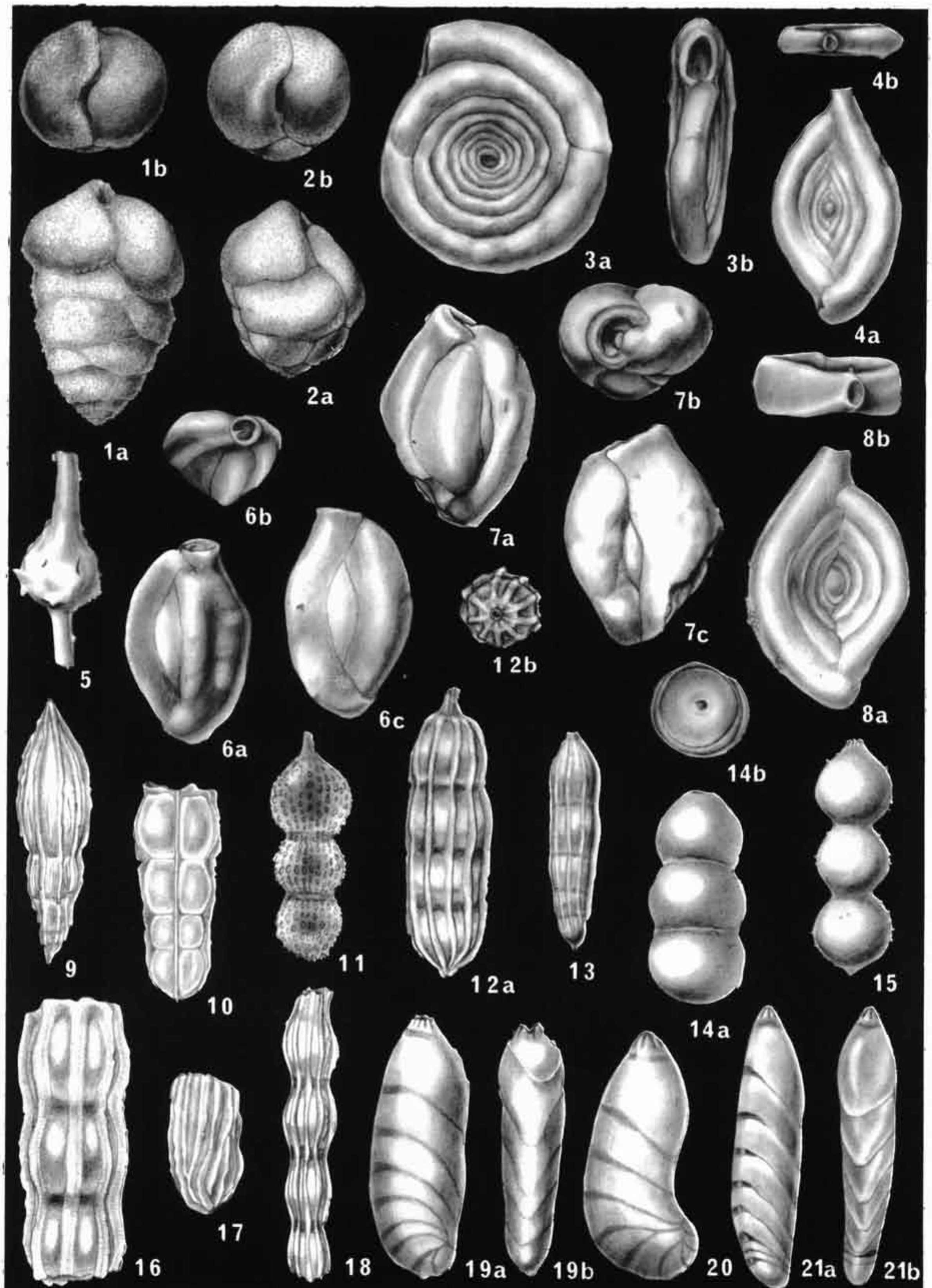
Sliter – Upper Cretaceous Foraminifera, Southern California and Northwestern Mexico.



Maximum length of figured hypotype, 0.61 mm.; diameter, 0.30 mm.

Discussion.—This form differs from *Nodosaria proboscidea* REUSS in being spinose and having more globular chambers. Originally described from the Cretaceous of Bohemia, *N. aspera* ranges from the Coniacian to the Maastrichtian. It is found in the upper samples at La Jolla and rarely at Point Loma.

Types and occurrence.—Figured hypotype (UCLA 44059) from sample S-28, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma (J177, L170).

NODOSARIA DISTANS Reuss

Plate 4, figure 18

Nodosaria distans REUSS, 1855, p. 264, pl. 8, fig. 5.——CUSHMAN, 1946, p. 71, pl. 26, fig. 1-2.

Test free, elongate, gradually tapering. Chambers inflated, subglobular, generally somewhat separated, increasing gradually in size. Sutures distinct, depressed, limbate. Wall calcareous, finely perforate, radial in structure, surface ornamented by longitudinal costae. Aperture terminal, radiate, somewhat produced.

Maximum length of figured hypotype, 1.05 mm.; diameter, 0.30 mm.

Discussion.—The present specimens agree closely to the original illustrations from the Turonian of Germany. This species differs from *Nodosaria septemcostata* GEINITZ in being less robust and having distinctly separated chambers. In the present samples, *N. distans* is limited to the upper portion of the section at La Jolla locality and occurs throughout the Point Loma section. In the American Gulf Coast it ranges from the Coniacian to the Campanian; the present record extends the overall stratigraphic range into the Maastrichtian.

Types and occurrence.—Figured hypotype (UCLA 44060) from sample L-10, Rosario Formation at Point Loma. Unfigured hypotypes from the Rosario Formation at La Jolla (J157, L72).

NODOSARIA LIMBATA d'Orbigny

Plate 4, figure 15

Nodosaria limbata D'ORBIGNY, 1840, p. 12, pl. 1, fig. 1.——CUSHMAN, p. 74, pl. 27, fig. 1-2.——SAID & KENAWY, 1956, p. 133, pl. 2, fig. 32.

Nodosaria concinna CUSHMAN & JARVIS (*non* REUSS), 1928, p. 97, pl. 14, fig. 5, 11.

Test free, large, elongate, uniserial. Chambers globular, inflated, of nearly equal size. Sutures distinct, depressed, limbate. Wall calcareous, finely perforate, radial in structure, surface smoothly finished. Aperture terminal, radiate.

Length of figured hypotype, 1.67 mm.; diameter, 0.54 mm.

Discussion.—The present specimens are nearly identical to the original illustrations from the Craie Blanche. This species is distinguished by its nearly equal, subglobular chambers and deeply depressed sutures. In the present samples, *Nodosaria limbata* is most commonly found in the upper La Jolla and Point Loma sections.

Types and occurrence.—Figured hypotype (UCLA 44061) from sample S-26, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma (J165, L99).

NODOSARIA NAVARROANA Cushman

Plate 4, figure 10

Nodosaria navarroana CUSHMAN, 1937b, p. 103, pl. 15, fig. 11.——CUSHMAN, 1946, p. 73, pl. 26, fig. 23-24.

Test free, elongate, slightly tapering. Chambers inflated, subglobular, increasing gradually in size. Sutures distinct, depressed. Wall calcareous, finely perforate,

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EXPLANATION OF PLATE 4

FIGURE

1. *Dorothia pupa* (REUSS); 1a,b, side and apertural views, ×33 (p. 50).
2. *Dorothia retusa* (CUSHMAN); 2a,b, side and apertural views, ×52 (p. 50).
3. *Cyclogyra* sp.; 3a,b, side and apertural views, ×97 (p. 50).
4. *Spiroloculina cretacea* REUSS; 4a,b, side and apertural views, ×66 (p. 51).
5. *Nodophthalmidium obscurum* (BOGDANOVICH), side view, ×66 (p. 51).
6. *Quinqueloculina* sp. cf. *Q. harrisi* HOWE & ROBERTS; 6a-c, side and apertural views, ×89 (p. 51).
7. *Quinqueloculina sandiegoensis* SLITER, n. sp.; 7a-c, side and apertural views, ×66 (p. 52).
8. *Spiroloculina truncata* SLITER, n. sp.; 8a,b, side and apertural views, ×66 (p. 51).
9. *Nodosaria amphioxys* REUSS; side view, ×66 (p. 52).
10. *Nodosaria navarroana* CUSHMAN; side view, ×66 (p. 53).
11. *Nodosaria aspera* REUSS; side view, ×66 (p. 52).

12-13. *Nodosaria proboscidea* REUSS; 12a,b, side and apertural views, ×89; 13, side view, ×89 (p. 54).

14. *Nodosaria* sp.; 14a,b, side and apertural views, ×97 (p. 54).
15. *Nodosaria limbata* D'ORBIGNY; side view, ×23 (p. 53).
16. *Nodosaria septemcostata* GEINITZ; side view, ×33 (p. 54).
17. *Nodosaria velascoensis* CUSHMAN; side view, ×45 (p. 54).
18. *Nodosaria distans* REUSS; side view, ×52 (p. 53).

19-21. *Astacolus jarvisi* (CUSHMAN); 19a,b, 20, side and face views, ×33; 21a,b, side and face views, ×66 (p. 54).

radial in structure, with 5 longitudinal costae. Aperture terminal, radiate.

Maximum length of figured hypotype, 0.46 mm.; diameter, 0.17 mm.

Discussion.—A single specimen from the upper portion of the La Jolla section is referred to this characteristically Maastrichtian species.

Types and occurrence.—Figured hypotype (UCLA 44062) from sample S-36, Rosario Formation at La Jolla (J221).

NODOSARIA PROBOSCIDEA Reuss

Plate 4, figure 12-13

Nodosaria proboscidea Reuss, 1851, p. 7, pl. 1, fig. 6.——Cushman, 1946, p. 72, pl. 26, fig. 12-13.

Test free, uniserial, rectilinear, elongate. Chambers distinct, subglobular, inflated. Sutures slightly limbate, depressed. Wall calcareous, finely perforate, surface costate. Aperture terminal, radiate, produced on distinct neck.

Maximum length of figured hypotypes, 0.40 to 0.56 mm.; diameter, 0.09 to 0.17 mm.

Discussion.—The present specimens are somewhat thinner and more elongate than those of the original illustration but closely resemble forms from the American Gulf Coast. This species occurs rarely at Point Loma and throughout the Carlsbad section. Carlsbad specimens are thinner and less strongly ornamented, but this seems merely to represent an intraspecific variation. Originally described from the Upper Cretaceous of Poland, *Nodosaria proboscidea* is characteristic of the Campanian.

Types and occurrence.—Figured hypotype (Fig. 12, UCLA 44066) from sample L-3, Rosario Formation at Point Loma. Figured hypotype (Fig. 13, UCLA 44065) from sample C-3, Rosario Formation at Carlsbad (C33, L138).

NODOSARIA SEPTEMCOSTATA Geinitz

Plate 4, figure 16

Nodosaria septemcostata Geinitz, 1842, p. V, 69, pl. 17, fig. 20. ——Bandy, 1951, p. 502, pl. 73, fig. 14.

Nodosaria affinis Reuss, Cushman, 1946, p. 70, pl. 25, fig. 8-23.

Test free, large, elongate, gradually tapering. Chambers inflated, subglobular, increasing gradually in size. Sutures distinct, limbate, depressed. Wall calcareous, finely perforate, radial in structure, with 7 to 13 longitudinal costae. Aperture terminal, radiate.

Maximum length of figured hypotype, 1.28 mm.; diameter, 0.46 mm.

Discussion.—This species, originally described from the Cretaceous of Bohemia, differs from *N. alternata* in being larger, having subglobular chambers throughout, and lacking secondary costae. The present occurrences are limited to Carlsbad, the lower portion of the section at La Jolla, and two rare occurrences at Punta Descanso. In the American Gulf Coast, this long-ranging species is of Austin to Navarro age.

Types and occurrence.—Figured hypotype (UCLA 44067) from sample S-1, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Carlsbad and Punta Descanso (C43, J48, D117).

NODOSARIA VELASCOENSIS Cushman

Plate 4, figure 17

Nodosaria fontannesi Berthelin var. *velascoensis* Cushman, 1926, p. 504, pl. 18, fig. 12.

Nodosaria velascoensis Cushman, Cushman & Campbell, 1935, p. 72, pl. 11, fig. 3.——Cushman, 1946, p. 73, pl. 26, fig. 27-30. ——Martin, 1964, p. 58, pl. 4, fig. 7-8.

Test free, elongate, gently tapering. Chambers initially indistinct, becoming distinct, slightly depressed. Wall calcareous, finely perforate, radial in structure, surface with numerous longitudinal costae which tend to be twisted in early portion of test. Aperture terminal, radiate.

Maximum length of figured hypotype, 0.48 mm.; diameter, 0.24 mm.

Discussion.—This species is rather rare in the present samples and is represented mainly by broken fragments of the basal portion of the test. These specimens agree more closely with illustrations by Cushman & Jarvis (1928) of specimens from the Lizard Springs Formation of Trinidad than with original illustration of a specimen from the Velasco Shale of Mexico. The California specimens reported by Cushman & Campbell (1935) and Martin (1964), however, closely resemble the type material. The present specimens are limited to the middle portions of the sections at La Jolla and Punta Descanso. *Nodosaria velascoensis* seems to range from the upper Campanian to the Paleocene.

Types and occurrence.—Figured hypotype (UCLA 44068) from sample S-16, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Punta Descanso (J126, D137).

NODOSARIA sp.

Plate 4, figure 14

Test free, small, elongate. Chambers globular, usually 3 in number, nearly subequal, final chamber may be somewhat reduced in diameter. Sutures distinct, depressed. Wall calcareous, finely perforate, surface smooth. Aperture terminal, small, rounded.

Maximum length of figured specimen, 0.37 mm.; diameter, 0.17 mm.

Discussion.—This small nodosariid is rare at all 4 locations. It is distinguished from related species by the relatively small size, few and subequal chambers and small, nonradiate aperture. As specimens commonly have only 3 to 4 chambers, they may represent the juvenile stage of some larger species.

Types and occurrence.—Figured specimen (UCLA 44069) from sample L-10, Rosario Formation at Point Loma. Unfigured hypotypes from Rosario Formation at La Jolla, Carlsbad and Punta Descanso (C133, J225, L78, D80).

Genus ASTACOLUS de Montfort, 1808

ASTOCOLUS JARVISI (Cushman)

Plate 4, figure 19-21

Marginulina jarvisi Cushman, 1938b, p. 35, pl. 5, fig. 17-18.——Cushman, 1946, p. 63, pl. 22, fig. 18-20.

Vaginulinopsis jarvisi (Cushman), Pożaryska, 1957, p. 116, pl. 11, fig. 10.

Astacolus jarvisi (Cushman), TRUJILLO, 1960, p. 317, pl. 46, fig. 2.
Astacolus sp. aff. *A. jarvisi* (Cushman), GRAHAM & CHURCH, 1963, p. 25, pl. 2, fig. 5-6.

Test free, elongate, arcuate, compressed, periphery subrounded, initial stage planispirally coiled, later uncoiling. Chambers overlapping, elongate, narrow. Sutures distinct, limbate, gently curved. Wall calcareous, finely perforate, radial in structure, surface smoothly finished. Aperture terminal, marginal, radiate.

Maximum length of figured hypotypes, 0.68 to 1.17 mm.; breadth, 0.17 to 0.68 mm.; thickness, 0.12 to 0.36 mm.

Discussion.—Present in most samples, this species has considerable morphologic variation in the presence or absence of the initially coiled portion, test dimensions, and degree of axial curvature. The Carlsbad forms are included here although they are smaller and less robust. Other characteristics are similar to those of specimens from the other areas, hence this size variation is regarded as environmentally caused. The present specimens are nearly identical to the original specimens illustrated from the lower Tertiary of Trinidad, and the species apparently represents a long-ranging stock.

Types and occurrence.—Figured hypotype (Fig. 19, UCLA 44071) from sample S-17; figured hypotype (Fig. 20, UCLA 44072) from sample S-25; both from Rosario Formation at La Jolla. Figured hypotype (Fig. 21, UCLA 44070) from sample C-3, Rosario Formation at Carlsbad. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (C69, J92, L43, D25).

ASTACOLUS MUNDUS (Cushman)

Plate 5, figure 1-2

Marginulina munda CUSHMAN, 1938b, p. 34, pl. 5, fig. 11-12.——CUSHMAN, 1946, p. 60, pl. 21, fig. 2-3.

Test free, elongate, compressed, periphery subacute, initial stage planispirally coiled, later uncoiling. Chambers becoming elongated and slightly inflated. Sutures distinct, limbate, gently curved, initially flush, later slightly depressed. Wall calcareous, finely perforate, radial in structure, surface smooth. Aperture terminal, marginal, radiate.

Maximum length of figured hypotypes, 0.53 to 0.88 mm.; breadth, 0.31 to 0.39 mm.; thickness, 0.15 to 0.22 mm.

Discussion.—*Astacolus mundus* is most common at Carlsbad and rare at the 3 other localities. It is well distinguished from *A. dissonus* PLUMMER (1931) by its relatively smaller test, less pronounced planispiral stage, and lack of raised sutures and weak costae. The latter species may represent *A. mundus* as modified by evolution in the Maastrichtian. Originally described from the upper Taylor Marl, this species is characteristic of Campanian strata.

Types and occurrence.—Figured hypotype (Fig. 1, UCLA 44073) from sample C-1, Rosario Formation at Carlsbad. Figured hypotype (Fig. 2, UCLA 44074) from sample E-10, Rosario Formation at Punta Descanso. Unfigured hypotypes from Rosario Formation at La Jolla and Point Loma (C71, J183, L101, D58).

ASTACOLUS sp. cf. A. RICHTERI (Brotzen)

Plate 5, figure 3-4

Planularia richteri BROTZEN, 1936, p. 59, pl. 3, fig. 3.

Test free, elongate, compressed, outer margin subacute, inner margin broadly truncate, initial stage in loose planispiral coil, later uncoiling. Chambers elongate, narrow, increasing rapidly in length. Sutures distinct, gently curved, flush. Wall calcareous, finely perforate, surface smoothly finished. Aperture terminal, marginal radiate.

Maximum length of figured specimens, 0.61 to 0.88 mm.; breadth, 0.22 to 0.34 mm.; thickness, 0.15 to 0.19 mm.

Discussion.—This species is rare at Carlsbad, La Jolla, and Point Loma. Specimens resemble *Astacolus richteri* from the Senonian of Sweden in their flattened inner periphery and elongate, narrow chambers, but differ in being somewhat smaller and less arcuate. These differences, however, may not be significant.

Types and occurrence.—Figured specimen (Fig. 3, UCLA 44075) from sample S-26, Rosario Formation at La Jolla. Figured specimen (Fig. 4, UCLA 44076) from sample C-3, Rosario Formation at Carlsbad. Unfigured hypotype from Rosario Formation at Point Loma (C125, J190, L122).

ASTACOLUS sp.

Plate 5, figure 5

Test free, elongate, compressed, with umbonal thickening, outer periphery subacute, inner periphery becoming broadly rounded, initial stage planispirally coiled, later uncoiling. Chambers elongate, narrow, becoming inflated. Sutures distinct, gently curved, initially flush, later depressed. Wall calcareous, finely perforate, surface smooth. Aperture terminal, marginal, radiate.

Maximum length of figured specimen, 0.60 mm.; breadth, 0.26 mm.; thickness, 0.12 mm.

Discussion.—Only a few rare specimens occur in the upper portion of the section at La Jolla. They have the umbonate thickening of *Astacolus umbonatus* (LOETTERLE, 1937) but lack the broadly truncate outer periphery and raised sutures. *A. liebusi* BROTZEN (1936), from the Senonian of Sweden, is similar in having inflated chambers but differs in being broadly truncate and relatively thicker.

Types and occurrence.—Figured specimen (UCLA 44077) from sample S-24, Rosario Formation at La Jolla (J180).

Genus CITHARINA d'Orbigny, 1839

CITHARINA MULTICOSTATA (Cushman)

Plate 5, figure 6

Vaginulina simondsi Carsey, CUSHMAN & CHURCH, 1929, p. 508, pl. 38, fig. 10.
Vaginulina multicostata CUSHMAN, 1930, p. 28, pl. 4, fig. 4.
Vaginulina sp. cf. *V. simondsi* Carsey, CUSHMAN & CAMPBELL, 1935, p. 69, pl. 11, fig. 7.

Vaginulina eriksdalensis BROTZEN, 1936, p. 94, pl. 6, fig. 3.
Planularia multicostata (Cushman), BANDY, 1951, p. 495, pl. 72, fig. 17.
Citharina multicostata (Cushman), POŻARYSKA, 1957, p. 171, pl. 14, fig. 8.——OLSSON, 1960, p. 19, pl. 3, fig. 10.
Citharina sp. B, GRAHAM & CHURCH, 1963, p. 26, pl. 2, fig. 10.

Test free, elongate, compressed, one margin straight, other convex, test thickness increases toward convex side. Chambers numerous, low, elongate, curved, extending nearly to base, increasing rapidly in breadth. Sutures curved, somewhat limbate, flush, slightly depressed. Wall calcareous, finely perforate, radial in structure, surface ornamented by longitudinal costae which are commonly initially continuous and distinct, later discontinuous and finely developed. Aperture terminal, radiate.

Maximum length of figured hypotype, 1.79 mm.; breadth, 0.34 mm.; thickness, 0.14 mm. Other hypotypes range to 2.21 mm. in length.

Discussion.—CUSHMAN (1946, p. 79) noted considerable variation in the ornamentation and test dimensions of *Citharina multicostata*. The present specimens, identical to those in my collection from the Kemp Clay (loc. 19 of CUSHMAN, 1946) also show this variation. The costae on the initial portion of the test are usually strongly developed and continuous over several chambers. On the ultimate chambers, costae are more weakly developed, discontinuous, and confined to chambers. Broken fragments of the upper portion of tests with weakly developed costae may even appear to be smooth. The degree of curvature and basal extension of the chambers also varies. In some specimens sutures extend nearly to the base, as illustrated by GRAHAM & CHURCH (1963, pl. 2, fig. 10), but in the majority of specimens the chambers are not as elongate. *C. eriksdalensis* (BROTZEN) is identical to the present specimens and is here placed in synonymy. In the present study, *C. multicostata* occurs most commonly at Carlsbad and is rare at La Jolla, Point Loma, and Punta Descanso. The recorded stratigraphic range of this species is from the Coniacian to Maastrichtian.

Types and occurrence.—Figured hypotype (UCLA 44078) from sample C-3, Rosario Formation at Carlsbad. Unfigured hypotypes from Rosario Formation at La Jolla, Point Loma and Punta Descanso (C42, J23, L69, D136).

CITHARINA SUTURALIS (Cushman)

Plate 5, figure 7

Vaginulina suturalis CUSHMAN, 1937b, p. 102, pl. 15, fig. 5-7.
Citharina suturalis (Cushman), BELFORD, 1960, p. 41, pl. 11, fig. 16-17.
Planularia eriksdalensis (Brotzen), TRUJILLO, 1960, p. 321, pl. 46, fig. 5.
Citharina sp. A, GRAHAM & CHURCH, 1963, p. 26, pl. 2, fig. 9.

Test free, elongate, slender, compressed, periphery subrounded to truncate. Chambers broad, low, curved. Sutures distinct, curved, flush to elevated, strongly oblique. Wall calcareous, finely perforate, radial in structure, surface costate over sutures. Aperture terminal, radiate.

Maximum length of figured hypotype, 1.45 mm.; breadth, 0.29 mm.; thickness, 0.17 mm.

Discussion.—This species is distinguished from *Citharina multicostata* by its elongate, slender test and distinct sutural costae. As in the latter species, test shape and costae vary considerably. In the initial portion of the test, sutures are generally strongly elevated and weakly costate. The ultimate stage has flush or more rarely slightly depressed sutures that are distinctly costate. These costae generally are confined to the sutural area but also may be developed weakly over the chambers. Examination of the specimen figured by TRUJILLO (1960) as *Planularia eriksdalensis* (BROTZEN) shows it to be identical. The present specimens occur throughout the La Jolla and Carlsbad sections and less frequently at Point Loma and Punta Descanso. This species, originally described from the Cretaceous of Arkansas, ranges from the Santonian to Maastrichtian.

Types and occurrence.—Figured hypotype (UCLA 44079) from sample S-1, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Carlsbad, Point Loma and Punta Descanso (C31, J79, L153, D139).

Genus DENTALINA Risso, 1826

DENTALINA ALTERNATA (Jones)

Plate 5, figure 12-13

Nodosaria zippei REUSS var. *alternata* JONES, 1886, p. 330, pl. 27, fig. 10.
Dentalina alternata (Jones), CUSHMAN, 1946, p. 64, pl. 22, fig. 29-33.——HAGN, 1953, p. 42, pl. 4, fig. 12.

Test free, elongate, rectilinear to slightly arcuate, commonly with basal spine. Chambers becoming inflated, subglobular, increasing gradually in size. Sutures distinct, depressed. Wall calcareous, finely perforate, radial in structure, with primary and secondary costae. Aperture terminal radiate.

Maximum length of figured hypotypes, 0.95 to 1.02 mm.; diameter, 0.19 to 0.26 mm.

Discussion.—This distinctive form is recognized by the primary and secondary costae and subglobular final chamber. Originally described as a *Nodosaria* from the Cretaceous of Ireland, this species later was placed in *Dentalina*. The similar form *Nodosaria intercostata* REUSS (1860), may be a conspecific variate as noted by POŻARYSKA (1957) and REUSS' name then would have priority over *D. alternata*. From an examination of topotype material, however, CUSHMAN (1946) considered the two as distinct; they are so regarded here. *Dentalina alternata* occurs in the middle and upper samples at La Jolla, throughout the Point Loma sections, and less commonly at Carlsbad. American Gulf Coast occurrences range from strata of Austin to Navarro age.

Types and occurrence.—Figured hypotype (Fig. 12, UCLA 44080) from samples S-16, Rosario Formation at La Jolla. Figured hypotype (Fig. 13, UCLA 44081) from sample C-3, Rosario

Formation at Carlsbad. Unfigured hypotypes from Rosario Formation at Point Loma (C119, J132, L52).

DENTALINA BASIPLANATA Cushman

Plate 5, figure 8-11

Dentalina basiplanata CUSHMAN, 1938b, p. 38, pl. 6, fig. 6-8.——CUSHMAN, 1946, p. 68, pl. 24, fig. 1-6.——BANDY, 1951, p. 499, pl. 73, fig. 6.——SAID & KENAWY, 1956, p. 132, pl. 2, fig. 29.——POŻARYSKA, 1957, p. 75, pl. 7, fig. 6.——BELFORD, 1960, p. 25, pl. 7, fig. 1-5.——OLSSON, 1960, p. 13, pl. 2, fig. 21-22.——TAPPAN, 1962, p. 174, pl. 45, fig. 17.——GRAHAM & CHURCH, 1963, p. 27, pl. 2, fig. 11.——MARTIN, 1964, p. 60, pl. 4, fig. 13.

Test free, elongate, gently arcuate, slightly tapering. Chambers initially low, overlapping, slightly compressed, later becoming inflated and somewhat elongated. Sutures distinct, slightly oblique, initially flush, limbate, later depressed. Wall smooth, finely perforate, radial in structure, surface smoothly finished. Aperture terminal, eccentric, radiate.

Maximum length of figured hypotypes, 1.07 to 1.41 mm.; diameter 0.22 to 0.29 mm.

Discussion.—Originally described from the Corsicana Marl of Texas, *Dentalina basiplanata* differs from *D. catenula* REUSS (1860) in being more elongate and in having more numerous and more strongly overlapping chambers. Present specimens are nearly identical to topotype material in my collection from the Corsicana Marl (locs. 26-28 of CUSHMAN, 1946). In general, the Carlsbad specimens are not as robust as those from La Jolla nor do they have the subglobular ultimate chambers. Two forms occur representing different stages in the life cycle. The less common form has an acute initial end and more strongly limbate sutures on the concave side of the test. Another variant at Carlsbad resembles the specimen illustrated by TAPPAN (1962) from the Senonian of Alaska. These specimens are thicker and more robust and have more strongly overlapping chambers. *D. basiplanata* is most common at Carlsbad and the lower samples at La Jolla but also occurs rarely at Point Loma and Punta Descanso. American Gulf Coast specimens occur most characteristically in Navarro strata and less commonly in the Taylor Group. In California, this species ranges from Santonian to Maastrichtian.

Types and occurrence.—Figured hypotype (Fig. 8, UCLA 44082) from sample S-1; figured hypotype (Fig. 9, UCLA 44083) from sample S-5; both from Rosario Formation at La Jolla. Figured hypotypes (Fig. 10-11, UCLA 44084-44085) from sample C-3, Rosario Formation at Carlsbad. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (C27, J35, L135, D68).

DENTALINA CATENULA Reuss

Plate 5, figure 14

Dentalina catenula REUSS, 1860, p. 185, pl. 3, fig. 6.——CUSHMAN & CHURCH, 1929, p. 509, pl. 39, fig. 1.——CUSHMAN, 1946, p. 67, pl. 23, fig. 27-32.——TRUJILLO, 1960, p. 327, pl. 47, fig. 3.——BELFORD, 1960, p. 27, pl. 8, fig. 1-4.

Dentalina catenula catenula Reuss, POŻARYSKA, 1957, p. 76, pl. 11, fig. 3.

Nodosaria sp. cf. *N. catenula* (Reuss), GRAHAM & CHURCH, 1963, p. 42, pl. 4, fig. 19-20.

Test free, elongate, gently arcuate, initial end may be enlarged and may have an apical spine. Chambers subglobular to pyriform, slightly overlapping. Sutures distinct, depressed, may be initially limbate. Wall calcareous, finely perforate, radial in structure, surface smooth. Aperture terminal, generally eccentric, radiate.

Maximum length of figured hypotype, 1.26 mm.; diameter, 0.24 mm. Other hypotypes range to 0.48 mm. in diameter.

Discussion.—This variable species, originally described from the Upper Cretaceous of Germany, is distinguished by the relatively large size, subglobular chambers and smooth surface. It occurs most abundantly in the middle samples at La Jolla and the upper samples at Point Loma. It is also found scattered throughout the Punta Descanso locality but is lacking at Carlsbad. In the American Gulf Coast, *Dentalina catenula* is confined to the middle and upper Taylor Group with a few occurrences in lower Navarro strata.

Types and occurrence.—Figured hypotypes from sample S-25, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (J74, L21, D55).

DENTALINA GRACILIS (d'Orbigny)

Plate 5, figure 15-16

Nodosaria (Dentalina) gracilis D'ORBIGNY, 1840, p. 14, pl. 1, fig. 5.

Dentalina gracilis (d'Orbigny), CUSHMAN, 1946, p. 65, pl. 23, fig. 3-6.——HAGN, 1953, p. 44, pl. 4, fig. 17.——SAID & KENAWY, 1956, p. 133, pl. 2, fig. 25.——POŻARYSKA, 1957, p. 80, fig. 15, pl. 7, fig. 1.——BELFORD, 1960, p. 29, pl. 8, fig. 8-11.——TAKAYANAGI, 1960, p. 95, pl. 5, fig. 9-10.

Test free, elongate, arcuate, slender. Chambers numerous, initially overlapping, later becoming elongated and inflated. Sutures distinct, initially transverse, flush, somewhat limbate, later oblique, depressed. Wall calcareous, finely perforate, radial in structure, surface smoothly finished. Aperture terminal, somewhat produced, eccentric, radiate.

Maximum length of figured hypotypes, 1.19 to 1.41 mm.; diameter, 0.14 to 0.19 mm.

Discussion.—Specimens referred to this species are characterized by a slender, arcuate test, oblique sutures, and pyriform chambers. They differ from elongate forms of *Dentalina legumen* (REUSS) in having transverse initial sutures as well as a less rapidly tapering test. *D. wimani* BROTZEN (1936), from the Senonian of Sweden, is very similar and may be synonymous. The specimen from Carlsbad illustrated as *D. wimani* by BANDY (1951) may belong here or may represent the elongated form of *D. legumen*. The present specimens of *D. gracilis* are from the middle and upper samples at La Jolla and more rarely at Carlsbad, Point Loma, and Punta Descanso. Originally described from the Craie Blanche, this species is regarded as long ranging by some authors (e.g., CUSHMAN, 1946;

TAKAYANAGI, 1960). Most references to this species are from Campanian to Maastrichtian strata. Older occurrences of this species require further verification.

Types and occurrence.—Figured hypotype (Fig. 15, UCLA 44087) from sample S-17; figured hypotype (Fig. 16, UCLA 4088) from sample S-10; both from Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Carlsbad, Point Loma and Punta Descanso (C139, J103, L171, D72).

DENTALINA LEGUMEN (Reuss)

Plate 5, figure 17-18, 24

Nodosaria (Dentalina) legumen REUSS, 1845, p. 28, pl. 13, fig. 23-24.

Dentalina legumen (Reuss), CUSHMAN, 1946, p. 65, pl. 23, fig. 1-2.——POŻARYSKA, 1957, p. 81, fig. 16.——GRAHAM & CHURCH, 1963, p. 29, pl. 2, fig. 14-16.

Test free, elongate, gently arcuate. Chambers initially strongly overlapping, later becoming elongated and inflated. Sutures oblique, initially flush, later depressed. Wall calcareous, finely perforate, structure radial, surface smoothly finished. Aperture terminal, eccentric, radiate.

Maximum length of figured hypotypes, 0.37 to 0.63 mm.; diameter, 0.12 to 0.19 mm.

Discussion.—The present specimens are placed here following the observations of CUSHMAN (1946). *Dentalina legumen* is recognized by distinctly oblique sutures and overlapping chambers. The present forms have considerable variation in test outline and dimensions and closely resemble specimens illustrated by GRAHAM & CHURCH (1963) from the Campanian of Stanford University campus. This species is most common at Carlsbad with scattered occurrences in the remaining 3 localities. The American Gulf Coast records of this species, originally described from the Cretaceous of Bohemia, range from strata of Austin to Navarro age.

Types and occurrence.—Figured hypotype (Fig. 17, UCLA 44089) from sample BR-3; figured hypotype (Fig. 18, UCLA 44091) from sample S-25; both from Rosario Formation at La Jolla. Figured hypotype (Fig. 24, UCLA 44090) from sample C-1, Rosario Formation at Carlsbad. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (C28, J56, L118, D95).

DENTALINA MARCKI Reuss

Plate 5, figure 19

Dentalina marcki REUSS, 1860, p. 188, pl. 2, fig. 7.——BROTZEN, 1936, p. 80, pl. 5, fig. 27.——SCHIJFSMA, 1946, p. 44, pl. 2, fig. 5-7.——BANDY, 1951, p. 500, pl. 73, fig. 9.——BELFORD, 1960, p. 31, pl. 9, fig. 1-3.

Test free, elongate, gently arcuate, with apical spine. Chambers initially strongly overlapping, later becoming inflated and elongate. Sutures distinct, initially nearly flush, limbate, later depressed. Wall calcareous, finely perforate, radial in structure, surface ornamented by 10-12 longitudinal costae on all but final chamber. Aperture terminal, eccentric, radiate.

Maximum length of figured hypotype, 1.22 mm.; diameter, 0.22 mm.

Discussion.—The present specimens are closely similar to the original illustrations of specimens from the Upper Cretaceous of Germany. The species differs from *Dentalina solvata* CUSHMAN in being larger and having more strongly overlapping chambers and more numerous and distinct costae. *D. marcki* is most common at Carlsbad, with rare scattered occurrences at La Jolla and Punta Descanso. The specimen illustrated by POŻARYSKA (1957) as *D. marcki* is not presently included in synonymy as it is rectilinear and lacks the eccentric aperture. The stratigraphic range of this species is reported to be upper Coniacian to Maastrichtian.

Types and occurrence.—Figured hypotype (UCLA 44092) from sample C-3, Rosario Formation at Carlsbad. Unfigured hypotypes from Rosario Formation at La Jolla and Punta Descanso (C32, J130, D150).

DENTALINA MARIEI Sliter, n. sp.

Plate 5, figure 26

Test free, elongate, arcuate, compressed, initial end rounded, greatest diameter nearly uniform throughout. Chambers 6 to 9 in adult, becoming slightly elongated and inflated. Sutures distinct, oblique, initially flush, later depressed. Wall calcareous, finely perforate, radiate in structure, surface smooth. Aperture terminal, becoming slightly produced, eccentric, radiate.

Maximum length of holotype, 0.85 mm.; breadth, 0.19 mm.; thickness, 0.17 mm.

Discussion.—This species closely resembles *Dentalina wilcoxensis* CUSHMAN (1944) from the Eocene of Alabama but seems to be distinct. The present specimens differ in having more numerous, ultimately inflated chambers, depressed sutures, and a relatively more robust test. As these forms probably are ancestral to *D. wilcoxensis*, the aforementioned differences may ultimately be shown to be due to geographic or stratigraphic variation, or both, and these two species to represent a single evolving population. *D. mariei* presently is found in the upper samples at La Jolla, throughout the Point Loma section, and more rarely at Punta Descanso. The present stratigraphic range is Campanian to Maastrichtian.

Types and occurrence.—Holotype (UCLA 44099) from sample E-22; paratype (UCLA 44100) from sample E-22; both from Rosario Formation at Punta Descanso (J186, L40, D93).

DENTALINA SOLVATA Cushman

Plate 5, figure 20-21

Dentalina solvata CUSHMAN, 1938b, p. 39, pl. 6, fig. 9-14.——CUSHMAN, 1946, p. 69, pl. 24, fig. 13-17, 22.

Dentalina sp. cf. *D. guttifera* d'Orbigny, TAKAYANAGI, 1960, p. 95, pl. 5, fig. 11.

Test free, elongate, gently arcuate. Chambers subspherical to elongated, initially somewhat overlapping, later separated by the elongate necks. Sutures distinct, limbate. Wall calcareous, finely perforate, radial in structure, wall of early chambers ornamented by several longitudinal costae, later stages with weak costae restricted to sutural area. Aperture terminal, eccentric, radiate.

Maximum length of figured hypotypes, 0.61 to 0.92 mm.; diameter, 0.09 to 0.29 mm.

Discussion.—Originally described from the Selma Chalk of Mississippi, this species is recognized by the separated, subglobular chambers and surface striation. It is quite variable in test dimensions and strength of costae. At La Jolla, Point Loma, and Punta Descanso broken segments of tests with two or three chambers and weak costae occur. The Carlsbad specimens are smaller, distinctly costate, and have less globular chambers. These differences seem to reflect local environmental conditions. The specimen illustrated as *Dentalina* sp. cf. *D. guttifera* D'ORBIGNY by TAKAYANAGI (1960) from the Campanian of Japan is regarded as synonymous. Another possibly synonymous specimen is *Siphonodosaria* sp. of GRAHAM & CHURCH (1963), from the Campanian of Stanford University campus. *D. solvata* is most characteristic of Taylor age strata in the American Gulf Coast.

Types and occurrence.—Figured hypotype (Fig. 21, UCLA 44094) from sample S-33, Rosario Formation at La Jolla. Figured hypotype (Fig. 20, UCLA 44095) from sample C-2, Rosario Formation at Carlsbad. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (C108, J39, L56, D71).

DENTALINA STEPHENSONI (Cushman)

Plate 5, figure 22-23

Ellipsonodosaria stephensoni CUSHMAN, 1936b, p. 52, pl. 9, fig. 10-15.——CUSHMAN, 1946, p. 134, pl. 56, fig. 2-7.——CUSHMAN, 1949, p. 9, pl. 4, fig. 10.
Dentalina stephensoni (Cushman), BANDY, 1951, p. 501, pl. 73, fig. 10-11.——BELFORD, 1960, p. 30, pl. 8, fig. 12-14.
Stilostomella stephensoni (Cushman), TAKAYANAGI, 1960, p. 121, pl. 8, fig. 3.

Test free, elongate, gently arcuate, uniserial. Chambers globular to elongate, inflated, increasing gradually in size. Sutures distinct, depressed, limbate. Wall calcareous, finely perforate, surface smooth, except for ring of spines at base of chamber. Aperture terminal, radiate.

Maximum length of figured hypotypes, 0.51 to 0.80 mm.; diameter, 0.12 to 0.15 mm.

Discussion.—The final chamber of this species commonly is broken off just above the limbate suture. The remaining broken portion often resembles the flaring neck typical of specimens of the genus *Stilostomella*. The specimen illustrated as *Siphonodosaria pseudoscripta* (CUSHMAN) by GRAHAM & CHURCH (1963) from the Campanian of the Stanford University campus may be synonymous. Gulf Coast specimens of *D. stephensoni* range from Austin to Navarro age. In Japan, this species ranges from the Santonian to the Campanian.

Types and occurrence.—Figured hypotype (Fig. 23, UCLA 44097) from sample S-8, Rosario Formation at La Jolla. Figured hypotype (Fig. 22, UCLA 44096) from sample C-3, Rosario Formation at Carlsbad. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (C44, J55, L94, D92).

DENTALINA VISTULAE Pożaryska

Plate 5, figure 25

Nodosaria ewaldi? Reuss, CUSHMAN & CHURCH, 1929, p. 510, pl. 39, fig. 7.
Dentalina sp. cf. *D. consobrina* d'Orbigny, CUSHMAN, 1946, p. 69, pl. 24, fig. 23-27.
Dentalina sp. cf. *D. pseudofiliformis* Brotzen, BANDY, 1951, p. 500, pl. 73, fig. 8.——TAKAYANAGI, 1960, p. 98, pl. 5, fig. 17.
Dentalina vistulae POŻARYSKA, 1957, p. 89, fig. 18, pl. 7, fig. 10.
Dentalina sp. OLSSON, 1960, p. 17, pl. 3, fig. 6.

Test free, elongate, slender, arcuate to rectilinear. Chambers elongate, slightly inflated, increasing rapidly in length. Sutures distinct, depressed. Wall calcareous, finely perforate, structure radial, surface smooth. Aperture terminal, somewhat eccentric, radiate.

Maximum length of figured hypotype, 1.46 mm.; diameter, 0.10 mm.

Discussion.—*Dentalina vistulae* has fewer, more elongated chambers and a less arcuate test than the associated *D. gracilis*. The present population includes two forms: one has an elongate initial chamber, commonly with a small basal spine and more numerous, less elongated chambers; the other has a subspherical proloculus and long, cylindrical chambers. They commonly occur together and seem to represent life-cycle dimorphism. The specimen illustrated as *D. coalvillensis* PETERSON by TRUJILLO (1960) from the Coniacian and Santonian of northern California also may be synonymous, but it differs in having less elongate and more numerous chambers. United States representatives of *D. vistulae*, originally described from the Danian of Poland, range from Campanian to Maastrichtian.

Types and occurrence.—Figured hypotype (UCLA 44098) from sample S-31, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Carlsbad, Point Loma and Punta Descanso (C84, J13, L19, E24).

DENTALINA sp.

Plate 5, figure 27

Test free, small, elongate, fusiform, both ends tapering. Chambers overlapping, increasing gradually in height. Sutures distinct, nearly transverse. Wall calcareous, finely perforate, surface smooth. Aperture terminal, eccentric, radiate.

Maximum length of figured specimen, 0.31 mm.; diameter, 0.09 mm.

Discussion.—The few specimens found at Carlsbad may be a variant of *Dentalina basiplanata* or small forms related to *D. cylindroides* REUSS (1860). They are distinguished, however, by their uniform size, fusiform shape, and smooth outline.

Types and occurrence.—Figured specimen (UCLA 44101) from sample C-2, Rosario Formation at Carlsbad (C110).

Genus FRONDICULARIA Defrance in d'Orbigny, 1826

FRONDICULARIA ARCHIACIANA d'Orbigny

Plate 6, figure 2

Frondicularia archiaciana D'ORBIGNY, 1840, p. 20, pl. 1, fig. 34-36.——CUSHMAN, 1946, p. 91, pl. 37, fig. 8-20.——POŻARYSKA, 1957, p. 137, pl. 21, fig. 3, text-plate 3, fig. 14.——GRAHAM &

CHURCH, 1963, p. 31, pl. 2, fig. 21-22.——MARTIN, 1964, p. 73, pl. 7, fig. 10.
Frondicularia chapmani Perner, TRUJILLO, 1960, p. 323, pl. 46, fig. 7.

Test free, elongate, compressed, gently tapering, sides flattened, peripheral outline smooth to slightly lobate, margin truncate. Chambers distinct, low, increasing gradually in size. Sutures distinct, limbate, slightly elevated to flush, commonly somewhat sigmoidal. Wall calcareous, finely perforate, radial in structure; surface smooth, except for several costae on the globular proloculus. Aperture terminal, radiate.

Maximum length of largest segment (figured hypotype), 2.21 mm.; breadth, 0.63 mm.; thickness, 0.19 mm.

Discussion.—Originally described from the Craie Blanche, this species is distinguished by its truncate margin, flattened sides, and smooth surface. Variation in the present population consists of differences in the lobate periphery, suture curvature, and test width. *Frondicularia bulla* BELFORD (1960), from the Upper Cretaceous of Australia, is similar but has an angular periphery and convex sides. It may represent a geographic variation of the present species. The specimen illustrated by BELFORD (1960) as *F. archiaciana* D'ORBIGNY is not here included in synonymy, as the surface appears to have fine, longitudinal costae, and it seems more closely related to *F. intermittens* REUSS. The specimen illustrated as *F. chapmani* PERNER by TRUJILLO (1960) is indistinguishable from present specimens. The stratigraphic range of *F. archiaciana* is Turonian to Maastrichtian.

Types and occurrence.—Figured hypotype (UCLA 44102) from sample S-5, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Carlsbad and Point Loma (C142, J36, L90).

FRONDICULARIA DURRELLI Trujillo

Plate 6, figure 1

Frondicularia durrelli TRUJILLO, 1960, p. 323, pl. 46, fig. 8.

Test free, elongate, compressed, sides nearly parallel, margins truncate, carinate. The 2 to 6 chambers increase gradually in size. Sutures distinct, generally flush, oblique. Wall calcareous, finely perforate, radial in structure, with 3 to 6 sinuate, longitudinal costae extending length of test. Aperture terminal, radiate.

Maximum length of figured hypotype, 1.51 mm.; breadth, 0.37 mm.; thickness, 0.20 mm.

Discussion.—The present population includes specimens identical to the types of this species from the Upper Cretaceous of northern California. The majority of specimens are more robust, however, and perhaps represent a geographic variant. *Frondicularia durrelli* differs from Gulf Coast specimens referred to *F. striatula* REUSS (1844) in having continuous costae, a carinate periphery, and straight sutures. *F. durrelli* first appears in the upper samples at La Jolla. It also ranges throughout the Point Loma locality and occurs less frequently at Punta Descanso. The stratigraphic range is Coniacian to Maastrichtian.

Types and occurrence.—Figured hypotype (UCLA 44103) from sample S-20, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (J155, L51, D32).

FRONDICULARIA FRANKEI Cushman

Plate 6, figure 3

Frondicularia frankei CUSHMAN, 1936a, p. 18, pl. 4, fig. 6-7.——CUSHMAN, 1946, p. 89, pl. 35, fig. 14-16, pl. 36, fig. 1.——SAID & KENAWY, 1956, p. 136, pl. 2, fig. 35.——POŻARYSKA, 1957, p. 142, pl. 24, fig. 4, text-plate 3, fig. 19.

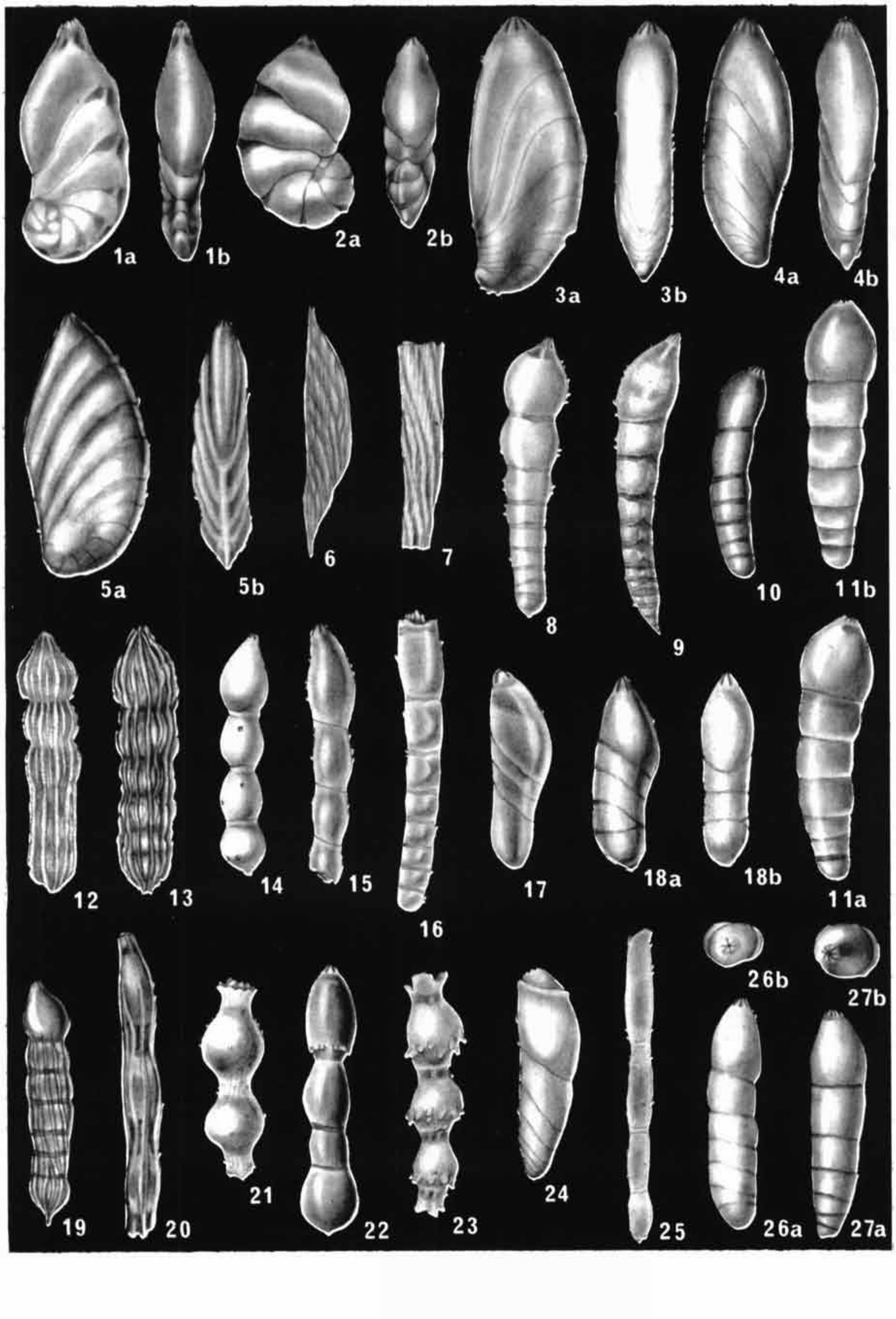
Test free, lanceolate, compressed, transverse section initially ovate, later flattened, periphery subacute in early stages, later truncate. Chambers gradually increasing in size, inflated at lower margin, becoming less inflated in ultimate stage. Sutures distinct, limbate, initially elevated, later may be nearly flush. Wall calcareous, finely perforate, radial in structure, ornamented by short, distinct, longitudinal costae where lower chamber margins overlap limbate sutures. Aperture terminal, radiate.

Maximum length of figured hypotype, 1.24 mm.; breadth, 0.25 mm.; thickness, 0.15 mm.

EXPLANATION OF PLATE 5

FIGURE

1-2. *Astacolus mundus* (CUSHMAN); 1a,b, side and face views, ×52; 2a,b, side and face views, ×66 (p. 55).
3-4. *Astacolus* sp. cf. *A. richteri* (BROTZEN); 3a,b, side and face views, ×52; 4a,b, side and face views, ×66 (p. 55).
5. *Astacolus* sp.; 5a,b, side and face views, ×66 (p. 55).
6. *Citharina multicostata* (CUSHMAN); side view, ×25 (p. 55).
7. *Citharina suturalis* (CUSHMAN); side view, ×23 (p. 56).
8-11. *Dentalina basiplanata* CUSHMAN; 8-10, 11a,b, side views, ×33 (p. 57).
12-13. *Dentalina alternata* (JONES); side views, ×45 (p. 56).
14. *Dentalina catenula* REUSS; side view, ×33 (p. 57).
15-16. *Dentalina gracilis* (D'ORBIGNY); side views, ×33 (p. 57).
17-18. *Dentalina legumen* (REUSS); 17, side view, ×97; 18a,b, side views, ×52 (p. 58).
19. *Dentalina marcki* (REUSS; side view, ×33 (p. 58).
20-21. *Dentalina solvata* CUSHMAN; 20, side view, ×89; 21, side view, ×33 (p. 58).
22-23. *Dentalina stephensoni* (CUSHMAN); 22, side view, ×89; 23, side view, ×52 (p. 59).
24. *Dentalina legumen* (REUSS); side view, ×66 (p. 58).
25. *Dentalina vistulae* POŻARYSKA; side view, ×33 (p. 59).
26. *Dentalina mariei* SLITER, n. sp.; 26a,b, side and apertural views, ×52 (p. 58).
27. *Dentalina* sp.; 27a,b, side and apertural views, ×129 (p. 59).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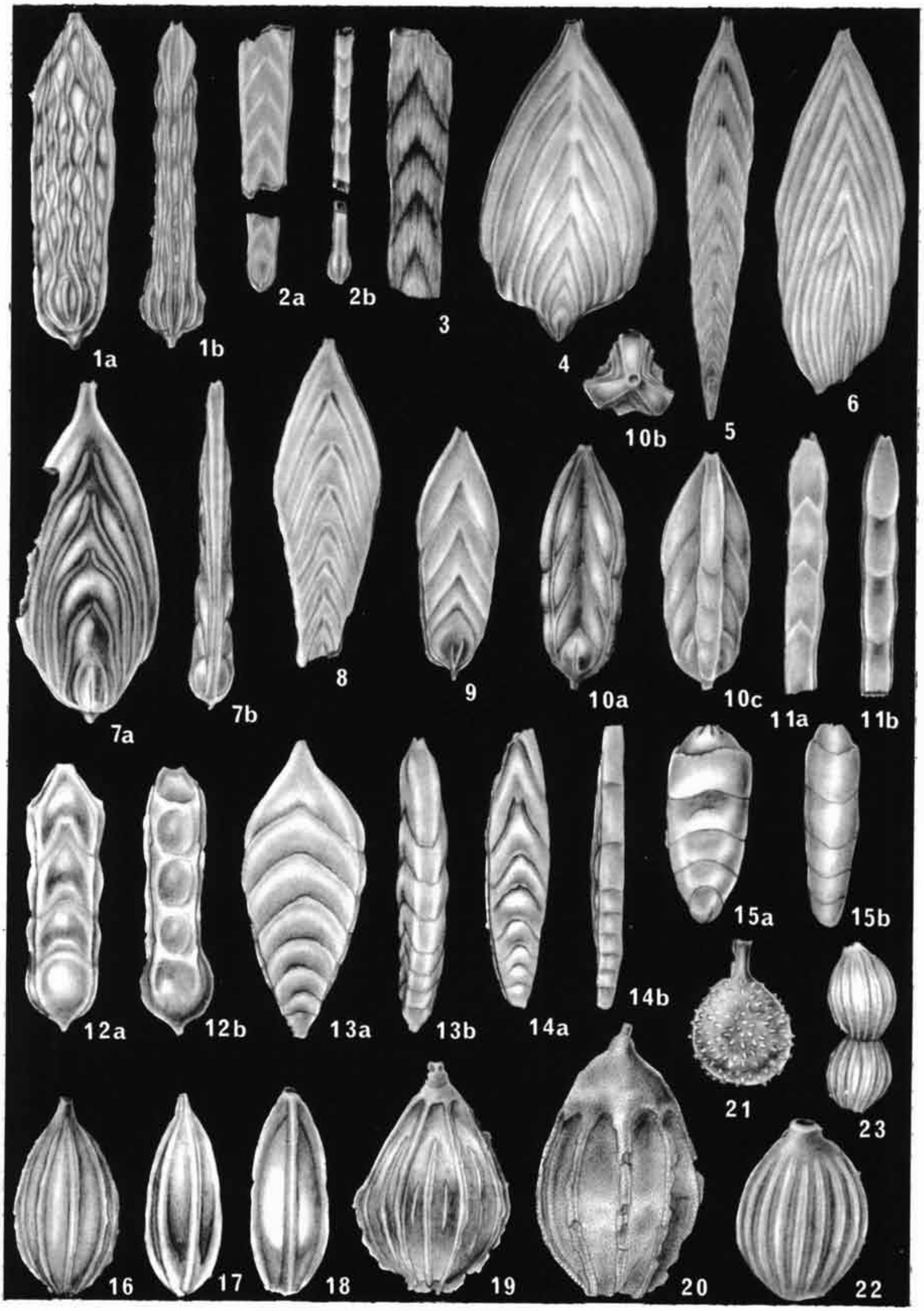
Sliter — Upper Cretaceous Foraminifera, Southern California and Northwestern Mexico.



Discussion.—The present forms differ somewhat from illustrations of the type and most of the Gulf Coast hypotypes illustrated by CUSHMAN (1946). They most closely resemble the illustrated specimen from the Pecan Gap Chalk of the Taylor Group (CUSHMAN, 1946, pl. 36, fig. 1). The differences appear in the subacute periphery and ovate transverse section of the major length of the test, smaller size, and less rapidly tapering outline. The relationship of this species to *Frondicularia intermittens* REUSS needs further clarification. The original description of *F. intermittens* noted an inflated lower margin of the chambers. This feature is not present in illustrated Gulf Coast specimens or those here referred to the species. In the present samples, *F. intermittens* occurs in the lower La Jolla section and at Carlsbad. At La Jolla, a stratigraphic break of about 50 feet separates this from the first appearance of *F. frankei*. The initial stage of the latter species is quite distinct from *F. intermittens*, although the ultimate chambers are similarly flattened, less strongly ornamented, and truncated at the periphery. They may represent, therefore, an evolutionary development of *F. intermittens* in test shape and ornamentation. REUSS' original specimen of *F. intermittens* would have an intermediate place in this succession. That described by MARIE (1941) as *F. sagittula* from the Campanian of France is very similar in shape but has a smooth surface. Another similar specimen is figured by FRANKE (1928) as *F. linguiformis* MARSSON, *emend.* FRANKE, from the upper Senonian of Germany, but the difference again lies in the strength of surface ornamentation. Two species here are recognized on the basis of morphologic variance and the stratigraphic break, although future investigation may prove them to be intergradational.

Types and occurrence.—Figured hypotype (UCLA 44104) from sample S-20, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (J138, L70, D140).

FRONDICULARIA GOLDFUSSI Reuss

Plate 6, figure 4

Frondicularia goldfussi REUSS, 1860, p. 192, pl. 4, fig. 7.——CUSHMAN, 1946, p. 87, pl. 34, fig. 18-20, pl. 35, fig. 1-2.——BANDY, 1951, p. 497, pl. 72, fig. 6.——SAID & KENAWY, 1956, p. 136, pl. 2, fig. 36.——POŻARYSKA, 1957, p. 143, pl. 22, fig. 4, pl. 25, fig. 3.

Test free, large, broad, compressed, periphery truncate. Chambers elongate, low enlarging gradually. Sutures distinct, flush limbate, oblique, gently curved. Wall calcareous, finely perforate, radial in structure, surface smooth. Aperture terminal, radiate.

Maximum length of figured hypotype, 1.35 mm.; breadth, 0.85 mm.; thickness, 0.12 mm.

Discussion.—This species, originally described from the Cretaceous of Germany, is distinguished by its broad test, truncate periphery, and elongate chambers. The species is most characteristic of the Carlsbad locality and is rare in the lower La Jolla section. The stratigraphic range of *F. goldfussi* is reported by POŻARYSKA to be Turonian to Maastrichtian.

Types and occurrence.—Figured hypotype (UCLA 44105) from sample C-4, Rosario Formation at Carlsbad. Unfigured hypotypes from Rosario Formation at La Jolla (C68, J90).

FRONDICULARIA INTERMITTENS Reuss

Plate 6, figure 5

Frondicularia intermittens REUSS, 1866, p. 460, pl. 1, fig. 11.——CUSHMAN, 1946, p. 88, pl. 35, fig. 11-13.

Frondicularia sp. aff. *F. intermittens* Reuss, GRAHAM & CHURCH, 1963, p. 32, pl. 2, fig. 33.

EXPLANATION OF PLATE 6

FIGURE

1. *Frondicularia durrelli* TRUJILLO; 1a,b, side and edge views, ×33 (p. 60).
2. *Frondicularia archiaciana* D'ORBIGNY; 2a,b, side and edge views, ×11 (p. 59).
3. *Frondicularia frankei* CUSHMAN; side view, ×33 (p. 60).
4. *Frondicularia goldfussi* REUSS; side view, ×23 (p. 61).
5. *Frondicularia intermittens* REUSS; side view, ×23 (p. 61).
6. *Frondicularia inversa* REUSS; side view, ×23 (p. 62).
7. *Frondicularia mucronata* REUSS; 7a,b, side and edge views, ×33 (p. 62).

8-10. *Frondicularia verneuiliana* D'ORBIGNY; 8, side view, ×33; 9, side view, ×52; 10a-c, side and apertural views of mutant, ×52 (p. 62).

11. *Frondicularia lomaensis* SLITER, n. sp.; 11a,b, side views, ×52 (p. 62).
12. *Frondicularia* sp. A; 12a,b, side and edge views, ×52 (p. 63).
13. *Frondicularia* sp. B; 13a,b, side edge views, ×66 (p. 63).
14. *Frondicularia* sp. C; 14a,b, side and edge views, ×66 (p. 63).
15. *Frondicularia* sp. D; 15a,b, side and edge views, ×66 (p. 63).

16-18. *Lagena paucicosta* FRANKE; side views showing variation in number of costae; 16, ×66; 17-18, ×129 (p. 64).

19-20. *Lagena semiinterrupta* BERRY; 19, side view, ×97; 20, side view, ×129 (p. 64).

21. *Lagena hispida* REUSS; side view, ×187 (p. 64).

22-23. *Lagena acuticosta* REUSS; 22, side view, ×97; 23, side view of double specimen, ×66 (p. 63).

Test free, lanceolate, compressed, sides flattened, periphery initially rounded, later truncate. Chambers narrow, gradually increasing in size. Sutures oblique, flush to slightly elevated, limbate. Wall calcareous, finely perforate, radial in structure, sutures ornamented by short, fine, longitudinal costae that may partially extend onto the succeeding chamber surface. Aperture terminal, radiate.

Maximum length of figured hypotype, 2.89 mm.; breadth, 0.48 mm.; thickness, 0.15 mm.

Discussion.—Originally described from the Cretaceous of Rumania, this species differs from *Frondicularia frankei* in the noninflated chambers, compressed test and reduced ornamentation (see remarks under *F. frankei*). The present specimens of *F. intermittens* are found in the lower samples at La Jolla and throughout the Carlsbad locality. In the American Gulf Coast this species is characteristic of Taylor age strata.

Types and occurrence.—Figured hypotypes from sample C-3, Rosario Formation at Carlsbad. Unfigured hypotypes from Rosario Formation at La Jolla (C46, J91).

FRONDICULARIA INVERSA Reuss

Plate 6, figure 6

Frondicularia inversa Reuss, 1844, p. 211; Reuss, 1845, p. 31, pl. 8, fig. 15-19, pl. 13, fig. 42.——Brotzen, 1936, p. 96, pl. 6, fig. 12.——Cushman, 1946, p. 86, pl. 33, fig. 11-18.——Pożaryska, 1957, p. 145, pl. 23, fig. 8, text-pl. 3, fig. 1.——Takayanagi, 1960, p. 112, pl. 6, fig. 22.

Test free, elongate, palmate, compressed, periphery rounded. Chambers numerous, narrow, elongate, later chambers fail to reach base, proloculus narrow, elongate. Sutures distinct, flush. Wall calcareous, finely perforate, radial in structure, surface smooth. Aperture terminal, radiate.

Maximum length of figured hypotype, 2.38 mm.; breadth, 0.80 mm.; thickness, 0.10 mm.

Discussion.—This species is distinguished by its size and test compression and elongate, narrow chambers that do not extend to the base. The similar *Frondicularia watersi* Cushman (1936a) and *F. austinana* Cushman (1936a) differ in the chambers extending to the base. The surface is more strongly ornamented. These two forms and the present species are closely related and are apparently part of a variable population that extends from strata of Austin to Navarro age. *F. inversa* occurs rarely at La Jolla and Carlsbad.

Types and occurrence.—Figured hypotype (UCLA 44107) from sample S-10, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Carlsbad (C149, J115).

FRONDICULARIA LOMAENSIS Sliter, n. sp.

Plate 6, figure 11

Amphimorphina? sp. Cushman & Goudkoff, 1944, p. 58, pl. 9, fig. 15-16.

Frondicularia sp. B, Graham & Church, 1963, p. 32, pl. 2, fig. 27-28.

Test free, elongate, sides nearly parallel, periphery truncate, with bordering carinae, square in transverse section. Chambers elongate, slightly inflated, increasing gradually in size. Sutures distinct, centrally depressed, chevron-shaped, somewhat limbate. Wall calcareous, finely perforate, radial in structure, surface smooth, chamber carinae commonly ornamented with fine longitudinal striae. Aperture terminal, radiate.

Maximum length of holotype, 1.19 mm.; breadth, 0.17 mm.; thickness, 0.15 mm.

Discussion.—The distinguishing characteristics of this species are the very narrow test and resultant square transverse section, carinate edges, and chevron-shaped sutures. Previous records are limited to the Upper Cretaceous of California. *Frondicularia tetragona* (Reuss) is similar, as noted by Graham & Church (1963), but differs in having more prominent carinae and more convex sides than the present form, and in lacking the distinctly shaped sutures. The present occurrences of *F. lomaensis* are limited to the upper samples (Maastrichtian) at La Jolla and Point Loma.

Types and occurrence.—Holotype (UCLA 44112) from sample S-23; paratype (UCLA 44113) from sample S-31; both from Rosario Formation at La Jolla. Unfigured paratypes from Rosario Formation at Point Loma (J162, L152).

FRONDICULARIA MUCRONATA Reuss

Plate 6, figure 7

Frondicularia mucronata Reuss, 1845, p. 31, pl. 13, fig. 43-44.——Cushman, 1946, p. 87, pl. 34, fig. 14-17.——Pożaryska, 1957, p. 151, fig. 40, pl. 23, fig. 7, pl. 25, fig. 6.——Belford, 1960, p. 45, pl. 12, fig. 10-11.

Test free, ovate in outline, compressed, periphery truncate. Chambers elongate, narrow, increasing gradually in size, proloculus elongate, with central ridge, followed by 2 inflated chambers, later chambers not inflated. Sutures distinct, initially slightly depressed, later flush. Wall calcareous, finely perforate, radial in structure, surface smoothly finished. Aperture terminal, radiate, with distinct neck.

Maximum length of figured hypotype, 1.53 mm.; breadth, 0.62 mm.; thickness, 0.17 mm.

Discussion.—This species is distinguished from *Frondicularia goldfussi* by the ridged, elongated proloculus, less numerous chambers, and distinct apertural neck. Originally described from the Cretaceous of Bohemia, *F. mucronata* has been reported from Poland, Australia, and the American Gulf Coast. The stratigraphic range is reported to be Turonian to Maastrichtian.

Types and occurrence.—Figured hypotype (UCLA 44108) from sample S-36, Rosario Formation at La Jolla (J220).

FRONDICULARIA VERNEUILIANA d'Orbigny

Plate 6, figure 8-10

Frondicularia verneuiliana d'Orbigny, 1840, p. 20, pl. 1, fig. 32-33. ——Cushman, 1946, p. 90, pl. 36, fig. 12-15.——Pożaryska,

1957, p. 157, fig. 42, pl. 21, fig. 1, pl. 22, fig. 1-2, 5, text-pl. 3, fig. 2.——BELFORD, 1960, p. 48, pl. 13, fig. 3-6.
Frondicularia archiaciana d'Orbigny, BANDY, 1951, p. 496, pl. 72, fig. 7.

Test free, elongate, compressed, sides flat to gently convex, periphery truncate. Chambers elongate, low, slightly inflated, increasing gradually in size. Sutures distinct, oblique, limbate, slightly elevated. Wall calcareous, finely perforate, radial in structure, surface smoothly finished, with several costae on globular proloculus. Aperture terminal, radiate.

Maximum length of figured hypotypes, 0.88 to 1.50 mm.; breadth, 0.27 to 0.46 mm.; thickness, 0.09 to 0.10 mm.

Discussion.—This species differs from *Frondicularia archiaciana* in being more flaring, relatively more compressed and having more elongate chambers. Of the present locations, *F. verneuiliana* is most common in the lower samples at La Jolla and at Carlsbad, and rare at Point Loma and Punta Descanso. The Carlsbad forms are fewer in number, less robust, and more commonly abnormal. This species ranges from the Coniacian to the Maastrichtian. American Gulf Coast occurrences are most characteristic in strata of Taylor age.

Types and occurrence.—Figured hypotypes (Fig. 9, 10, UCLA 44110-44111) from sample C-4, Rosario Formation at Carlsbad. Figured hypotype (Fig. 8, UCLA 44109) from sample S-16, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (C55, J45, L154, D126).

FRONDICULARIA sp. A
Plate 6, figure 12

Test free, elongate, compressed, sides nearly parallel, periphery slightly lobate, margin subrounded with bordering carinae. Chambers inflated, increasing gradually in size. Sutures distinct, flush to gently depressed, sigmoidal, limbate. Wall calcareous, hyaline, finely perforate, radial in structure, surface smoothly finished. Aperture terminal, radiate.

Maximum length of figured specimens, 0.97 mm.; breadth, 0.29 mm.; thickness, 0.17 mm.

Discussion.—Only 2 specimens of this form were found at the Point Loma locality. They are most similar to *Frondicularia lomaensis* SLITER, n. sp., but differ in having inflated chambers, sigmoidal sutures, and a relatively larger test dimension.

Type and occurrence.—Figured specimen (UCLA 44114) from sample L-7, Rosario Formation at Point Loma (L155).

FRONDICULARIA sp. B
Plate 6, figure 13

Test free, palmate, compressed, periphery truncate. Chambers slightly inflated, narrow, increasing rapidly in size. Sutures distinct, slightly depressed, arched, somewhat limbate. Wall calcareous, hyaline, finely perforate, surface smoothly finished. Aperture terminal, radiate, with distinct neck.

Maximum length of figured specimen, 0.78 mm.; breadth, 0.31 mm.; thickness, 0.14 mm.

Discussion.—A single specimen of this distinctive palmate form found at Point Loma somewhat resembles the specimen described by BELFORD (1960) as *Frondicularia* sp. D from the Santonian of Australia, but is smaller with more numerous chambers.

Type and occurrence.—Figured specimen (UCLA 44115) from sample L-10, Rosario Formation at Point Loma (L149).

FRONDICULARIA sp. C
Plate 6, figure 14

Test free, elongate, compressed, periphery truncate. Chambers slightly inflated, increasing rapidly in height, initially subglobular, later becoming elongated. Sutures distinct, slightly depressed, limbate, initially arched, later oblique. Wall calcareous, finely perforate, surface smooth. Aperture terminal, radiate.

Maximum length of figured specimen, 0.71 mm.; breadth, 0.15 mm.; thickness, 0.09 mm.

Discussion.—This species occurs rarely at Carlsbad, La Jolla, and Point Loma. It is similar to *Frondicularia* sp. B in chamber arrangement but differs in being much narrower and elongate. The 2 forms may represent dimorphism in the life cycle of a single species.

Type and occurrence.—Figured specimen (UCLA 44116) from sample L-11, Rosario Formation at Point Loma. Unfigured hypotypes from Rosario Formation at La Jolla (J164, L145).

FRONDICULARIA sp. D
Plate 6, figure 15

Test free, elongate, compressed, periphery rounded. Chambers slightly overlapping, almost as high as broad, becoming nearly parallel-sided in later stage. Sutures distinct, flush, gently arched. Wall calcareous, finely perforate, somewhat hyaline, surface smooth. Aperture terminal, radiate.

Maximum length of figured specimen, 0.51 mm.; breadth, 0.22 mm.; thickness, 0.14 mm.

Discussion.—This form is restricted to Carlsbad. It somewhat resembles the Recent *Frondicularia bassensis* PARR (1950), but is much smaller and lacks the limbate, depressed sutures and polished surface.

Type and occurrence.—Figured specimen (UCLA 44117) from sample C-7, Rosario Formation at Carlsbad (C150).

Genus LAGENA Walker & Jacob in Kanmacher, 1798

LAGENA ACUTICOSTA Reuss
Plate 6, figure 22-23

Lagena acuticosta REUSS, 1862, p. 305, pl. 1, fig. 4.——CUSHMAN, 1946, p. 94, pl. 39, fig. 14-15.

Test free, subglobular. Wall calcareous, finely perforate, radial in structure, surface ornamented with 11 to

19 longitudinal costae. Aperture terminal, at end of short tubular neck.

Maximum length of figured hypotypes, 0.20 to 0.31 mm.; diameter, 0.15 to 0.20 mm.

Discussion.—This species, originally described from the Cretaceous of the Netherlands, is recognized by the subglobular shape and number of costae. It occurs most commonly at Carlsbad and rarely at La Jolla and Punta Descanso. The Carlsbad population also includes rare double specimens connected by the apertural neck. American Gulf Coast records of this species indicate a range from strata of Austin to Navarro age. The specimen referred to the Recent *Lagena sulcata* (WALKER & JACOB) by SAID & KENAWY (1956) also may be synonymous.

Types and occurrence.—Figured hypotype (Fig. 22, UCLA 44118) from sample S-2, Rosario Formation at La Jolla. Figured hypotype (Fig. 23, UCLA 44119) from sample C-6, Rosario Formation at Carlsbad. Unfigured hypotypes from Rosario Formation at Punta Descanso (C88, J59, E138).

LAGENA GRAHAMI Sliter, n. sp.

Plate 7, figure 2

Lagena sulcata (Walker & Jacob) var. *semistriata* Williamson, HAGN, 1953, p. 70, pl. 2, fig. 28.

Lagena semilineata Wright, POŻARYSKA, 1957, p. 51, pl. 1, fig. 5.

Lagena sp. GRAHAM & CHURCH, 1963, p. 33, pl. 3, fig. 8.

Test free, subspherical, may have short apical spine. Wall calcareous, finely perforate, radial in structure, lower two-thirds of test ornamented by 11 to 15 longitudinal costae that become more strongly developed at test base. Aperture terminal, at end of slender, tapering apertural neck.

Maximum length of holotype, 0.36 mm.; diameter, 0.26 mm.

Discussion.—This species differs from the Recent species to which it has been referred in being more globular and having more distinct costae in the apical portion of the test. The specimen illustrated by CUSHMAN (1946) as *Lagena semilineata* differs in being more ovate in outline and having less distinct costae. Specimens of *L. grahami* are most common in the middle sections at La Jolla and the upper samples at Point Loma and Punta Descanso. The recorded stratigraphic range extends from Campanian to Danian.

Types and occurrence.—Holotype (UCLA 44127) from sample S-8; paratype (UCLA 44128) from sample S-16; both from Rosario Formation at La Jolla. Unfigured paratypes from Rosario Formation at Point Loma and Punta Descanso (J107, L53, D26).

LAGENA HISPIDA Reuss

Plate 6, figure 21

Lagena hispida REUSS, 1863, p. 335, pl. 6, fig. 77-79.——CUSHMAN, 1946, p. 93, pl. 39, fig. 13.——CUSHMAN, 1949, p. 6, pl. 3, fig. 8.——HAGN, 1953, p. 68, pl. 2, fig. 31.——POŻARYSKA, 1957, p. 47, pl. 2, fig. 8.

Test free, small, subspherical with tubular apertural neck. Wall calcareous, finely perforate, surface ornamented with fine spines. Aperture terminal, round.

Maximum length of figured hypotype, 0.12 mm.; diameter, 0.09 mm.

Discussion.—A few, small, spinose specimens from La Jolla and Point Loma are referred to this species, originally described from the Tertiary of Germany. A number of previous references seem to represent incomplete forms of other species. These include *Lagena hispida* of POŻARYSKA (1957, pl. 3, fig. 3), MARTIN (1964, pl. 5, fig. 7), and SAID & KENAWY (1956, pl. 3, fig. 9).

Types and occurrence.—Figured hypotype (UCLA 44120) from sample S-21, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma (J102, L80).

LAGENA PAUCICOSTA Franke

Plate 6, figure 16-18

Lagena amphora REUSS var. *paucicosta* FRANKE, 1928, p. 87, pl. 7, fig. 38.——CUSHMAN, 1946, p. 94, pl. 40, fig. 4-5.——BELFORD, 1960, p. 54, pl. 14, fig. 10-11.——MARTIN, 1964, p. 62, pl. 5, fig. 5.

Lagena sp. CUSHMAN & CHURCH, 1929, p. 512, pl. 39, fig. 11.

Test free, pyriform. Wall calcareous, finely perforate, structure radial, surface ornamented with 5 to 8 longitudinal costae. Aperture terminal, rounded, at end of short neck.

Maximum length of figured hypotypes, 0.27 to 0.41 mm.; diameter, 0.10 to 0.20 mm.

Discussion.—The present specimens show the same degree of variation in test width and the number of costae as do American Gulf Coast specimens referred to the same species by CUSHMAN (1946). *Lagena acuticosta* differs in being pyriform and having fewer costae. The present specimens are most common in the lower two-thirds of the La Jolla section and rare in the other 3 locations. Originally described from the Upper Cretaceous of Germany, this species is reported from strata of Austin to Navarro Age in the American Gulf Coast.

Types and occurrence.—Figured hypotypes (Fig. 16-17, UCLA 44121-44122) from sample S-31, Rosario Formation at La Jolla. Figured hypotype (Fig. 18, UCLA 44123) from sample E-1, Rosario Formation at Punta Descanso. Unfigured hypotypes from Rosario Formation at Carlsbad and Point Loma (C77, J33, L79, D70).

LAGENA SEMIINTERRUPTA Berry

Plate 6, figure 19-20

Lagena sulcata (WALKER & JACOB) var. *semiinterrupta* BERRY in BERRY & KELLEY, 1929, p. 5, pl. 3, fig. 19.——CUSHMAN, 1946, p. 94, pl. 39, fig. 18-21.

Lagena isabella (d'Orbigny), BROTZEN, 1936, p. 111, fig. 37 *(partim)*, pl. 7, fig. 5.

Lagena acuticosta REUSS var. *brevipostica* BANDY, 1951, p. 502, pl. 73, fig. 19.——MARTIN, 1964, p. 61, pl. 5, fig. 3.

Lagena acuticosta REUSS var. *proboscidialis* BANDY, 1951, p. 503, pl. 73, fig. 18.

Lagena elegantissima (BORNEMANN) var. *semiinterrupta* BERRY, HAGN, 1953, p. 67, pl. 2, fig. 32.

Test free, pyriform. Wall calcareous, finely perforate, structure radial, surface ornamented by 9 to 20 longitudinal costae that are commonly divided or loop-shaped at the base of test and at apertural end form thickened area with distinct shoulder; may have secondary and tertiary costae. Aperture terminal, rounded, produced on short, cylindrical neck.

Maximum length of figured hypotypes, 0.32 to 0.34 mm.; diameter, 0.19 to 0.22 mm.

Discussion.—Originally described from the Maastrichtian of Tennessee, this species varies considerably in test dimensions and number of costae in both the American Gulf Coast and California. It is distinguished from *Lagena acuticosta* by its more pyriform shape, divided costae, and thickened shoulder. The present specimens have been compared to material in my collection from the Kemp Clay and lower Navarro Group (locs. 19, 43, respectively, of CUSHMAN, 1946) and found to have the same degree of variation. Specimens illustrated as *L. isabella* by BROTZEN (1936) from the Senonian of Sweden, which here are placed in synonymy also show the characteristic variation of this species. Some of the specimens, however, in BROTZEN's figure 37 may belong to *L. acuticosta*. The specimen referred to *L. acuticosta* REUSS *proboscidialis* BANDY by MARTIN (1964) probably also belongs to the present species but the illustration is somewhat stylized. The Recent species *L. sulcata* (WALKER & JACOB in KANMACHER) (1798) and *L. isabella* (D'ORBIGNY) (1839) differ from the Cretaceous species in being more subglobular and in lacking the distinct shoulder and test thickening at the apertural end.

The present species occurs most commonly at Carlsbad and forms an intergradational population; it is rare at La Jolla and Punta Descanso.

Types and occurrence.—Figured hypotype (Fig. 20, UCLA 44124) from sample S-27; figured hypotype (Fig. 19, UCLA 44125) from sample S-34; both from Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Carlsbad and Punta Descanso (C19, J195, D131).

LAGENA STAVENSIS Bandy

Plate 7, figure 1

Lagena sp. cf. *L. globosa* Montagu, CUSHMAN, 1946, p. 95, pl. 39, fig. 26.——SAID & KENAWY, 1956, p. 136, pl. 3, fig. 7.
Lagena laevis (MONTAGU) var. *stavensis* BANDY, 1949, p. 56, pl. 7, fig. 15.——BANDY, 1951, p. 503, pl. 73, fig. 18.
Lagena laevis (Montagu), HAGN, 1953, p. 69, pl. 2, fig. 29.
Lagena laevis stavensis BANDY, GRAHAM & CHURCH, 1963, p. 33, pl. 3, fig. 7.

Test free, ovoid to subspherical. Wall calcareous, finely perforate, surface smooth. Aperture terminal, round, produced on distinct, short, neck.

Maximum length of figured hypotype, 0.46 mm.; diameter, 0.39 mm.

Discussion.—This species, originally described from the upper Eocene of Alabama, occurs in all present sections except Punta Descanso. It is recognized by the ovoid to subspherical test, smooth surface, and distinct neck. Specimens from the Cretaceous and lower Tertiary seem distinct from the Recent *Lagena laevis* (MONTAGU) (1803), which is characterized by the pyriform shape, hyaline wall and less distinct neck.

Types and occurrence.—Figured hypotype (UCLA 44126) from sample S-2, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Carlsbad and Point Loma (C45, J54, L54).

Genus LENTICULINA Lamarck, 1804

LENTICULINA CALIFORNIENSIS Trujillo

Plate 7, figure 3

Lenticulina californiensis TRUJILLO, 1960, p. 311, pl. 45, fig. 7.——GRAHAM & CHURCH, 1963, p. 34, pl. 3, fig. 14.

Test free, planispiral, biumbonate, umbones flattened, wide, periphery with thin, ragged carina. Chambers 10 to 12 in final whorl, increasing very gradually in size. Sutures distinct, strongly curved, limbate. Wall calcareous, finely perforate, radial in structure, surface smooth. Aperture at peripheral angle, radiate.

Maximum diameter of figured hypotype, 0.87 mm.; thickness, 0.31 mm.

Discussion.—The present specimens have been compared to the holotype and agree closely. This species differs from *Lenticulina muensteri* (ROEMER) in being smaller and having more numerous chambers, flattened umbones, and more strongly curved sutures. At La Jolla, this species first appears in the middle of the section and become more common toward the top. The specimens also show a progressive increase in size with the largest forms appearing in the younger samples. *L. californiensis* occurs rarely at Point Loma and Punta Descanso but is lacking at Carlsbad. The California stratigraphic range extends from Coniacian to Maastrichtian.

Types and occurrence.—Figured hypotype (UCLA 44129) from sample S-27, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (J118, L124, D154).

LENTICULINA CARLSBADENSIS Sliter, n. sp.

Plate 8, figure 1-3

Test free, large, compressed, initial portion planispirally coiled or rarely somewhat trochospiral, later stage may uncoil, periphery rounded to subrounded. Chambers increasing rapidly in size, may become slightly inflated in ultimate stage. Sutures distinct, limbate, curved, usually flush but later ones may become somewhat depressed. Wall calcareous, finely perforate, radial in structure, surface smooth. Aperture at peripheral angle, radiate, with extension on apertural face.

Maximum diameter of holotype, 1.05 mm.; thickness, 0.31 mm.

Discussion.—This form is easily distinguished from the associated species by the compressed test, rounded periphery, and tendency to uncoil in the later stage. The test outline resembles that of the Eocene *Lenticulina inflata* (GAUGER) and *L. winniana* (HOWE & ELLIS) but differs in the type of periphery, chamber shape and degree of inflation, and apertural characteristics. *L. carlsbadensis* is most abundant and best developed at Carlsbad with smaller specimens occurring in the lower samples at La Jolla and the middle portion of the Punta Descanso section. The stratigraphic range is middle to upper Campanian.

Types and occurrence.—Holotype (Fig. 1, UCLA 44143) from sample C-4; paratype (Fig 2, UCLA 44144) from sample C-3; both from Rosario Formation at Carlsbad. Paratype (Fig. 3, UCLA 44145) from sample S-8, Rosario Formation at La Jolla (C17, J81, D56).

LENTICULINA DAVISI (Bandy)

Plate 7, figure 4

Robulus convergens Bornemann, JENNINGS, 1936, p. 16, pl. 1, fig. 16.

Robulus davisi BANDY, 1949, p. 59, pl. 8, fig. 4.

Test free, lenticular, planispiral, biumbonate, periphery subrounded. Chambers 8 to 10 in final whorl, increasing gradually in size. Sutures distinct, flush, limbate, slightly curved, tangential. Wall calcareous, finely perforate, radial in structure, surface smooth. Aperture at peripheral angle of final chamber, radiate, with somewhat produced apertural extension.

Maximum diameter of figured hypotype, 0.92 mm.; thickness, 0.56 mm.

Discussion.—Originally described from the Eocene of Alabama, this species is distinguished from *Lenticulina modesta* (BANDY) by the relatively thicker, more robust test, larger umbonal area, gently curved sutures, and subrounded periphery. The present specimens closely resemble illustrations of the type, differing only in the larger size and somewhat more curved sutures; hence they are not presently regarded as distinct. The specimen referred to *L. convergens* (BORNEMANN) by JENNINGS from the Maastrichtian of New Jersey seems synonymous with this species. In the present samples, *L. davisi* occurs in the upper La Jolla and Punta Descanso sections and throughout the Point Loma locality.

Types and occurrence.—Figured hypotype (UCLA 44130) from sample S-20, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (J158, L71, D148).

LENTICULINA MODESTA (Bandy)

Plate 7, figure 5

Robulus modestus BANDY, 1951, p. 493, pl. 72, fig. 9.——MARTIN, 1964, p. 69, pl. 6, fig. 11.

Lenticulina modesta (Bandy), TRUJILLO, 1960, p. 313, pl. 45, fig. 3.

Test free, planispiral, lenticular, biumbonate, periphery acute. Chambers 7 to 9 in final whorl, increasing gradually in size. Sutures distinct, flush, gently curved, limbate. Wall calcareous, finely perforate, radial in structure, surface smooth. Aperture at peripheral angle, radiate, with apertural extension.

Maximum diameter of figured hypotype, 1.19 mm.; thickness, 0.43 mm.

Discussion.—Originally described from the Upper Cretaceous at Carlsbad by BANDY (1951), this species seems related to *Lenticulina stephensoni* (CUSHMAN) from the Taylor and Navarro Groups of the American Gulf Coast. Although smaller and lacking the strongly limbate sutures and slight keel of the Gulf specimens, future study may show them to be conspecific. *L. modesta* occurs in the lower part of the section at La Jolla, preceding the first appearance of *L. taylorensis* (PLUMMER). The same situation holds true for the lowest samples at Carlsbad, whereas *L. modesta* and *L. taylorensis* occur together in the upper samples. Previous California occurrences of *L. modesta* range from Turonian to Campanian.

Types and occurrence.—Figured hypotype (UCLA 44131) from sample C-3, Rosario Formation at Carlsbad. Unfigured hypotypes from Rosario Formation at La Jolla (C56, J50).

LENTICULINA MUENSTERI (Roemer)

Plate 7, figure 9, 13

Robulina münsteri ROEMER, 1839, p. 48, pl. 22, fig. 29.

Robulus münsteri (Roemer), CUSHMAN, 1946, p. 53, pl. 17, fig. 3-9.

Lenticulina exarata (von Hagenow) Reuss, GRAHAM & CHURCH, 1963, p. 34, pl. 3, fig. 9.

Test free, planispiral, biumbonate, periphery carinate. Chambers 8 to 12 in final whorl, increasing gradually in size. Sutures distinct, limbate, gently curved, flush to slightly elevated. Wall calcareous, finely perforate, structure radiate, surface smoothly finished. Aperture at peripheral angle, radiate.

Maximum diameter of figured hypotypes, 0.94 to 1.53 mm.; thickness, 0.49 to 0.63 mm.

Discussion.—The present specimens agree closely with the Gulf Coast specimens referred to this species by CUSHMAN (1946). Specimens in the population vary considerably in test dimensions, number of chambers, and elevation of the thickened umbones and sutures. Gradual increase in the development of the raised and thickened umbo occurs at La Jolla. Specimens in the lower samples have smooth umbones and a small central thickened area, whereas the umbones of later specimens are strongly produced and thickened. These variations apparently represent a single stock that is found throughout the La Jolla, Point Loma, and Punta Descanso sections and rarely at Carlsbad. American Gulf Coast specimens occur in the Austin, Taylor, and Navarro Groups.

Types and occurrence.—Figured hypotype (Fig. 9, 44132) from sample S-1; figured hypotype (Fig. 13, UCLA 44133) from sample S-6; both from Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Carlsbad, Point Loma, and Punta Descanso (C148, J9, L17, D3).

LENTICULINA OVALIS (Reuss)

Plate 7, figure 12

Cristellaria ovalis REUSS, 1845, p. 34, pl. 8, fig. 49, pl. 12, fig. 19, pl. 13, fig. 60-63.

Lenticulina ovalis (Reuss), HAGN, 1953, p. 36, pl. 3, fig. 6.——POŻARYSKA, 1957, p. 126, pl. 15, fig. 4.——GRAHAM & CHURCH, 1963, p. 35, pl. 3, fig. 12-13.

Test free, planispiral, consisting of large globular proloculus and 2 to 5 chambers, increasing rapidly in size. Sutures distinct, flush, limbate, curved. Wall calcareous, finely perforate, surface smooth. Aperture at peripheral angle, radiate.

Maximum diameter of figured hypotype, 0.65 mm.; thickness, 0.51 mm.

Discussion.—The present specimens closely resemble the original illustrations from the Cretaceous of Bohemia. Whether they represent a distinct species, juveniles, or a stage in the life cycle of another species such as *Lenticulina muensteri*, remains to be determined. For the present they are separated. Specimens of *L. ovalis* occur rarely at all the present locations except at Carlsbad. The species is more common in Europe and ranges from Turonian to Maastrichtian.

Types and occurrence.—Figured hypotype (UCLA 44134) from sample S-20, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (J60, L73, D128).

LENTICULINA PONDI (Cushman)

Plate 7, figure 10

Robulus pondi CUSHMAN, 1931c, p. 25, pl. 2, fig. 9.——CUSHMAN, 1946, p. 52, pl. 16, fig. 1-5.

Test free, lenticular, planispiral, biumbonate, periphery subrounded, slightly nodose in outline. Chambers numerous, 12 in final whorl, increasing gradually in size. Sutures somewhat indistinct, slightly curved, flush. Wall calcareous, finely perforate, surface smooth. Aperture at peripheral angle, radiate.

Maximum diameter of figured hypotype, 0.97 mm.; thickness, 0.31 mm.

Discussion.—This species is rare at La Jolla. It is distinguished from *Lenticulina muensteri* by the relatively thinner test and the subrounded, nodose periphery. *L. pondi* is characteristic of upper Taylor and lower Navarro strata in the American Gulf Coast.

Types and occurrence.—Figured hypotype (UCLA 44135) from sample S-15, Rosario Formation at La Jolla (J140).

LENTICULINA REVOLUTA (Israelsky)

Plate 7, figure 11

Robulus pseudocultratus Cole, BANDY, 1951, p. 493, pl. 72, fig. 5.
Robulus revolutus ISRAELSKY, 1955, p. 49, pl. 15, fig. 3-6.
Lenticulina sp. cf. *L. incrassata* Marie, POŻARYSKA, 1957, p. 123, pl. 17, fig. 2.

Test free, planispiral, lenticular, biumbonate, periphery carinate. Chambers 8 to 10 in final whorl, low, arcuate, increasing gradually in size. Sutures distinct, strongly curved, flush, limbate. Wall calcareous, finely perforate, radial in structure, surface smoothly finished. Aperture at peripheral angle, radiate, with somewhat produced apertural extension.

Maximum diameter of figured hypotype, 1.00 mm.; thickness, 0.41 mm.

Discussion.—Originally described from the Paleocene of California, this species differs from *Lenticulina muensteri* in having narrower chambers, more strongly curved septa, and a wider keel. The present specimens correspond closely to *L. revoluta.* BANDY (1951) referred this form to *L. pseudocultrata* (COLE), but that species lacks the narrow chambers and strongly curved sutures of the present specimens. ISRAELSKY (1955) noted the similarity of the specimen illustrated by BANDY to *L. revoluta* but separated them on the basis of test thickness and form of the apertural process. The present population, however, includes test and apertural variations that compare well to the original illustrations of *L. revoluta. L. microptera* (REUSS) (1860) is similar in chamber and suture shape but lacks the clear, thickened umbones of the present forms. It may represent a Cretaceous variant. The similar *L. pseudovortex* MARIE (1941), from the Campanian of France, is differentiated by the lack of a peripheral carina. The specimen from the Maastrichtian of Poland, compared to *L. incrassata* MARIE by POŻARYSKA (1957) seems conspecific and is here placed in synonymy. The present specimens of *L. revoluta* are found commonly at *Carlsbad*, with a rare additional occurrence at La Jolla.

Types and occurrence.—Figured hypotype (UCLA 44136) from sample C-4, Rosario Formation at Carlsbad. Unfigured hypotype from Rosario Formation at La Jolla (C48, J160).

LENTICULINA SPACHHOLTZI (Reuss)

Plate 7, figure 6

Cristellaria spachholtzi REUSS, 1851, p. 33, pl. 3, fig. 10.

Test free, planispiral, lenticular, somewhat biumbilicate, periphery subacute. Chambers 7 to 10 in final whorl, increasing gradually in size, becoming somewhat evolute. Sutures distinct, initially flush, limbate, may become slightly depressed. Wall calcareous, finely perforate, structure radial, surface smoothly finished. Aperture at peripheral angle of final chamber, radiate.

Maximum diameter of figured hypotype, 0.80 mm.; thickness, 0.37 mm.

Discussion.—Originally described from the Upper Cretaceous of Poland, this species is recognized by the relatively compressed, biumbilicate test. It lacks the thickened umbonal areas of related species. Variation is observed in chamber number and test thickness. This species is rare in all the present localities.

Types and occurrence.—Figured hypotype (UCLA 44137) from sample S-26, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Carlsbad, Point Loma and Punta Descanso (C128, J95, L91, D60).

LENTICULINA SPISSOCOSTATA (Cushman)

Plate 7, figure 7-8

Robulus spisso-costatus (CUSHMAN), 1938b, p. 32, pl. 5, fig. 2.——CUSHMAN, 1946, p. 52, pl. 16, fig. 11-14, pl. 17, fig. 1.

Test free, large, lenticular, planispiral, biumbonate, periphery subacute to carinate. Chambers numerous, 9 to

12 in final whorl, increasing gradually in size. Sutures distinct, curved, strongly limbate, elevated, becoming thickened toward umbo. Wall calcareous, finely perforate, radial in structure, surface smooth. Aperture at peripheral angle, radiate.

Maximum diameter of figured hypotypes, 1.46 to 1.87 mm.; thickness, 0.51 to 0.88 mm.

Discussion.—Specimens in the present population exhibit certain morphological features characteristic of both *Lenticulina spissocostata* and *L. navarroensis extruata* (Cushman) (1938b). These include the presence or absence of a peripheral keel, thickened sutures, and degree of sutural fusion on the umbo. These characters appear to be gradational in the present population, and the majority of specimens have a subacute periphery; hence they are here referred to *L. spissocostata*. This species occurs rarely in all present locations. Specimens from the American Gulf Coast are characteristic of Maastrichtian strata.

Types and occurrence.—Figured hypotype (Fig. 7, UCLA 44138) from sample S-6, Rosario Formation at La Jolla. Figured hypotype (Fig. 8, UCLA 44139) from sample C-6, Rosario Formation at Carlsbad. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (C107, J101, L85, D151).

LENTICULINA TAYLORENSIS (Plummer)

Plate 7, figure 14-15

Astacolus taylorensis Plummer, 1931, p. 143, pl. 11, fig. 16, pl. 15, fig. 8-11.

Robulus taylorensis (Plummer), Cushman, 1946, p. 53, pl. 18, fig. 20.

Test free, planispiral, becoming slightly evolute, biumbonate, periphery subacute, with slight keel. Chambers 7 to 9 in final whorl, increasing moderately in size, becoming slightly inflated, final chamber may be elongated. Sutures distinct, gently curved, initially limbate, flush, later depressed. Wall calcareous, finely perforate, radial in structure, surface smooth. Aperture at peripheral angle, radiate, may be somewhat produced.

Maximum diameter of figured hypotypes, 0.63 to 0.75 mm.; thickness, 0.26 to 0.27 mm.

Discussion.—The test shape, produced final chamber, and gently curved sutures easily distinguish this species. At La Jolla and Carlsbad, it occurs in the upper half of the section, whereas at Point Loma and Punta Descanso, it ranges throughout. In the American Gulf Coast it is characteristic of the Taylor Group.

Types and occurrence.—Figured hypotypes (Fig. 14, 15, UCLA 44141-44140) from sample S-17, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Carlsbad, Point Loma and Punta Descanso (C129, J123, L18, D15).

LENTICULINA sp. cf. L. WILLIAMSONI (Reuss)

Plate 7, figure 16

Cristellaria williamsoni Reuss, 1862, p. 327, pl. 6, fig. 4.

Lenticulina williamsoni (Reuss), Cushman & Church, 1929, p. 503, pl. 36, fig. 13-14.

Robulus williamsoni (Reuss), Cushman, 1931b, p. 37, pl. 5, fig. 2.

Test free, planispiral, involute, lenticular, biumbonate, periphery subacute. Chambers 7 to 8 in final whorl, increasing gradually in size. Sutures strongly curved, limbate, overlapping, flush. Wall calcareous, finely perforate, radial in structure, surface smooth. Aperture at peripheral margin, radiate.

Maximum diameter of figured specimen, 0.94 mm.; thickness, 0.51 mm.

EXPLANATION OF PLATE 7

FIGURE

1. *Lagena stavensis* Bandy; side view, ×66 (p. 65).
2. *Lagena grahami* Sliter, n. sp.; side view, ×97 (p. 64).
3. *Lenticulina californiensis* Trujillo; 3a,b, side and face views, ×33 (p. 65).
4. *Lenticulina davisi* (Bandy); 4a,b, side and face views, ×52 (p. 66).
5. *Lenticulina modesta* (Bandy); 5a,b, side and face views, ×33 (p. 66).
6. *Lenticulina spachholtzi* (Reuss); 6a,b, side and face views, ×52 (p. 67).

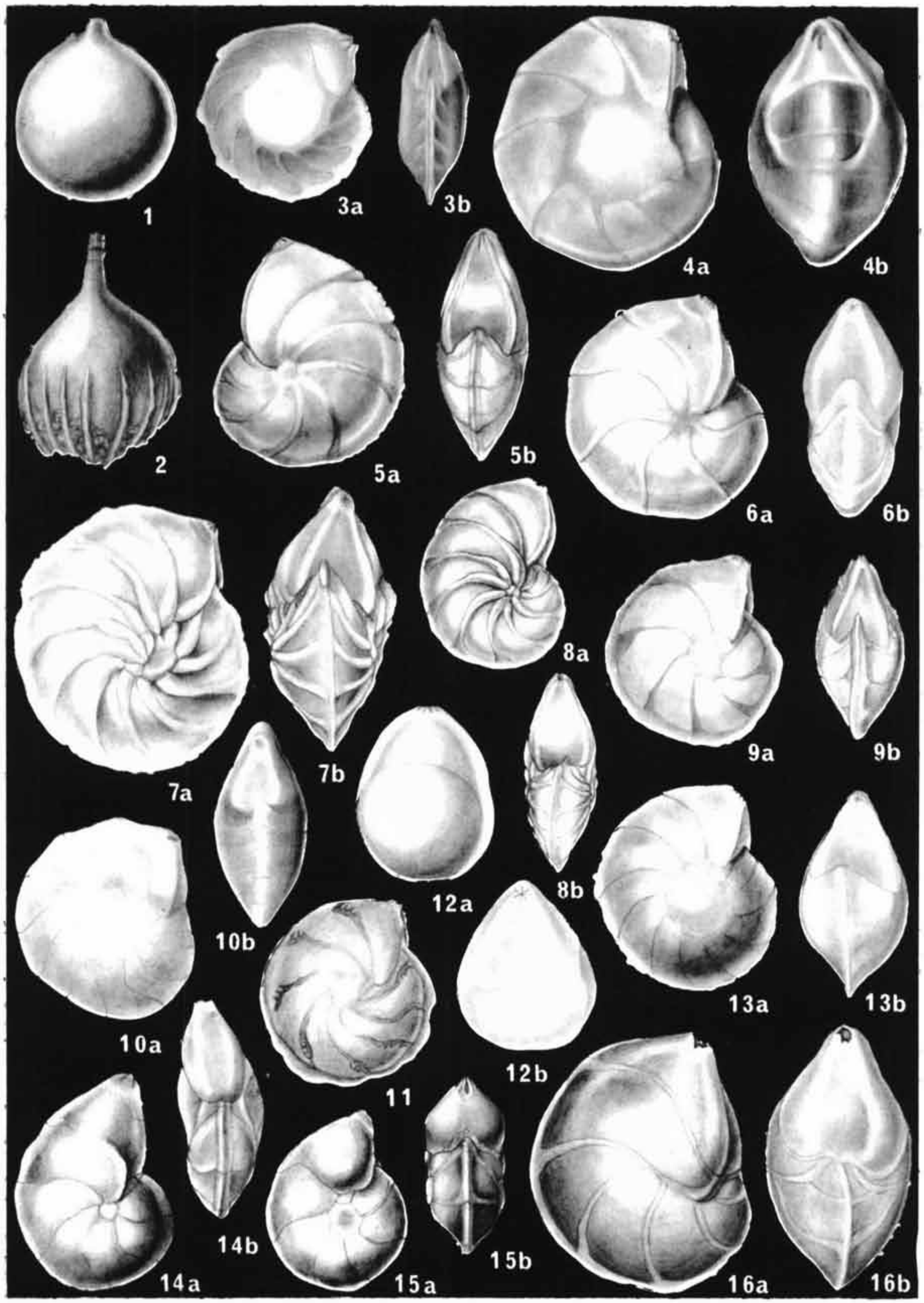
7-8. *Lenticulina spissocostata* (Cushman); 7a,b, side and face views, ×25; 8a,b, side and face views, ×23 (p. 67).

9, 13. *Lenticulina muensteri* (Roemer); 9a,b, side and face views, ×23; 13a,b, side and face views, ×33 (p. 66).

10. *Lenticulina pondi* (Cushman); 10a,b, side and face views, ×33 (p. 67).
11. *Lenticulina revoluta* (Israelsky); side view ×33 (p. 67).
12. *Lenticulina ovalis* (Reuss); 12a,b, side and face views, ×52 (p. 66).

14-15. *Lenticulina taylorensis* (Plummer); 14a,b, side and face views, ×66; 15a,b, side and face views, ×52 (p. 68).

16. *Lenticulina* sp. cf. *L. williamsoni* (Reuss); 16a,b, side and face views, ×52 (p. 68).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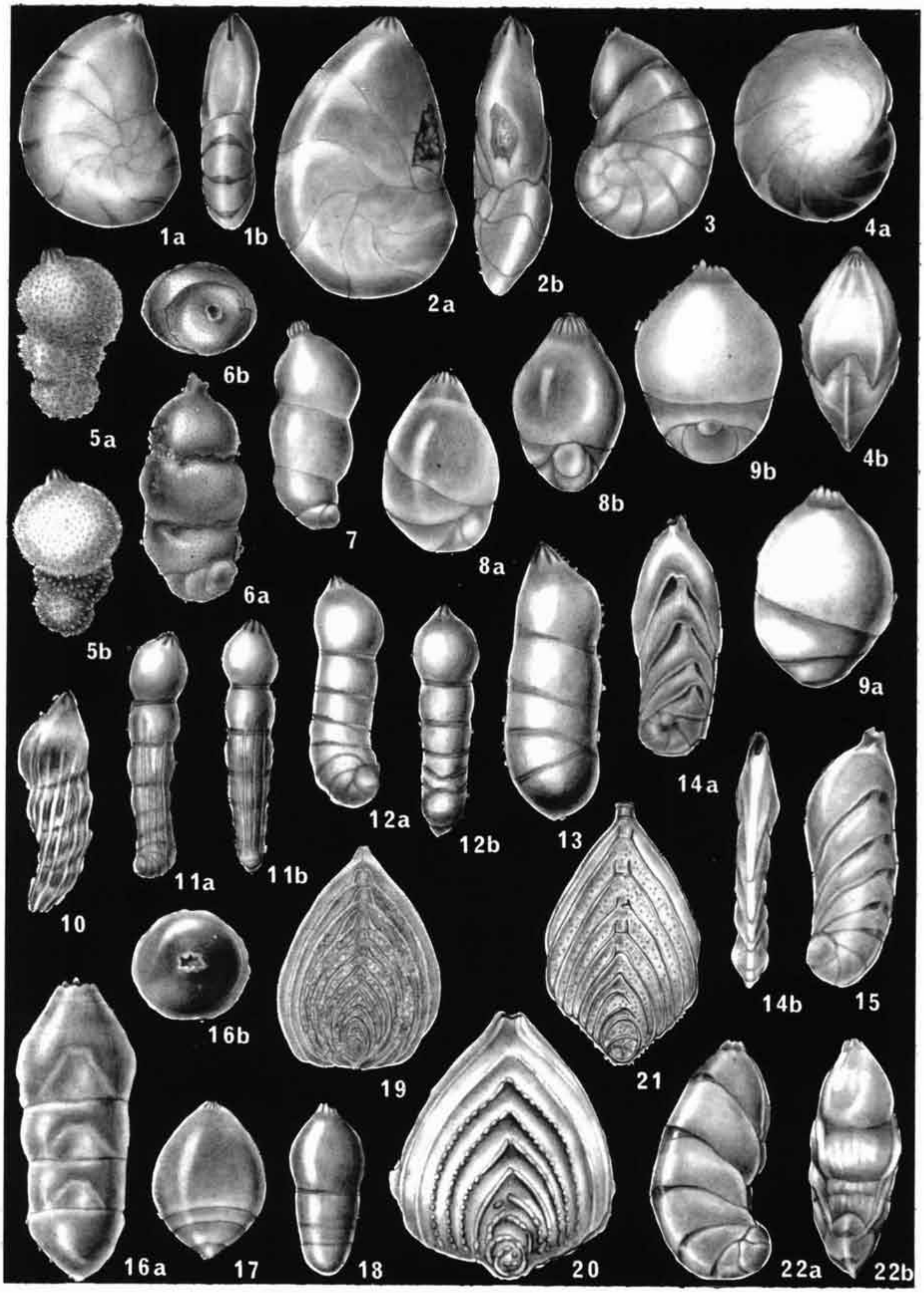
Sliter – Upper Cretaceous Foraminifera, Southern California and Northwestern Mexico.



Discussion.—The present forms closely resemble the specimen illustrated by CUSHMAN (1931) but differ in being more involute and having a more rounded apertural face on the final chamber and flush sutures. Another similar species, *Lenticulina discrepans* REUSS (1862), from the Cretaceous of Germany, differs in being less robust and less involute. Rare in the upper samples at La Jolla and Point Loma, *L.* sp. cf. *L. williamsoni* occurs in a single sample at Carlsbad.

Types and occurrence.—Figured specimen (UCLA 44142) from sample S-28, Rosario Formation at La Jolla. Unfigured specimens from Rosario Formation at Carlsbad and Point Loma (C83, J200, L147).

LENTICULINA sp.

Plate 8, figure 4

Lenticulina warregoensis Crespin, TRUJILLO, 1960, p. 314, pl. 45, fig. 4.

Test free, lenticular, planispiral, involute, periphery carinate. Chambers low, elongate, 7 to 9 in final whorl, increasing gradually in size. Sutures flush, limbate, strongly curved, overlapping. Wall calcareous, finely perforate, structure radial, surface smoothly finished. Aperture at peripheral angle, radiate.

Maximum diameter of figured specimen, 0.99 mm.; thickness, 0.49 mm.

Discussion.—A few rare specimens differ from *Lenticulina* sp. cf. *L. williamsoni* in their low, elongated chambers, peripheral keel, and more strongly curved sutures. These may represent a subspecies or may be distinct. The specimen illustrated by TRUJILLO (1960) as *L. warregoensis* CRESPIN is identical to the present forms but differs from the original illustrations in being less elongate, relatively thicker, and more strongly involute. Based on the evidence recorded by TRUJILLO, this form ranges from Turonian to Maastrichtian. The extended range may be indicative of a homeomorphic series. It is rare in the upper La Jolla samples and throughout the Punta Descanso location.

Types and occurrence.—Figured specimen (UCLA 44147) from sample S-36, Rosario Formation at La Jolla. Unfigured specimens from Rosario Formation at Punta Descanso (J213, D79).

Genus MARGINULINA d'Orbigny, 1826

MARGINULINA ARMATA Reuss

Plate 8, figure 5

Marginulina armata REUSS, 1860, p. 209, pl. 7, fig. 7.——CUSHMAN, 1946, p. 60, pl. 21, fig. 1.

Test free, elongate, initially slightly coiled, later uncoiling, gently arcuate. Chambers inflated, subglobular, increasing rapidly in size. Sutures distinct, depressed. Wall calcareous, finely perforate, surface spinose. Aperture terminal, eccentric, radiate, somewhat produced.

Maximum length of figured hypotype, 0.56 mm.; diameter, 0.32 mm.

Discussion.—The present specimens are identical to those of CUSHMAN (1946) from the American Gulf Coast. This species occurs commonly in the middle samples at La Jolla and Punta Descanso and is rare throughout the Point Loma section. The Texas specimens are from the upper Taylor Marl.

Types and occurrence.—Figured hypotype (UCLA 44148) from sample S-9, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (J77, L128, D110).

EXPLANATION OF PLATE 8

FIGURE

1-3. *Lenticulina carlsbadensis* SLITER, n. sp.; 1a,b, side and face views of holotype, ×33; 2a,b, side and face views of paratype, ×66; 3, side view of paratype, ×17 (p. 65).

4. *Lenticulina* sp.; 4a,b, side and face views, ×33 (p. 69).

5. *Marginulina armata* REUSS; 5a,b, side views, ×52 (p. 69).

6-7. *Marginulina bullata* REUSS; 6a,b, side and apertural views, ×66; 7, side view, ×52 (p. 70).

8-9. *Marginulina* sp. cf. *M. curvatura* CUSHMAN; 8a,b, side and face views, ×97; 9a,b, side views, ×66 (p. 70).

10. *Marginulina navarroana* CUSHMAN; side view, ×97 (p. 70).

11. *Marginulinopsis striatocarinata* (CUSHMAN & CAMPBELL); 11a,b, side and edge views, ×23 (p. 70).

12-13. *Marginulinopsis texasensis* (CUSHMAN); 12a,b, side and edge views, ×33; 13, side view, ×52 (p. 71).

14-15. *Palmula primitiva* CUSHMAN; 14a,b, side and edge views, ×52; 15, side view, ×66 (p. 72).

16. *Pseudonodosaria*, sp.; 16a,b, side and apertural views, ×197 (p. 72).

17. *Pseudonodosaria obesa* (LOEBLICH & TAPPAN); side view, ×66 (p. 72).

18. *Pseudonodosaria manifesta* (REUSS); side view, ×66 (p. 72).

19-20. *Neoflabellina pilulifera* (CUSHMAN & CAMPBELL); side views, ×33, ×45 (p. 71).

21. *Neoflbellina rugosa* (D'ORBIGNY); side view, ×33 (p. 71).

22. *Saracenaria jarvisi* (BROTZEN); 22a,b, side and face views, ×52 (p. 73).

MARGINULINA BULLATA Reuss
Plate 8, figure 6-7

Marginulina (Marginulina) bullata REUSS, 1845, p. 29, pl. 13, fig. 34-38.
Marginulina bullata Reuss, CUSHMAN, 1946, p. 62, pl. 21, fig. 32-37.——BANDY, 1951, p. 498, pl. 72, fig. 13.——HAGN, 1953, p. 40, pl. 4, fig. 1.——POŻARYSKA, 1957, p. 106, pl. 12, fig. 6.——MARTIN, 1964, p. 63, pl. 5, fig. 10.

Test free, elongate, usually gently arcuate, circular in transverse section, initial portion slightly coiled, later uncoiling. Chambers becoming inflated, initially increasing rapidly in size, later nearly uniform in size or slightly reduced. Sutures depressed, nearly transverse. Wall calcareous, finely perforate, radial in structure, surface smoothly finished. Aperture terminal, eccentric, radiate, with distinct cylindrical neck.

Maximum length of figured hypotypes, 0.58 to 0.71 mm.; diameter, 0.27 to 0.31 mm.

Discussion.—This variable species, originally described from the Cretaceous of Bohemia, is characterized by inflated chambers and distinct, cylindrical apertural neck. Two forms are present; one is elongate with uniformly enlarging chambers, the other is smaller and has fewer, more rapidly enlarging chambers. Both have approximately the same stratigraphic range and the distinctive apertural neck, hence here they are considered to represent different generations in the life cycle of this species. The specimen referred to *Marginulina bullata* by GRAHAM & CHURCH (1963) differs from the present specimens in having less inflated chambers and in lacking the apertural neck. *M. bullata* of CUSHMAN & CHURCH (1929) may be correctly referred, although the illustrated specimen is broken and apertural details are not evident. *M. bullata* is common at Carlsbad in the middle samples at La Jolla and scattered throughout the Point Loma and Punta Descanso sections. It is most characteristic of the Taylor Group in the American Gulf Coast.

Types and occurrence.—Figured hypotype (Fig. 7, UCLA 44149) from sample C-2, Rosario Formation at Carlsbad. Figured hypotype (Fig. 6, UCLA 44150) from sample S-17, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (C47, J139, L116, D111).

MARGINULINA sp. cf. M. CURVATURA Cushman
Plate 8, figure 8-9

Marginulina curvatura CUSHMAN, 1938b, p. 34, pl. 5, fig. 13-14. ——CUSHMAN, 1946, p. 63, pl. 22, fig. 11-14.

Test free, globose to elongate, initially slightly coiled, later tending to uncoil. Chambers inflated, increasing rapidly in size. Sutures distinct, depressed, gently curved. Wall calcareous, finely perforate, surface smooth. Aperture terminal, eccentric, radiate.

Maximum length of figured hypotypes, 0.34 to 0.54 mm.; diameter, 0.20 to 0.39 mm.

Discussion.—The specimens referred to this species are similar to the two forms of *Marginulina bullata* but differ in lacking the apertural neck. Topotype material from the Corsicana Marl of Texas (locs. 26-28 of CUSHMAN, 1946) include specimens identical to those here figured. The known distribution of these forms also argues for their separation from *M. bullata*. At La Jolla, they appear prior to *M. bullata* and then extend beyond the range of the latter. In the Carlsbad section, only *M. bullata* is present, whereas at Point Loma and Punta Descanso, the species occur together. GRAHAM & CHURCH (1963) assigned very similar forms to the Albian species *M. trunculata* (BERTHELIN), whereas TAPPAN (1962) referred similar forms in the Albian of Alaska to *M. planiuscula* (REUSS). Further stratigraphic evidence is needed to determine if these occurrences indicate a single long ranging species or homeomorphic growth stages in various distinct species of *Marginulina*.

Types and occurrence.—Figured hypotype (Fig. 8, UCLA 44151) from sample L-2, Rosario Formation at Point Loma. Figured hypotype (Fig. 9, UCLA 44152) from sample S-11, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Punta Descanso (J26, L55, D28).

MARGINULINA NAVARROANA Cushman
Plate 8, figure 10

Marginulina navarroana CUSHMAN, 1937a, p. 98, pl. 14, fig. 17-18. ——CUSHMAN, 1946, p. 62, pl. 22, fig. 1-5.

Test free, elongate, tapering, slightly coiled initially, rapidly becoming uncoiled. Chambers inflated, increasing moderately in size. Sutures initially obscure, later distinct, depressed and slightly oblique. Wall calcareous, finely perforate, surface ornamented by distinct longitudinal costae that are slightly twisted on the initial portion of the test. Aperture terminal, marginal, radiate and somewhat projecting.

Maximum length of figured hypotype, 0.36 mm.; diameter, 0.12 mm.

Discussion.—This species occurs rarely in the upper samples at La Jolla. It is distinguished by the tapering test and twisted costae. In the American Gulf Coast it is characteristic of Navarro strata.

Types and occurrence.—Figured hypotype (UCLA 44153) from sample S-23, Rosario Formation at La Jolla (J174).

Genus MARGINULINOPSIS Silvestri, 1904

MARGINULINOPSIS STRIATOCARINATA (Cushman & Campbell)
Plate 8, figure 11

Marginulina striato-carinata CUSHMAN & CAMPBELL, 1935, p. 67, pl. 10, fig. 4, 7.

Test free, elongate, rectilinear to gently arcuate, initial portion planispirally coiled, compressed, periphery acute or carinate, later uncoiling and circular in transverse section. Chambers initially overlapping, later becoming inflated. Sutures distinct, initially flush and commonly limbate, later depressed. Wall calcareous, finely perforate, radial in structure, surface ornamented by fine longitudinal costae extending nearly to final chamber, commonly more distinct across sutures, or surface may be nearly smooth. Aperture terminal, eccentric, radiate.

Maximum length of figured hypotype, 1.75 mm.; diameter, 0.39 mm.

Discussion.—Originally described from the Moreno Formation of California, this species is more elongate and relatively thinner than *Marginulinopsis texasensis* (CUSHMAN) and has a carinate initial periphery and numerous costae. The present specimens differ considerably in strength of the costae, as well as in presence of the initial carina. Some specimens are nearly smooth and are nearly identical to those illustrated by GRAHAM & CHURCH (1963) as *M. hemicylindrica* (NOTH). These may be synonymous to the present species and represent a non-costate variation. *M. striatocarinata* is most common in the lower samples at La Jolla and rare at Point Loma.

Types and occurrence.—Figured hypotype (UCLA 44154) from sample S-1, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma (J52, L158).

MARGINULINOPSIS TEXASENSIS (Cushman)

Plate 8, figure 12-13

Marginulina texana CUSHMAN, (*non* GARRETT & ELLIS), 1937a, p. 95, pl. 14, fig. 1-4.

Marginulina texasensis CUSHMAN, 1938, p. 95.——CUSHMAN, 1946, p. 61, pl. 21, fig. 21-29, 38, 40.——TAKAYANAGI, 1960, p. 90, pl. 4, fig. 13.

Marginulina sp. GRAHAM & CHURCH, 1963, p. 39, pl. 4, fig. 6-7.

Test free, elongate, early portion planispirally coiled, compressed, margin subacute, later uncoiling, rectilinear to gently arcuate, circular in transverse section. Chambers overlapping, becoming inflated. Sutures distinct, limbate, depressed in later stage. Wall calcareous, finely perforate, radial in structure, surface smooth. Aperture terminal, marginal, radiate.

Maximum length of figured hypotypes, 0.88 to 1.10 mm.; diameter, 0.29 to 0.32 mm.

Discussion.—This species was originally described from the Pecan Gap Chalk Member of the Taylor Marl of Texas and is recognized by the initial compressed coil and later inflated, noncompressed chambers. The specimen illustrated by CUSHMAN & CHURCH (1929) as *Marginulina elongata* D'ORBIGNY may be synonymous as they describe the later chambers as nearly circular in transverse section. The illustrations, however, clearly show the entire test to be compressed, so that it is not included in the synonymy. The 2 specimens here illustrated show the variation present in the initial coil. The present specimens are most common at Carlsbad and rare at La Jolla and Point Loma. American Gulf Coast occurrences include the Taylor and lower Navarro Groups.

Types and occurrences.—Figured hypotype (Fig. 12, UCLA 44155) from sample S-11; figured hypotype (Fig. 13, UCLA 44156) from sample S-38; both from Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Carlsbad and Point Loma (C112, J125, L100).

Genus NEOFLABELLINA Bartenstein, 1948

NEOFLABELLINA PILULIFERA (Cushman & Campbell)

Plate 8, figure 19-20

Flabellina pilulifera CUSHMAN & CAMPBELL, 1935, p. 67, pl. 10, fig. 6.

Flabellina numismalis WEDEKIND, 1940, p. 200, pl. 9, fig. 1-3, pl. 11, fig. 8-9.

Neoflabellina pilulifera (Cushman & Campbell), GRAHAM & CHURCH, 1963, p. 40, pl. 5, fig. 4-5.——MARTIN, 1964, p. 72, pl. 7, fig. 8.

Test free, large, broad, compressed, initial end blunt, periphery truncate, sides parallel. Chambers initially planispiral, later rectilinear, elongate, narrow, equitant. Sutures distinct, elevated, acute, tuberculate in early portion, later continuous. Wall calcareous, perforate, surface between sutures generally smooth. Aperture, radiate, terminal, slightly produced.

Maximum length of figured hypotypes, 1.07 to 1.11 mm.; breadth, 0.75 to 0.92 mm.; thickness, 0.14 to 0.21 mm.

Discussion.—The distinguishing features of this species are the broad, initially flattened test, initially tuberculate sutures, and smooth intersutural surface. The European species *Flabellina numismalis* WEDEKIND also possesses these morphologic characteristics and has the same relative size and stratigraphic range, hence is regarded as synonymous to *N. pilulifera*. California records of *N. pilulifera* include the original description from the Upper Cretaceous Moreno Shale, the Campanian of Stanford University campus (GRAHAM & CHURCH, 1963), and the Maastrichtian of the Panoche Group, Merced County (MARTIN, 1964). European occurrences include the middle and upper Campanian of Germany.

Types and occurrence.—Figured hypotype (Fig. 19, UCLA 44157) from sample S-11; figured hypotype (Fig. 20, UCLA 44158) from sample S-4; both from Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (J88, L131, D143).

NEOFLABELLINA RUGOSA (d'Orbigny)

Plate 8, figure 21

Flabellina rugosa D'ORBIGNY, 1840, p. 23, pl. 2, fig. 4-5, 7.——BROTZEN, 1936, p. 107, fig. 35.

Palmula rugosa (d'Orbigny), CUSHMAN, 1946, p. 83, pl. 31, fig. 9-16 (not 17).

Neoflabellina rugosa (d'Orbigny), LOEBLICH & TAPPAN, 1964, p. C522, fig. 407, 6.——MARTIN, 1964, p. 72, pl. 7, fig. 9.

Test free, large, palmate, compressed, periphery truncate, sides parallel. Chambers initially planispiral, later rectilinear, elongate, narrow, equitant. Sutures distinct, elevated, acute, continuous. Wall calcareous, perforate, surface between sutures tuberculate. Aperture terminal, radiate, produced.

Maximum length of figured hypotype, 1.35 mm.; breadth, 0.79 mm.; thickness, 0.18 mm.

Discussion.—This species, originally described from the Craie Blanche, is distinguished from *Neoflabellina pilulifera* by the palmate test, slightly wider chambers, and tuberculate surface ornamentation. The present specimens are relatively scarce and vary considerably in test outline. Many are identical to the European subspecies *N. rugosa leptodisca* (WEDEKIND) but are intergradational to other forms in the population. For this reason, the recognition here of the subspecies recorded in Europe by WEDEKIND (1940) and HILTERMANN & KOCH (1955, 1956, 1957, 1960) must await the recovery of larger populations. In the La Jolla section, *N. rugosa* is restricted to the lower samples whereas *N. pilulifera* extends higher in the section. The specimens illustrated as *N. rugosa* by MCGUGAN (1964) from the Senonian of Vancouver Island, Canada, are not presently included in the synonymy as they lack the distinctly tuberculate surface ornamentation. *N. rugosa* occurs throughout Austin, Taylor, and Navarro strata in the American Gulf Coast and the Senonian of Europe.

Types and occurrence.—Figured hypotype (UCLA 44159) from sample C-2, Rosario Formation at Carlsbad. Unfigured hypotypes from Rosario Formation at La Jolla and Punta Descanso (C82, J83, D141).

Genus PALMULA Lea, 1833

PALMULA PRIMITIVA Cushman

Plate 8, figure 14-15

Palmula primitiva CUSHMAN, 1939, p. 91, pl. 16, fig. 4-5.——CUSHMAN, 1946, p. 84, pl. 32, fig. 1-2.——BANDY, 1951, p. 495, pl. 72, fig. 14.——MARTIN, 1964, p. 72, pl. 7, fig. 2.

Falsopalmula primitiva (Cushman), POŻARYSKA, 1957, p. 169, pl. 20, fig. 2.

Test free, elongate, compressed, initially planispirally coiled, later uncoiled, rectilinear, with low, arched chambers. Sutures distinct, limbate, slightly depressed to flush. Wall calcareous, finely perforate, surface may have fine longitudinal striae, especially over sutures. Aperture terminal, radiate.

Maximum length of figured hypotypes, 0.66 to 0.85 mm.; breadth, 0.22 to 0.29 mm.; thickness, 0.10 to 0.12 mm.

Discussion.—*Palmula primitiva* is presently restricted to Carlsbad where it occurs in all but one sample. Two forms are present; one has a globular proloculus, a more elongate test, lacks striations, and shows less tendency to develop chevron-shaped chambers; the other has a wider test, chevron chambers, and fine striations. These 2 forms seem to represent different generations in the life cycle. The present specimens are nearly identical to the original illustrations from the Pecan Gap Member of the Taylor Marl of Texas. American Gulf Coast occurrences are limited to Taylor strata.

Types and occurrence.—Figured hypotypes (Fig. 14-15, UCLA 44160-44161) from sample C-3, Rosario Formation at Carlsbad (C49).

Genus PSEUDONODOSARIA Boomgaart, 1949

PSEUDONODOSARIA MANIFESTA (Reuss)

Plate 8, figure 18

Glandulina manifesta REUSS, 1851, p. 22, pl. 1, fig. 4.——CUSHMAN & CHURCH, 1929, p. 511, pl. 39, fig. 10.

Nodosaria larva CARSEY, 1926, p. 31, pl. 2, fig. 2.

Pseudoglandulina manifesta (Reuss), CUSHMAN, 1946, p. 76, pl. 27, fig. 20-26.

Pseudonodosaria larva (Carsey), LOEBLICH & TAPPAN, 1955, p. 6, pl. 1, fig. 1-7.——MARTIN, 1964, p. 59, pl. 4, fig. 11.

Rectoglandulina sp. B, GRAHAM & CHURCH, 1963, p. 46, pl. 5, fig. 3.

Test free, elongate, uniserial, rectilinear. Chambers strongly overlapping, becoming inflated. Sutures distinct, initially flush, limbate, later depressed. Wall calcareous, finely perforate, surface smooth. Aperture terminal, radiate.

Maximum length of figured hypotype, 0.43 mm.; diameter, 0.10 mm.

Discussion.—This species is distinguished by the strongly overlapping chambers, short, tapering test and radiate aperture. The present forms are identical to those in my collection from the Kemp Clay (loc. 19 of CUSHMAN, 1946). Morphologic variation is noted in the degree of apical bluntness, depression of sutures, and length of test. Originally described from the Upper Cretaceous of Poland, this widespread species ranges from Austin to Navarro age in the American Gulf Coast.

Types and occurrence.—Figured hypotype (UCLA 44162) from sample C-5, Rosario Formation at Carlsbad. Unfigured hypotypes from Rosario Formation at La Jolla and Punta Descanso (C130, J46, D155).

PSEUDONODOSARIA OBESA (Loeblich & Tappan)

Plate 8, figure 17

Rectoglandulina obesa LOEBLICH & TAPPAN, 1955, p. 5, pl. 1, fig. 5-6.——GRAHAM & CHURCH, 1963, p. 46, pl. 5, fig. 1.

Test free, ovate in outline, initial end pointed. Chambers distinct, strongly embracing, uniserially arranged, rectilinear. Sutures distinct, flush. Wall calcareous, finely perforate, surface smoothly finished. Aperture terminal, radiate.

Maximum length of figured hypotype, 0.39 mm.; diameter, 0.29 mm.

Discussion.—Originally described from the lower Campanian Ozan sand of Arkansas, this species is recognized by its oval outline and large final chamber. The present specimens occur characteristically at Carlsbad with a single additional occurrence at Point Loma.

Types and occurrence.—Figured hypotype (UCLA 44163) from sample C-3, Rosario Formation at Carlsbad. Unfigured hypotype from Rosario Formation at Point Loma (C113, L110).

PSEUDONODOSARIA sp.

Plate 8, figure 16

Test free, small, elongate, rectilinear. Chambers uniserial, overlapping, becoming slightly inflated. Sutures distinct, depressed. Wall calcareous, hyaline, finely perforate, surface smooth. Aperture terminal, radiate, slightly produced.

Maximum length of figured specimen, 0.26 mm.; diameter, 0.10 mm.

Discussion.—Only rare specimens were found at La Jolla and Carlsbad. They resemble *Pseudonodosaria kirschneri* (TAPPAN, 1957) from the Albian of Alaska but are smaller and lack the inflated final chamber.

Types and occurrence.—Figured specimen (UCLA 44164) from sample S-3, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Carlsbad (C138, J78).

Genus SARACENARIA Defrance in de Blainville, 1824

SARACENARIA CALIFORNICA Sliter, n. sp.

Plate 9, figure 5

Test free, lenticular, initial portion planispirally coiled, later uncoiling, periphery carinate, apertural face flattened. Chambers numerous, 10 to 12 in final whorl, low, elongate, increasing gradually in size. Sutures distinct, limbate, flush, curved. Wall calcareous, finely perforate, surface smoothly finished. Aperture at peripheral angle, radiate.

Maximum diameter of holotype, 0.58 mm.; thickness, 0.27 mm.

Discussion.—This species is easily recognized by the numerous chambers, keeled periphery, and tendency to uncoil in later stage. A somewhat similar species, *Saracenaria sina* (KARRER) (1870) from the Upper Cretaceous of Germany, becomes more elongate and has a more distinctive apertural face and sinuous sutures. *S. californica* occurs at La Jolla, Point Loma and more rarely at Punta Descanso in strata of Campanian to Maastrichtian age.

Types and occurrence.—Holotype (UCLA 44170) from sample S-15; paratype (UCLA 44171) from sample S-17; both from Rosario Formation at La Jolla. Unfigured paratypes from Rosario Formation at Point Loma and Punta Descanso (J76, L117, D94).

SARACENARIA JARVISI (Brotzen)

Plate 8, figure 21

Astacolus jarvisi BROTZEN, 1936, p. 56, fig. 17 *(partim)*, pl. 3, fig. 6-7.

Saracenaria jarvisi (Brotzen), SCHIJFSMA, 1946, p. 61, pl. 3, fig. 2.

Test free, elongate, initially planispiral, later uncoiling, apertural face relatively narrow, margins acute. Chambers elongate, narrow, curved. Sutures distinct, flush to slightly depressed, limbate. Wall calcareous, finely perforate, radiate in structure, surface smooth. Aperture terminal, radiate.

Maximum length of figured hypotype, 0.87 mm.; breadth, 0.46 mm.; thickness, 0.32 mm.

Discussion.—A few rare specimens at Carlsbad, referred to this species, differ from *Saracenaria saratogana* HOWE & WALLACE in being smaller, more compressed and in having acute margins. In the original concept of the species, BROTZEN included 2 types which he believed to be representative of variation within the population. In the present samples, they seem not to be intergradational. Type 1 (BROTZEN, 1936, fig. 17,*1-2*) represents specimens here placed in *S. triangularis* (D'ORBIGNY) while type 2 *(3-5)* is similar to the present forms. Thus the concept of *S. jarvisi* is restricted to those specimens illustrated by BROTZEN (fig. 17,*3-5*; pl. 5, fig. 6-7). A similar form illustrated by TAKAYANAGI (1960) as *S. saratogana* may be synonymous.

Types and occurrence.—Figured hypotype (UCLA 44165) from sample C-1, Rosario Formation at Carlsbad (C81).

SARACENARIA NAVICULA (d'Orbigny)

Plate 9, figure 1

Cristellaria navicula D'ORBIGNY, 1840, p. 27, pl. 2, fig. 19-20.

Lenticulina navicula (d'Orbigny), CUSHMAN, 1946, p. 56, pl. 18, fig. 16.

Saracenaria navicula (d'Orbigny), BANDY, 1951, p. 493, pl. 72, fig. 12.——HAGN, 1953, p. 52, pl. 6, fig. 6.

Test free, planispiral, periphery subacute to acute, apertural face of final chamber flattened to gently convex, broad, periphery subacute to somewhat rounded. Chambers 7 to 9 in final whorl, increasing moderately in size, becoming elongated. Sutures distinct, curved, limbate, flush. Wall calcareous, finely perforate, surface smooth. Aperture at peripheral angle, radiate.

Maximum diameter of figured hypotype, 0.83 mm.; thickness, 0.48 mm.

Discussion.—Originally described from the Craie Blanche, *Saracenaria navicula* is distinguished from *S. jarvisi* by the involute test and relatively wide apertural face. Specimens are quite variable. In the lower samples at La Jolla, they have a broad flattened apertural face with a distinctly angular periphery. By the top of the section, a second form has appeared, which is recognized by the thinner test and more convex apertural face with less angular periphery. The latter type is also found most commonly at Carlsbad but intergrades with a less common angular form. Both types are presently included in *S. navicula*.

Types and occurrence.—Figured hypotype (UCLA 44166) from sample S-18, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Carlsbad, Point Loma and Punta Descanso (C41, J19, L45, D29).

SARACENARIA SARATOGANA Howe & Wallace

Plate 8, figure 2

Saracenaria italica Cushman (*non* Defrance), CUSHMAN, 1931a, p. 305, pl. 34, fig. 15-16.

Saracenaria saratogana HOWE & WALLACE, 1932, p. 40.——CUSHMAN, 1946, p. 58, pl. 28, fig. 4-6.

Test free, large, elongate, initially biserial, later uncoiling, margins subacute to rounded. Chambers elongate, curved, increasing rapidly in size. Sutures distinct, flush, curved. Wall calcareous, finely perforate, radial in structure, surface smooth. Aperture terminal, radiate.

Maximum length of figured hypotype, 0.99 mm.; breadth, 0.56 mm.; thickness, 0.58 mm.

Discussion.—Originally described from the Saratoga Chalk of Arkansas, this species has a tendency to uncoil in the later stage and has rounded margins and an elongate test. The present specimens are most common at Carlsbad and infrequent at La Jolla and Point Loma. In the American Gulf Coast, *Saracenaria saratogana* is characteristic of Maastrichtian strata.

Types and occurrence.—Figured hypotype (UCLA 44167) from sample S-1, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Carlsbad and Point Loma (C85, J41, L98).

SARACENARIA TRIANGULARIS (d'Orbigny)

Plate 9, figure 3-4

Cristellaria triangularis D'ORBIGNY, 1840, p. 27, pl. 2, fig. 21-22.

Saracenaria triangularis (d'Orbigny), CUSHMAN, 1946, p. 58, pl. 28, fig. 1-3.——BANDY, 1951, p. 494, pl. 72, fig. 11.——HAGN, 1953, p. 52, pl. 6, fig. 4.——SAID & KENAWY, 1956, p. 131, pl. 3, fig. 1.——TRUJILLO, 1960, p. 316, pl. 45, fig. 12.

Saracenaria sp. cf. *S. triangularis* (d'Orbigny), TAKAYANAGI, 1960, p. 106, pl. 6, fig. 8.

Saracenaria jarvisi (Brotzen), GRAHAM & CHURCH, 1963, p. 46, pl. 5, fig. 13.

Test free, large, initially planispirally coiled, later tending to uncoil, triangular in transverse section, margins acute. Chambers elongate, curved, increasing rapidly in size. Sutures distinct, flush to slightly depressed, curved. Wall calcareous, finely perforate, structure radial, surface smooth. Aperture terminal, radiate.

Maximum length of figured hypotypes, 0.46 to 1.29 mm.; breadth, 0.34 to 0.70 mm.; thickness, 0.31 to 0.66 mm.

Discussion.—Specimens here assigned to this species show considerable variation and, with the exception of Carlsbad, occur rather sporadically. They appear to be part of a gradational population that is distinguished from *Saracenaria saratogana* by its wider, more distinct triangular section, acute margins, and a lessened tendency to uncoil. Certain forms resemble *S. pseudonavicula* MARIE (1941) but no basis is presently available for separating these as a distinct species. Originally described from the Craie Blanche, *S. triangularis* ranges in the American Gulf Coast from Austin to Navarro age.

Types and occurrence.—Figured hypotype (Fig. 3, UCLA 44169) from sample S-1, Rosario Formation at La Jolla. Figured hypotype (Fig. 4, UCLA 44168) from sample C-2, Rosario Formation at Carlsbad. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (C67, J40, L136, D83).

Genus TRIBRACHIA Schubert, 1912

TRIBRACHIA sp.

Plate 9, figure 6

Test free, elongate, narrow, uniserial, rectilinear, triangular in section, peripheral angles truncate. Chambers distinct, numerous, low, strongly arched. Sutures distinct, strongly curved, slightly depressed. Wall calcareous, hyaline, finely perforate, surface smooth, with longitudinal costae. Aperture terminal, radiate.

Maximum length of figured specimen, 1.48 mm.; breadth, 0.26 mm.

Discussion.—Only 2 fragments of this form were recovered from the upper samples at La Jolla. It differs from *Tribrachia tricarinata* (D'ORBIGNY) (1840), originally described from the Craie Blanche, in having longitudinal costae and a somewhat less lobate periphery. Nevertheless, it appears to be closely related to the latter species and may constitute a morphologic variant.

Type and occurrence.—Figured specimen (UCLA 44172) from sample S-26, Rosario Formation at La Jolla (J192).

Genus VAGINULINA d'Orbigny, 1826

VAGINULINA OLSSONI Sliter, n. sp.

Plate 9, figure 7

Nodosaria confluens Reuss, EGGER, 1899-1902, p. 72, pl. 9, fig. 27-28.

Test free, elongate, straight to slightly arcuate, compressed, with basal spine. Chambers initially overlapping, later elongate and inflated. Sutures distinct, transverse to the longitudinal axis, limbate, flush in early stage, later depressed. Wall calcareous, finely perforate, surface ornamented with numerous, distinct, longitudinal costae. Aperture terminal, marginal, produced on distinct neck, radiate.

Maximum length of holotype, 1.36 mm.; breadth, 0.24 mm.; thickness, 0.19 mm.

Discussion.—This species differs from the original illustrations of *Dentalina confluens* (REUSS, 1862) in being compressed throughout, in lacking subglobular ultimate chambers, and in having a more distinct apertural neck. The form referred to the latter species by EGGER is nearly identical to the present specimens and is here included in synonymy. Examined hypotypes from the upper Taylor Marl (loc. 148 of CUSHMAN, 1946) in the American Gulf Coast which are referred to *D. confluens* do indeed belong to that genus. Furthermore, the specimen illustrated by OLSSON as *D. crosswicksensis* OLSSON (1960) from the Hornerstown Formation of New Jersey appears to be a topotype of *D. confluens*, originally described from the Cretaceous greensand of New Jersey. It seems obvious that the present specimens are clearly distinct from *D. confluens* and represent a new species of *Vaginulina*. This species is presently limited to the Carlsbad locality and occurs throughout the section.

Types and occurrence.—Holotype (UCLA 44174) from sample C-4; paratype (UCLA 44175) from sample C-7; both from Rosario Formation at Carlsbad (C20).

VAGINULINA PLUMMERAE (Cushman)

Plate 9, figure 8

Marginulina plummerae CUSHMAN, 1937a, p. 97, pl. 13, fig. 21-23.—POŻARYSKA, 1957, p. 110, pl. 13, fig. 5.

Vaginulina plummerae (Cushman), BANDY, 1951, p. 494, pl. 72, fig. 15.

Test free, elongate, straight to gently arcuate, compressed, more strongly so in early stage. Chambers numerous, initially overlapping, later becoming inflated. Sutures distinct, flush to slightly raised in early stage, especially limbate in middle portion, later depressed. Wall calcareous, finely perforate, surface smoothly finished. Aperture terminal, radiate.

Maximum length of figured hypotype, 1.55 mm.; breadth, 0.29 mm.; thickness, 0.24 mm. Other hypotypes range to 2.30 mm. in length.

Discussion.—The present specimens are identical to hypotypes in my collection from the Kemp Clay (loc. 19 of CUSHMAN, 1946). They occur most commonly at Carlsbad, with a few rare specimens present at Punta Descanso. Originally described from the Corsicana Marl of Texas, the American Gulf Coast occurrences of this species are characteristic of the Navarro.

Types and occurrence.—Figured hypotype (UCLA 44173) from sample C-3, Rosario Formation at Carlsbad. Unfigured hypotypes from Rosario Formation at Punta Descanso (C57, D112).

Genus VAGINULINOPSIS Silvestri, 1904

VAGINULINOPSIS DIRECTA (Cushman)

Plate 9, figure 9

Marginulina austinana Cushman var. *directa* CUSHMAN, 1937a, p. 93, pl. 13, fig. 5-8.——CUSHMAN, 1946, p. 59, pl. 20, fig. 11-16.
Marginulina directa Cushman, BANDY, 1951, p. 498, pl. 73, fig. 1.

Test free, elongate, compressed, initial portion planispirally coiled, later uncoiling. Chambers numerous, increasing gradually in size in later stage, becoming slightly inflated. Sutures distinct, gently curved, flush in early stage, later depressed, limbate throughout, somewhat more strongly centrally and at outer margin. Wall calcareous, finely perforate, surface smoothly finished. Aperture terminal, marginal, radiate.

Maximum length of figured hypotype, 1.87 mm.; breadth, 0.65 mm.; thickness, 0.43 mm.

Discussion.—Originally described from the Austin Chalk of Texas, this species differs from *Vaginulinopsis silicula* (PLUMMER, 1931) in being relatively smaller and less compressed and in lacking the basal spines and raised, limbate sutures. The species is locally confined to the Carlsbad section with two rare occurrences at La Jolla. The American Gulf Coast specimens range from upper Austin to the middle of the Taylor Group.

Types and occurrence.—Figured hypotype (UCLA 44176) from sample C-3, Rosario Formation at Carlsbad. Unfigured hypotypes from Rosario Formation at La Jolla (C121, J181).

Subfamily LINGULININAE Loeblich & Tappan, 1961

Genus LINGULINA d'Orbigny, 1826

LINGULINA PYGMAEA Reuss

Plate 9, figure 10

Lingulina pygmaea REUSS, 1875, p. 90, pl. 2 (20), fig. 23.——GRAHAM & CHURCH, 1963, p. 37, pl. 3, fig. 24-25.
Lingulina californiensis TRUJILLO, 1960, p. 314, pl. 45, fig. 8.

Test free, elongate, compressed, uniserial, nearly parallel-sided, periphery slightly lobate, edge subacute, initial end commonly blunt, with ragged periphery. Chambers slightly inflated, overlapping, increasing gradually in size. Sutures distinct, slightly depressed, limbate. Wall calcareous, finely perforate, surface smooth. Aperture a terminal, ovate slit.

Maximum length of figured hypotype, 0.34 mm.; breadth, 0.22 mm.; thickness, 0.15 mm.

Discussion.—This distinctive species is rare at La Jolla and Point Loma and the specimens are identical to those recorded by GRAHAM & CHURCH (1963) from the Campanian of the Stanford University campus. Examination of the holotype and paratypes of *Lingulina californiensis* TRUJILLO from the Coniacian of northern California shows it to be synonymous. *L. californiensis* of MARTIN (1964), from the upper Santonian of California, differs in having the small projecting keels characteristic of *L. taylorana* CUSHMAN. The Gulf Coast specimen referred to by CUSHMAN (1946) differs in having relatively fewer, higher chambers and less limbate sutures. These specimens may represent a morphologic variation or a distinct species. The California stratigraphic range of *L. pygmaea* is from Coniacian to Maastrichtian.

Types and occurrence.—Figured hypotype (UCLA 44177) from sample S-30, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma (J144, L167).

LINGULINA sp.

Plate 9, figure 11

Test free, elongate, compressed, slightly arcuate, periphery rounded. Chambers inflated, overlapping, increasing moderately in size. Sutures distinct, depressed. Wall calcareous, finely perforate, hyaline, surface smoothly finished. Aperture an elongate, terminal slit, displaced to one side.

Maximum length of figured specimen, 0.54 mm.; breadth, 0.17 mm.; thickness, 0.15 mm.

Discussion.—This specimen bears some resemblance to the arcuate Albian species, *Lingulina stillula* BERTHELIN.

Types and occurrence.—Figured specimen (UCLA 44178) from sample E-12, Rosario Formation at Punta Descanso (D142).

Genus BERTHELINELLA Loeblich & Tappan, 1957

BERTHELINELLA MINUTA (Sullivan)

Plate 9, figure 12-13

Plectofrondicularia minuta SULLIVAN, 1962, p. 269, pl. 13, fig. 1-4.

Test free, elongate, compressed, initially biserial or uniserial, flaring, later nearly parallel-sided, uniserial, periphery subrounded. Chambers few, biserial portion generally consisting of 3 globular chambers, followed by curved, narrow and inflated uniserial chambers; peripheral spines at base of chamber tend to become reduced in adult stage. Sutures distinct, depressed. Wall calcareous, finely perforate, surface granular. Aperture a terminal elongate slit.

Maximum length of hypotype, 1.16 mm.; breadth, 0.37 mm.; thickness, 0.10 mm.

Discussion.—Originally described from the Eocene of California, this species includes 2 forms; the rarer specimens have a globular proloculus followed by uniserial chambers while in the more common forms, the initial chambers are biserially arranged. Specimens lacking a biserial stage somewhat resemble *Lingulina praelonga* TEN DAM (1946) from the Lower Cretaceous of the Netherlands but are larger and have a spinose periphery and granular texture. The present specimens are here referred to *Berthelinella* on the basis of the nonradiate, slitlike aperture and elongate, palmate test. This species occurs in the upper samples at La Jolla and the lower samples at both Point Loma and Punta Descanso. The stratigraphic range is Campanian to Eocene.

Types and occurrence.—Figured hypotype (Fig. 12, UCLA 44179) from sample S-24, Rosario Formation at La Jolla. Figured hypotype (Fig. 13, UCLA 44181) from sample E-6, Rosario Formation at Punta Descanso (J178, L81, D57).

Genus BERTHELINOPSIS Sliter, n. gen.

Type species.—Berthelinopsis carlsbadensis SLITER, n. sp.

Test free, elongate, compressed, periphery subrounded. Chambers elongate, narrow, biserially arranged throughout. Wall calcareous, finely perforate, radial in structure. Aperture terminal, slitlike.

Discussion.—*Berthelinopsis* differs from the genus *Berthelinella* in lacking the uniserial ultimate stage, truncate periphery, and palmate outline. The final chamber may be elongate, but the aperture remains terminal rather than at the base of the final chamber as in *Bolivina*, and there is no tooth plate.

BERTHELINOPSIS CARLSBADENSIS Sliter, n. sp.

Plate 9, figure 16

Test free, small, elongate, compressed, periphery subrounded. Chambers biserially arranged, elongate, narrow, slightly overlapping from 3 to 4 pairs in adult. Sutures distinct, flush. Wall calcareous, finely perforate, radial in structure, surface smooth. Aperture an elongate slit in plane of compression.

Maximum length of holotype, 0.31 mm.; breadth, 0.14 mm.; thickness, 0.90 mm.

Discussion.—This minute species occurs rarely at Carlsbad and shows some morphologic variation in the shape of the final chamber and the amount of slight twisting of the initial chambers. The stratigraphic range is middle to upper Campanian.

Types and occurrence.—Holotype (UCLA 44182) from sample C-4; paratype (UCLA 44183) from sample C-3; both from Rosario Formation at Carlsbad (C118).

Genus ELLIPSOCRISTELLARIA Silvestri, 1920

ELLIPSOCRISTELLARIA sp.

Plate 9, figure 14

Globulina sp. A, GRAHAM & CHURCH, 1963, p. 49, pl. 5, fig. 17.

Test free, small subspherical, slightly compressed, planispiral, 3 chambers in final whorl. Chambers subglobular, inflated, strongly embracing. Sutures distinct,

EXPLANATION OF PLATE 9

FIGURE

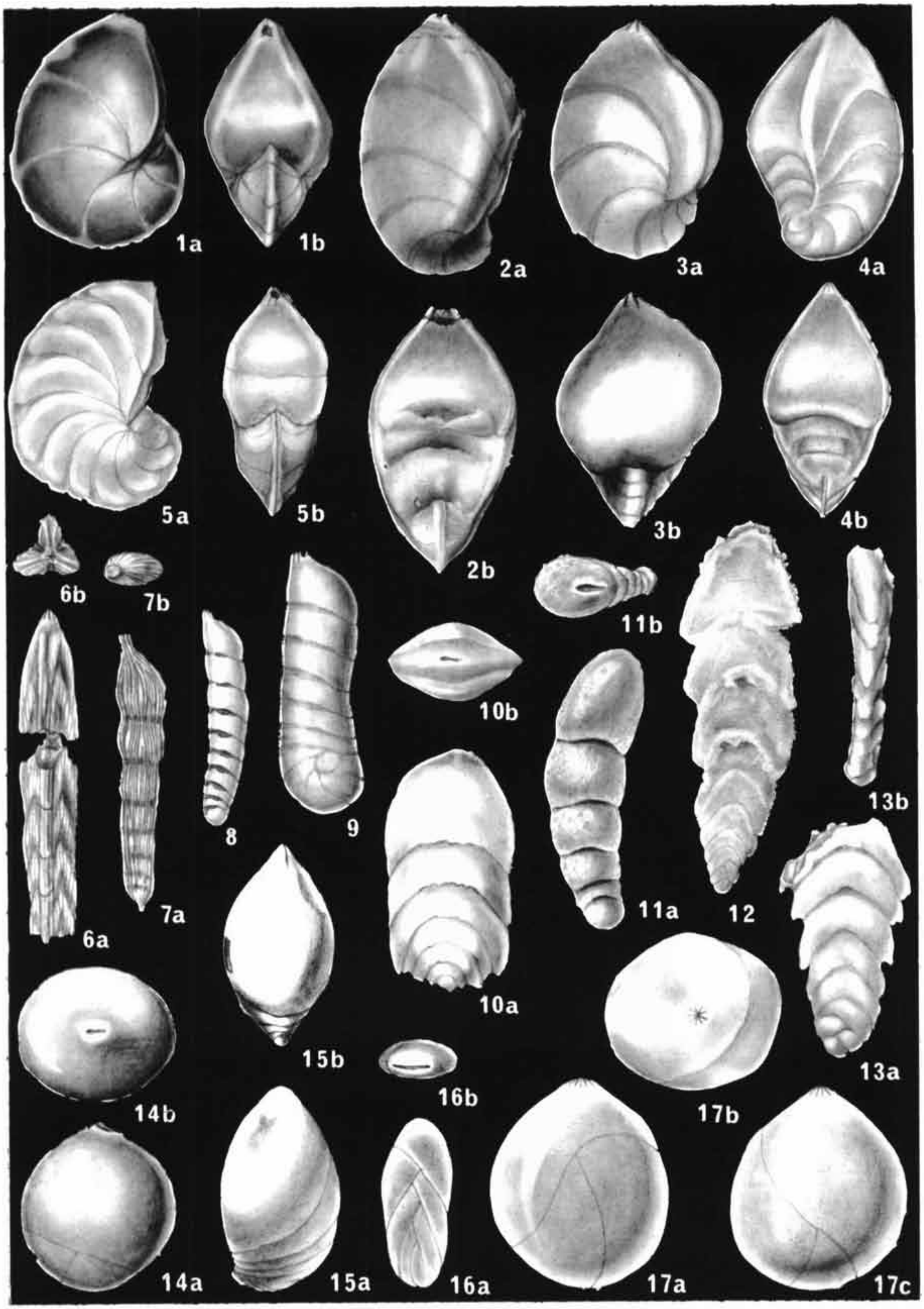
1. *Saracenaria navicula* (D'ORBIGNY); 1a,b, side and face views, ×52 (p. 73).
2. *Saracenaria saratogana* HOWE & WALLACE; 2a,b, side and face views, ×45 (p. 73).

3-4. *Saracenaria triangularis* (D'ORBIGNY); 3a,b, side and face views, ×89; 4a,b, side and face views, ×33 (p. 74).

5. *Saracenaria californica* SLITER, n. sp.; 5a,b, side and face views, ×66 (p. 73).
6. *Tribrachia* sp.; 6a,b, side and apertural views, ×33 (p. 74).
7. *Vaginulina olssoni* SLITER, n. sp.; 7a,b, side and apertural views, ×33 (p. 74).
8. *Vaginulina plummerae* (CUSHMAN); side view, ×23 (p. 74).
9. *Vaginulinopsis directa* (CUSHMAN); side view, ×23 (p. 75).
10. *Lingulina pygmaea* REUSS; 10a,b, side and apertural views, ×97 (p. 75).
11. *Lingulina* sp.; 11a,b, side and apertural views, ×89 (p. 75).

12-13. *Berthelinella minuta* (SULLIVAN); 12, side view of holotype, ×52; 13a,b, side and edge views of paratype, ×66 (p. 75).

14. *Ellipsocristellaria* sp.; 14a,b, side and apertural views, ×187 (p. 76).
15. *Lingulinopsis* sp.; 15a,b, side and edge views, ×66 (p. 77).
16. *Berthelinopsis carlsbadensis* SLITER, n. gen., n. sp.; 16a,b, side and apertural views, ×97 (p. 76).
17. *Globulina lacrima* (REUSS); 17a-c, opposite sides and apertural views, ×97 (p. 77).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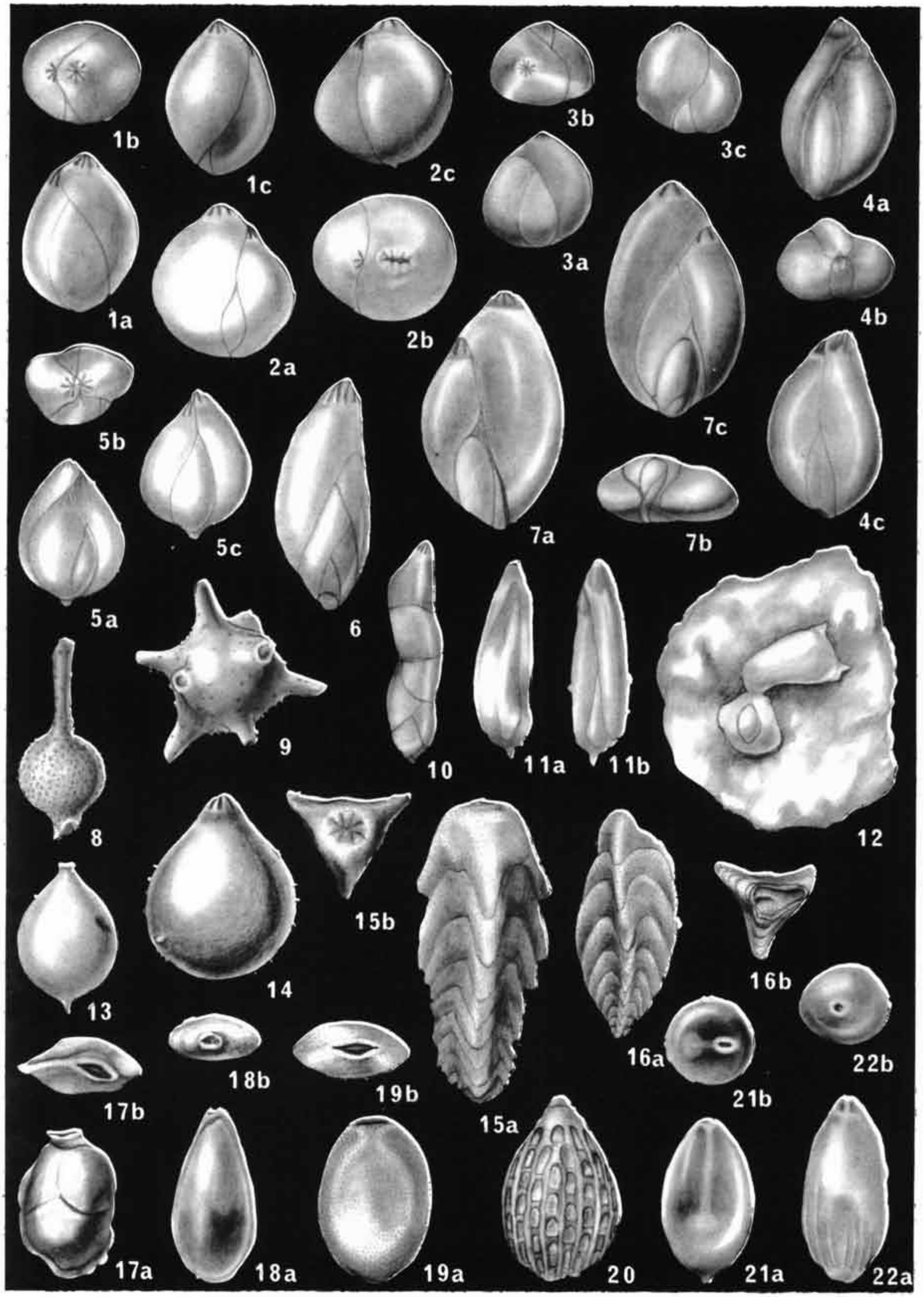
Sliter — Upper Cretaceous Foraminifera, Southern California and Northwestern Mexico.



flush. Wall calcareous, finely perforate, surface smoothly finished. Aperture a terminal slit, parallel to plane of compression.

Maximum length of figured specimen, 0.14 mm.; thickness, 0.12 mm. Other specimens range to 0.27 mm. in length.

Discussion.—Only a few, rare specimens of this foraminifer were found in the upper samples at La Jolla. The subglobular, planispirally arranged chambers and slitlike aperture distinguish this form.

Types and occurrence.—Figured specimen (UCLA 44184) from sample S-22, Rosario Formation at La Jolla (J172).

Genus LINGULINOPSIS Reuss, 1860

LINGULINOPSIS sp.

Plate 9, figure 15

Test free, slightly compressed, initially enrolled, later uncoiling, becoming uniserial, periphery subrounded. Chambers numerous, inflated, strongly embracing, earlier chambers narrow, arcuate. Sutures distinct, slightly depressed. Wall calcareous, finely perforate, smooth. Aperture an elongate, terminal slit in plane of compression.

Maximum length of figured specimen, 0.53 mm.; breadth, 0.31 mm.; thickness, 0.29 mm.

Discussion.—A single specimen of this distinctive form was recovered from Point Loma.

Types and occurrence.—Figured specimen (UCLA 44185) from sample L-13, Rosario Formation at Point Loma (L132).

Family POLYMORPHINIDAE d'Orbigny, 1839

Subfamily POLYMORPHININAE d'Orbigny, 1839

Genus GLOBULINA d'Orbigny, 1839

GLOBULINA LACRIMA (Reuss)

Plate 9, figure 17; Plate 10, figure 1

Polymorphina (Globulina) lacrima REUSS, 1845, p. 40, pl. 12, fig. 6, pl. 13, fig. 83.

Globulina lacrima Reuss, CUSHMAN, 1946, p. 96, pl. 40, fig. 11-12. ——HOFKER, 1957, p. 170, fig. 212-213.

Globulina lacrima lacrima (Reuss), GRAHAM & CHURCH, 1963, p. 48, pl. 5, fig. 15.

Test free, subglobular, tending to become elongate. Chambers strongly appressed, extending nearly to the base, becoming sigmoidal. Sutures distinct, flush. Wall calcareous, finely perforate, surface smooth. Aperture terminal, radiate.

Maximum length of figured hypotypes, 0.36 to 0.41 mm.; breadth, 0.31 mm.; thickness, 0.27 to 0.31 mm.

Discussion.—This cosmopolitan species is characterized by the somewhat elongate, subglobular test and flush sutures. It is common at Carlsbad and rare at La Jolla and Point Loma. This species occurs in Europe and in North America where it is most characteristic of Taylor and Navarro strata.

Types and occurrence.—Figured hypotype (Fig. 17, UCLA 44187) from sample S-37, Rosario Formation at La Jolla. Figured hypotype (Fig. 1, UCLA 44186) from sample L-19, Rosario Formation at Point Loma. Unfigured hypotypes from Rosario Formation at Carlsbad (C127, J173, L82).

EXPLANATION OF PLATE 10

FIGURE

1. *Globulina lacrima* (REUSS); 1a-c, opposite sides and apertural views, ×66 (p. 77).
2-3. *Globulina subsphaerica* (BERTHELIN); 2a-c, opposite sides and apertural views, ×97; 3a-c, same, ×129 (p. 78).
4, 7. *Guttulina adhaerens* (OLSZEWSKI); 4a-c, opposite sides and basal views, ×66; 7a-c, same, ×97 (p. 78).
5. *Guttulina cuspidata* CUSHMAN & OZAWA; 5a-c, opposite sides and apertural views, ×89 (p. 78).
6. *Pyrulina apiculata* (MARIE); side view, ×97 (p. 78).
8. *Ramulina pseudoaculeata* (OLSSON); side view, ×33 (p. 79).
9. *Ramulina globotubulosa* (CUSHMAN); side view, ×129 (p. 79).
10. *Pyrulina* sp. cf. *P. cylindroides* (ROEMER); side view, ×17 (p. 78).
11. *Sigmomorphina* sp.; 11a,b, opposite sides, ×97 (p. 79).
12. *Vitriwebbina biosculata* FRIZZELL; side view, ×33 (p. 79).
13. *Oolina apiculata* REUSS; side view, ×97 (p. 80).
14. *Oolina globulosa* (MONTAGUQ; side view, ×66 (p. 80).
15. *Tristix* sp.; 15a,b, side and apertural views, ×52 (p. 80).
16. *Trixtix excavata* (REUSS); 16a,b, side and apertural views, ×129 (p. 79).
17. *Seabrookia cretacica* BERMÚDEZ; 17a,b, side and apertural views, ×187 (p. 80).
18-19. *Fissurina oblonga* REUSS; 18a,b, 19a,b, side and apertural views, ×129 (p. 82).
20. *Oolina* sp. cf. *O. tokaoi* (ASANO); side view, ×129 (p. 81).
21-22. *Oolina delicata* SLITER, n. sp.; 21a,b, side and apertural views of holotype, ×129; 22a,b, side and apertural views of paratype, ×187 (p. 80).

GLOBULINA SUBSPHAERICA (Berthelin)

Plate 10, figure 2-3

Polymorphina subsphaerica BERTHELIN, 1880, p. 58, pl. 4, fig. 18.
Globulina lacrima Reuss var. *subsphaerica* (Berthelin), CUSHMAN & GOUDKOFF, 1944, p. 57, pl. 9, fig. 14.——CUSHMAN, 1946, p. 96, pl. 40, fig. 13.——HOFKER, 1957, p. 171, fig. 214-215.
Globulina lacrima Reuss subsp. *subsphaerca* (Berthelin), MARTIN, 1964, p. 73, pl. 7, fig. 13, pl. 8, fig. 1.

Test free, subglobular, slightly compressed, chambers strongly overlapping, usually 3 visible in final whorl, increasing rapidly in size, causing test to be more produced on one side. Sutures distinct, usually flush. Wall calcareous, finely perforate, surface smooth. Aperture terminal, radiate.

Figured hypotypes range in length from 0.15 to 0.27 mm.; breadth, 0.14 to 0.27 mm.; thickness, 0.12 to 0.24 mm.

Discussion.—This species is characterized by the subglobular, slightly compressed test. The present specimens are smaller than the Gulf Coast material but otherwise identical. Occurrences are limited to the upper samples at La Jolla and less commonly at Point Loma and Punta Descanso. Originally described from the Albian of France, this species ranges to the Maastrichtian.

Types and occurrence.—Figured hypotype (Fig. 3, UCLA 44188) from sample BR-2, Rosario Formation at La Jolla. Figured hypotype (Fig. 2, UCLA 44189) from sample L-2, Rosario Formation at Point Loma. Unfigured hypotypes from Rosario Formation at Punta Descanso (J143, L41, D31).

Genus GUTTULINA d'Orbigny, 1839

GUTTULINA ADHAERENS (Olszewski)

Plate 10, figure 4, 7

Polymorphina adhaerens OLSZEWSKI, 1875, p. 119, pl. 1, fig. 11.
Guttulina adhaerens (Olszewski), CUSHMAN, 1946, p. 96, pl. 40, fig. 8-10.——HOFKER, 1957, p. 165, fig. 204.

Test free, compressed, ovate in outline, tending to become elongate. Chambers distinct, inflated, added in quinqueloculine series, increasing rapidly in size. Sutures distinct, slightly depressed. Wall calcareous, finely perforate, surface smoothly finished. Aperture terminal, radiate.

Maximum length of figured hypotypes, 0.39 to 0.48 mm.; breadth, 0.24 to 0.29 mm.; thickness, 0.14 to 0.20 mm.

Discussion.—This species is recognized by the compressed test, inflated chambers and slightly depressed sutures. The earlier chambers tend to project from one side, while the other side is concave. The American Gulf Coast representatives of this species, originally described from the Senonian of Poland, are most characteristic of Navarro strata.

Types and occurrence.—Figured hypotypes (Fig. 4, 7, UCLA 44191-44190) from sample C-3, Rosario Formation at Carlsbad (C89).

GUTTULINA CUSPIDATA Cushman & Ozawa

Plate 10, figure 5

Guttulina adhaerens (Olszewski) var. *cuspidata* CUSHMAN & OZAWA, 1930, p. 37, pl. 6, fig. 6.
Guttulina caudata d'Orbigny, HOFKER, 1957, p. 166, fig. 205.

Test free, compressed, flattened on one side, generally with distinct basal spine. Chambers inflated, in quinqueloculine arrangement, somewhat sigmoidal, increasing rapidly in size. Sutures distinct, depressed. Wall calcareous, finely perforate, surface smoothly finished. Aperture terminal, radiate.

Maximum length of figured hypotype, 0.27 mm.; breadth, 0.22 mm.; thickness, 0.17 mm. Other hypotypes range to 0.31 mm. in length.

Discussion.—This species, originally described from the Cretaceous of England, is distinguished from *Guttulina adhaerens* by its smaller size, more depressed sutures, relatively thicker test, and distinct basal spine. The specimen illustrated by HOFKER (1957) as *Guttulina caudata* D'ORBIGNY, seems synonymous. The present occurrence is limited to the upper samples at La Jolla and a rare occurrence at Point Loma.

Types and occurrence.—Figured hypotype (UCLA 44192) from sample S-22, Rosario Formation at La Jolla. Unfigured hypotype from Rosario Formation at Point Loma (J169, L169).

Genus PYRULINA d'Orbigny, 1839

PYRULINA APICULATA (Marie)

Plate 10, figure 6

Pyrulina cylindroides (Roemer) var. *apiculata* MARIE, 1941, p. 175, pl. 27, fig. 257-258.
Apiopterina apiculata (Marie), BANDY, 1951, p. 503, pl. 73, fig. 17.

Test free, fusiform, initial end more sharply pointed. Chambers initially triserial, later biserial, elongate, somewhat overlapping, increasing rapidly in size. Sutures distinct, flush. Wall calcareous, finely perforate, surface smooth. Aperture terminal, radiate.

Maximum length of figured hypotype, 0.43 mm.; diameter, 0.15 mm.

Discussion.—The present specimens compare favorably to the original illustration from the Campanian of France (MARIE, 1941). This species differs from *Pyrulina cylindroides* (ROEMER) in being more pointed apically, relatively thicker and less elongate. The specimen illustrated by MARTIN (1964) as *Apiopterina cylindroides* (ROEMER) may be more closely related to this species. The present specimens of *P. apiculata* are only from the Carlsbad locality.

Types and occurrence.—Figured hypotype (UCLA 44193) from sample C-4, Rosario Formation at Carlsbad (C120).

PYRULINA sp. cf. P. CYLINDROIDES (Roemer)

Plate 10, figure 10

Polymorphina cylindroides ROEMER, 1838, p. 385, pl. 3, fig. 26.

Pyrulina cylindroides (Roemer), Cushman, 1946, p. 97, pl. 40, fig. 18-19.——Hofker, 1957, p. 168, fig. 207-209.

Test free, large, elongate, initially triserial, later irregularly biserial. Chambers elongate, somewhat embracing. Sutures flush, initially somewhat indistinct, later distinct. Wall calcareous, finely perforate, surface smoothly finished. Aperture terminal, radiate.

Maximum length of figured hypotype, 2.21 mm.; diameter, 0.49 mm.

Discussion.—A single irregular specimen is compared to this species. It differs from *Pyrulina apiculata* in being much larger, more cylindrical and in having a blunt initial end.

Types and occurrence.—Figured hypotype (UCLA 44194) from sample C-5, Rosario Formation at Carlsbad (C143).

Genus SIGMOMORPHINA Cushman & Ozawa, 1928

SIGMOMORPHINA sp.

Plate 10, figure 11

Sigmomorphina sp. Graham & Church, 1963, p. 50, pl. 5, fig. 23.

Test free, elongate, compressed, with apical spine. Chambers distinct, elongate, sigmoidal, added nearly 180° apart. Sutures distinct, depressed. Wall calcareous, finely perforate, surface smooth. Aperture terminal, radiate.

Maximum length of figured specimen, 0.34 mm.; breadth, 0.10 mm.; thickness, 0.07 mm.

Discussion.—The single specimen found is identical to that figured by Graham & Church (1963) from the Campanian of the Stanford University campus.

Types and occurrence.—Figured specimen (UCLA 44195) from sample S-36, Rosario Formation at La Jolla (J214).

Subfamily WEBBINELLINAE Rhumbler, 1904

Genus VITRIWEBBINA Chapman, 1892

VITRIWEBBINA BIOSCULATA Frizzell

Plate 10, figure 12

Bullopora laevis (Sollas), Cushman & Todd, 1943b, p. 63, pl. 11, fig. 8.——Cushman, 1946, p. 98, pl. 42, fig. 1-4.
Vitriwebbina biosculata Frizzell, 1954, p. 158.

Test attached, consisting of initial oval chamber surrounded by collar-like flange, followed by series of pear-shaped chambers. Wall calcareous, finely perforate, surface smooth. Aperture at open end of 1 to 4 (typically 2) small tubular projections.

Maximum length of figured hypotype, 0.51 mm.; breadth, 0.24 mm.

Discussion.—This species occurs rarely throughout the Carlsbad section. The specimens agree well with the original illustrations from the Corsicana Marl of Texas. Specimens from the American Gulf Coast range from Austin to Navarro age.

Types and occurrence.—Figured hypotype (UCLA 44196) from sample C-2, Rosario Formation at Carlsbad (C58).

Subfamily RAMULININAE Brady, 1884

Genus RAMULINA Jones in Wright, 1875

RAMULINA GLOBOTUBULOSA Cushman

Plate 10, figure 9

Ramulina globo-tubulosa Cushman, 1938b, p. 44, pl. 7, fig. 16.

Test free, consisting of a globular chamber with numerous radiating tubular extensions. Wall calcareous, finely perforate, surface hispid. Aperture at open ends of tubular extensions.

Maximum diameter of chamber, 0.15 mm.

Discussion.—Originally described from the Ripley Formation of Tennessee, this species is recognized by the globular chamber and tubular projections. The present specimens are rare at Carlsbad and La Jolla.

Types and occurrence.—Figured hypotype (UCLA 44197) from sample C-7, Rosario Formation at Carlsbad. Unfigured hypotype from Rosario Formation at La Jolla (C145, J224).

RAMULINA PSEUDOACULEATA (Olsson)

Plate 10, figure 8

Dentalina aculeata (d'Orbigny), Cushman, 1946, p. 67, pl. 26, fig. 17-18.——Bandy, 1951, p. 499, pl. 73, fig. 4.——Martin, 1964, p. 60, pl. 4, fig. 12.
Dentalina pseudoaculeata Olsson, 1960, p. 14, pl. 3, fig. 1-2.

Test free, consisting of globular chambers with single connecting tube. Wall calcareous, finely perforate, surface spinose. Aperture at end of tubular extension.

Maximum length of figured hypotype, 0.94 mm.; diameter, 0.39 mm.

Discussion.—This species differs from *Ramulina aculeata* (d'Orbigny) (1840) in having more globular chambers and more distinctly elongate, tubular necks. Originally described from the Upper Cretaceous of New Jersey, *R. pseudoaculeata* has also been recorded from the American Gulf Coast and California. The reported California stratigraphic range is upper Santonian to Maastrichtian.

Types and occurrence.—Figured hypotype (UCLA 44198) from sample S-27, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Carlsbad and Point Loma (C98, J166, L83).

Family GLANDULINIDAE Reuss, 1860

Subfamily GLANDULININAE Reuss, 1860

Genus TRISTIX Macfadyen, 1941

TRISTIX sp. cf. T. EXCAVATA (Reuss)

Plate 10, figure 16

Rhabdogonium excavatum Reuss, 1863, p. 91, pl. 12, fig. 8.
Tristix excavata (Reuss), Hofker, 1957, p. 141, fig. 163.

Test free, elongate, uniserial, rectilinear, triangular in section. Chambers narrow, curved, increasing gradually in size. Sutures distinct, curved, slightly depressed. Wall calcareous, hyaline, finely perforate, surface smooth. Aperture obscure.

Maximum length of figured hypotype, 0.32 mm.; breadth, 0.14 mm.

Discussion.—These specimens are compared to this characteristically early Cretaceous form.

Types and occurrence.—Figured hypotype (UCLA 44199) from sample C-4, Rosario Formation at Carlsbad. Unfigured hypotype from Rosario Formation at La Jolla (C136, J191).

TRISTIX sp.

Plate 10, figure 15

Test free, large, robust, elongate, uniserial, rectilinear, triangular in section, axial periphery ragged. Chambers numerous, narrow, curved, becoming spinose at peripheral angles. Sutures distinct, depressed, curved. Wall calcareous, finely perforate, surface smooth. Aperture terminal, radiate.

Maximum length of figured specimen, 0.94 mm.; breadth, 0.39 mm.

Discussion.—This form differs from *Tristix* sp. cf. *T. excavata* in being larger, more robust, and in having spinose peripheral chamber projections. It is very rare, occurring at La Jolla and Carlsbad.

Types and occurrence.—Figured specimen (UCLA 44200) from sample S-26, Rosario Formation at La Jolla (C137, J189).

Subfamily SEABROOKIINAE Cushman, 1927

Genus SEABROOKIA Brady, 1890

SEABROOKIA CRETACICA Bermúdez

Plate 10, figure 17

Seabrookia cretacica Bermúdez, 1938, p. 164, fig. 1-3.

Test free, small, ovate, compressed, one side more convex than other, periphery carinate. Chambers indistinct, last chamber involute. Sutures indistinct, visible as slight depressions. Wall calcareous, finely perforate, surface smoothly finished. Aperture terminal, elongate, with short neck and distinct lip.

Maximum length of figured hypotype, 0.15 mm.; breadth, 0.10 mm.; thickness, 0.05 mm.

Discussion.—Originally described from the Upper Cretaceous of Cuba, this species is very rare in the present samples, occurring only at Carlsbad. The test shape and apertural characteristics make this form easily recognized.

Types and occurrence.—Figured hypotype (UCLA 44201) from sample C-2, Rosario Formation at Carlsbad (C111).

Subfamily OOLININAE Loeblich & Tappan, 1961

Genus OOLINA d'Orbigny, 1839

OOLINA APICULATA Reuss

Plate 10, figure 13

Oolina apiculata Reuss, 1851, p. 22, pl. 2, fig. 1.——Loeblich & Tappan, 1964, p. C540, fig. 425,5.

Lagena apiculata (Reuss), Cushman, 1946, p. 94, pl. 39, fig. 23.——Pożaryska, 1957, p. 40, pl. 3, fig. 9.——Martin, 1964, p. 62, pl. 5, fig. 6.

Test free, consisting of single subglobular chamber, with small apical spine. Wall calcareous, commonly hyaline, finely perforate, surface smooth. Aperture terminal, rounded, with entosolenian tube, at end of distinct neck.

Maximum length of figured hypotype, 0.26 mm.; diameter, 0.19 mm.

Discussion.—This species was originally described from the Upper Cretaceous of Poland. It is characterized by the apical spine and apertural neck. The present specimens are confined to Carlsbad.

Types and occurrence.—Figured hypotype (UCLA 44202) from sample C-3, Rosario Formation at Carlsbad (C99).

OOLINA DELICATA Sliter, n. sp.

Plate 10, figure 21-22

Test free, consisting of single ovate chamber, may have short apical spine. Wall calcareous, hyaline, finely perforate, surface smooth or finely costate at apical end. Aperture terminal, radiate, with entosolenian tube.

Maximum length of holotype, 0.24 mm.; diameter, 0.12 mm. Paratype 0.17 mm. in length, 0.09 mm. in diameter.

Discussion.—This species differs from *Oolina apiculata* in being more tapered and elongate, having basal costae, and a reduced basal spine, and lacking a distinct neck. The present forms are restricted to Carlsbad (middle to late Campanian).

Types and occurrence.—Holotype (Fig. 21, UCLA 44207) and paratype (Fig. 22, UCLA 44208) from sample C-3, Rosario Formation at Carlsbad (C59).

OOLINA GLOBULOSA (Montagu)

Plate 10, figure 14

Vermiculum globosum Montagu, 1803, p. 523.

Entolagena globosa (Montagu), Silvestri, 1900, p. 4.

Lagena globosa (Montagu), Brotzen, 1936, p. 109, pl. 7, fig. 3.——Schijfsma, 1946, p. 54, pl. 2, fig. 16.——Hagn, 1953, p. 68, pl. 2, fig. 30.

Test free, large, subglobular. Wall calcareous, finely perforate, radial in structure, surface smoothly finished. Aperture terminal and radiate, Recent specimens with internal tube which is not seen in present Cretaceous specimens because of preservation.

Maximum length of figured hypotype, 0.44 mm.; diameter, 0.36 mm.

Discussion.—This species was described originally from the Recent of England; it may represent a long-ranging form or a homeomorphic series. *Lagena simplex* (Reuss) (1851), from the Upper Cretaceous of Poland, may be a Cretaceous representative of this series but differs from the present specimens in having a central, rounded aperture. The present specimens are very similar to the initial chamber of *Nodosaria limbata* d'Orbigny

(1840), but they appear lower in the section at La Jolla than does *N. limbata*.

Types and occurrence.—Figured hypotype (UCLA 44203) from sample S-2, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (J53, L44, D30).

OOLINA sp. cf. O. TOKAOI (Asano)
Plate 10, figure 20

Entosolenia tokaoi ASANO, 1952, p. 98, pl. 6, fig. 3.

Test free, pyriform. Wall calcareous, finely perforate, surface ornamented by series of longitudinal costae crossed by short transverse costae to form a series of subquadrangular depressions, costae coalesce into thickened collar at apertural end. Aperture terminal, rounded, with short neck.

Maximum length of figured specimen, 0.26 mm.; diameter, 0.15 mm.

Discussion.—Rare specimens occur in the upper samples at La Jolla and in a single sample at Punta Descanso. Both the number of longitudinal costae and size of the depressions vary. They most closely resemble this species from the middle Miocene of Japan but are more globular and have more numerous costae. *Lagena mariae* KARRER (1877), from the Miocene of Austria, is similar in shape but has more numerous depressions and lacks the thickened collar. The same is true of the Recent species *Oolina melo* D'ORBIGNY (1839).

Types and occurrence.—Figured specimen (UCLA 44206) from sample E-11, Rosario Formation at Punta Descanso. Unfigured specimen from Rosario Formation at La Jolla (J167, D130).

Genus FISSURINA Reuss, 1850

FISSURINA AKPATII Sliter, n. sp.
Plate 11, figure 9

Test free, ovate, compressed, with peripheral keel and 2 weakly developed marginal keels, one on each side, all radiating from aperture; initial end may have 1 or 2 radiating costae. Wall calcareous, finely perforate, with fine longitudinal costae and aligned punctae. Aperture terminal, an elongate slit, with entosolenian tube.

Maximum length of holotype, 0.20 mm.; breadth, 0.14 mm.; thickness, 0.07 mm.

Discussion.—The compressed test, 3 carinae, and aligned punctae readily distinguish this species. It occurs rarely throughout most of the Carlsbad samples (middle to late Campanian).

Types and occurrence.—Holotype (UCLA 44215) from sample C-3; paratype (UCLA 44216) from sample C-3; both from Rosario Formation at Carlsbad (C60).

FISSURINA BANDYI Sliter, n. sp.
Plate 11, figure 7

Test free, ovate, somewhat compressed, consisting of subglobular chamber with narrow bordering keel; 2 weakly marginal keels more divergent at initial end. Wall calcareous, finely perforate, costate, with aligned punctae. Aperture terminal, ovate, with entosolenian tube.

Maximum length of holotype, 0.27 mm.; breadth, 0.22 mm.; thickness, 0.17 mm.

Discussion.—This form, rare throughout the Carlsbad section (middle to late Campanian), differs from *Fissurina sandiegoensis* SLITER, n. sp., in being larger and thicker and in having weakly developed marginal keels and coarser punctae. The specimens show considerable variation in size of punctae; some as much as 0.02 mm. in diameter.

Types and occurrence.—Holotype (UCLA 44220) and paratype (UCLA 44221) from sample C-3, Rosario Formation at Carlsbad (C35).

FISSURINA LATICARINATA Sliter, n. sp.
Plate 11, figure 6

Test free, compressed, ovate, with subglobular chamber surrounded by single, wide, hyaline keel. Wall calcareous, finely perforate, surface smooth. Aperture terminal, ovate, connected to chamber by tubular extension through keel.

Maximum length of holotype, 0.24 mm.; breadth, 0.22 mm.; thickness, 0.11 mm.

Discussion.—Rare at Carlsbad, these specimens differ from *Fissurina orbignyana* SEGUENZA in having a wide, single, hyaline keel, a more circular chamber, and smoother surface. A similar species from the Miocene of Sicily, *F. elegans* SEGUENZA (1862), has a more circular chamber and lacks apertural thickening in the carina. Stratigraphic range middle to upper Campanian.

Types and occurrence.—Holotype (UCLA 44213) from sample C-4; paratype (UCLA 44214) from sample C-3; both from Rosario Formation at Carlsbad (C106).

FISSURINA MEYERIANA (Chapman)
Plate 11, figure 1-2

Lagena meyeriana CHAPMAN, 1894, p. 706, pl. 34, fig. 7.

Test free, ovate to nearly circular in outline, compressed, periphery truncate, carinate, with bordering depression, both sides gently convex. Wall calcareous, finely perforate, surface smoothly finished. Aperture terminal, slitlike, with entosolenian tube.

Maximum length of figured hypotypes, 0.17 to 0.24 mm.; breadth, 0.14 mm.; thickness, 0.07 to 0.10 mm.

Discussion.—This species, originally described from the Lower Cretaceous of England, is distinguished readily by its truncate periphery and carinate margins. It constitutes a rare but persistent member of the fauna in all present locations. The population also includes a few elongate, relatively larger specimens with a small apical spine; there seems to be a morphologic variant of the species.

Types and occurrence.—Figured hypotype (Fig. 1, UCLA 44210) from sample S-20, Rosario Formation at La Jolla. Figured hypotype

(Fig. 2, UCLA 44211) from sample C-3, Rosario Formation at Carlsbad. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (C18, J100, L137, D129).

FISSURINA OBLONGA Reuss
Plate 10, figure 18-19

Fissurina oblonga REUSS, 1863, p. 339, pl. 7, fig. 89.

Test free, ovate, compressed, periphery subrounded to subacute, apertural end elongated. Wall calcareous, finely perforate, surface smooth. Aperture terminal, ovate, with entosolenian tube.

Maximum length of figured hypotypes, 0.22 to 0.24 mm.; breadth, 0.12 to 0.15 mm.; thickness, 0.07 to 0.09 mm.

Discussion.—These rare forms are found only at Carlsbad. Originally described from the Oligocene of Germary, this species is distinguished by its elongate, tapering form.

Types and occurrence.—Figured hypotypes (fig. 18-19, UCLA 44205-44204) from sample C-3, Rosario Formation from Carlsbad (C104).

FISSURINA ORBIGNYANA Seguenza
Plate 11, figure 3

Fissurina orbignyana SEGUENZA, 1862, p. 66, pl. 2, fig. 25-26.——POŻARYSKA, 1957, p. 61, pl. 6, fig. 1-3.——MARTIN, 1964, p. 63, pl. 5, fig. 9.

Lagena orbignyana (Seguenza), CUSHMAN, 1931c, p. 39, pl. 6, fig. 2.

Test free, consisting of a subglobular chamber surrounded by a distinct lateral keel; 2 narrow bordering keels. Wall calcareous, finely perforate; surface smooth, may be costate near aperture. Aperture terminal, ovate, situated within thickening of lateral keel, with entosolenian tube.

Maximum length of figured hypotype, 0.27 mm.; breadth, 0.24 mm.; thickness, 0.17 mm.

Discussion.—*Fissurina orbignyana* differs from *F. meyeriana* in its distinct lateral keel and smaller bordering carinae.

Types and occurrence.—Figured hypotype (UCLA 44212) from sample S-31, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Punta Descanso (J109, D104).

FISSURINA SANDIEGOENSIS Sliter, n. sp.
Plate 11, figure 4-5

Test free, compressed, circular in outline, subglobular chamber surrounded by narrow peripheral carina, may be bordered by aligned punctae. Wall calcareous, finely perforate, surface smooth to fine costate. Aperture terminal, slitlike, with entosolenian tube.

Maximum diameter of holotype, 0.17 mm.; thickness, 0.09 mm. Paratype diameter 0.19 mm.; thickness, 0.09 mm.

Discussion.—This species is distinguished from *Fissurina laticarinata* by its circular outline, narrower keel, and common costae. The specimens differ in the presence or absence of costae, bordering punctae, and degree of compression. *F. sandiegoensis* occurs rarely throughout the La Jolla and Carlsbad localities and in a single sample at Punta Descanso. Stratigraphic range middle to upper Campanian.

Types and occurrence.—Holotype (Fig. 4, UCLA 44217) from sample C-3, Rosario Formation at Carlsbad. Paratype (Fig. 5, UCLA 44219) from sample S-2, Rosario Formation at La Jolla. Unfigured paratypes from Rosario Formation at Punta Descanso (C29, J58, D127).

FISSURINA SIMULATA Sliter, n. sp.
Plate 11, figure 8

Test free, ovate, compressed; consisting of subglobular chamber with thickened peripheral keel that may be slightly extended in plane of compression. Wall calcareous, finely perforate, smoothly finished. Aperture terminal, slitlike opening in distinct carinal thickening, with entosolenian tube.

Maximum length of holotype, 0.24 mm.; breadth, 0.15 mm.; thickness, 0.09 mm.

Discussion.—Occurring rarely throughout the Carlsbad locality (middle to late Campanian), this species differs from *Fissurina laticarinata* in being more ovate and in having a narrow carina and apertural thickening. The specimens vary in width and extension of the peripheral keel, the latter commonly being narrow and thickened.

Types and occurrence.—Holotype (UCLA 44222) from sample C-7; paratype (UCLA 44223) from sample C-3; both from Rosario Formation at Carlsbad (C30).

Superfamily BULIMINACEA Jones, 1875

Family TURRILINIDAE Cushman, 1927

Subfamily TURRILININAE Cushman, 1927

Genus NEOBULIMINA Cushman & Wickenden, 1928

NEOBULIMINA CANADENSIS Cushman & Wickenden
Plate 11, figure 10, 14

Neobulimina canadensis CUSHMAN & WICKENDEN, 1928, p. 13, pl. 1, fig. 1-2.——JENNINGS, 1936, p. 31, pl. 3, fig. 22.——CUSHMAN, 1946, p. 125, pl. 52, fig. 11-12.——TAPPAN, 1962, p. 185, pl. 48, fig. 18-27.——LOEBLICH & TAPPAN, 1964, p. C544, fig. 426,6-7.

Test free, small, elongate, initially triserial, later biserial. Chambers subglobular, inflated. Sutures distinct, depressed. Wall calcareous, finely perforate, surface smoothly finished. Aperture loop-shaped, extending upward from base of final chamber.

Maximum length of figured hypotypes, 0.19 to 0.22 mm.; breadth, 0.10 to 0.14 mm.

Discussion.—*Neobulimina canadensis* occurs in all present sections and is recognized easily by its chamber shape and arrangement and type of its aperture. Originally described from the Upper Cretaceous of Canada, this species is reported from Turonian to Maastrichtian.

Types and occurrence.—Figured hypotype (Fig. 10, UCLA 44224) from sample C-3, Rosario Formation at Carlsbad. Figured hypotype (Fig. 14, UCLA 44225) from sample S-1, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (C3, J29, L141, D37).

Genus PRAEBULIMINA Hofker, 1953

PRAEBULIMINA ANGULATA Sliter, n. sp.

Plate 12, figure 6

Test free, small, transverse section subtriangular with nearly flat sides. Chambers distinct, inflated, higher than broad, increasing rapidly in size. Sutures distinct, gently depressed. Wall calcareous, finely perforate, surface smooth. Aperture loop-shaped, extending up face of final chamber.

Maximum length of holotype, 0.17 mm.; breadth, 0.10 mm.

Discussion.—This species is characterized by its subtriangular section, small size, and inflated chambers. It is most similar to *Praebulimina trihedra* (Cushman) (1926b), from the Upper Cretaceous of Mexico, but is much smaller and has a reduced spire. Future investigation may show the smaller West Coast forms to be synonymous to the Mexican and Gulf Coast species. *Praebulimina angulata* occurs throughout all present Campanian locations and ranges into Maastrichtian strata.

Types and occurrence.—Holotype (UCLA 44239) from sample S-1; paratype (UCLA 44240) from sample S-26; both from Rosario Formation at La Jolla. Unfigured paratypes from Rosario Formation at Carlsbad, Point Loma and Punta Descanso (C2, J20, L26, D74).

PRAEBULIMINA ASPERA Cushman & Parker

Plate 11, figure 11-13

Bulimina aspera Cushman & Parker, 1940, p. 44, pl. 8, fig. 18-19. ——Cushman, 1946, p. 121, pl. 51, fig. 7, 10, 13, 15-16.——Cushman & Parker, 1947, p. 83, pl. 19, fig. 28-30, pl. 21, fig. 1-2.——Martin, 1964, p. 86, pl. 11, fig. 4.

Test free, elongate, gently tapering, circular in cross section. Chambers numerous, inflated, subrectangular, commonly arranged directly above one another or slightly offset in spiral fashion. Sutures distinct, depressed. Wall calcareous, finely perforate, surface may be initially roughened, later smooth. Aperture loop-shaped, at base of final chamber, with simple tooth plate.

Maximum length of figured hypotypes, 0.20 to 0.71 mm.; breadth, 0.15 to 0.33 mm. Majority of specimens near 0.43 mm. in length.

Discussion.—This relatively large species is distinguished from *Praebulimina kickapooensis* (Cole) by somewhat smaller size, subrectangular chambers, and nearly vertical chamber arrangement. It first occurs abundantly in the middle samples at La Jolla associated with *P. kickapooensis* and extends to the youngest samples. The oldest specimens are larger than those from the type locality, but they become smaller in later samples. Two forms are present throughout, one with a blunt apex and one pointed. These seem to represent dimorphic stages in the life cycle. The presence of the initial roughened portion of the test and of the apical spines varies considerably within the present population. Specimens having a roughened test are more common in the older samples. Specimens illustrated by Martin (1964) as *Bulimina prolixa* Cushman & Parker may be synonymous. The size, circular transverse section, and degree of flaring are more indicative of the present species than of *P. prolixa*. *P. aspera* is characteristic of Taylor and Navarro strata in the American Gulf Coast.

Types and occurrence.—Figured hypotypes (Fig. 11-13, UCLA 44226, 44227, 44228) from sample S-13, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (J99, L46, D19).

PRAEBULIMINA CARSEYAE (Plummer)

Plate 11, figure 16

Buliminella carseyae Plummer, 1931, p. 179, pl. 8, fig. 9.——Cushman, 1946, p. 119, pl. 50, fig. 17-20.——Cushman & Parker, 1947, p. 58, pl. 15, fig. 8.——Martin, 1964, p. 88, pl. 11, fig. 11.

Buliminella hofkeri Brotzen, 1936, p. 129, fig. 45, pl. 8, fig. 3.

Praebulimina carseyae (Plummer), Hofker, 1957, p. 192, fig. 235-236, 237 (*partim*).——Tappan, 1962, p. 186, pl. 48, fig. 11-15.

Test free, small, ovate, tapering. Chambers commonly 4 per whorl, increasing gradually in size, slightly inflated. Sutures distinct, depressed. Wall calcareous, finely perforate, surface smooth. Aperture loop-shaped, extending up face of final chamber.

Maximum length of figured hypotype, 0.29 mm.; breadth, 0.19 mm.

Discussion.—This species was described originally from Texas and is recognized by its small size and 4 slightly inflated chambers per whorl. It occurs in Austin, Taylor, and lower Navarro strata in the Gulf Coast, Senonian of Alaska, and Santonian of central California. The present specimens are restricted to the Carlsbad area.

Types and occurrence.—Figured hypotype (UCLA 44229) from sample C-3, Rosario Formation at Carlsbad (C6).

PRAEBULIMINA CUSHMANI (Sandidge)

Plate 11, figure 15

Buliminella cushmani Sandidge, 1932, p. 280, pl. 42, fig. 18-19. ——Cushman, 1946, p. 119, pl. 50, fig. 15.——Cushman & Parker, 1947, p. 58, pl. 15, fig. 10-11.——Martin, 1964, p. 89, pl. 11, fig. 13.

Praebulimina cushmani (Sandidge), Hofker, 1957, p. 188, fig. 228-229.——Tappan, 1962, p. 187, pl. 49, fig. 1-5.——Graham & Church, 1963, p. 54, pl. 6, fig. 2-3.

Test free, small, robust. Chambers inflated, 4 in final whorl, increasing rather rapidly in size. Sutures distinct, depressed. Wall calcareous, finely perforate, surface smooth. Aperture a broad loop extending up face of final chamber.

Maximum length of figured hypotype, 0.18 mm.; breadth, 0.15 mm. Other hypotypes range to 0.22 mm. in length.

Discussion.—This species is distinguished from *Praebulimina carseyae* by its smaller size and wider, more flaring test. The present forms are identical to those described by TAPPAN (1962) from Alaska but differ from illustrations of the original specimens in being somewhat wider and more robust and in having more inflated chambers. As topotype specimens are not available for comparison, the present specimens here are included within this species. Originally described from the Upper Cretaceous Ripley Formation of Alabama, this species also occurs in Austin to Navarro age strata in the American Gulf Coast, Senonian of Alaska, and Santonian and Campanian of central California. *P. cushmani* first appears in the lower La Jolla section and continues to the top. It also is found at Point Loma and Punta Descanso but does not occur at Carlsbad.

Types and occurrence.—Figured hypotype UCLA (44230) from sample S-22, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (J122, L65, D86).

PRAEBULIMINA KICKAPOOENSIS (Cole)

Plate 11, figure 17-19

Bulimina kickapooensis COLE, 1938, p. 45, pl. 3, fig. 5.——CUSHMAN, 1946, p. 123, pl. 51, fig. 11-12, 14.——CUSHMAN & PARKER, 1947, p. 81, pl. 19, fig. 19.

Bulimina aspera Cushman & Parker, BANDY, 1951, p. 511, pl. 75, fig. 10.

Praebulimina kickapooensis (Cole), HOFKER, 1957, p. 190, fig. 233-234.——GRAHAM & CHURCH, 1963, p. 54, pl. 6, fig. 4-7.

Test free, elongate, tapering. Chambers numerous, distinct, high, slightly inflated. Sutures distinct, gently depressed. Wall calcareous, finely perforate, surface smooth. Aperture loop-shaped, at apex of final chamber, with simple tooth plate.

Figured hypotypes range in length from 0.26 to 0.77 mm.; breadth, 0.22 to 0.51 mm.

Discussion.—This relatively large species, originally described from the Taylor Marl of Texas, is distinguished from *Praebulimina aspera* by its larger size, higher, less inflated chambers, and chamber arrangement. The present specimens are identical to the original illustrations and show the same type of morphologic variation. In the middle of the section, prior to the last appearance of this species, some specimens become thicker and more flaring yet remain part of the gradational population. The population consists of both blunt and pointed individuals, representing different stages in the life cycle. This species ranges from Coniacian to Maastrichtian.

Types and occurrence.—Figured hypotype (Fig. 18, UCLA 44231) from sample S-17; figured hypotype (Fig. 17, UCLA 44232) from sample S-21; figured hypotype (Fig. 19, UCLA 44233) from sample S-34; all from the Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Carlsbad, Point Loma and Punta Descanso (C131, J43, L4, D63).

PRAEBULIMINA LAJOLLAENSIS Sliter, n. sp.

Plate 12, figure 9-10

Test free, small, globular, single whorl visible, composed of 3 to 4 inflated, subglobular chambers. Sutures distinct, depressed. Wall calcareous, finely perforate, surface smooth. Aperture loop-shaped, at base of final chamber, with simple tooth plate.

EXPLANATION OF PLATE 11

FIGURE

1-2. *Fissurina meyeriana* (CHAPMAN); 1a,b, 2a,b, side and apertural views, ×129 (p. 81).

3. *Fissurina orbignyana* SEGUENZA; 3a,b, side and apertural views, ×97 (p. 82).

4-5. *Fissurina sandiegoensis* SLITER, n. sp.; 4a-c, side, apertural, and edge views of holotype, ×129; 5a,b, side apertural views of paratype, ×187 (p. 82).

6. *Fissurina laticarinata* SLITER, n. sp.; 6a,b, side and apertural views, ×129 (p. 81).

7. *Fissurina bandyi* SLITER, n. sp.; 7a,b, side and edge views, ×129 (p. 81).

8. *Fissurina simulata* SLITER, n. sp.; 8a,b, side and apertural views, ×129 (p. 82).

9. *Fissurina akpatii* SLITER, n. sp.; 9a,b, side and apertural views, ×129 (p. 81).

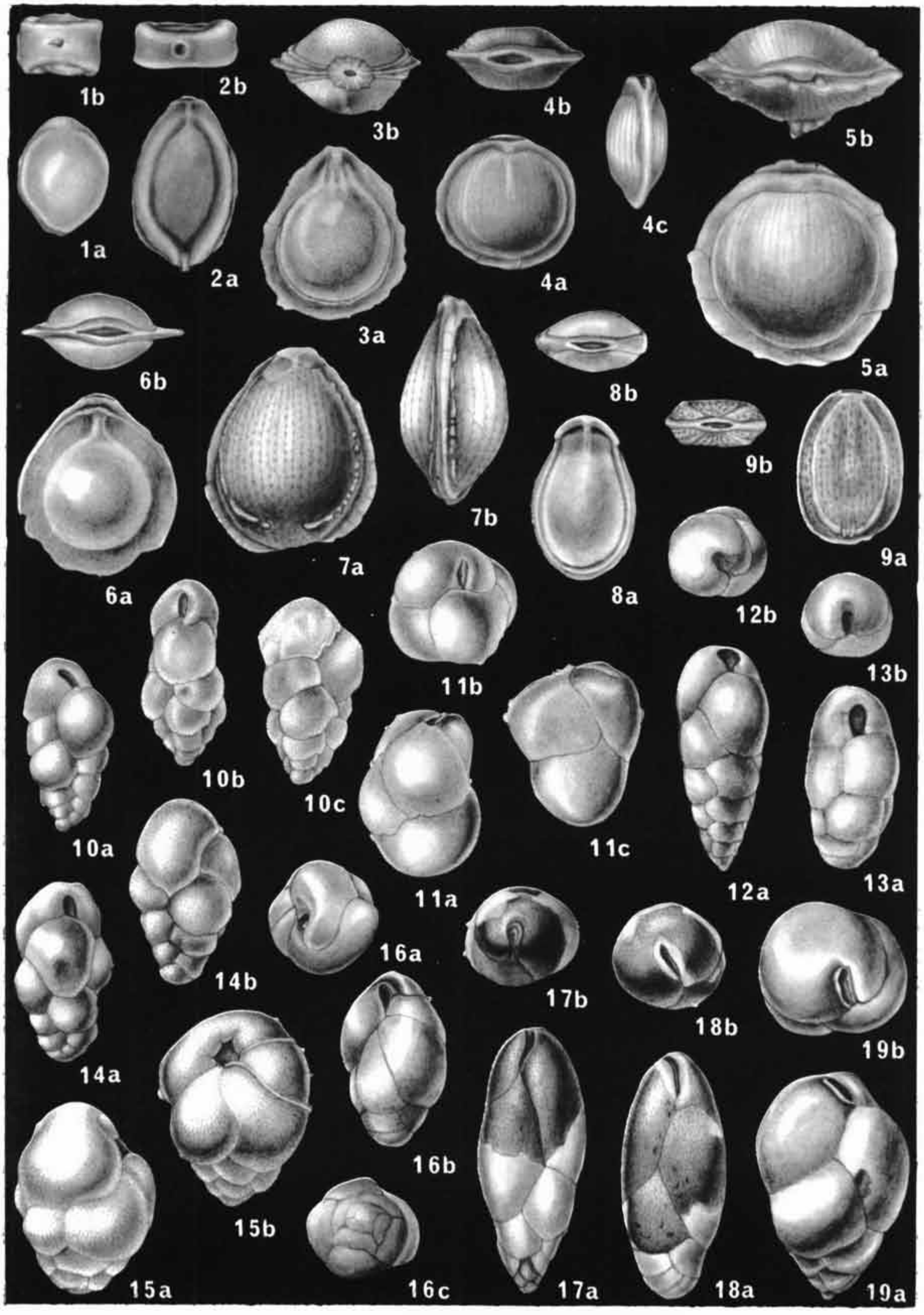
10, 14. *Neobulimina canadensis* CUSHMAN & WICKENDEN; 10a-c, side views, ×129; 14a,b, side views, ×187 (p. 82).

11-13. *Praebulimina aspera* CUSHMAN & PARKER; 11a-c, side and apertural views, ×66; 12a,b, 13a,b, side and apertural views, ×52 (p. 83).

15. *Praebulimina cushmani* (SANDIDGE); 15a,b, side views, ×187 (p. 83).

16. *Praebulimina carseyae* (PLUMMER); 16a-c, apertural, side, and basal views, ×97 (p. 83).

17-19. *Praebulimina kickapooensis* (COLE); 17a,b, 18a,b, side and apertural views, ×66; 19a,b, side and apertural views, ×52 (p. 84).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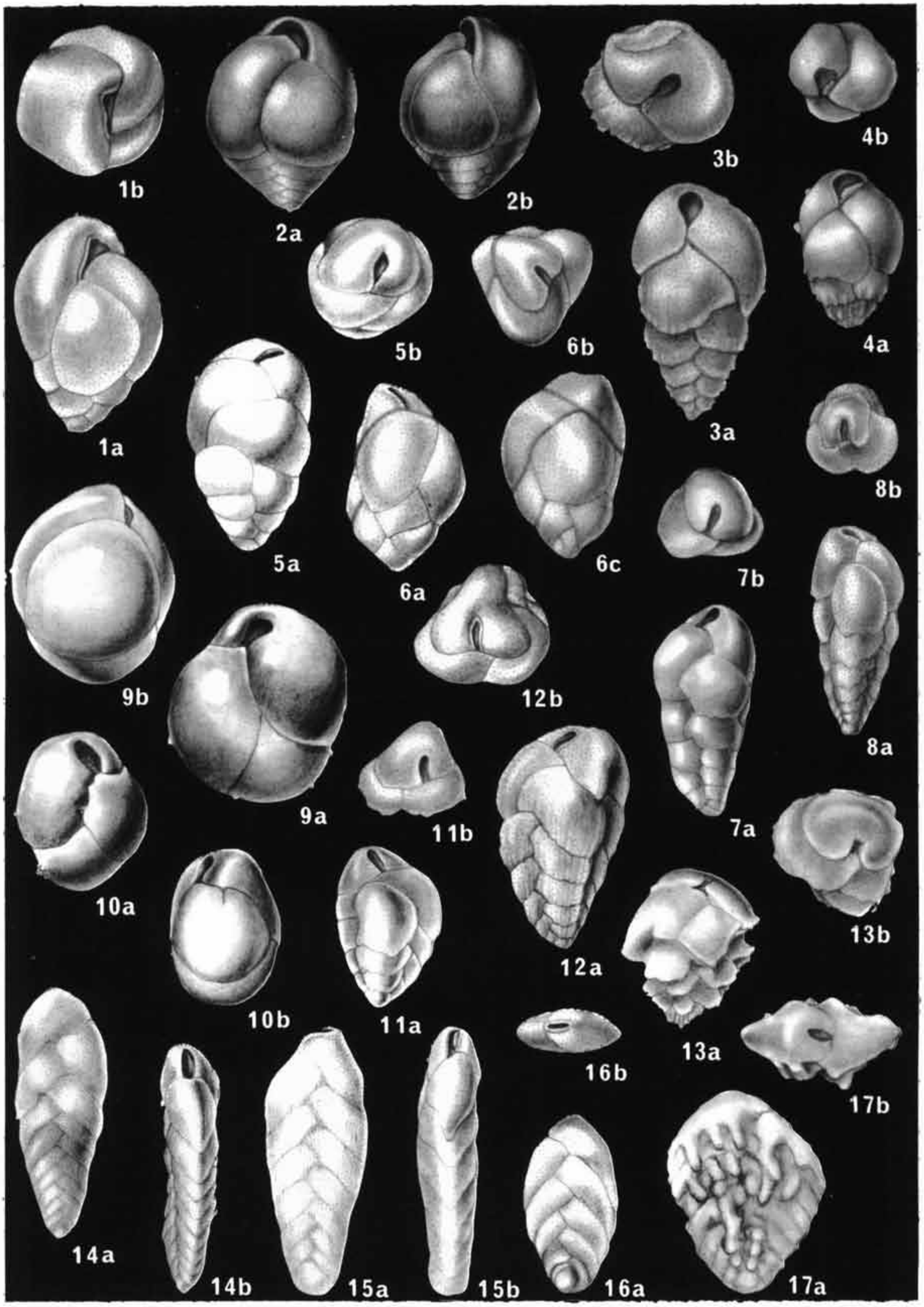
Sliter — Upper Cretaceous Foraminifera, Southern California and Northwestern Mexico.



Maximum length of holotype, 0.34 mm.; breadth, 0.31 mm.; thickness, 0.27 mm.

Discussion.—This species is easily distinguished by the 3 to 4 subglobular chambers and loop-shaped aperture. It is associated with *Praebulimina kickapooensis* in several samples but does not intergrade. This form is not regarded as a juvenile stage of *P. kickapooensis* owing to its relatively large size and uniform morphologic characters. *P. lajollaensis* occurs in the middle samples at La Jolla and rarely at Point Loma (middle to late Campanian).

Types and occurrence.—Holotype (Fig. 9, UCLA 44241) from sample S-18; paratype (Fig. 10, UCLA 44242) from sample S-7; both from Rosario Formation at La Jolla. Unfigured paratypes from Rosario Formation at Point Loma (J127, L140).

PRAEBULIMINA REUSSI (Morrow)

Plate 12, figure 1-2

Bulimina ovulum Reuss, 1844 (*non B. ovula* d'Orbigny, 1839), p. 215.——Reuss, 1845, pl. 8, fig. 57, pl. 13, fig. 73.

Bulimina reussi Morrow, 1934, p. 195, pl. 29, fig. 12.——Cushman & Parker, 1935, p. 99, pl. 15, fig. 8, 10.——Cushman, 1946, p. 120, pl. 51, fig. 1-5.——Cushman & Parker, 1947, p. 84, pl. 19, fig. 31, pl. 20, fig. 1-5.——Martin, 1964, p. 88, pl. 11, fig. 9.

Bulimina ventricosa Brotzen, 1936, p. 124, fig. 42-43, pl. 8, fig. 1.

Praebulimina reussi (Morrow), Hofker, 1957, p. 187, fig. 227 (*partim*).

Praebulimina ventricosa (Brotzen), Hofker, 1957, p. 187, fig. 223-224.

Test free, small, ovate in outline, tapering. Chambers distinct, inflated, increasing rapidly in size. Sutures distinct, depressed. Wall calcareous, finely perforate, surface smoothly finished. Aperture loop-shaped, extending up flattened apertural face.

Maximum length of figured hypotype, 0.17 to 0.20 mm.; breadth, 0.14 mm.

Discussion.—This species differs from *Praebulimina venusae* (Nauss) (1947) in being smaller and more ovate in outline and in having a more widely flaring test. The present forms vary considerably in size, outline, and number of whorls but occur together in a single gradational population. Certain specimens are identical to the European forms referred to *Bulimina ovulum* Reuss, which was subsequently placed in synonymy with this species by Cushman & Parker (1935). *P. reussi* ranges from Turonian to Maastrichtian.

Types and occurrence.—Figured hypotype (Fig. 1, UCLA 44234) from sample C-3, Rosario Formation at Carlsbad. Figured hypotype (Fig. 2, UCLA 44235) from sample S-20, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (C23, J75, L77, D52).

PRAEBULIMINA SPINATA (Cushman & Campbell)

Plate 12, figure 3-4

Bulimina spinata Cushman & Campbell, 1935, p. 72, pl. 11, fig. 1.——Cushman & Parker, 1947, p. 86, pl. 20, fig. 21.——Martin, 1964, p. 88, pl. 11, fig. 10.

Test free, small, tapering, generally with 4 whorls. Chambers distinct, inflated, increasing rapidly in size, lower margin acute with distinct shoulder, initial chambers with short spines projecting toward apex, later chambers smooth. Sutures distinct, depressed. Wall calcareous, finely perforate, surface smooth. Aperture loop-shaped, at base of final chamber.

Figured hypotypes range from 0.14 to 0.22 mm. in length; 0.09 to 0.12 mm. in breadth. Other hypotypes range to 0.26 mm. in length.

EXPLANATION OF PLATE 12

FIGURE

1-2. *Praebulimina reussi* (Morrow); 1a,b, side and apertural views, ×187; 2a,b, side views, ×187 (p. 85).

3-4. *Praebulimina spinata* (Cushman & Campbell); 3a,b, 4a,b, side and apertural views, ×187 (p. 85).

5. *Praebulimina venusae* (Nauss); 5a,b, side and apertural views, ×129 (p. 86).

6. *Praebulimina angulata* Sliter, n. sp.; 6a-c, side and apertural views, ×187 (p. 83).

7-8. *Pyramidina prolixa* (Cushman & Parker); 7a,b, side and apertural views, ×129; 8a,b, side and apertural views, ×97 (p. 86).

9-10. *Praebulimina lajollaensis* Sliter, n. sp.; 9a,b, side views of holotype, ×97; 10a,b, side and apertural views of paratype, ×97 (p. 84).

11. *Pyramidina triangularis* (Cushman & Parker); 11a,b, side and apertural views, ×187 (p. 87).

12. *Pyramidina rudita* (Cushman & Parker); 12a,b, side and apertural views, ×187 (p. 86).

13. *Pyramidina szajnochae* (Grzybowski); 13a,b, side and apertural views, ×97 (p. 87).

14. *Bolivina incrassata* Reuss; 14a,b, side and edge views, ×129 (p. 88).

15. *Bolivina incrassata gigantea* Wicher; 15a,b, side and edge views, ×52 (p. 88).

16. *Bolivina decurrens* (Ehrenberg); 16a,b, side and apertural views, ×187 (p. 87).

17. *Bolivinoides draco draco* (Marsson); 17a,b, side and apertural views, ×97 (p. 88).

Discussion.—The present specimens form a common element of the smaller species at La Jolla, Point Loma, and Punta Descanso. In these samples considerable variation is noted in test size and development of chamber spines. Because of this variation and the identical morphologic characteristics, some specimens of smaller size are included in the present species. The 2 forms seem to represent different stages in the life cycle, one being larger and more elongate, and the other more ovate in plan and commonly more distinctly ornamented. This species was described originally from the Upper Cretaceous of central California and also has been found by MARTIN (1964) in the Campanian-Maastrichtian of Merced County, California. *Bulimina joaquinensis* MARTIN may be synonymous and represent another part of the variable population.

Types and occurrence.—Figured hypotypes (Fig. 3-4, UCLA 44236-44237) from sample S-1, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (J18, L25, E21).

PRAEBULIMINA VENUSAE (Nauss)
Plate 12, figure 5

Bulimina venusae NAUSS, 1947, p. 334, pl. 48, fig. 10.
Praebulimina venusae (Nauss), TAPPAN, 1962, p. 188, pl. 49, fig. 19-21.

Test free, small, elongate, flaring. Chambers numerous, inflated, initially arranged in regular triserial series, later increasing rapidly in size. Sutures distinct, depressed. Wall calcareous, finely perforate. Aperture loop-shaped, extending up face of final chamber.

Maximum length of figured hypotype, 0.29 mm.; breadth, 0.17 mm. Additional hypotypes range in length from 0.12 mm. to 0.29 mm.

Discussion.—This species is more elongate than *Praebulimina cushmani* (SANDIDGE) (1932) and has 3 inflated chambers in the final whorl. The initial regular triserial portion, generally consisting of 3 whorls followed by the enlarged later chambers also distinguishes this species. Originally described from the Senonian of Canada, *P. venusae* also has been recorded from the Senonian of Alaska. The present specimens are somewhat thicker than those shown in the original illustration but seem to fall within the degree of variation reported for this species. The species first occurs in the middle of the La Jolla section but does not become common until the upper samples. A rare occurrence also is noted at Point Loma.

Types and occurrence.—Figured hypotype (UCLA 44238) from sample S-37, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma (J136, L160).

Genus PYRAMIDINA Brotzen, 1948

PYRAMIDINA PROLIXA (Cushman & Parker)
Plate 12, figure 7-8

Bulimina prolixa CUSHMAN & PARKER, 1935, p. 98, pl. 15, fig. 5.——CUSHMAN & GOUDKOFF, 1944, p. 58, pl. 10, fig. 1.——CUSHMAN, 1946, p. 122, pl. 51, fig. 19-22.——CUSHMAN & PARKER, 1947, p. 84, pl. 20, fig. 7-8.
Reussella prolixa (Cushman & Parker), HOFKER, 1957, p. 209, fig. 255-256 *(partim)*.

Test free, small, elongate, narrow, gradually tapering, subtriangular in transverse section with rounded angles. Chambers numerous, distinct, increasing rather slowly in size, slightly inflated, arranged directly over one another or somewhat twisted. Sutures distinct, slightly depressed. Wall calcareous, distinctly perforate, surface smooth. Aperture nearly terminal, loop-shaped, at base of final chamber.

Maximum length of figured hypotypes, 0.27 to 0.36 mm.; breadth, 0.14 to 0.15 mm.

Discussion.—This species, originally described from the Upper Cretaceous Selma Chalk of Tennessee, is recognized by its narrow and elongate test, subtriangular section, vertically aligned chambers, and nearly terminal aperture. *Bulimina prolixa* MARTIN (1964) has been omitted from synonymy as the illustrated specimens lack several diagnostic features. At La Jolla, the species is scattered throughout the section but becomes most abundant toward the top. It occurs commonly at Carlsbad, rarely at Point Loma, and is lacking at Punta Descanso. This species is reported from the Upper Cretaceous of Europe and North America and is characteristically found in strata of upper Taylor to Navarro age in the Gulf Coast area.

Types and occurrence.—Figured hypotype (Fig. 7, UCLA 44245) from sample S-34, Rosario Formation at La Jolla. Figured hypotype (Fig. 8, UCLA 44244) from sample C-3, Rosario Formation at Carlsbad. Unfigured hypotypes from Rosario Formation at Point Loma (C5, J114, L126).

PYRAMIDINA RUDITA (Cushman & Parker)
Plate 12, figure 12

Bulimina ornata CUSHMAN & PARKER, (*non* EGGER), 1935, p. 97, pl. 15, fig. 4.
Bulimina rudita CUSHMAN & PARKER, 1936, p. 45.——CUSHMAN, 1946, p. 122, pl. 51, fig. 24.——CUSHMAN & PARKER, 1947, p. 82, pl. 19, fig. 26.
Reusella minima BROTZEN, 1936, p. 136, fig. 48 *(partim)*, pl. 8, fig. 6.

Test free, small, tapering, triangular in transverse section, with rounded angles, sides concave, some specimens twisted on axis. Chambers distinct, slightly inflated, arranged in regular triserial fashion. Sutures distinct, depressed, becoming sigmoidal. Wall calcareous, finely perforate, hispid. Aperture nearly terminal, loop-shaped, at base of final chamber, with slight lip.

Maximum length of figured hypotype, 0.20 mm.; breadth, 0.12 mm.

Discussion.—This small, distinctive species, originally described from the Taylor Formation of Texas, is a consistent faunal element in all the present locations. The variable characters observed in the present population include test dimensions and degree of axial twisting. *Ruessella minima*, from the Senonian of Sweden, seems synonymous, although it differs in having the spines limited to the basal part of the test. In the American Gulf Coast, *Pyramidina rudita* ranges from Coniacian to Maastrichtian.

Types and occurrence.—Figured hypotype (UCLA 44246) from sample C-3, Rosario Formation at Carlsbad. Unfigured hypotypes from Rosario Formation at La Jolla, Point Loma, and Punta Descanso (C36, J7, L27, D20).

PYRAMIDINA SZAJNOCHAE (Grzybowski)
Plate 12, figure 13

Verneuilina szajnochae GRZYBOWSKI, 1896, p. 287, pl. 9, fig. 19.
Bulimina limbata WHITE, 1929, p. 48, pl. 5, fig. 9.
Reussella californica CUSHMAN & GOUDKOFF, 1944, p. 59, pl. 10, fig. 3-5.
Reussella szajnochae californica Cushman & Goudkoff, NOTH, 1951, p. 65, pl. 7, fig. 6.——ETERNOD OLVERA, 1959, p. 83, pl. 3, fig. 1-2.
Reussella szajnochae (Grzybowski) subspp., BELFORD, 1960, p. 66, pl. 16, fig. 16-19.
Reussella szajnochae (Grzybowski), GRAHAM & CHURCH, 1963, p. 53, pl. 6, fig. 9.——MARTIN, 1964, p. 91, pl. 12, fig. 4.

Test free, small, nearly as broad as long, triangular in transverse section, flaring. Chambers numerous, subtriangular, with sharp peripheral ridge. Sutures distinct, depressed, rather deeply excavated. Wall calcareous, finely perforate, surface smooth. Aperture nearly terminal, loop-shaped, extending from lower margin of final chamber.

Maximum length of figured hypotype, 0.26 mm.; breadth, 0.22 mm.

Discussion.—Only a few small specimens of this distinctive species were recovered. Previous California occurrences range from Santonian to Campanian.

Types and occurrence.—Figured hypotypes (UCLA 44247) from sample S-31, Rosario Formation at La Jolla (J207).

PYRAMIDINA TRIANGULARIS (Cushman & Parker)
Plate 12, figure 11

Bulimina triangularis CUSHMAN & PARKER, 1935, p. 97, pl. 15, fig. 4.——CUSHMAN, 1946, p. 122, pl. 51, fig. 23.——CUSHMAN & PARKER, 1947, p. 82, pl. 19, fig. 25.——BELFORD, 1960, p. 65, pl. 16, fig. 10-12.
Reussella buliminoides Brotzen, HOFKER, 1957, p. 207, fig. 251-253.

Test free, small, flaring, robust, triangular in transverse section with rounded angles. Chambers somewhat indistinct, very slightly inflated, increasing rapidly in size. Sutures commonly indistinct, slightly depressed. Wall calcareous, distinctly perforate, surface initially smooth to spinose, later smooth. Aperture nearly terminal, loop-shaped, at base of final chamber.

Maximum length of figured hypotype, 0.15 mm.; breadth, 0.10 mm. Other hypotypes range to 0.22 mm. in length.

Discussion.—This species differs from *Pyramidina rudita* (CUSHMAN & PARKER) (1936) in being proportionately shorter but more widely flaring and having a smoother surface texture. As HOFKER (1957, p. 208) noted, specimens illustrated as *Reussella buliminoides* BROTZEN (1936) are very similar to the present species; they here are placed in synonymy. These specimens, however, as well as the original illustrations of *P. triangularis* from the Taylor Formation of Texas, differ from *Reussella buliminoides* in being more triangular in section, more widely flaring, and more coarsely perforate. The present rare specimens of *P. triangularis* are found scattered throughout all locations. In the American Gulf Coast, this species is most characteristic of strata of Taylor age.

Types and occurrence.—Figured hypotype (UCLA 44248) from sample S-30, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Carlsbad, Point Loma and Punta Descanso (C114, J37, L106, D106).

Family BOLIVINITIDAE Cushman, 1927

Genus BOLIVINA d'Orbigny, 1839

BOLIVINA DECURRENS (Ehrenberg)
Plate 12, figure 16

Bolivina decurrens (Ehrenberg), CUSHMAN, 1946, p. 127, pl. 53, fig. 12-13.
Grammostomum? decurrens EHRENBERG, 1854, pl. 30, fig. 17.

Test free, small, elongate, compressed, periphery subacute. Chambers somewhat overlapping, increasing moderately in size, with distinct projection at peripheral basal margin of each chamber. Sutures distinct, oblique, slightly depressed, straight. Wall calcareous, finely perforate, surface smooth. Aperture nearly terminal, elongate.

Maximum length of figured hypotype, 0.19 mm.; breadth, 0.10 mm.; thickness, 0.05 mm. Other hypotypes range to 0.29 mm. in length.

Discussion.—*Bolivina decurrens* is distinguished from *B. incrassata* REUSS in its smaller size, more oblique sutures, and pointed chamber margins. The present specimens, which are quite rare, occur in the upper portion of the La Jolla section, at Punta Descanso, and in most Carlsbad samples. The Carlsbad forms differ in being somewhat more robust and less elongate than those from La Jolla and Punta Descanso. Specimens from all four locations, however, lie within the range of variation of this species as shown by specimens in my collection from the Corsicana Marl (locs. 26-28 of CUSHMAN, 1946). The American Gulf Coast specimens of this species, originally described from the Upper Cretaceous of Europe, occur characteristically in strata of Navarro age.

Types and occurrence.—Figured hypotype (UCLA 44249) from sample E-14, Rosario Formation at Punta Descanso. Unfigured hypotypes from Rosario Formation at La Jolla and Carlsbad (C126, J208, D119).

BOLIVINA INCRASSATA Reuss
Plate 12, figure 14

Bolivina incrassata REUSS, 1851, p. 29, pl. 5, fig. 13.——CUSHMAN & CAMPBELL, 1935, p. 73, pl. 11, fig. 10.——HOFKER, 1957, p. 228, fig. 282-286, 291.——GRAHAM & CHURCH, 1963, p. 52, pl. 5, fig. 26.——MARTIN, 1964, p. 90, pl. 11, fig. 14.——MCGUGAN, 1964, p. 942, pl. 150, fig. 22-23.

Test free, elongate, biserial, compressed, periphery subacute to acute. Chambers low, broad, increasing gradually in size, gently arcuate, commonly becoming slightly inflated. Sutures distinct, gently curved, limbate, especially near longitudinal axis, initially flush, later depressed, may be slightly elevated axially. Wall calcareous, finely perforate, radial in structure, surface smooth. Aperture an elongate loop at base of final chamber, with tooth plate.

Maximum length of figured hypotype, 0.29 mm.; breadth, 0.12 mm.; thickness, 0.06 mm.

Discussion.—*Bolivina incrassata* is recognized by the test and chamber dimensions, limbate sutures, and relative size. Specimens from present localities gradually trend toward thinner and more compressed tests, curved sutures, and acute periphery; this seems a slow evolutionary change with time. The species is separated from the thicker, larger bolivinid *B. incrassata gigantea* WICHER, which locally is restricted to Carlsbad and Punta Descanso. These localities are referred to an upper-shelf environment, whereas localities containing *B. incrassata s.s.* represent deposition in deeper water. A somewhat similar variation in the test dimensions of Recent bolivinids has been reported by LUTZE (1964) and correlated with a depth parameter, in this case the oxygen content of the bottom water. The stratigraphic range of this species in Europe, North America, Mexico, and the Near East is Campanian to Maastrichtian.

Types and occurrence.—Figured hypotype (UCLA 44250) from sample S-20, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma (J153, L162).

BOLIVINA INCRASSATA GIGANTEA Wicher
Plate 12, figure 15

Bolivina incrassata Reuss, CUSHMAN, 1946, p. 127, pl. 53, fig. 8-11.——BANDY, 1951, p. 510, pl. 75, fig. 5.——SAID & KENAWY, 1956, p. 144, pl. 4, fig. 6.——ETERNOD OLVERA, 1959, p. 79, pl. 2, fig. 17-18.

Bolivina incrassata Reuss forma *gigantea* WICHER, 1949, p. 57 (Serbian), 85 (English), pl. 5, fig. 2-3.

Bolivina incrassata gigantea Wicher, BETTENSTAEDT & WICHER, 1955, p. 502, pl. 2, fig. 19.——HILTERMANN & KOCH, 1960, p. 75, table 3.

Test free, elongate, biserial, compressed, periphery subrounded. Chambers broad, low, increasing gradually in size, subrectangular. Sutures distinct, gently curved, limbate, generally flush, may be slightly elevated axially. Wall calcareous, finely perforate, radial in structure, surface smooth, wall commonly thickened with clear calcite. Aperture an elongate loop at base of final chamber, with tooth plate.

Maximum length of figured hypotype, 0.60 mm.; breadth, 0.17 mm.; thickness, 0.10 mm.

Discussion.—*Bolivina incrassata gigantea* originally was described from Maastrichtian deposits at Nierental, Austria, and separated from *B. incrassata* by the larger size and typical Maastrichtian development. In the present localities, it is restricted to Carlsbad and Punta Descanso and appears prior to the initial appearance of *B. incrassata.* These 2 localities seem to represent an upper-shelf depositional environment, and the restriction of the larger, thickened *B. incrassata gigantea* to these locations may reflect the effects of ecologic conditions rather than a typical Maastrichtian development as in northern Europe.

Types and occurrence.—Figured hypotype (UCLA 44251) from sample C-2, Rosario Formation at Carlsbad. Unfigured hypotypes from Rosario Formation at Punta Descanso (C21, D98).

Genus BOLIVINOIDES Cushman, 1927

BOLIVINOIDES DRACO DRACO (Marsson)
Plate 12, figure 17

Bolivina draco MARSSON, 1878, p. 157, pl. 3, fig. 25.

Bolivinoides rhomboidea CUSHMAN, 1927, p. 90, pl. 12, fig. 10.

Bolivinoides draco draco (Marsson), HILTERMANN & KOCH, 1950, p. 598, fig. 1,*72-73*, 2-4,*52-54*, *58-60*, 5,*53*, *69-70*.——EDGELL, 1954, p. 73, pl. 13, fig. 1-3, pl. 14, fig. 1-3.——REISS, 1954, p. 155, pl. 29, fig. 1-3.——VAN HINTE, 1963, p. 106, pl. 14, fig. 3.

Bolivinoides draco (Marsson), MONTANARO GALLITELLI, 1957, p. 145, pl. 33, fig. 14-16.——ETERNOD OLVERA, 1959, p. 80, pl. 2, fig. 10, 12.

Test free, rhomboidal, compressed, flaring. Chambers biserially arranged, low, broad and oblique. Sutures generally indistinct except along outer margins, oblique, gently curved, flush. Wall calcareous, finely perforate, radial in structure, surface ornamented by 2 distinct longitudinal costae separated by median sulcus, with less well developed lateral costae and tubercules. Aperture elongate, loop-shaped, at base of final chamber, with tooth plate and narrow lip.

Maximum length of figured hypotype, 0.35 mm.; breadth, 0.27 mm.; thickness, 0.17 mm.

Discussion.—The present specimens occur rarely in the upper samples at La Jolla. The typical subspecies, originally described from the Upper Cretaceous of Germany, is distinguished from *Bolivinoides draco miliares* HILTERMANN & KOCH (1950) by the stronger ornamentation which results in a pair of distinct longitudinal costae. In the La Jolla section, *B. draco miliares* appears first and then together with *B. draco draco* but in reduced numbers. Finally, the youngest samples contain only the latter species. As noted by BARR (1966), *B. draco draco* apparently evolved from *B. draco miliares* during the upper part of the lower Maastrichtian. This species is reported from Europe, Israel, Australia, and Mexico.

Types and occurrence.—Figured hypotype (UCLA 44252) from sample S-24, Rosario Formation at La Jolla (J223).

BOLIVINOIDES DRACO MILIARES Hiltermann & Koch
Plate 13, figure 1

Bolivinoides draco miliares HILTERMANN & KOCH, 1950, p. 604, fig. 2-4,*26, 32-34, 39-41, 46-48,* fig. 5,*39.*——REISS, 1954, p. 155, pl. 28, fig. 9-12, 14.——VAN HINTE, 1963, p. 106, pl. 13, fig. 7-8.——BARR, 1966, p. 234, pl. 35, fig. 4-5.

Test free, rhomboidal, compressed, flaring, periphery subacute. Chambers biserial, somewhat indistinct, low, broad. Sutures commonly obscured by surface ornamentation except along outer margins, oblique, gently curved, flush. Wall calcareous, finely perforate, structure radial, surface ornamented by distinct lobes that are discontinuous along longitudinal median sulcus. Aperture an elongate loop at base of final chamber, with internal tooth plate.

Maximum length of figured specimen, 0.46 mm.; breadth, 0.31 mm.; thickness, 0.17 mm.

Discussion.—This subspecies is differentiated from *Bolivinoides draco draco* by the initial, pustulose ornamentation that later fails to develop the distinctive, continuous longitudinal costae of the former subspecies. *B. draco miliares,* originally described from the upper Senonian of Germany, occurs in the upper samples at La Jolla preceding the first appearance of *B. draco draco.* The stratigraphic range of the former species is upper Campanian to lower Maastrichtian. It has previously been reported from Europe and Israel.

Types and occurrence.—Figured hypotype (UCLA 44253) from sample S-24, Rosario Formation at La Jolla (J176).

BOLIVINOIDES LAEVIGATUS Marie
Plate 13, figure 2

Bolivinoides decorata (Jones) var. *laevigata* MARIE, 1941, p. 189, pl. 29, fig. 281.
Bolivinoides praecursor REISS, 1954, p. 156, pl. 30, fig. 4-7.
Bolivinoides laevigata Marie, HILTERMANN & KOCH, 1955, p. 367, pl. 27, fig. 13-15.——HILTERMANN & KOCH, 1960, p. 72, table 3.——BARR, 1966, p. 237, pl. 34, fig. 7, pl. 38, fig. 1-5.
Bolivinoides delicatulus Cushman, GRAHAM & CHURCH, 1963, p. 51, pl. 5, fig. 24.

Test free, elongate, flaring, compressed, periphery acute. Chambers biserial throughout, low, broad. Sutures slightly depressed, partially obscured by surface ornamentation. Wall calcareous, perforate, surface ornamented by distinct, slightly elongate tubercules, irregular on early chambers, later developing two paramedian rows. Aperture an elongate loop at base of final chamber, lip weakly developed.

Maximum length of figured hypotype, 0.30 mm.; breadth, 0.18 mm.; thickness, 0.10 mm.

Discussion.—As noted by BARR (1966), *Bolivinoides laevigatus* differs from *B. decoratus* (JONES) in being smaller, more compressed, and having much more weakly developed ornamentation. The present classification follows that of BARR, who regards *B. praecursor* REISS as a junior synonym of *B. laevigatus.* The specimen illustrated by GRAHAM & CHURCH (1963) from the Campanian of the Stanford campus is identical to the present forms in size and morphologic characteristics; hence it is here regarded as *B. laevigatus.* Originally described from the *Belemnitella mucronata* Zone of the Paris Basin, this species ranges from the upper Campanian to the lower Maastrichtian.

Types and occurrence.—Figured hypotype (UCLA 44254) from sample S-22, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma (J159, L95).

Genus TAPPANINA Montanaro Gallitelli, 1955

TAPPANINA SELMENSIS (Cushman), 1933

Bolivinita selmensis CUSHMAN, 1933b, p. 58, pl. 7, fig. 3-4.——CUSHMAN, 1946, p. 114, pl. 49, fig. 1 (not fig. 2).——BROTZEN, 1948, p. 56, fig. 16, pl. 9, fig. 7.
Tappanina selmensis (Cushman), MONTANARO GALLITELLI, 1956, p. 37, pl. 7, fig. 3-4.——PERLMUTTER & TODD, 1965, p. 115, pl. 2, fig. 16.

Test free, small, tapering, nearly rectangular in transverse section, sides concave, periphery rounded. Chambers distinct, flattened, slightly inflated in adult. Sutures arched, becoming depressed and less distinct in later stage. Wall calcareous, finely perforate, surface smooth with rounded carinae becoming more strongly developed in adult. Aperture loop-shaped, at base of final chamber.

Maximum length of hypotypes, 0.14 to 0.25 mm.; breadth, 0.11 to 0.14 mm.; thickness, 0.07 to 0.08 mm.

Discussion.—*Tappanina selmensis* is recognized by the concave sides, slight axial twisting in direction of coiling and transverse carinae developed on later chambers. Originally described from the Selma Chalk of Tennessee, this widespread species is reported to range from Campanian to Paleocene. The present occurrences are restricted to Carlsbad.

Types and occurrence.—Unfigured hypotypes from Rosario Formation at Carlsbad (C105).

TAPPANINA TUBEROSA Sliter, n. sp.
Plate 13, figure 3

Test free, small, tapering, biserial, compressed, sides concave, periphery rounded. Chambers subrectangular, inflated, with truncate lower margin, increasing moderately in size. Sutures indistinct, nearly perpendicular to axis, depressed, central median suture strongly depressed. Wall calcareous, finely perforate, surface hispid, becoming coarser along the truncate base of each chamber. Aperture loop-shaped, at base of final chamber.

Maximum length of holotype, 0.26 mm.; breadth, 0.12 mm.; thickness, 0.10 mm.

Discussion.—This species differs from *Tappanina selmensis* (CUSHMAN) (1933b) in being less twisted axially, hispid, having less concave sides and more inflated chambers and lacking the distinct carinae. Carinae are replaced on the present specimens by unconsolidated pustules, which may become quite pronounced. *T. tuberosa* occurs stratigraphically higher than *T. selmensis* in the upper portion of the La Jolla section (upper Campanian to Maastrichtian).

Types and occurrence.—Holotypes (UCLA 44255) and paratype (UCLA 44256) from sample S-29, Rosario Formation at La Jolla (J204).

Family EOUVIGERINIDAE Cushman, 1927

Genus EOUVIGERINA Cushman, 1926

EOUVIGERINA HISPIDA Cushman

Plate 13, figure 4, 9

Eouvigerina hispida CUSHMAN, 1931c, p. 45, pl. 7, fig. 12-13.——CUSHMAN, 1946, p. 115, pl. 49, fig. 7-8.

Test free, elongate, compressed, initially biserial, later becoming uniserial, with apical spine. Chambers subglobular, inflated, increasing rapidly in size. Sutures distinct, depressed. Wall calcareous, finely perforate, surface spinose, initial end more strongly ornamented. Aperture terminal, rounded, with short neck and small lip.

Maximum length of figured hypotypes, 0.20 mm.; breadth, 0.09 to 0.10 mm.; thickness, 0.07 to 0.09 mm. Other hypotypes range from 0.14 to 0.20 mm. in length.

Discussion.—This distinctive species is easily recognized by its compressed test and hispid surface ornamentation. It occurs most commonly at Carlsbad but is also found rarely at La Jolla.

Types and occurrence.—Figured hypotype (Fig. 4, UCLA 44257) sample S-36, Rosario Formation at La Jolla. Figured hypotype (Fig. 9, UCLA 44258) from sample C-4, Rosario Formation at Carlsbad (C86, J219).

EOUVIGERINA ROSARIOENSIS Sliter, n. sp.

Plate 13, figure 8

Test free, small, cylindrical, biserial throughout, final chamber central, nearly uniserial, periphery rounded. Chambers distinct, subglobular, inflated, overlapping, initially increasing rapidly in size, and later more slowly, so that test has nearly parallel sides. Sutures distinct, depressed. Wall calcareous, finely perforate, surface hispid. Aperture circular, terminal, with distinct neck and phialine lip.

Maximum length of holotype, 0.19 mm.; diameter, 0.09 mm.

Discussion.—This species differs from *Eouvigerina hispida* CUSHMAN in being somewhat smaller, more cylindrical and less compressed and in having more overlapping chambers. *Uvigerina maqfiensis* LEROY (1953), described from the Paleocene-lower Eocene of Egypt, is somewhat similar in outline and chamber arrangement. It differs, however, in being twice as large, more elongate and coarsely hispid, having a greater biserial portion of the test, and heavier, more pronounced apertural neck. The present occurrences of *E. rosarioensis* are restricted to Carlsbad and the middle and upper portion of the La Jolla section (middle to late Campanian).

Types and occurrence.—Holotype (UCLA 44259) from sample S-20; paratype (UCLA 44260) from sample S-21; both from Rosario Formation at La Jolla (C101, J151).

Genus STILOSTOMELLA Guppy, 1894

STILOSTOMELLA IMPENSIA (Cushman)

Plate 13, figure 5

Ellipsonodosaria alexanderi Cushman var. ***impensia*** CUSHMAN, 1938b, p. 48, pl. 8, fig. 4-5.——CUSHMAN, 1946, p. 136, pl. 56, fig. 16-18.——CUSHMAN, 1949, p. 9, pl. 4, fig. 11.

Nodosaria spinifera Cushman & Campbell, TRUJILLO, 1960, p. 328, pl. 47, fig. 7.

Test free, elongate, gently arcuate, uniserial. Chambers inflated, becoming elongated, increasing gradually in size. Sutures distinct, depressed. Wall calcareous, hyaline, finely perforate, surface distinctly spinose. Aperture terminal, produced on short neck, with indentation on one side.

Maximum length of figured hypotype, 1.77 mm.; diameter, 0.29 mm.

Discussion.—The present specimens are identical to hypotypes from the Corsicana Marl (locs. 26-28 of CUSHMAN, 1946). The figured specimen illustrates the gradation in the strength, number, and position of spines between the initial end and, in this case, the regenerated later less calcified portion of the test. This species, originally described from the Corsicana Marl of Texas as a variety of *Ellipsonodosaria alexanderi,* is characteristic of Navarro strata in the Gulf Coast of North America. On the West Coast, the specimen illustrated as *Nodosaria spinifera* CUSHMAN & CAMPBELL by TRUJILLO (1960) belongs to this species. The original illustration of *N. spinifera* by CUSHMAN & CAMPBELL (1935) as well as the specimen illustrated by MARTIN (1964) differ from the present forms in being more cylindrical and having elongate chambers.

Types and occurrence.—Figured hypotype (UCLA 44261) from sample S-31, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Carlsbad, Point Loma and Punta Descanso (C135, J10, L20, D27).

STILOSTOMELLA PSEUDOSCRIPTA (Cushman)

Plate 13, figure 6-7

Ellipsonodosaria pseudoscripta CUSHMAN, 1937b, p. 103, pl. 15, fig. 14.

Nodogenerina spinosa HOFKER, 1956, p. 69, pl. 6, fig. 26.

Stilostomella spinosa (Hofker), HOFKER, 1957, p. 142, fig. 164.

Siphonodosaria sp. cf. *S. paleocenica* (Cushman & Todd), GRAHAM & CHURCH, 1963, p. 55, pl. 6, fig. 10-12.

Test free, elongate, gently tapering, uniserial, rectilinear. Chambers inflated, initially globular, later pyriform. Sutures distinct, depressed, somewhat limbate. Wall calcareous, finely perforate, surface spinose, becoming coarser at base of chamber, suture area may be smooth. Aperture terminal, rounded, with simple tooth and phialine lip.

Maximum length of figured hypotypes, 0.57 to 0.66 mm.; diameter, 0.10 mm.

Discussion.—This species is distinguished from the related species by its smaller size and less distinct ornamentation. Unlike the Texas specimens, the present forms show a morphologic variation in strength of spines and shape of chambers. The population includes intergradational forms that closely resemble *Stilostomella plummerae* (CUSHMAN) (1940b) from the Midway Group of Alabama. These specimens have a less elongate, more subglobular ultimate chamber that is commonly excavated at the base. Because of the intergradational nature of these 2 forms and the prevalence of the elongated specimens, both are here included in the present species. The specimens illustrated by GRAHAM & CHURCH (1963) as *S.* sp. cf. *S. paleocenica* (CUSHMAN & TODD) from the Campanian of the Stanford University campus are identical to the present forms. *S. spinosa* (HOFKER) from the Maastrichtian of Denmark also is nearly identical. The stratigraphic range of *S. pseudoscripta*, originally described from the upper Taylor Marl of Texas, is from Santonian to Maastrichtian.

Types and occurrence.—Figured hypotype (Fig. 6, 44262) from sample S-2; figured hypotype (Fig. 7, 44263) from sample S-15; both from Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Carlsbad, Point Loma, and Punta Descanso (C117, J25, L68, D69).

Family UVIGERINIDAE Haeckel, 1894

Genus PSEUDOUVIGERINA Cushman, 1927

PSEUDOUVIGERINA CALIFORNICA Sliter, n. sp.

Plate 13, figure 10

Test free, small, tapering, triserial throughout, periphery rounded. Chambers subglobular, inflated. Sutures distinct, depressed. Wall calcareous, finely perforate, surface smooth. Aperture terminal, rounded, with short neck and lip.

Maximum length of holotype, 0.17 mm.; breadth, 0.09 mm.

Discussion.—This species most closely resembles *Eouvigerina hofkeri* SAID & KENAWY (1956) from the Upper Cretaceous of Egypt; the latter, however, is much larger, more elongate, and reportedly becomes biserial in its final stage. The small size, triserial arrangement, and globular chambers distinguish the California species. The Eocene species *Uvigerina minuta* CUSHMAN & STONE (1949) and *U. garzaensis* CUSHMAN & SIEGFUS (1939) both differ from *Pseudouvigerina californica* in being more robust, twice as large, hispid and having a less acute initial end. The present specimens occur most commonly at Carlsbad but also are found rarely in the lower portion of the La Jolla section in strata of Campanian age.

Types and occurrence.—Holotype (UCLA 44265) from sample C-2; paratype (UCLA 44266) from sample C-3; both from Rosario Formation at Carlsbad (C90, J110).

PSEUDOUVIGERINA PLUMMERAE Cushman

Plate 13, figure 11

Pseudouvigerina plummerae CUSHMAN, 1927b, p. 115, pl. 23, fig. 8.
——CUSHMAN, 1946, p. 116, pl. 49, fig. 14-16.
Pseudouvigerina cretacea Cushman, BANDY, 1951, p. 513, pl. 75, fig. 13.

Test free, small, elongate, triserial throughout, triangular in section. Chambers distinct, increasing rapidly in size, somewhat inflated, periphery rounded or with 2 weak vertical costae. Sutures distinct, depressed. Wall calcareous, finely perforate, surface smooth. Aperture circular, terminal, with short neck and phialine lip.

Maximum length of figured hypotype, 0.31 mm.; breadth, 0.19 mm.

Discussion.—This species, originally described from the Pecan Gap Chalk of Texas, is distinguished by the double peripheral costae, crenulate margins, and triangular section. BANDY (1951), referred these California representatives to *Pseudouvigerina cretacea* CUSHMAN, but that species has a subrounded section and lacks the surface ornamentation. The present species is characteristic of the Carlsbad section and varies in the strength of the vertical costae. Identical specimens in my collection from the upper Taylor Marl (loc. 226-T-8 of Texas Bur. Econ. Geol., PLUMMER loc. no. 347) also exhibit the degree of variation mentioned by CUSHMAN (1946, p. 117). The Carlsbad specimens are more robust than the Texas representatives but less strongly ornamented. *P. plummerae* also occurs in the basal portion of the La Jolla section. This species has been reported to range from upper Austin to Navarro strata.

Types and occurrence.—Figured hypotype (UCLA 44264) from sample C-3, Rosario Formation at Carlsbad. Unfigured hypotypes from Rosario Formation at La Jolla (C4, J116).

Superfamily DISCORBACEA Ehrenberg, 1838

Family DISCORBIDAE Ehrenberg, 1838

Subfamily SEROVAININAE Sliter, n. subf.

Test free, trochospiral, umbilical area closed. Wall calcareous, perforate, radial in structure, monolamellar. Aperture basal.

Genus SEROVAINA Sliter, n. gen.

Type species.—*Serovaina orbicella* (BANDY).

Test free, trochospiral, umbilicate, periphery rounded. Chambers increasing rather rapidly in size. Sutures distinct, radial, depressed. Wall calcareous, finely perforate, radial in structure, monolamellar, surface smooth. Aperture slitlike, interiomarginal, at base of final chamber, with slight lip on upper border.

Discussion.—The examination of numerous specimens shows the wall structure to be radially constructed and monolamellar, thus excluding it from the superfamily Cassidulinacea. These forms are referred to the Discorbacea and are interpreted to represent a new subfamily and genus. The apertural modifications of the subfamily Bagginінae and the genus *Valvulinaria* are clearly distinct from the present specimens. Thus, a new subfamily is proposed to include these monolarmelliar forms having radial wall structure, an open umbilicus, and a slitlike aperture extending from periphery to umbilicus.

SEROVAINA ORBICELLA (Bandy)

Plate 13, figure 12

Gyroidina globosa (Hagenow) var. *orbicella* BANDY, 1951, p. 505, pl. 74, fig. 2.

Gyroidina globosa orbicella Bandy, MARTIN, 1964, p. 95, pl. 13, fig. 2.

Test free, trochospiral, spiral side partially evolute, all chambers visible, gently convex to flattened, umbilical side involute, strongly convex with small umbilicus, axial periphery broadly rounded. Chambers 6 to 8 in final whorl, increasing rather rapidly in size, becoming inflated. Sutures distinct, radial, depressed. Wall calcareous, finely perforate, radial in structure, monolamellar, surface smoothly finished. Aperture a low interiomarginal slit at base of high apertural face extending from near periphery to umbilicus, occasionally with small lip.

Maximum diameter of figured hypotype, 0.29 mm.; thickness, 0.17 mm. Other hypotypes range to 0.31 mm. in diameter.

Discussion.—BANDY (1951) described this species as a new variety of *Gyroidina globosa*. Due to the wall structure and apertural characteristics it is here referred to *Serovaina* SLITER, n. gen. This species is found throughout the La Jolla and Carlsbad sections and more sporadically at Point Loma and Punta Descanso. In the La Jolla samples, a trend toward increased size is noted; nevertheless, the specimens are not as large as the Carlsbad forms. This variance seems to represent an environmental difference between these two localities. The stratigraphic range is Campanian to Maastrichtian.

Types and occurrence.—Figured hypotype (UCLA 44267) from sample S-11, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Carlsbad, Point Loma and Punta Descanso (C13, J51, L115, D107).

Superfamily SPIRILLINACEA Reuss, 1862

Family SPIRILLINIDAE Reuss, 1862

Subfamily PATELLININAE Rhumbler, 1906

Genus PATELLINA Williamson, 1858

PATELLINA SUBCRETACEA Cushman & Alexander

Plate 13, Figure 14

Patellina subcretacea CUSHMAN & ALEXANDER, 1930, p. 10, pl. 3, fig. 1.——LOEBLICH & TAPPAN, 1949, p. 264, pl. 51, fig. 3.

EXPLANATION OF PLATE 13

FIGURE

1. *Bolivinoides draco miliares* HILTERMANN & KOCH; 1a,b, side and apertural views, ×97 (p. 89).
2. *Bolivinoides laevigatus* MARIE; 2a,b, side and apertural views, ×129 (p. 89).
3. *Tappanina tuberosa* SLITER, n. sp.; 3a,b, side and edge views, ×187 (p. 89).

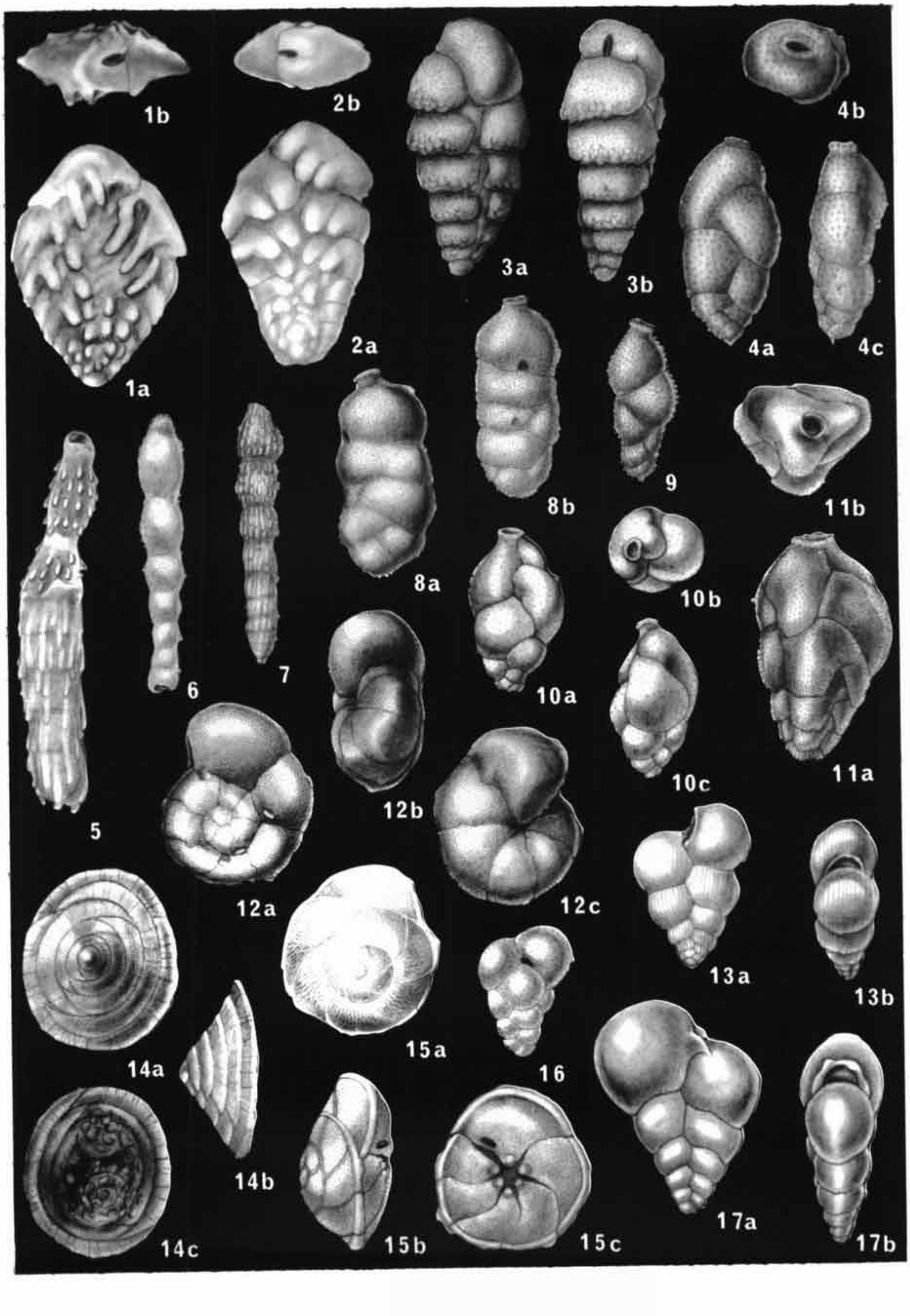
4, 9. *Eouvigerina hispida* CUSHMAN; 4a-c, side apertural, and edge views, ×187; 9, edge view, ×129 (p. 90).

5. *Stilostomella impensia* (CUSHMAN); side view showing regenerated chambers, ×33 (p. 90).

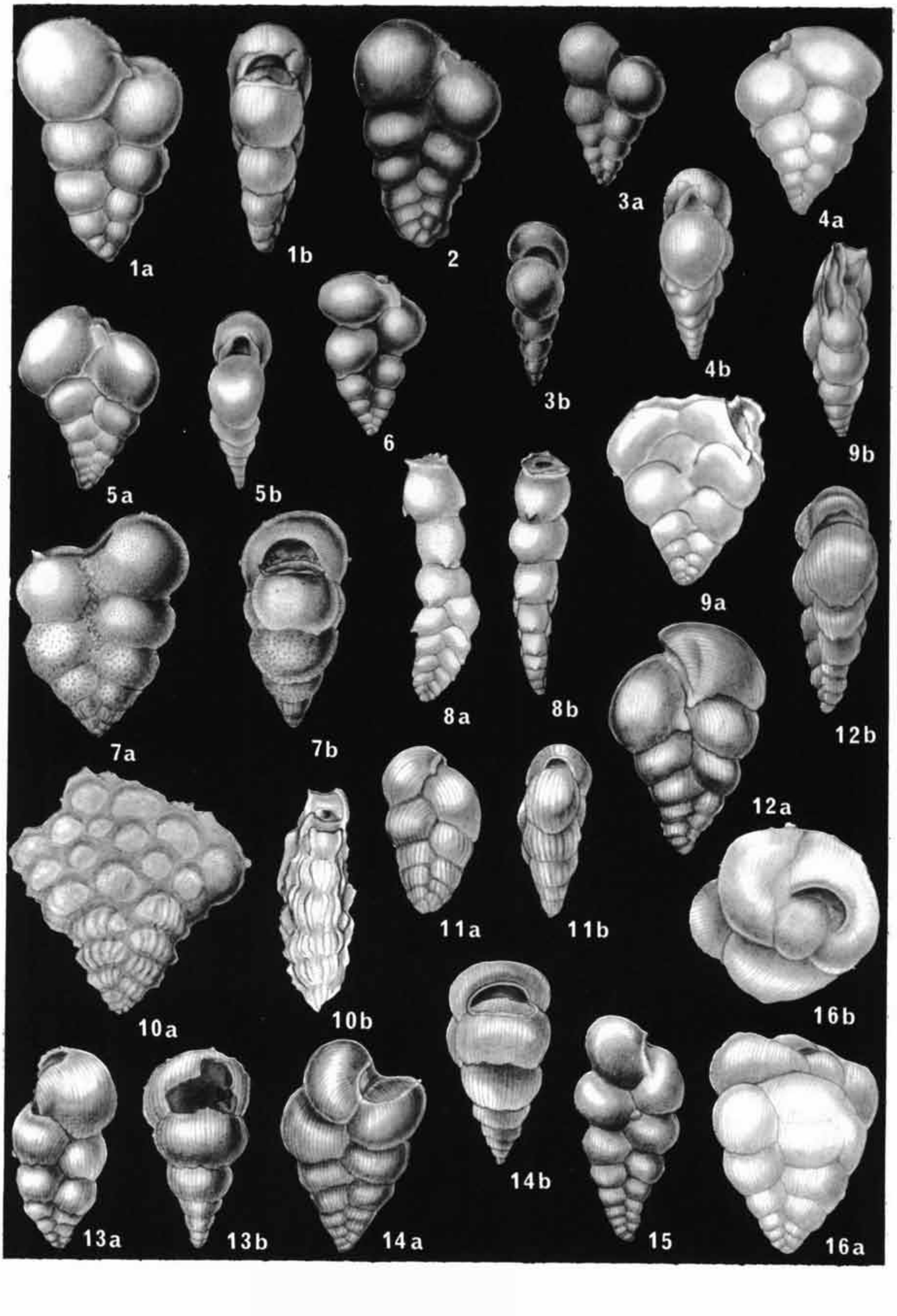
6-7. *Stilostomella pseudoscripta* (CUSHMAN); side views, ×66 (p. 90).

8. *Eouvigerina rosarioensis* SLITER, n. sp.; 8a,b, side views, ×187 (p. 90).
10. *Pseudouvigerina californica* SLITER, n. sp.; 10a-c, side and apertural views, ×187 (p. 91).
11. *Pseudouvigerina plummerae* CUSHMAN; 11a,b, side and apertural views, ×129 (p. 91).
12. *Serovaina orbicella* (BANDY); 12a-c, spiral, edge, and umbilical views, ×97 (p. 92).
13. *Heterohelix striata* (EHRENBERG); 13a,b, side and edge views, ×97 (p. 96).
14. *Patellina subcretacea* CUSHMAN & ALEXANDER; 14a-c, spiral, edge, and umbilical views, ×97 (p. 92).
15. *Pararotalia praenaheolensis* (OLSSON); 15a-c, spiral, edge, and umbilical views, ×187 (p. 93).
16. *Guembelitria cretacea* CUSHMAN; side view, ×187 (p. 94).
17. *Heterohelix glabrans* (CUSHMAN); 17a,b, side and edge views, ×187 (p. 94).

Sliter – Upper Cretaceous Foraminifera, Southern California and Northwestern Mexico.



Sliter – Upper Cretaceous Foraminifera, Southern California and Northwestern Mexico.



Test free, conical, spiral side convex, evolute, consisting of proloculus followed by short undivided chamber, later with 2 narrow and crescentic chambers per whorl, umbilical side concave, involute, axial periphery acute. Sutures distinct, gently depressed. Wall calcareous, hyaline, distinctly perforate, surface smooth, finely corrugated. Aperture a low arch under scroll-like median septa.

Maximum diameter of hypotype, 0.21 mm.; thickness, 0.10 mm. Other hypotypes range from 0.14 to 0.21 mm. in diameter.

Discussion.—This species occurs rarely in the present samples. The specimens show considerable variation in test height which, in adult forms, results from postdepositional deformation. Juvenile tests, however, are relatively higher-spired than the adults. The secondary septa are weakly developed, with surface corrugations commonly being the only indication of their presence. Specimens are distinctly perforate, more coarsely so on the initial chambers, with the later ones developing a nonperforate band just above the suture. The morphologic characters correspond so well to *Patellina subcretacea* as not to warrant the proposing of a new species name. It thus represents a long-ranging form, being originally described from the Albian of Texas. The range may possibly indicate homeomorphism.

Types and occurrence.—Figured hypotype (UCLA 44269) from sample S-25, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (J137, L84, D36).

Superfamily ROTALIACEA Ehrenberg, 1839

Family ROTALIIDAE Ehrenberg, 1839

Subfamily ROTALIINAE Ehrenberg, 1839

Genus PARAROTALIA Y. Le Calvez, 1949

PARAROTALIA PRAENAHEOLENSIS (Olsson)

Plate 13, figure 15

Lamarckina praenaheolensis Olsson, 1960, p. 37, pl. 6, fig. 18-20.

Test free, trochospiral, biconvex to planoconvex, spiral side more strongly convex, evolute, all chambers visible, umbilical side flattened, involute, only final whorl showing, umbilicate, umbilical plug may or may not be visible, axial periphery acute, with imperforate keel. Chambers usually 6 in final whorl, increasing rapidly in size, broadly rounded, each with blunt peripheral spine. Sutures distinct, strongly curved, limbate, flush on spiral side, radiate to sinuate, slightly depressed on umbilical side. Wall calcareous, finely perforate, radial in structure, surface smoothly finished. Aperture consisting of interiomarginal, extraumbilical-umbilical arched openings bordering umbilicus, with small lip and ovate areal aperture.

Maximum diameter of figured hypotype, 0.17 mm.; thickness, 0.09 mm. Other hypotypes range from 0.10 to 0.31 mm. in diameter.

Discussion.—This species is easily recognized by its peripheral chamber spines, areal aperture, and umbilical plug. The present specimens seem conspecific with the

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EXPLANATION OF PLATE 14

FIGURE

1-3. *Heterohelix globulosa* (Ehrenberg); 1a,b, side and edge views, ×187; 2, side view, ×187; 3a,b, side and edge views, ×97 (p. 94).

4-6, 9. *Heterohelix pulchra* (Brotzen); 4a,b, 5a,b, 9a,b, side and edge views, ×97; 6, side view, ×97 (p. 95).

7. *Heterohelix punctulata* (Cushman); 7a,b, side and edge views, ×66 (p. 96).

8. *Bifarina douglasi* Sliter, n. sp.; 8a,b, side and edge views, ×66 (p. 96).

10. *Planoglobulina ornatissima* (Cushman & Church); 10a,b, side and edge views, ×66 (p. 97).

11-12. *Pseudoguembelina costulata* (Cushman); 11a,b, side and edge views, ×133; 12a,b, same, ×129 (p. 97).

13-15. *Pseudotextularia elegans* (Rzehak); 13a,b, side and edge views, ×97; 14a,b, side and edge views, ×187; 15, side view, ×187 (p. 98).

16. *Racemiguembelina fructicosa* (Egger); 16a,b, side and apertural views, ×97 (p. 98).

form illustrated by OLSSON (1960) as *Lamarckina praenaheolensis* OLSSON, although the original description lacks any reference to the areal aperture. The species is here placed in the genus *Pararotalia* on the basis of the test and chamber characteristics. Considerable morphologic variation is noted in the present population in regard to the visibility of the umbilical plug and to the test thickness. The Carlsbad forms are commonly higher-spired than those from the other locations. This species is similar to *P. inermis* (TERQUEM) (1882), from the Eocene of France but differs in being more spirally convex, having fewer chambers, and in lacking a distinctly lobate periphery.

Types and occurrence.—Figured hypotype (UCLA 44270) from sample S-29, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Carlsbad and Point Loma (C66, J205, L144).

Superfamily GLOBIGERINACEA Carpenter, Parker & Jones, 1862

Family HETEROHELICIDAE Cushman, 1927

Subfamily GUEMBELITRIINAE Montanaro Gallitelli, 1957

Genus GUEMBELITRIA Cushman, 1933

GUEMBELITRIA CRETACEA Cushman

Plate 13, figure 16

Gümbelitria cretacea CUSHMAN, 1933a, p. 37, pl. 4, fig. 12.——JENNINGS, 1936, p. 28, pl. 3, fig. 12.——CUSHMAN & HEDBERG, 1941, p. 91, pl. 22, fig. 17.——CUSHMAN & TODD, 1943, p. 65, pl. 11, fig. 16.

Guembelitria cretacea Cushman, MONTANARO GALLITELLI, 1958, p. 19, pl. 3, fig. 1-3.——OLSSON, 1960, p. 27, pl. 4, fig. 8.

Test free, small, triserial. Chambers inflated, subspherical. Sutures distinct, depressed. Wall calcareous, finely perforate, smooth. Aperture a low arch at base of final chamber, with slight lip.

Maximum length of figured hypotype, 0.12 mm.; breadth, 0.09 mm.

Discussion.—The figured specimen is smaller and more tapering and has a smaller aperture than the holotype. In this respect it more closely resembles the specimen illustrated by MONTANARO GALLITELLI (1958) from northern Italy. This is a rare species in California, recorded only from Punta Descanso. Similar forms are characteristic of Navarro age strata in the Gulf Coast and New Jersey. The species has also been recorded from the Upper Cretaceous of Colombia and Italy.

Types and occurrence.—Figured hypotype (UCLA 44271) from sample E-10, Rosario Formation at Punta Descanso (E101).

Subfamily HETEROHELICINAE Cushman, 1927

Genus HETEROHELIX Ehrenberg, 1843

HETEROHELIX GLABRANS (Cushman)

Plate 13, figure 17

Gümbelina glabrans CUSHMAN, 1938a, p. 15, pl. 3, fig. 1-2.——CUSHMAN & TODD, 1943b, p. 64, pl. 11, fig. 14.

Test free, small, biserial, early portion of test slightly keeled. Chambers subrectangular, slightly compressed, periphery moderately acute, 5 pairs of chambers in adult, increasing rapidly in size. Sutures distinct, depressed, slightly curved. Wall calcareous, very finely perforate, surface smooth, polished. Aperture a broad, low arch at inner margin of final chamber, with small lip and lateral flanges extending onto previous chamber.

Maximum length of figured hypotype, 0.20 mm.; breadth, 0.15 mm.; thickness, 0.09 mm.

Discussion.—Comparison of the figured hypotype to the holotype (CUSHMAN coll. 24382) and to hypotypes from the Corsicana Marl (loc. 43 of CUSHMAN, 1946) shows it to be identical. *Heterohelix glabrans* differs from *H. globulosa* (EHRENBERG) in the subacute periphery, subrectangular chambers, and polished surface. The specimens illustrated by CUSHMAN & HEDBERG (1941) from Colombia as *H. glabrans* more closely resemble *H. pulchra* (BROTZEN). This species is known from Navarro-age strata within the Gulf Coast.

Types and occurrence.—Figured hypotype (UCLA 44272) from sample S-36, Rosario Formation at La Jolla (J218).

HETEROHELIX GLOBULOSA (Ehrenberg)

Plate 14, figure 1-3

Textularia globulosa EHRENBERG, 1839 [1840], p. 135, pl. 4, fig. 4B.

Heterohelix globulosa (Ehrenberg), MONTANARO GALLITELLI, 1957, p. 137, pl. 31, fig. 12-15.——ETERNOD OLVERA, 1959, p. 69, pl. 1, fig. 17-18.——BELFORD, 1960, p. 59, pl. 15, fig. 10-11.——TAPPAN, 1962, p. 196, pl. 55, fig. 1-2.——GRAHAM & CHURCH, 1963, p. 61, pl. 7, fig. 11.——MARTIN, 1964, p. 84, pl. 10, fig. 10.——TAKAYANAGI, 1965, p. 195, pl. 20, fig. 1.

Test free, small, biserial, flaring, initial chambers commonly planispiral, ultimate pair of chambers in large specimens less flaring to parallel sided. Chambers globular, 5 to 7 pairs, increasing moderately in size. Sutures distinct, depressed, straight. Wall calcareous, finely perforate, surface smooth to finely striate. Aperture a broad low arch with slight lip at inner margin of final chamber.

Hypotypes range in length from 0.10 to 0.32 mm.; breadth, 0.10 to 0.19 mm.; thickness, 0.09 to 0.12 mm.

Discussion.—Examination of the plesiotypes of *Guembelina globulosa* (EHRENBERG) in the CUSHMAN collection (nos. 24397, 24399, 24400) show them to be identical to the present specimens. This species is characterized by the globular chambers, generally smooth surface, and small size. Morphologic variation is noted in the position of the final chamber, presence of the initial planispiral coil, and presence or absence of surface ornamentation. The present specimens as well as the plesiotypes show varying degrees of faint striation or alignment of fine pores, producing a striated effect. This feature depends, of course, on the degree of preservation. Although *Heterohelix globulosa* has generally weaker striations than *H. striata* (EHRENBERG), the species also may be differentiated by test and chamber proportions. *H. globulosa* differs from *H. striata* in being smaller, more slowly tapering, and with globular chambers that increase more gradually in size. This last feature causes the last-formed pairs of chambers to be nearly equal in thickness. Large populations of *H. globulosa* include some individuals with as many as 14 chambers. Specimens of this size resemble *H. moremani* (CUSHMAN) (1938a) whose holotype has 19 chambers. Both species have the same thickness, chamber shape, and pore alignment. *H. globulosa* typically differs, however, in having fewer chambers and a test that tapers more rapidly until the 4th or 5th pair of chambers and then becomes nearly parallel-sided. Examination of topotype material of *H. moremani* is needed to indicate the relationship between these similar species. *H. globulosa* occurs in Europe, Far East, Australia, Africa, mid-Pacific, and North and South America. In California the species is recorded from Santonian to Maastrichtian.

Types and occurrence.—Figured hypotype (Fig. 3, UCLA 44273) from sample S-1, Rosario Formation at La Jolla. Figured hypotypes (Fig. 1-2, UCLA 44274-44275) from sample C-4, Rosario Formation at Carlsbad. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (C10, J31, L159, D49).

HETEROHELIX PULCHRA (BROTZEN)

Plate 14, figure 4-6, 9

Gümbelina pulchra BROTZEN, 1936, p. 121, pl. 9, fig. 2-3.
Gümbelina pseudotessera CUSHMAN, 1938a, p. 14, pl. 2, fig. 19-21.
Gümbelina planata CUSHMAN, 1938a, p. 12, pl. 2, fig. 13-14.
Gublerina hedbergi BRÖNNIMANN & BROWN, 1953, p. 155, fig. 11-12.
Gublerina acuta robusta DE KLASZ, 1953, p. 247, pl. 8, fig. 4-5.
Heterohelix pulchra (Brotzen), MONTANARO GALLITELLI, 1957, p. 137, pl. 31, fig. 20.——PESSAGNO, 1962, p. 358, pl. 1, fig. 3.——MARTIN, 1964, p. 85, pl. 11, fig. 2.——TAKAYANAGI, 1965, p. 197, pl. 20, fig. 3.
Guembelina lata (Egger), MONTANARO GALLITELLI, 1957, p. 137, pl. 31, fig. 19.
Heterohelix planata (Cushman), MONTANARO GALLITELLI, 1958, p. 20, pl. 2, fig. 9-10.
Gublerina ornatissima (Cushman & Church), BRÖNNIMANN & RIGASSI, 1963, pl. 17, fig. 4.
Heterohelix sp. cf. *H. planata* (Cushman), TAKAYANAGI, 1965, p. 196, pl. 20, fig. 2.

Test free, small, biserial, flaring, initial chambers commonly planispiral, later biserial, may become irregular, producing flabelliform test, initial periphery keeled, later subrounded. Chambers 5 to 7 pairs, increasing rapidly in size, initially globular, later reniform or irregular, compressed. Sutures distinct, depressed, limbate. Wall calcareous, perforations often initially coarse, later becoming fine, surface finely striate to smooth. Aperture a high arch at inner margin of last chamber, with distinct lateral flanges, may be hooded, irregular or multiple in final stage.

Maximum length of figured hypotypes, 0.34 to 0.36 mm.; breadth, 0.21 to 0.29 mm.; thickness, 0.10 to 0.12 mm.

Discussion.—This species is distinguished from the associated heterohelicids by its reniform chambers, compressed test, apertural flanges, and sporadic presence of a flabelliform stage. A complete gradation occurs from the more numerous biserial forms to the rarer ones with a flabelliform stage. The latter is encountered more frequently in the Carlsbad section. This flabelliform stage is very similar to that illustrated for the microspheric *Heterohelix pulchra* by BROTZEN (1936, pl. 9, fig. 2) from the Senonian of Sweden but differs in being somewhat larger and having less deeply depressed sutures. A paratype of *Gublerina hedbergi* BRÖNNIMANN & BROWN (USNM no. P5441) (= *G. acuta robusta* DE KLASZ) is identical to specimens in the present material. MONTANARO GALLITELLI (1957, p. 141) examined the paratype of *G. hedbergi* and concluded that although the specimen is bicamerate, unlike *Gublerina*, it has the wide central area typical of the genus. As noted by TAKAYANAGI (1965, p. 197) this central area is produced by the apertural flanges and becomes more extreme in wider specimens until the advent of the irregular chambers. Furthermore, the initial portions of both biserial and flabelliform types are identical in shape, surface ornamentation, and apertural modifications. On the basis of these features and the intergradational sequence, *G. hedbergi* is here placed in synonymy with *H. pulchra*. The holotype of *G. glaessneri* BRÖNNIMANN & BROWN (USNM no. P5442) differs from *H. pulchra* in being much larger and having a wider central area and coarser surface ornamentation. It thus seems evident that the present interpretation of *Gublerina* encompasses 2 morphologically similar taxa: the irregular forms of *Heterohelix* such as the irregular stage of *H. pulchra* that possibly represents a reproductive modification, and the distinctive forms with a definite biserial divergence belonging to *Gublerina*. The holotypes of *H. pseudotessera* (CUSHMAN) and *H. planata* (CUSHMAN) (CUSHMAN collection nos. 24380 and 24376 respectively) were examined and found to be synonymous to *H. pulchra*. A trend in the appearance and increase in size of the apertural flaps is noticed between Coniacian and Campanian specimens here referred to this species. Coniacian specimens commonly lack flaps, whereas by Campanian time they are generally well developed. The late Campanian-early Maastrichtian biserial chamber divergence and lateral extension of the apertural flaps produces a progressive increase of flabelliform specimens.

Heterohelix lata (EGGER) of CUSHMAN (1938a) and MONTANARO GALLITELLI (1957) also appears to be similar to the present species. The original illustration of *H. lata*, however, differs from the present species in showing subrectangular chambers, a less rapidly tapering test, distinct striations, and a larger size; hence the species seem distinct. *H. pulchra* as here recognized ranges from Coniacian to Maastrichtian. Recorded occurrences include the Gulf and Atlantic seaboard, Western Interior and Pacific Coast of America, mid-Pacific, Cuba, Puerto Rico, and Europe.

Types and occurrence.—Figured hypotypes (Fig. 5-6, UCLA 44278-44279) from sample C-4; hypotype (Fig. 9, UCLA 44276) from sample C-1; all from Rosario Formation at Carlsbad. Figured hypotype (Fig. 4, UCLA 44277) from sample S-13, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (C39, J14, L34, D23).

HETEROHELIX PUNCTULATA (Cushman)

Plate 14, figure 7

Gümbelina punctulata CUSHMAN, 1938a, p. 13, pl. 2, fig. 15-16.
Pseudoguembelina punctulata (Cushman), BRÖNNIMANN & BROWN, 1953, p. 154, fig. 7-8.
Heterohelix punctulata (Cushman), PESSAGNO, 1962, p. 358, pl. 1, fig. 11.

Test free, large, biserial, initial portion more widely flaring than in adult early chambers may be slightly keeled. Chambers globular, increasing less rapidly in size in adult stage. Sutures distinct, initially flush and somewhat limbate, later becoming depressed. Wall calcareous, perforate, initial chambers commonly costate, chambers in mid-portion of test pitted and lightly striate, ultimate chambers lightly striated to smooth. Aperture a broad arch at inner margin of final chamber, with narrow lip and small lateral flanges.

Maximum length of figured hypotype, 0.53 mm.; breadth, 0.39 mm.; thickness, 0.28 mm.

Discussion.—This species, placed in the genus *Pseudoguembelina* by BRÖNNIMANN & BROWN (1953) was restudied by MONTANARO GALLITELLI (1957) and reassigned to *Heterohelix*. At that time, *Pseudoguembelina* was restricted to forms with strong chamber modification producing accessory apertures, whereas those with occasional accessory apertures, i.e., *H. punctulata* and *H. striata* (EHRENBERG), were referred to *Heterohelix*. In the present samples the accessory apertures are rarely preserved but the species is easily distinguished by its punctate surface, globular chambers, and relatively large size. *H. punctulata* is characteristic of Campanian-Maastrichtian strata and occurs in the Gulf Coast of America, Cuba, and Puerto Rico.

Types and occurrence.—Figured hypotype (UCLA 44280) from sample S-11, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Carlsbad, Point Loma and Punta Descanso (C93, J71, L89, D46).

HETEROHELIX STRIATA (Ehrenberg)

Plate 13, figure 13

Textularia striata EHRENBERG, 1839 [1840], p. 135, pl. 4, fig. 1-3.
Gümbelina striata (Ehrenberg), BANDY, 1951, p. 510, pl. 75, fig. 8-9.
Heterohelix striata (Ehrenberg), ETERNOD OLVERA, 1959, p. 71, pl. 2, fig. 4, 8.——BERGGREN, 1962, p. 21, pl. 4, fig. 1-5.——MARTIN, 1964, p. 85, pl. 11, fig. 1.
Pseudoguembelina striata (Ehrenberg), BELFORD, 1960, p. 60, pl. 15, fig. 12-13.
Heterohelix globulosa (Ehrenberg), TRUJILLO, 1960, p. 344, pl. 50, fig. 10.

Test free, small, flaring, biserial, initial chambers commonly planispiral. Chambers globular to subglobular, from 5 to 7 pairs in adult, increasing rapidly in size. Sutures distinct, depressed, straight. Wall calcareous, finely perforate, surface ornamented with longitudinal striae that become fine or lacking in the ultimate chamber. Aperture a broad low arch with distinct lip at the inner margin of the final chamber, lateral flanges poorly developed or lacking.

Maximum length of figured hypotype, 0.31 mm.; breadth, 0.22 mm.; thickness, 0.12 mm.

Discussion.—The species is characterized by inflated, globular chambers, rapid increase in size and thickness, and striated surface. Examination of large groups of specimens reveals several types of morphologic variation: specimens generally taper evenly throughout but may have nearly parallel sides in the final stage; the final chamber may be displaced centrally, toward the plane of biseriality, and may be reduced in size; accessory apertures occur rarely at inner margin of final 2 chambers; and striations vary from quite prominent to barely visible. Forms with weak striations closely resemble the holotype of *Heterohelix reussi* (CUSHMAN) (1938a) from the Austin Chalk (CUSHMAN Coll. no. 24374) and the latter may be identical. The variation in ornamentation of *H. striata* has been mentioned previously (BANDY, 1951; LOEBLICH, 1951; HOFKER, 1957; MONTANARO GALLITELLI, 1957; BERGGREN, 1962) and further strengthens the need for more precise specific criteria within the heterohelicids. As noted by TAKAYANAGI (1965, p. 199), *H. globulosa* of TRUJILLO should be referred to *H. striata* on the basis of its prominent striations, inflated and globular chambers, and test thickness. *H. striata* is widely distributed, occurring in the Upper Cretaceous of Europe, Australia, North America, Mexico, and the Caribbean. California occurrences include the Campanian of Carlsbad (BANDY, 1951) and the Maastrichtian of Fresno County (MARTIN, 1964).

Types and occurrence.—Figured hypotype (UCLA 44281) from sample C-3, Rosario Formation at Carlsbad. Unfigured hypotypes from the Rosario Formation at La Jolla, Point Loma and Punta Descanso (C25, J22, L33, D45).

Genus BIFARINA Parker & Jones, 1872

BIFARINA DOUGLASI Sliter, n. sp.

Plate 14, figure 8

Test free, elongate, initially biserial, later uniserial. Chambers in biserial portion subrectangular, inflated, with small marginal spine at base of chamber, uniserial chambers inflated, globular, with 2 marginal spines. Sutures distinct, depressed, gently curved. Wall calcareous, finely perforate, surface smoothly finished. Aperture terminal, rounded.

Maximum length of holotype, 0.67 mm.; breadth, 0.18 mm.; thickness, 0.16 mm.

Discussion.—This species is rare in the present samples. It differs from *Bifarina cretacea* (CUSHMAN) (1932a) in being larger and in having more globular chambers, marginal spines, and no evidence of an apertural neck. *B. douglasi* occurs in the upper part (Campanian to Maastrichtian) of the La Jolla section and at Point Loma.

Types and occurrence.—Holotype (UCLA 44282) from sample BR-1; paratype (UCLA 44283) from sample BR-1; both from Rosario Formation at La Jolla. Unfigured paratypes from Rosario Formation at Point Loma (J152, L130).

Genus PLANOGLOBULINA Cushman, 1927

PLANOGLOBULINA ORNATISSIMA (Cushman & Church)

Plate 14, figure 10

Ventilabrella ornatissima CUSHMAN & CHURCH, 1929, p. 512, pl. 39, fig. 12-15.

Gublerina ornatissima (Cushman & Church), GRAHAM & CHURCH, 1963, p. 61, pl. 7, fig. 10.——MARTIN, 1964, p. 86, pl. 11, fig. 3.——TAKAYANAGI, 1965, p. 200, pl. 20, fig. 6-8.

Test free, large, initially biserial, flaring, later flabelliform, with numerous chambers in biserial plane, compressed. Chambers subglobular, initially more inflated, periphery of biserial portion subrounded, adult periphery rounded. Sutures distinct, limbate, initially depressed, later flush to slightly elevated. Wall calcareous, finely perforate, surface initially costate, later smooth. Aperture not observed, owing to broken ultimate chambers.

Maximum length of figured hypotype, 0.63 mm.; breadth, 0.53 mm.; thickness, 0.21 mm.

Discussion.—Some confusion exists concerning the taxonomic position of this species. *Planoglobulina ornatissima* is characterized by a flabelliform test, proliferation of chambers in the plane of biseriality that completely fill the test area, and thicker, costate, and commonly pustulose initial portion. The absence of a nonseptate central area clearly separates this species from the genus *Gublerina* but not from *Planoglobulina.* The species is easily distinguished and common to all the present locations. Examination of numerous specimens shows the central area to be filled with inflated chambers surrounded by limbate sutures. The central chambers have 2 arched apertures communicating with the adjacent chambers in a diagonal series. *P. ornatissima* thus is not synonymous with *G. cuvillieri* KIKÖINE (1948). Examination of the holotype of *G. glaessneri* BRÖNNIMANN & BROWN (USNM no. P5442) from the Maastrichtian of Cuba demonstrates a close resemblance to *P. ornatissima. G. glaessneri* is pustulose and thickened in the early portion of the test but differs in the thinner walls, more compressed ultimate stage, and apparent tendency for biserial chambers to diverge and leave the central nonseptate area characteristic of *Gublerina. P. eggeri* (CUSHMAN) differs from *P. ornatissima* in the less developed early biserial stage, distinctly inflated chambers, more uniform lateral compression, less limbate sutures, less pronounced initial costae, and smaller size. *P. acervulinoides* (EGGER) (1899) differs from *P. ornatissima* in the less strongly ornamented initial portion of the test, less limbate sutures, and larger size. The latter species is apparently restricted to the Upper Cretaceous of the Pacific Coast. Future investigation may show that some species now placed in the genus *Gublerina* and having distinct initial ornamentation and later proliferation of chambers are closely related to this species, thus expanding the geographic distribution. *P. ornatissima* has been recorded from the northern, central, and southern sections of California. The form referred to *Ventilabrella* sp. cf. *V. austinana* CUSHMAN by MCGUGAN (1964) from the Upper Cretaceous of Vancouver Island, Canada, is probably more closely related to the present species.

Types and occurrence.—Figured hypotype (UCLA 44284) from sample S-20, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Carlsbad, Point Loma and Punta Descanso (C24, J72, L32, D67).

Genus PSEUDOGUEMBELINA Brönnimann & Brown, 1953

PSEUDOGUEMBELINA COSTULATA (Cushman)

Plate 14, figure 11-12

Gümbelina excolata Cushman, VOORWIJK, 1937, p. 194, pl. 1, fig. 7-8.

Gümbelina costulata CUSHMAN, 1938a, p. 16, pl. 3, fig. 7-9.——CIVRIEUX, 1952, p. 271, pl. 6, fig. 15.——HAMILTON, 1953, p. 234, pl. 30, fig. 12.

Pseudoguembelina costulata (Cushman), MONTANARO GALLITELLI, 1957, p. 139, pl. 31, fig. 21-22.——PESSAGNO, 1962, p. 358, pl. 1, fig. 6.

Test free, small, biserial, initial chambers commonly keeled. Chambers slightly inflated, reniform. Sutures limbate and flush in early portion, later becoming depressed. Wall calcareous, perforate, ornamented throughout with fine longitudinal costae. Principal aperture a low arch with lip at inner margin of last chamber, accessory apertures developed by the extension of lateral flaps.

Maximum length of figured hypotypes, 0.25 to 0.32 mm.; breadth, 0.16 to 0.21 mm.; thickness, 0.11 mm.

Discussion.—The costate ornamentation, compressed test, reniform chambers, and common accessory apertures characterize this species. It differs from *Pseudoguembelina excolata* CUSHMAN (1926a) of the Gulf Coast in the smaller size, less coarse ornamentation, and less inflated, more reniform chambers. These characteristics, plus the presence of accessory apertures, serve to distinguish this species from *Heterohelix striata. P. costulata* was originally described from the Campanian of Texas and has since been recorded from the Campanian and Maastrichtian of the Gulf Coast (CUSHMAN, 1946), the Upper Cretaceous of the mid-Pacific (HAMILTON, 1953), and the Campanian-Maastrichtian of Venezuela (CIVRIEUX, 1952) and Puerto Rico (PESSAGNO, 1962).

Types and occurrence.—Figured hypotype (Fig. 12, UCLA 44285) from sample C-4; figured hypotype (Fig. 11, UCLA 44286) from sample C-1; both from Rosario Formation at Carlsbad. Unfigured hypotypes from the Rosario Formation at La Jolla and Punta Descanso (C40, J47, D146).

Genus PSEUDOTEXTULARIA Rzehak, 1891

PSEUDOTEXTULARIA ELEGANS (Rzehak)

Plate 14, figure 13-15

Cuneolina elegans RZEHAK, 1891, p. 4.

Guembelina plummerae LOETTERLE, 1937, p. 33, pl. 5, fig. 1-2.——CIVRIEUX, 1952, p. 270, pl. 6, fig. 11-12.——HAMILTON, 1953, p. 234, pl. 30, fig. 10.——NAGAPPA, 1959, pl. 7, fig. 5-6.

Pseudotextularia elegans (Rzehak), aff. var. *deformis* (Kikoïne), DE KLASZ, 1953, p. 232, pl. 5, fig. 3.

Pseudotextularia elegans (Rzehak), MONTANARO GALLITELLI, 1957, p. 138, pl. 33, fig. 6.——GRAHAM & CLARK, 1961, p. 111, pl. 5, fig. 5.——PESSAGNO, 1962, p. 356, pl. 1, fig. 9.

Heterohelix striata (Ehrenberg), GRAHAM & CHURCH, 1963, p. 62, pl. 7, fig. 12.——TAKAYANAGI, 1965, p. 198, pl. 20, fig. 4.

Test free, large, biserial, flaring. Chambers initially subglobular, later one strongly inflated, laterally compressed with thickness commonly exceeding breadth, ultimate chamber may be nearly central in position and may be either enlarged or reduced in size, small peripheral chambers may be added in plane of biseriality. Sutures distinct, depressed, straight to slightly curved. Wall calcareous, finely perforate, surface distinctly costate. Aperture a broad, low interiomarginal arch, with slight lip.

Maximum length of figured hypotypes, 0.34 to 0.42 mm.; breadth, 0.17 to 0.25 mm.; thickness, 0.17 to 0.21 mm.

Discussion.—This species is distinguished by the lateral compression of the test so that test thickness equals or exceeds its breadth, common central position of the final chamber, costate ornamentation, and relatively large size. Specimens from all 4 locations exhibit variations in test length, breadth, and thickness similar to those illustrated by NOTH (1951) from the Austrian Alps. Sporadically the degree of thickness approaches that in material from the Taylor Formation of Texas. The early chambers of *Pseudotextularia elegans*, prior to the advent of lateral compression, superficially resemble those of *Heterohelix striata* but the species may be differentiated by the strong costae and the more subrectangular chambers. A progressive increase in the strength of the costate ornamentation, both in the amount of relief and the lateral separation of individual costae, is noticed between Coniacian and Maastrichtian specimens. A widespread Upper Cretaceous species *P. elegans* has been reported from the Gulf, plains, and western states of America, and from Mexico, Venezuela, Europe, Egypt, India, and the mid-Pacific. Two California occurrences closely resembling *P. elegans* and here included in the synonymy are *H. striata* of GRAHAM & CHURCH (1963) and *H. striata* of TAKAYANAGI (1965).

Types and occurrence.—Figured hypotypes (Fig. 14-15, UCLA 44288-44289) from sample C-4, Rosario Formation at Carlsbad. Figured hypotype (Fig. 13, UCLA 44287) from sample S-20, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (C52, J32, L67, D47).

Genus RACEMIGUEMBELINA Montanaro Gallitelli, 1957

RACEMIGUEMBELINA FRUCTICOSA (Egger)

Plate 14, figure 16

Gümbelina fructicosa EGGER, 1901, p. 35, pl. 14, fig. 8-9.

Pseudotextularia varians Rzehak, CUSHMAN, 1946, p. 110, pl. 47, fig. 4-9.——HAMILTON, 1953, p. 235, pl. 30, fig. 9.

Racemiguembelina fructicosa (Egger), MONTANARO GALLITELLI, 1957, p. 142, pl. 32, fig. 14-15.——ETERNOD OLVERA, 1959, p. 78, pl. 2, fig. 5-7, 11.

Pseudotextularia elegans (Rzehak), NAGAPPA, 1959, pl. 7, fig. 7-8.

Test free, subconical, early chambers biserial, later becoming proliferated perpendicular to growth axis. Early chambers globular, later ones irregular, inflated. Sutures distinct, depressed, slightly curved. Wall calcareous, finely perforate, surface ornamented with longitudinal costae. Aperture a broad low arch, with slight lip, at base of terminal chamber.

Maximum length of figured hypotype, 0.43 mm.; breadth, 0.34 mm.

Discussion.—A single specimen of this distinctive species was found. *Racemiguembelina fructicosa* differs from *Pseudotextularia elegans* in the proliferation of chambers at the crown producing the subconical test. It has been recorded previously from the Navarro of the Gulf Coast (CUSHMAN, 1946), Campanian and Maastrichtian of Mexico (ETERNOD OLVERA, 1959), Upper Cretaceous of the mid-Pacific (HAMILTON, 1953), Upper Cretaceous of northwest Germany (HOFKER, 1957), and Maastrichtian of northeast India (NAGAPPA, 1959).

Type and occurrence.—Figured hypotype (UCLA 44290) from sample L-12, Rosario Formation at Point Loma (L139).

Family PLANOMALINIDAE Bolli, Loeblich & Tappan, 1957

Genus GLOBIGERINELLOIDES Cushman & ten Dam, 1948

GLOBIGERINELLOIDES ALVAREZI (Eternod Olvera)

Plate 15, figure 1-2

Planomalina alvarezi ETERNOD OLVERA, 1959, p. 91, pl. 4, fig. 5-7.——MARTIN, 1964, p. 84, pl. 10, fig. 8-9.

Planomalina yaucoensis PESSAGNO, 1960, p. 98, pl. 2, fig. 14-15.

Globigerinella aspera (Ehrenberg), HERM, 1962, p. 49, pl. 3, fig. 6.

Planomalina (Globigerinelloides) aspera aspera (Ehrenberg), VAN HINTE, 1963, p. 97, pl. 12, fig. 2.

Globigerinelloides asper (Ehrenberg), TAKAYANAGI, 1965, p. 201, pl. 20, fig. 9.

Test free, small, planispiral, biumbilicate, periphery moderately lobate. Chambers 7 to 8 in the final whorl, inflated, globular, slightly overlapping. Sutures distinct, depressed, radial. Wall calcareous, finely perforate, surface smooth to finely hispid. Aperture a moderately high arch at base of final chamber, with small lip and occasionally preserved relic apertures.

Maximum diameter of figured hypotypes, 0.22 mm.; thickness ranges from 0.09 to 0.11 mm. Other hypotypes range from 0.17 to 0.31 mm. in diameter.

Discussion.—This species, originally described from the Campanian-Maastrichtian of Mexico, is distinguished from *Globigerinelloides messinae* (BRÖNNIMANN) by the greater number of chambers in the final whorl, thinner test, and commonly greater diameter. In the present samples, 2 species of *Globigerinelloides* are consistently observed. These have been referred to the present species and to *G. messinae*, omitting any reference to *G. asper* (EHRENBERG) (1854) owing to its confused taxonomy (see remarks under *G. messinae*). Nevertheless, were the status of *G. asper* clarified, the original illustrations are of a form with 5 to 6 chambers in the final whorl, and thus differing from the present specimens. This species may represent a long-ranging conservative stock or the Campanian-Maastrichtian examples may be stratigraphically distinct. For the present, the latter possibility is chosen. The specimen illustrated by TAKAYANAGI from the Campanian of northern California appears identical to the present material. The stratigraphic range of this species is Santonian to Maastrichtian.

Types and occurrence.—Figured hypotype (Fig. 1, UCLA 44292) from sample C-2, Rosario Formation at Carlsbad. Figured hypotype (Fig. 2, UCLA 44291) from sample S-37, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma, and Punta Descanso (C102, J30, L157, D90).

GLOBIGERINELLOIDES MESSINAE (Brönnimann)
Plate 15, figure 3, 5

Globigerinella aspera (Ehrenberg), BANDY, 1951, p. 508, pl. 75, fig. 3.

Globigerinella messinae messinae BRÖNNIMANN, 1952, p. 42, fig. 20, pl. 1, fig. 6-7.

Globigerinella biforaminata HOFKER, 1956, p. 53, fig. 2, 5.

Planomalina (Globigerinelloides) messinae (Brönnimann), BERGGREN, 1962, p. 44, fig. 6,*1-6*, 7,*1-8*, pl. 8, fig. 4-8.

Globigerinella voluta pinguis HERM, 1962, p. 52, pl. 1, fig. 1.

Planomalina (Globigerinelloides) messinae messinae (Brönnimann), VAN HINTE, 1963, p. 100, pl. 12, fig. 6.

Planomalina (Globigerinelloides) messinae biforaminata (Hofker), VAN HINTE, 1963, p. 102, pl. 12, fig. 4.

Globigerinelloides messinae (Brönnimann), OLSSON, 1964, p. 174, pl. 7, fig. 6-8.

Planomalina aspera (Ehrenberg), MARTIN, 1964, p. 84, pl. 10, fig. 7.

Test free, small, planispiral, biumbilicate, moderately involute, equatorial periphery lobate, axial periphery rounded. Chambers 5, rarely 6 in final whorl, increasing rapidly in size, globular. Sutures radial, depressed. Wall calcareous, finely perforate, radial in structure, surface hispid. Aperture in early stages a broad, low interiomarginal, equatorial arch bordered by a lip whose lateral, umbilical extensions from relict apertures, later stages commonly develop a bipartite primary aperture, occasionally covered by small, thin walled chamber or bulla.

Maximum diameter of figured hypotypes, 0.24 mm. to 0.27 mm.; thickness, 0.14 mm.

Discussion.—This species, originally described from the upper Maastrichtian of Trinidad, is characterized by globular chambers (generally 5 in final whorl), rounded periphery, open umbilicus, and sporadic bipartite aperture. Present specimens have been compared to the holotype and some members of the population are identical to it. It differs, however, in being slightly larger, somewhat more compressed and having more elongate chambers than average California specimens. These features are regarded as intraspecific or geographic variations inasmuch as the present examples are identical to Atlantic Coast holotype material and illustrations of Scandinavian specimens (BERGGREN, 1962). Complete gradations from specimens with single apertures to the rarer double apertures are found in the present samples. I agree with BERGGREN (1962) that *Biglobigerinella* represents an artificial genus. Specimens with bipartite apertures have been found in populations with single apertures from Aptian (BOLLI, LOEBLICH & TAPPAN, 1957), Campanian to Maastrichtian (SUBBOTINA, 1953; BERGGREN, 1962; OLSSON, 1964) and Tertiary, i.e., late Eocene (DIENI & PROTO DECIMA, 1964; SULEIMANOV, 1966), and apparently represent an end-point in the morphologic development of these lineages.

The species *Globigerinelloides asper* (EHRENBERG) has been purposely omitted from discussion because of agreement with BRÖNNIMANN (1952) that the original illustrations and description of this species are inadequate. Furthermore, several of the original illustrations, i.e., pl. 23, fig. 28; pl. 27, fig. 57; pl. 28, fig. 42; pl. 31, fig. 44 (EHRENBERG, 1854), show a trochospiral coil indicative of *Hedbergella*. One need only refer to the literature to note the differing interpretations of this species. Therefore, until type material is restudied, the present specimens are placed in *G. messinae*. The stratigraphic range of this species within California is upper Campanian to lower Maastrichtian. Other occurrences include upper Campanian and Maastrichtian of New Jersey and Delaware, uppermost Cretaceous of the Netherlands, and Maastrichtian of Trinidad and Scandinavia.

Types and occurrence.—Figured hypotype (Fig. 3, UCLA 44293) from sample C-6; figured hypotype (Fig. 5, UCLA 44294) from sample C-2; both from Rosario Formation at Carlsbad. Unfigured hypotypes from Rosario Formation at La Jolla, Point Loma and Punta Descanso (C9, J11, L31, D87).

Family SCHACKOINIDAE Pokorný, 1958

Genus SCHACKOINA Thalmann, 1932

SCHACKOINA MULTISPINATA (Cushman & Wickenden)

Plate 15, figure 7

Hantkenina multispinata CUSHMAN & WICKENDEN, 1930, p. 40, pl. 6, fig. 4-6.

Hantkenina trituberculata MORROW, 1934, p. 195, pl. 29, fig. 24, 26-28.

Schackoina trituberculata (Morrow), LOETTERLE, 1937, p. 47, pl. 7, fig. 7.——BOLIN, 1952, p. 56, pl. 4, fig. 4.

Schackoina multispinata (Cushman & Wickenden), LOEBLICH & TAPPAN, 1961, p. 271, pl. 1, fig. 8-10.——GRAHAM & CHURCH, 1963, p. 61, pl. 7, fig. 9.

Test free, small, low trochospiral; chambers 3 in final whorl, increasing rapidly in size, radially elongate, producing single peripheral tubulospine, later chambers with 2 or 3 additional tubulospines randomly distributed. Sutures depressed, radial. Wall calcareous, finely perforate, surface smooth. Aperture interiomarginal, equatorial, with bordering lip.

Maximum diameter of figured hypotype, 0.10 mm.; thickness, 0.05 mm.

Discussion.—This species is characterized by small size and radially elongate chambers with tubulospines. Within California, *Schackoina multispinata* has been recorded from the Campanian of the Stanford campus (GRAHAM & CHURCH, 1963). Gulf Coast occurrences include parts of the Eagle Ford Group, Austin Chalk, and Pecan Gap Member of the Taylor Marl. Western Interior occurrences range from Cenomanian to Santonian, whereas in Europe this species has been recorded from the middle and upper Senonian of Italy and Maastrichtian of North Africa, Germany, Russia, and northern Spain.

Types and occurrence.—Figured hypotype (UCLA 44295) from sample E-2, Rosario Formation at Punta Descanso (D102).

Family ROTALIPORIDAE Sigal, 1958

Subfamily HEDBERGELLINAE Loeblich & Tappan, 1961

Genus HEDBERGELLA Brönnimann & Brown, 1958

HEDBERGELLA HOLMDELENSIS Olsson

Plate 15, figure 6, 8

Hedbergella holmdelensis OLSSON, 1964, p. 160, pl. 1, fig. 1-2.

Test free, small, low trochospiral, spiral and umbilical sides nearly flat, giving a planispiral appearance, test composed of 3 whorls, equatorial periphery lobate. Chambers 5 to 7 in final whorl, globular, increasing moderately in size may be somewhat radially elongate in later stage. Sutures distinct, depressed, radial to slightly curved. Wall calcareous, perforate, surface finely hispid to smooth. Umbilicus moderately wide and deep. Aperture a low arch, interiomarginal, extraumbilical-umbilical, with small flap, successive apertural flaps visible in umbilicus.

Maximum diameter of figured hypotypes, 0.15 to 0.19 mm.; thickness, 0.09 to 0.10 mm. Other hypotypes range in diameter from 0.12 to 0.19 mm.

Discussion.—As observed by OLSSON (1964), *Hedbergella holmdelensis* appears to have evolved from *H. planispira* (TAPPAN) (1940) by a reduction in the number of chambers in the final whorl, an increase in chamber inflation, and some elongation of chambers. The present specimens, as compared to topotypes of *H. planispira* from the Del Rio Formation, are generally more robust and have more inflated chambers. Variation within the species is noted by rare specimens with radially elongate chambers and a slightly convex spiral side (i.e., Pl. 15, fig. 6). Comparative material from the upper Campanian Marshalltown Formation of New Jersey contains specimens identical to those in the present samples. A previous California reference may be the specimen referred to *H. planispira* (TAPPAN) by TAKAYANAGI (1965, pl. 21, fig. 7) from the Campanian Forbes Formation. The amount of chamber inflation and elongation closely resembles that of *H. holmdelensis*.

Types and occurrence.—Figured hypotype (Fig. 8, UCLA 44297) from sample C-2, and (Fig. 6, UCLA 44298) from sample C-3, both from Rosario Formation at Carlsbad. Unfigured hypotypes

EXPLANATION OF PLATE 15

FIGURE

1-2. *Globigerinelloides alvarezi* (ETERNOD OLVERA); 1a,b, 2a,b, side and edge views, ×187 (p. 98).

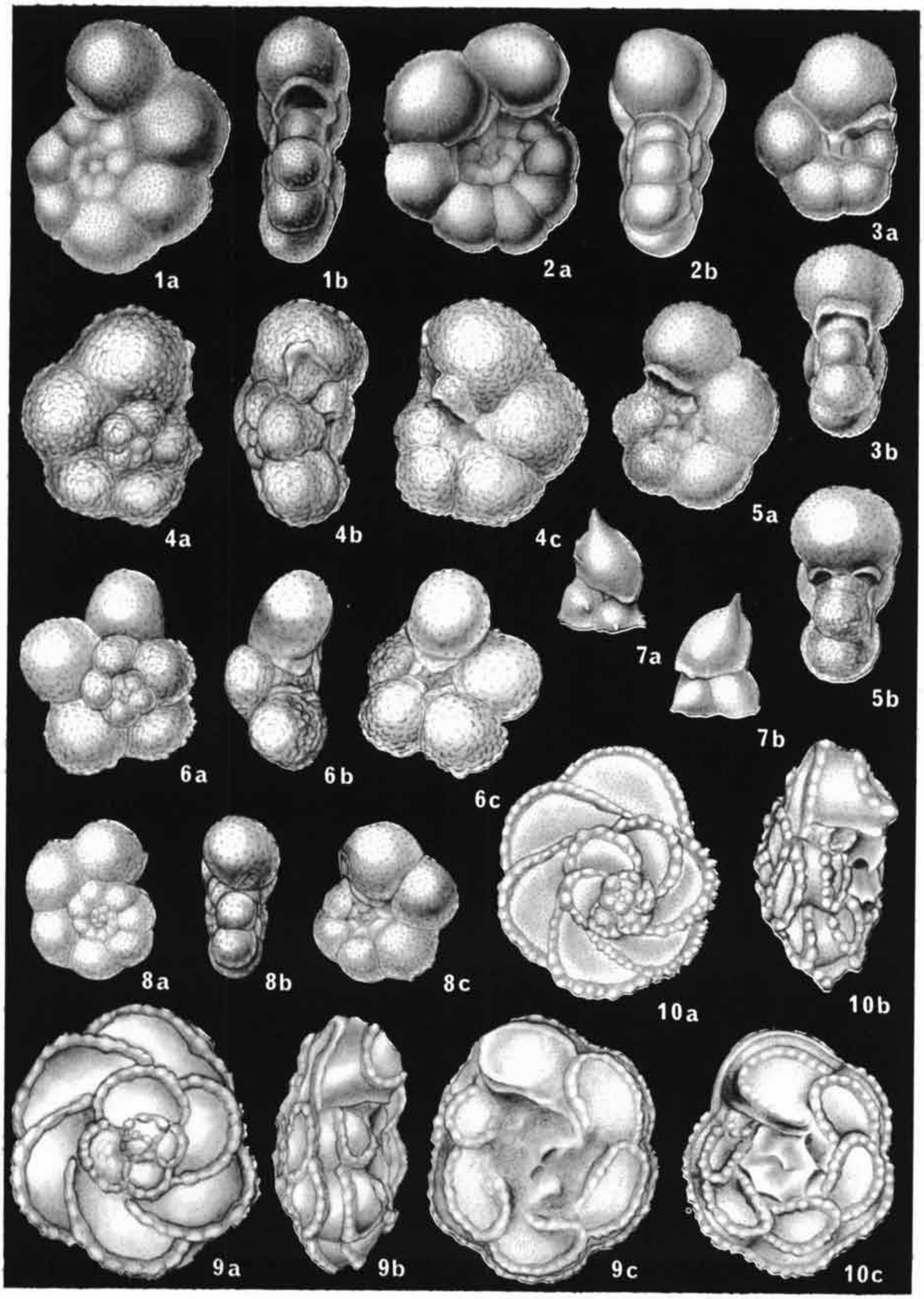
3, 5. *Globigerinelloides messinae* (BRÖNNIMANN); 3a,b, 5a,b, side and edge views, ×129 (p. 99).

4. *Hedbergella monmouthensis* (OLSSON); 4a-c, spiral, edge, and umbilical views, ×187 (p. 101).

6, 8. *Hedbergella holmdelensis* (OLSSON); 6a-c, spiral, edge, and umbilical views, ×187 (p. 100).

7. *Schackoina multispinata* (CUSHMAN & WICKENDEN); 1a,b, opposite sides, ×187 (p. 100).

9-10. *Globotruncana arca* (CUSHMAN); 9a-c, spiral, edge, and umbilical views, ×89; 10a-c, same, ×97 (p. 101).


1a
1b
2a
2b
3a
3b
4a
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4c
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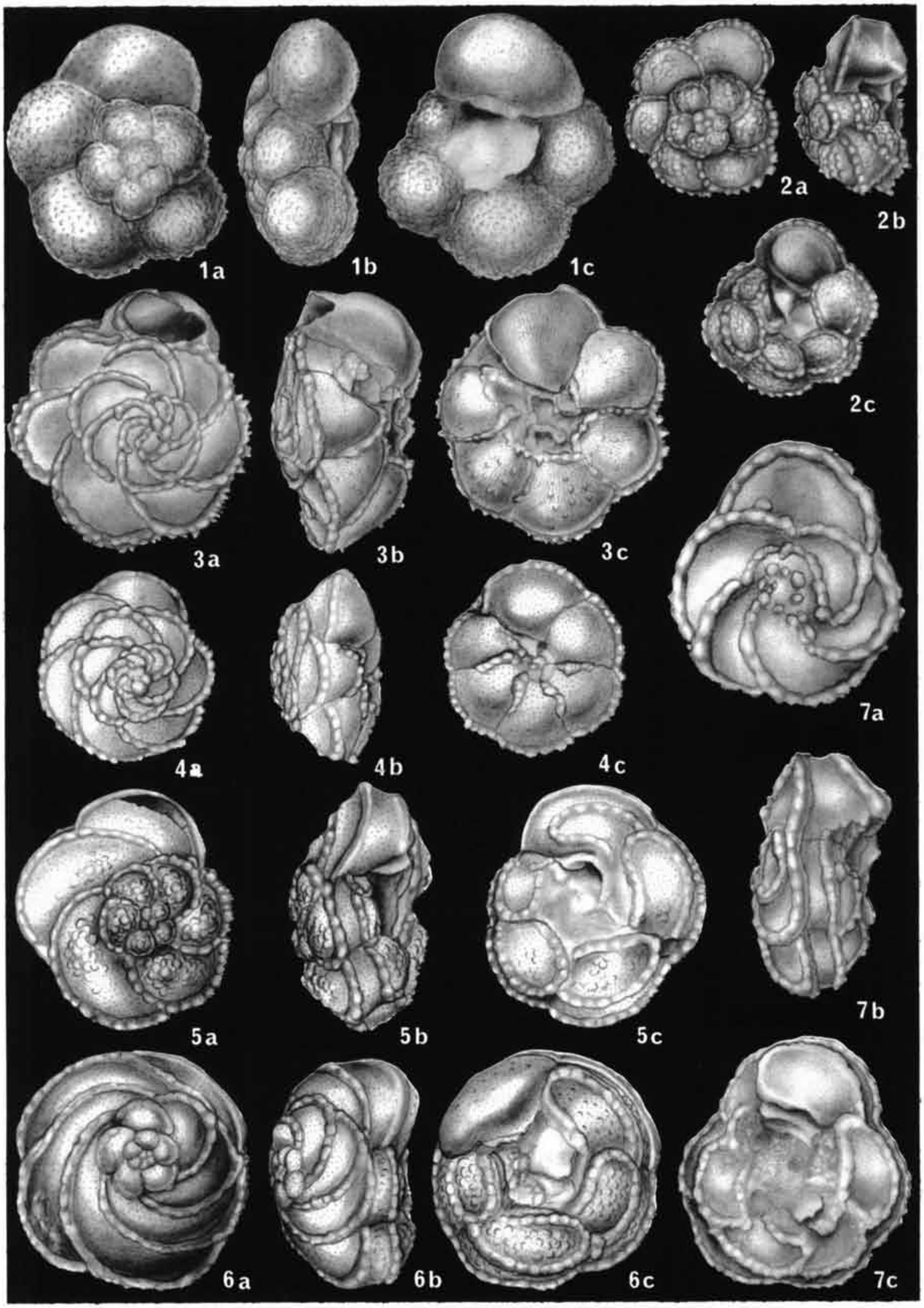
Sliter — Upper Cretaceous Foraminifera, Southern California and Northwestern Mexico.



from Rosario Formation at La Jolla, Point Loma, and Punta Descanso (C94, J38, L64, D48).

HEDBERGELLA MONMOUTHENSIS (Olsson)
Plate 15, figure 4

Globorotalia monmouthensis OLSSON, 1960, p. 74, pl. 9, fig. 22-24.
Praeglobotruncana (Hedbergella) monmouthensis (Olsson), BERGGREN, 1962, p. 37, fig. 4,*1-5*, pl. 8, fig. 1-3.
Hedbergella monmouthensis (Olsson), OLSSON, 1964, p. 161, pl. 1, fig. 3.

Test free, small, low trochospiral, spiral side nearly flat, test composed of two whorls, equatorial periphery distinctly lobate. Chambers 5 to 6 in final whorl, increasing rapidly in size, inflated, nearly spherical. Sutures distinct, depressed, radial to slightly curved. Wall calcareous, perforate, surface pustulose. Umbilicus narrow, deep. Aperture a low interiomarginal, extraumbilical-umbilical arch, with distinct spatulate flap, may be covered by thin walled spherical chamber or bulla, successive apertural flaps visible in umbilicus.

Maximum diameter of figured hypotype, 0.20 mm.; thickness, 0.10 mm. Other hypotypes range from 0.18 to 0.32 mm. in length and 0.11 to 0.18 mm. in thickness.

Discussion.—This species is distinguished from *Hedbergella holmdelensis* by its fewer and more strongly inflated chambers, larger size, and pustulose ornamentation. *H. planispira* of TAKAYANAGI (1965, pl. 22, fig. 1) from the Campanian Forbes Formation of northern California is very similar if not identical to the present species. Originally described from the Maastrichtian Redbank Formation of New Jersey, this species occurs in all present localities. The stratigraphic range of this species in California is Campanian to Maastrichtian.

Types and occurrence.—Figured hypotype (UCLA 44296) from sample C-2, Rosario Formation at Carlsbad. Unfigured hypotypes from Rosario Formation at La Jolla, Point Loma and Punta Descanso (C92, J73, L111, D97).

Family GLOBOTRUNCANIDAE Brotzen, 1942

Genus GLOBOTRUNCANA Cushman, 1927

GLOBOTRUNCANA ARCA (Cushman)
Plate 15, figure 9-10

Pulvinulina arca CUSHMAN, 1926a, p. 23, pl. 3, fig. 1.
Globotruncana arca (Cushman), BANDY, 1951, p. 509, pl. 75, fig. 1.——BRÖNNIMANN & BROWN, 1956, p. 539, pl. 23, fig. 10-12.——BOLLI, LOEBLICH & TAPPAN, 1957, p. 44, pl. 11, fig. 6-11.——KLAUS, 1960, p. 824, pl. 7, fig. 5.——HERM, 1962, p. 67, pl. 7, fig. 3.——MARTIN, 1964, p. 79, pl. 9, fig. 4.——OLSSON, 1964, p. 162, pl. 4, fig. 1-3.——TAKAYANAGI, 1965, p. 209, pl. 23, fig. 1-2.
Globotruncana (Globotruncana) arca (Cushman), BERGGREN, 1962, p. 49, pl. 9, fig. 1-2.——VAN HINTE, 1963, p. 80, pl. 6, fig. 2.
Globotruncana riojae Eternod Olvera, MARTIN, 1964, p. 82, pl. 9, fig. 6.

Test free, low to moderately high trochospiral, biconvex, usually more spiroconvex, equatorial periphery lobate, axial periphery angular truncate with 2 distinct keels. Chambers 6 or 7 in final whorl, increasing gradually in size, petaloid to crescentic on spiral side, subrectangular on umbilical side, imbricated. Sutures curved, limbate, beaded on spiral side, slightly curved, depressed on umbilical side. Wall calcareous, perforate, radial in structure, surface of early chambers lightly pustulose, later ones smooth. Umbilicus deep and wide. Primary aperture interiomarginal, umbilical, commonly covered by tegilla with intra- and infralaminal apertures.

Maximum diameter of figured hypotypes, 0.44 to 0.49 mm.; thickness, 0.25 to 0.26 mm.

Discussion.—*Globotruncana arca* is distinguished by its biconvex test, distinct and well-separated double keels, and peripheral carinal band that slopes prominently toward the umbilicus. This species is the most common planktonic element in the present samples. Several authors (BRÖNNIMANN & BROWN, 1956; BERGGREN, 1962) have regarded *G. arca* as restricted to the Maastrichtian, whereas others (KLAUS, 1960; VAN HINTE, 1963) have extended the lower limit downward as far as the upper Coniacian. As presently interpreted, this species appears to range from late Santonian to Maastrichtian. Examination of the specimen of *G. riojae* ETERNOD OLVERA figured by MARTIN (1964) shows it to be synonymous. Originally described from the upper Maastrichtian of the Méndez Shale of Mexico, *G. arca* has been widely reported from Alaska, Canada, North and South America, Europe, Russia, North Africa and Australia.

EXPLANATION OF PLATE 16

FIGURE

1. *Globotruncana cretacea* (D'ORBIGNY); 1a-c, spiral, edge, and umbilical views, ×129 (p. 102).
2. *Globotruncana churchi* MARTIN; 2a-c, spiral, edge, and umbilical views, ×97 (p. 102).
3. *Globotruncana elevata* (BROTZEN); 3a-c, spiral, edge, and umbilical views, ×66 (p. 102).
4. *Globotruncana* sp.; 4a-c, spiral, edge, and umbilical views, ×66 (p. 108).

5-7. *Globotruncana fornicata* PLUMMER; 5a-c, spiral, edge, and umbilical views, ×97; 6a-c, 7a-c, same, ×89 (p. 103).

Types and occurrence.—Figured hypotype (Fig. 9, UCLA 44299) from sample S-8, Rosario Formation at La Jolla. Figured hypotype (Fig. 10, UCLA 44300) from sample C-1, Rosario Formation at Carlsbad. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (C7, J6, L23, D22).

GLOBOTRUNCANA CHURCHI Martin

Plate 16, figure 2

Globotruncana arca (Cushman), CUSHMAN & CHURCH, 1929, p. 518, pl. 41, fig. 1-3.——TAKAYANAGI, 1965, p. 209, pl. 22, fig. 6.
Globotruncana churchi MARTIN, 1964, p. 79, pl. 9, fig. 5.

Test free, trochospiral, biconvex, spiral side moderately trochospiral with inner whorls distinctly elevated, umbilical side often slightly concave, axial periphery truncate, inclined towards umbilicus, with 2 distinct keels, umbilical keel often weakly developed on last chamber, equatorial periphery moderately lobate. Chambers 6 to 7 in final whorl, slightly inflated, increasing gradually in size, petaloid on spiral side, subrectangular on umbilical side. Sutures curved, limbate, elevated, beaded on spiral side, slightly curved, depressed on umbilical side. Wall calcareous, perforate, surface initially pustulose, later chambers smooth. Umbilicus moderately wide, deep. Aperture interiomarginal, umbilical, covered by tegilla with infra- and intralaminal accessory apertures.

Maximum diameter of figured hypotype, 0.31 mm.; thickness, 0.19 mm.

Discussion.—Originally described from the California Campanian by CUSHMAN & CHURCH (1929), this species was included within the *Globotruncana arca* assemblage until MARTIN (1964) recognized its distinctive features and separated it as *G. churchi*. Later work within California has shown the stratigraphic usefulness of this species. *G. churchi* differs from *G. arca* in being smaller, relatively thicker, and in having more petaloid chambers and higher spire with an acute shoulder formed by the exposed spiral carina. In the area studied, this species is a limited and characteristic marker in the lower portions of the La Jolla and Punta Descanso sections and throughout that at Carlsbad. California occurrences of *G. churchi* range from upper Santonian to Campanian, the latter apparently being the most characteristic.

Types and occurrence.—Figured hypotype (UCLA 44301) from sample C-3, Rosario Formation at Carlsbad. Unfigured hypotypes from the Rosario Formation at La Jolla and Punta Descanso (C122, J117, D100).

GLOBOTRUNCANA CRETACEA (d'Orbigny)

Plate 16, figure 1

Globigerina cretacea D'ORBIGNY, 1840, p. 34, pl. 3, fig. 12-14.
Globotruncana globigerinoides BROTZEN, 1936, p. 177, pl. 12, fig. 3, pl. 13, fig. 3.——HERM, 1962, p. 80, pl. 5, fig. 6.
Globotruncana cretacea (d'Orbigny), BANNER & BLOW, 1960, p. 8, pl. 7, fig. 1.——BARR, 1962, p. 567, pl. 69, fig. 9.——OLSSON, 1964, p. 164, pl. 2, fig. 2.
Globotruncana (Globotruncana) cretacea (d'Orbigny), VAN HINTE, 1963, p. 65, pl. 6, fig. 3.
Globotruncana mariai Gandolfi, MARTIN, 1964, p. 82, pl. 9, fig. 7.

Test free, low trochospiral, biconvex, axial periphery ovate, with 2 weak keels commonly present on all but ultimate chamber, all chambers with poreless margin, equatorial periphery moderately lobate. Chambers 5 to 6 in final whorl, increasing gradually in size, globular, inflated, becoming elongate in direction of coiling, final chamber commonly slightly compressed. Sutures distinct, slightly curved, depressed on spiral side, radial to slightly curved, depressed on umbilical side. Wall calcareous, perforate, radial in structure, surface pustulose to hispid, initial chambers more coarsely ornamented, final chamber nearly smooth. Umbilicus wide, deep. Primary aperture interiomarginal, umbilical, commonly with tegilla showing intra- and infralaminal accessory apertures.

Maximum diameter of figured hypotype, 0.35 mm.; thickness, 0.18 mm.

Discussion.—The present specimens are nearly identical to the lectotype illustrated by BANNER & BLOW. These specimens show morphologic variation in the degree of compression of the final chamber, number of chambers, and strength of the double carinae. Some specimens have distinct early carinae that become weakly developed or lacking in the final chamber, others lack distinct carinae on the final whorl. Thin sections of the latter type show the development of distinct carinae on early chambers and replacement of these carinae in the final whorl by an imperforate peripheral band. These forms also have the wide, deep umbilicus and tegilla, which together with the imperforate margin are characteristic of the genus *Globotruncana*. The specimen illustrated as *G. cretacea* by TAKAYANAGI (1965) lacks the open umbilicus and has instead a distinct apertural flap; hence it is not included in the present synonymy. Originally described from the lower Campanian of France, *G. cretacea* appears to range from Coniacian to lower Maastrichtian.

Types and occurrence.—Figured hypotype (UCLA 44303) from Rosario Formation at Point Loma. Unfigured hypotype from Rosario Formation at La Jolla, Carlsbad and Punta Descanso (C51, J119, L66, D134).

GLOBOTRUNCANA ELEVATA (Brotzen)

Plate 16, figure 3

Rotalia elevata BROTZEN, 1934, p. 66, pl. 3, fig. c.
Globotruncana andori DE KLASZ, 1953, p. 233, pl. 6, fig. 1.
Globotruncana (Globotruncana) elevata elevata (Brotzen), DALBIEZ, 1955, p. 169, fig. 9.
Globotruncana elevata elevata (Brotzen), KNIPSCHEER, 1956, p. 51, fig. 1.
Globotruncana stuarti elevata (Brotzen), OLSSON, 1964, p. 169, pl. 5, fig. 7.

Test free, low trochospiral, biconvex, spiral side slightly convex, strongly umbilicoconvex, axial periphery acute with distinct single keel, equatorial periphery moderately lobate. Chambers 6 to 7 in final whorl, increasing gradually in size, ultimate chambers commonly reduced in size, petaloid in spiral view, subpetaloid in umbilical view. Sutures curved, elevated, limbate, beaded on spiral side, radial to slightly curved, depressed on umbilical side. Wall calcareous, perforate, radial in structure, surface smooth to slightly pustulose. Umbilicus moderately wide, deep. Primary aperture interiomarginal, umbilical, covered by tegilla with intra- and infralaminal accessory apertures.

Maximum diameter of figured hypotype, 0.68 mm.; thickness, 0.40 mm.

Discussion.—This species differs from *Globotruncana stuartiformis* DALBIEZ in being nearly planoconvex with a raised central cone, is more strongly umbilicoconvex and has petaloid chambers which become subrectangular on the umbilical side. The present specimens commonly have a wide carinal band flanking the single peripheral keel. The species occurs rarely in the La Jolla and Point Loma sections. The reported stratigraphic range is Campanian to lower Maastrichtian.

Types and occurrence.—Figured hypotype (UCLA 44304) from sample S-36, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma (J217, L63).

GLOBOTRUNCANA FORNICATA Plummer

Plate 16, figure 5-7

Globotruncana fornicata PLUMMER, 1931, p. 198, pl. 13, fig. 4-6. ——BRÖNNIMANN & BROWN, 1956, p. 542, pl. 21, fig. 7, 14-15. ——GRAHAM & CLARK, 1961, p. 112, pl. 5, fig. 10.——HERM, 1962, p. 78, pl. 7, fig. 2.——GRAHAM & CHURCH, 1963, p. 63, pl. 7, fig. 14.——OLSSON, 1964, p. 164, pl. 2, fig. 3-4, pl. 3, fig. 7-8.——TAKAYANAGI, 1965, p. 214, pl. 24, fig. 4.

Globotruncana (Globotruncana) fornicata Plummer, VAN HINTE, 1963, p. 61, pl. 1, fig. 1-2, pl. 20, fig. 3.

Globotruncana morozovae Vassilenko, TAKAYANAGI, 1965, p. 219, pl. 26, fig. 5.

Test free, low trochospiral, biconvex, moderately umbilicate, axial periphery angular truncate with 2 distinct keels, equatorial periphery slightly lobate. Chambers increasing gradually in size, 5 or 6 in final whorl, commonly somewhat inflated, elongate, crescentic on spiral side, subrectangular on umbilical side, overlapping. Sutures, curved, limbate, beaded on spiral side, radial to slightly curved, depressed on umbilical side. Wall calcareous, perforate, radial in structure, surface initially pustulose later chambers smooth. Umbilicus wide and deep. Aperture interiomarginal, umbilical, covered by tegilla with infra- and intralaminal apertures commonly preserved.

Maximum diameter of figured hypotypes, 0.43 to 0.49 mm.; thickness, 0.24 to 0.28 mm.

Discussion.—Originally described from the upper Taylor Marl of Texas, this species is easily distinguished by its double keel and long, narrow, crescentic chambers in the final whorl. The present specimens are very similar to examined topotypes but are somewhat thicker and have a more pronounced surface ornamentation. These differences seem to be the result of geographic or ecologic variation, or both. The ancestral relationship of *Globotruncana fornicata* to *G. contusa* (CUSHMAN) has been referred to by previous authors. This gradual evolutionary change apparently occurred in late Campanian to early Maastrichtian time, and the relative percentages of *G. contusa* and *G. fornicata*, within the Tethyan province, provide a Maastrichtian marker. In the present samples, typical *G. contusa* is lacking; however, in 3 of the present sections (La Jolla, Point Loma, Punta Descanso) a trend toward higher-spired, conical forms is observed in passing to younger specimens. These resemble *G. contusa patelliformis* GANDOLFI, originally described from the Campanian of Colombia, and seems to reflect the ecologic isolation of the Maastrichtian northern Pacific fauna. Examination of hypotypes of *G. morozovae* VASSILENKO of TAKAYANAGI shows them to fall within the range of morphologic variation of *G. fornicata*. The stratigraphic range of this widespread species is generally regarded as Coniacian to Maastrichtian. The upper Turonian occurrences referred to by several authors needs further verification and may prove in part to be based on specific misidentification.

Types and occurrence.—Figured hypotype (Fig. 7, UCLA 44305) from sample S-4; figured hypotype (Fig. 6, UCLA 44306) from sample S-15; both from Rosario Formation at La Jolla. Figured hypotype (Fig. 5, UCLA 44307) from sample C-3, Rosario Formation at Carlsbad. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (C91, J70, L123, D88).

GLOBOTRUNCANA HAVANENSIS Voorwijk

Plate 17, figure 1-2

Globotruncana havanensis VOORWIJK, 1937, p. 195, pl. 1, fig. 25-26.——LOEBLICH & TAPPAN, 1964, p. C663, fig. 529,*3*.

Globorotalia pschadae KELLER, 1946, p. 99, 108, pl. 2, fig. 4-6.

Globotruncana citae BOLLI, 1951, p. 197, pl. 35, fig. 4-6.

Rugotruncana havanensis (Voorwijk), BRÖNNIMANN & BROWN, 1956, p. 552, pl. 22, fig. 4-6.

Praeglobotruncana coarctata BOLLI, 1957, p. 55, pl. 12, fig. 2-3.

Globotruncanella havanensis (Voorwijk), ETERNOD OLVERA, 1959, p. 94, pl. 4, fig. 12-14.——VAN HINTE, 1963, p. 94, pl. 10, fig. 3, pl. 11, fig. 4-5, pl. 12, fig. 1.

Praeglobotruncana (Praeglobotruncana) havanensis (Voorwijk), BERGGREN, 1962, p. 26, pl. 7, fig. 1.

Test free, low trochospiral, biconvex to spiroconvex, axial periphery acute with single keel that may become an imperforate band on last chamber. Chambers 5 or 6 in final whorl, increasing moderately in size, subglobular, compressed. Sutures on spiral side slightly curved, depressed, may be slightly limbate, beaded to smooth, umbilical sutures radial to slightly curved, depressed. Wall calcareous, finely perforate, radial in structure, surface finely hispid to smooth. Umbilicus small, shallow. Primary aperture interiomarginal, umbilical with apertural flaps that may form tegilla with intra- and infralaminal accessory apertures.

Maximum diameter of figured hypotypes, 0.36 to 0.39 mm.; thickness, 0.14 to 0.15 mm.

Discussion.—The present specimens are identical to the original illustrations and to topotypes from the Habana Formation of Cuba. *Globotruncana havanensis* is easily distinguished by its single keel, flat and compressed test, and lobate periphery. Following the present classification, this species is included in *Globotruncana* because of its keeled periphery and umbilical tegilla. The tegilla commonly is broken, its remnants appearing to be spatulate flaps extending over the umbilical area. In future, the compressed, single-keeled to nonkeeled, thin-walled forms such as *G. havanensis* and *G. petaloidea* (GANDOLFI) may be excluded from *Globotruncana*. For the present, these species are not referred to *Globotruncanella* REISS pending a more detailed examination of the wall structures. The stratigraphic range extends from upper Campanian through Maastrichtian.

Types and occurrence.—Figured hypotype (Fig. 1, UCLA 44308) from sample S-23; figured hypotype (Fig. 2, UCLA 44309) from sample T-1; both from the Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (J97, L30, D43).

GLOBOTRUNCANA LINNEIANA (d'Orbigny)

Plate 17, figure 3-4

Globotruncana lapparenti lapparenti BROTZEN, 1936, p. 175.
Rosalina linneiana D'ORBIGNY, 1839, p. 101, pl. 5, fig. 10-12.
Globotruncana canaliculata (Reuss), BANDY, 1951, p. 509, pl. 75, fig. 2.
Globotruncana linneiana (d'Orbigny), BRÖNNIMANN & BROWN, 1956, p. 540, pl. 20, fig. 13-17, pl. 21, fig. 16-18.——BRÖNNIMANN & RIGASSI, 1963, pl. 17, fig. 5.——VAN HINTE, 1963, p. 75, pl. 5, fig. 1-2.——OLSSON, 1964, p. 166, pl. 2, fig. 6,8.——MARTIN, 1964, p. 81, pl. 10, fig. 3.——TAKAYANAGI, 1965, p. 217, pl. 26, fig. 1.
Globotruncana lapparenti lapparenti Brotzen, TOLLMANN, 1960, p. 192, pl. 20, fig. 10.——HERM, 1962, p. 82, pl. 6, fig. 2.

Test free, low trochospiral, spiral and umbilical sides nearly flat to slightly biconvex, axial periphery angular truncate with 2 distinct keels, carinal band parallel to axis of coiling, equatorial periphery lobate. Chambers increasing gradually in size, 6 or 7 in final whorl, final chambers may be somewhat reduced in size, chambers petaloid on spiral side, subrectangular on umbilical side. Sutures curved, elevated, limbate, beaded on spiral side, radial to slightly curved, depressed on umbilical side. Wall calcareous, perforate, radial in structure, surface smooth to finely pustulose. Primary aperture interiomarginal, umbilical, well-preserved specimens possess tegilla with infra- and intralaminal accessory apertures.

Maximum diameter of figured hypotypes, 0.48 to 0.56 mm.; thickness, 0.25 to 0.26 mm.

Discussion.—This species is distinguished by its flattened spiral and umbilical surfaces, widely spaced double keels, and squared periphery. The present specimens are identical to the neotype illustrated by BRÖNNIMANN & BROWN (1956). *Globotruncana canaliculata* (REUSS) (1854) and several species presently assigned to *G. lapparenti* BROTZEN (1936) are here regarded as synonymous to *G. linneiana*. The compressed Turonian to Santonian forms from California and elsewhere recently referred to *G. linneiana* and *G. lapparenti* (as by TRUJILLO, 1960; KLAUS, 1960), however, seems to represent a different species. These bicarinate specimens differ from *G. linneiana* in being more compressed and somewhat biconvex, with closer peripheral keels. In fact, these forms are nearer the original concept of *G. lapparenti* and should, therefore, be re-evaluated. As the types chosen by BROTZEN to represent *G. lapparenti*, however, occur together with *G. linneiana*, they are believed to represent morphologic variations of the latter species. *G. linneiana* is recorded from upper Turonian to Maastrichtian.

Types and occurrence.—Figured hypotype (Fig. 3, UCLA 44310) from sample S-36, Rosario Formation at La Jolla. Figured hypotype (Fig. 4, UCLA 44311) from sample C-1, Rosario Formation at Carlsbad. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (C37, J67, L75, D42).

GLOBOTRUNCANA MARGINATA (Reuss)

Plate 17, figure 5-6

Rosalina marginata REUSS, 1845, p. 36, pl. 8, fig. 54, 74, pl. 13, fig. 68.
Globotruncana linnei bulloides VOGLER, 1941, p. 287, pl. 23, fig. 32-39.
Globotruncana sp. aff. *G. paraventricosa* (Hofker), GRAHAM & CLARK, 1961, p. 112, pl. 5, fig. 7.
Globotruncana marginata (Reuss), BARR, 1962, p. 574, pl. 70, fig. 3.——HERM, 1962, p. 85, pl. 5, fig. 5.
Globotruncana (Globotruncana) marginata (Reuss), VAN HINTE, 1963, p. 83, pl. 7, fig. 2, pl. 8, fig. 3-4.
Globotruncana paraventricosa (Hofker), MARTIN, 1964, p. 81, pl. 10, fig. 4.

Test free, low trochospiral, biconvex, axial periphery angular truncate with 2 keels bordering a narrow carinal band, equatorial periphery lobate. Chambers globular, subcircular on spiral side, inflated, subrectangular on umbilical side. Sutures depressed, curved, limbate, beaded on spiral side, depressed, gently curved to nearly radial on umbilical side. Wall calcareous, perforate, radial surface with coarse spines or hispid, carinal band smooth. Umbilicus wide and deep. Primary aperture interiomarginal, umbilical, covered by tegilla with intra- and infralaminal accessory apertures.

Maximum diameter of figured hypotypes, 0.34 to 0.35 mm.; thickness, 0.19 to 0.21 mm.

Discussion.—*Globotruncana marginata* is differentiated from *G. arca* by inflated, globular to subglobular chambers, more compressed test, and less well-developed keels. These features also serve to distinguish this form from the associated and distinctive species, *G. linneiana*. The California forms referred to *G. paraventricosa* (HOFKER) by GRAHAM & CLARK (1961) and MARTIN (1964) are here placed in synonymy. Originally described from the Turonian of Germany, *G. marginata* is found in all the present locations. The stratigraphic range extends from Turonian to Maastrichtian.

Types and occurrence.—Figured hypotype (Fig. 5, UCLA 44313) from sample S-34, Rosario Formation at La Jolla. Figured hypotype (Fig. 6, UCLA 44312) from sample C-3, Rosario Formation at Carlsbad. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (C38, J69, L29, D89).

GLOBOTRUNCANA MARIEI Banner & Blow

Plate 17, figure 7-8

Globotruncana cretacea CUSHMAN, 1938c, p. 67, pl. 11, fig. 6.
Globotruncana mariei BANNER & BLOW, 1960, p. 8.——OLSSON, 1964, p. 167, pl. 4, fig. 8, 10.
Globotruncana (Globotruncana) mariei Banner & Blow, BERGGREN, 1962, p. 54, pl. 9, fig. 5.
Globotruncana goudkoffi MARTIN, 1964, p. 80, pl. 10, fig. 1.

Test free, low trochospiral, biconvex, axial periphery acute to slightly truncate, initially with 2 keels, the umbilical keel being weaker and commonly lacking on later chambers, carinal band sloping strongly towards umbilicus. Chambers increase gradually in size, 5 or 6 in final whorl, broadly petaloid on spiral side, subpetaloid on umbilical side. Sutures curved, limbate, flush to slightly elevated, beaded on spiral side, radial to slightly curved, depressed on umbilical side. Wall calcareous, perforate, radial in structure, surface initially beaded, later becoming smooth. Umbilicus moderately wide and deep. Primary aperture interiomarginal, umbilical, covered by tegilla, with intra- and infralaminal accessory apertures.

Maximum diameter of figured hypotypes, 0.35 to 0.39 mm.; thickness, 0.18 to 0.19 mm.

Discussion.—This species is more compressed and has a less truncate periphery than *Globotruncana arca*. A weaker umbilical keel commonly is poorly developed on the last-formed chambers. The present scattered geographic distribution of this species undoubtedly will be emended as specimens presently included in *G. arca*, *G. cretacea*, and *G. rosetta* are restudied and redefined. *G. goudkoffi* MARTIN, seems to fall within the variation of this species. *G. mariei* ranges from lower Senonian into the Maastrichtian.

Types and occurrence.—Figured hypotype (Fig. 7, UCLA 44314) from sample S-36, Rosario Formation at La Jolla. Figured hypotype (Fig. 8, UCLA 44315) from sample L-15, Rosario Formation at Point Loma. Unfigured hypotypes from Rosario Formation at Punta Descanso (J96, L61, D96).

GLOBOTRUNCANA PETALOIDEA Gandolfi

Plate 18, figure 1-2

Globotruncana (Rugoglobigerina) petaloidea GANDOLFI, 1955, p. 52, pl. 3, fig. 13.
Praeglobotruncana (Hedbergella) petaloidea (Gandolfi), BERGGREN, 1962, p. 41, pl. 7, fig. 4.
Rugoglobigerina petaloidea petaloidea (Gandolfi), HERM, 1962, p. 59, pl. 2, fig. 5.
Praeglobotruncana petaloidea (Gandolfi), OLSSON, 1964, p. 162, pl. 1, fig. 6-7, pl. 2, fig. 1.

Test free, low trochospiral, low to moderately spiroconvex, slightly umbilicoconcave, axial periphery ovate to subacute, with poreless margin on all chambers. Chambers 4 or 5 in final whorl, increasing rapidly in size, subglobular, compressed. Sutures slightly curved and depressed on spiral side, radial and depressed on umbilical side. Wall calcareous, finely perforate, radial in structure, surface moderately to lightly hispid, coarser spines often located along chamber periphery. Umbilicus narrow, shallow. Aperture an interiomarginal, extraumbilical-umbilical arch with prominent apertural flap extending over portion of umbilicus.

Maximum diameter of figured hypotypes, 0.24 to 0.36 mm.; thickness, 0.10 to 0.12 mm.

Discussion.—This species, originally described from the Upper Cretaceous of Colombia, differs from *Globotruncana havanensis* in lacking the peripheral keel and in having more globular, less compressed chambers. As noted by OLSSON (1964), an imperforate peripheral band can be observed on many specimens, thus eliminating from consideration the genus *Hedbergella*. The holotype was examined and found to be identical to some of the present specimens but lacks any suggestion of apertural flaps or tegilla. Present specimens, as well as some illustrated by OLSSON (1964, pl. 1, fig. 6; pl. 2, fig. 1), however, have a large apertural flap that may extend over the umbilicus. Based on the umbilical covering (tegilla), imperforate carinal band, and close similarity to *G. havanensis*, this species is included in the genus *Globotruncana*. The taxonomic position of this species and of *G. havanensis* may be determined by future studies on wall structures, at which time these atypical globotruncanid forms may be shown to belong to a separate genus. In the present samples, *G. petaloidea* is found somewhat lower in the sections than *G. havanensis*, whereas the latter form extends into younger strata. The stratigraphic range of this species appears to be upper Campanian to Maastrichtian.

Types and occurrence.—Figured hypotype (Fig. 2, UCLA 44316) from sample S-36; figured hypotype (Fig. 1, UCLA 44317) from sample S-13; both from Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Carlsbad, Point Loma and Punta Descanso (C78, J98, L62, D44).

GLOBOTRUNCANA ROSETTA (Carsey)

Plate 18, figure 3-4

Globigerina rosetta CARSEY, 1926, p. 44, pl. 5, fig. 3.
Globotruncana rosetta (Carsey), BANDY, 1951, p. 509, pl. 75, fig. 4.——BRÖNNIMANN & BROWN, 1956, p. 545, pl. 21, fig. 11-13. ——MARTIN, 1964, p. 83, pl. 10, fig. 5.
Globotruncana (Globotruncana) rosetta (Carsey), BERGGREN, 1962, p. 56, pl. 10, fig. 1.
Globotruncana (Globotruncana) rosetta rosetta (Carsey), VAN HINTE, 1963, p. 89, pl. 9, fig. 3.

Test free, trochospiral, biconvex, spiral side slightly convex, umbilical side moderately to strongly convex, axial periphery acute with single keel in ultimate whorl, equatorial periphery moderately lobate. Chambers 5 or 6 in final whorl, increasing gradually in size, broadly petaloid on spiral side, subpetaloid on umbilical side. Sutures curved, elevated, limbate, beaded on spiral side, nearly radial, depressed on umbilical side. Wall calcareous, perforate, radial in structure, surface smooth. Umbilicus moderately wide, deep. Aperture interiomarginal, umbilical, covered by tegilla with infra- and intralaminal accessory apertures.

Maximum diameter of figured hypotypes, 0.48 to 0.53 mm.; thickness, 0.22 to 0.27 mm.

Discussion.—Topotype specimens of *Globotruncana rosetta* from the upper Taylor Marl (loc. 226-T-8 of PLUMMER, 1931) are distinctive in being nearly planoconvex with an acute periphery. The specimens are ultimately single-keeled and may or may not be initially double-keeled in the final whorl. Axial sections, however, show the species to be double-keeled in earlier chambers. The spiral surface is gently undulating, whereas the axial profile of the umbilical surface is characteristically straight to gently curved. These criteria delineate a form that is intermediate in biconvexity and type of carinae between *G. mariei* and *G. stuartiformis* DALBIEZ. Many previous references to *G. rosetta* have included one or both of these species in the synonymy. The present material includes forms nearly identical to the Taylor specimens but differing slightly in the degree of biconvexity and curvature of the umbilical profile. These differences are judged to result from geographic or ecologic variation of this species, or both. *G. rosetta* occurs in the basal half of the La Jolla section, throughout the Carlsbad samples, and rarely in the lower samples at Point Loma and Punta Descanso. *G. mariei* increases markedly after the last occurrence of *G. rosetta* and may have occupied the same ecologic position. This species ranges from Campanian to Maastrichtian, but in the present material is restricted to the Campanian.

Types and occurrence.—Figured hypotype (Fig. 3, UCLA 44318) from sample C-3; figured hypotype (Fig. 4, UCLA 44319) from sample C-8; both from Rosario Formation at Carlsbad. Unfigured hypotypes from the Rosario Formation at La Jolla, Point Loma and Punta Descanso (C8, J82, L76, D99).

GLOBOTRUNCANA STUARTIFORMIS Dalbiez

Plate 18, figure 5-6

Globotruncana (Globotruncana) elevata stuartiformis DALBIEZ, 1955, p. 169, fig. 10.

Globotruncana (Globotruncana) elevata elevata (Brotzen), EDGELL, 1957, p. 112, pl. 4, fig. 4-6.

Globotruncana elevata stuartiformis Dalbiez, HERM, 1962, p. 77, pl. 8, fig. 2.

Globotruncana (Globotruncana) stuarti stuartiformis Dalbiez, PESSAGNO, 1962, p. 362, pl. 2, fig. 4-6.

Globotruncana elevata elevata (Brotzen), GRAHAM & CHURCH, 1963, p. 63, pl. 7, fig. 13.

Globotruncana stuarti stuartiformis Dalbiez, OLSSON, 1964, p. 170, pl. 5, fig. 6, 8.

Globotruncana putahensis TAKAYANAGI, 1965, p. 221, pl. 27, fig. 2.

Test free, low trochospiral, biconvex, spiral side gently convex, umbilical side strongly convex, axial periphery acute with prominent single keel and sporadic row of pustules simulating 2nd keel. Chambers 6 or 7 in final whorl, increasing gradually in size, broadly petaloid to subangular on spiral side, subrectangular on umbilical side. Sutures curved, elevated, limbate and beaded on spiral side, slightly curved, depressed on umbilical side. Wall calcareous, perforate, radial in structure, surface smooth on spiral side, smooth to pustulose on umbilical side. Umbilicus moderately large and deep. Primary aperture interiomarginal, umbilical tegilla and accessory apertures rarely preserved.

Maximum diameter of figured hypotypes, 0.44 to 0.52 mm.; thickness, 0.26 to 0.31 mm.

Discussion.—*Globotruncana stuartiformis*, originally described from the Upper Cretaceous of Tunisia, is distinguished from *G. rosetta* by the more umbilicoconvex test, subangular chambers, and larger size. The species differs from *G. elevata* in being more biconvex and less produced umbilically and having subangular chambers and a more even periphery. The present specimens are similar to original illustrations and the hypotypes from the Atlantic Coast. Random specimens in the present material have a wide imperforate margin flanked by a broken row of pustules on the initial chambers of the final whorl, thus resembling a weakly developed 2nd keel. This form, designated as the new species *G. putahensis* by TAKAYANAGI, intergrades with otherwise morphologically identical specimens lacking this feature. Furthermore, thin sections of both forms have not revealed double keels on the earlier chambers. The imperforate area is thinner than the adjacent wall however, resulting in a shallow exterior furrow. Specimens lacking the row of pustules have varying widths of the imperforate margin, but this area is much reduced in the majority. Although both forms are found throughout the present locations with the exception of Carlsbad, numbers of the pustulose examples seem to decline in the uppermost samples. Both forms are considered to be synonymous to *G. stuartiformis*. The formation of the pustulose margin and varying widths of the imperforate margin may be the result of an admixture of geographically separated, or Pacific, specimens because Australian examples (EDGELL, 1957) also show this feature. The transition of *G. stuartiformis* to *G. stuarti* (DE LAPPARENT) does not occur in the present locations. Throughout the samples, occasional specimens are found with flangelike surface ornamentation. These represent the remnants of broken septa as the edges and peripheral margins commonly are serrated. As the other morphologic and stratigraphic criteria are identical, these specimens are included in *G. stuartiformis*. The stratigraphic range of this species is Campanian to Maastrichtian.

Types and occurrence.—Figured hypotype (Fig. 5, UCLA 44320) from sample L-19; figured hypotype (Fig. 6, UCLA 44321) from sample L-14; both from Rosario Formation at Point Loma. Unfigured hypotypes from the Rosario Formation at La Jolla and Punta Descanso (J24, L24, D50).

GLOBOTRUNCANA TRICARINATA (Quereau)
Plate 19, figure 1

Pulvinulina tricarinata QUEREAU, 1893, p. 89, pl. 5, fig. 3a.
Globotruncana lapparenti tricarinata (Quereau), KLAUS, 1960, p. 823, pl. 8, fig. 3.
Globotruncana tricarinata (Quereau), HERM, 1962, p. 93, pl. 6, fig. 4.——VAN HINTE, 1963, p. 79, pl. 6, fig. 1.——OLSSON, 1964, p. 171, pl. 5, fig. 4-5.——TAKAYANAGI, 1965, p. 225, pl. 27, fig. 4.

Test free, low to moderate trochospiral, biconvex, axial periphery angular truncate with 2 distinct keels, carinal band parallel to axis of coiling, periumbilical extension of umbilical carinae elevated to form "third" keel, equatorial periphery slightly lobate. Chambers 6 or 7 in final whorl, subpetaloid on spiral side, subrectangular on umbilical side. Sutures curved, limbate, elevated, beaded on spiral side, radial to slightly curved on umbilical side. Wall calcareous, perforate, radial in structure, surface initially often pustulose, later chambers smooth. Umbilicus wide and deep. Primary aperture interiomarginal, umbilical, tegilla present in well-preserved material, showing intra- and infralaminal accessory apertures.

Maximum diameter of figured hypotype, 0.37 mm.; thickness, 0.21 mm.

Discussion.—Originally described from the Campanian-Maastrichtian of Switzerland, the types are illustrated only by unoriented thin sections without reference to external morphology. As such, the species has been variously interpreted as being more closely related to *Globotruncana arca*, *G. linneiana*, or an intermediate transitional form. Nevertheless, within the *G. linneiana* group both in the present samples and assemblages from northern California, the Gulf and Atlantic Coasts, and several European localities, forms can be differentiated that have the characteristics of the original description. These specimens differ from *G. linneiana* in being slightly more biconvex and having the elevated periumbilical extensions of the umbilical keel. As the stratigraphic range of these specimens, here interpreted to represent *G. tricarinata*, is very similar to *G. linneiana*, possibly these individuals represent a recurring divergence from the *G. linneiana* assemblage. It has been suggested previously (BERGGREN, 1962; OLSSON, 1964) that *G. tricarinata* gave rise to *G. arca* in the upper Campanian-lower Maastrichtian; occurrences of *G. arca*, however, from at least as early as the late Santonian refute this. Several references have been omitted from the synonymy, because they deal with forms probably best referred to other species. *G. tricarinata* of BERGGREN (1962) and GRAHAM & CHURCH (1961) and *G. lapparenti tricarinata* of TOLLMANN (1960) appear more closely related to *G. linneiana*, whereas some forms illustrated by OLSSON (1964) as *G. tricarinata* (Pl. 5, fig. 2-3) are very similar to *G. arca*. Until such time as *G. tricarinata* is restudied and a neotype that can be compared to other similar species is selected, interpretation of this species will remain confused. The stratigraphic range of *G. tricarinata* is from Turonian to Maastrichtian.

Types and occurrence.—Figured hypotype (UCLA 44322) from sample C-1, Rosario Formation at Carlsbad. Unfigured hypotypes from Rosario Formation at La Jolla, Point Loma and Punta Descanso (C73, J68, L28, D51).

GLOBOTRUNCANA VENTRICOSA White
Plate 18, figure 7-8

Globotruncana canaliculata var. *ventricosa* WHITE, 1928b, p. 284, pl. 38, fig. 5.
Globotruncana ventricosa White, SACAL & DEBOURLE, 1957, p. 62, pl. 27, fig. 3, 5.——VAN HINTE, 1963, p. 86, pl. 7, fig. 3.——TAKAYANAGI, 1965, p. 226, pl. 29, fig. 1.

Test free, low trochospiral, slightly biconvex to planoconvex, spiral side nearly flat, umbilical side strongly convex, axial periphery angular truncate with 2 closely spaced keels, equatorial periphery lobate. Chambers 6 or 7 in final whorl, increasing gradually in size, petaloid on spiral side, subpetaloid on umbilical side. Sutures curved, elevated, limbate, beaded on spiral side, slightly curved, depressed on umbilical side. Wall calcareous, perforate, radial in structure, surface smooth, initially beaded in many specimens. Umbilicus wide, deep. Aperture interiomarginal, umbilical, commonly with tegilla showing intra- and infralaminal accessory apertures.

Maximum diameter of figured hypotypes, 0.53 to 0.54 mm.; thickness, 0.26 to 0.28 mm.

Discussion.—Undoubtedly this species has been confused with *Globotruncana tricarinata*. Both have a low convex spiral side and a convex umbilical side, truncate periphery, large umbilical area, and common size and both were described from the Campanian. The differences between these species seems to be one of degree, with *G. ventricosa* reportedly being somewhat larger, more strongly umbilicoconvex, and with more narrowly spaced keels. Again the lack of a clear definition of *G. tricarinata* prevents positive comparison. For the present, however, the species are considered distinct and specimens referred to *G. tricarinata* are easily distinguished by their closer relationship to *G. linneiana*, i.e., the more biconvex test and widely spaced carinae. The specimen illustrated by GRAHAM & CLARK (1961) as *G. ventricosa* differs in being less umbilicoconvex and single keeled in the final chambers. These characteristics imply a closer relationship to *G. mariei*. The range of *G. ventricosa*, originally described from the Campanian of Mexico, is upper Coniacian to lower Maastrichtian.

Types and occurrence.—Figured hypotype (Fig. 8, UCLA 44323) from sample S-9, Rosario Formation at La Jolla. Figured hypotype (Fig. 7, UCLA 44324) from sample L-12, Rosario Formation at Point Loma. Unfigured hypotypes from Rosario Formation at Carlsbad and Punta Descanso (C74, J112, L47, D133).

GLOBOTRUNCANA sp.

Plate 16, figure 4

Test free, trochospiral, biconvex, umbilical side slightly convex to flat, axial periphery acute, with a distinct single keel, equatorial periphery slightly lobate. Chambers 6 or 7 in final whorl, increasing gradually in size, petaloid on spiral side, subpetaloid on umbilical side. Sutures curved, elevated, limbate, beaded on spiral side, radial to slightly curved, depressed on umbilical side. Wall calcareous, perforate, radial in structure, surface smooth to finely hispid. Umbilicus moderately large, deep. Aperture interiomarginal, umbilical, covered by tegilla with accessory apertures.

Maximum diameter of figured hypotype, 0.49 mm.; thickness, 0.28 mm.

Discussion.—The illustrated specimen somewhat resembles *Globotruncana conica* WHITE (1928b) in overall morphology but differs in lacking the subrectangular spiral chambers and the nearly radial umbilical sutures. As such it may represent a variant of *G. rosetta* (CARSEY), *G. mariei* BANNER & BLOW, or an early transitional stage leading toward the development of *G. conica.*

Type and occurrence.—Figured hypotype (UCLA 44302) from sample S-36, Rosario Formation at La Jolla (J216).

Genus RUGOGLOBIGERINA Brönnimann, 1952

RUGOGLOBIGERINA RUGOSA (Plummer)

Plate 19, figure 2

Globigerina rugosa PLUMMER, 1927, p. 38, pl. 2, fig. 10.

Rugoglobigerina rugosa (Plummer), BOLLI, LOEBLICH & TAPPAN, 1957, p. 42, pl. 11, fig. 2.——BERGGREN, 1962, p. 71, fig. 8, pl. 11, fig. 1-5.——OLSSON, 1964, p. 173, pl. 7, fig. 2-5.

Rugoglobigerina rugosa rugosa (Plummer), CORMINBOEUF, 1961, p. 119, pl. 2, fig. 5.——HERM, 1962, p. 60, pl. 3, fig. 2.——BRÖNNIMANN & RIGASSI, 1963, pl. 18, fig. 1.

Globotruncana (Rugoglobigerina) rugosa (Plummer), VAN HINTE, 1963, p. 92, pl. 11, fig. 1-3.

Test free, low trochospiral, biconvex, spiral side less strongly convex than umbilical side, axial periphery globular, equatorial periphery lobate. Chambers 5 or 6 in final whorl, increasing moderately in size, globular, inflated, later chambers produced towards umbilicus. Sutures slightly curved, depressed on spiral side, nearly radial, depressed on umbilical side. Wall calcareous, perforate, radial in structure, surface ornamentation rugose, radiating from a mid-chamber, peripheral point. Umbilicus wide and deep. Primary aperture interiomarginal, umbilical, covered by tegilla with intra- and infralaminal accessory apertures, rarely with apertural bulla.

Maximum diameter of figured hypotype, 0.42 mm.; thickness, 0.28 mm.

Discussion.—This species, originally described from the Kemp Clay of Texas, is distinguished easily by its inflated, globular chambers, rugose surface ornamentation, and wide and deep umbilicus. The previous California specimens referred to *Rugoglobigerina rugosa* (GRAHAM & CLARK, 1961; MARTIN, 1964; TAKAYANAGI, 1965) lack these morphologic features and are better referred to *Hedbergella* or *Globotruncana. R. rugosa* is commonly thought to range from Campanian to Maastrichtian, the latter being most characteristic.

Types and occurrence.—Figured hypotype (UCLA 44325) from sample T-2, Rosario Formation at La Jolla (J222).

Superfamily ORBITOIDACEA Schwager, 1876

Family CIBICIDIDAE Cushman, 1927

Subfamily CIBICIDINAE Cushman, 1927

Genus EPITHEMELLA Sliter, n. gen.

Type species.—Epithemella martini (BROTZEN).

Test attached, discoidal, early chambers trochospiral, later in annular series, all visible from spiral side, umbilical chamber extensions arranged in a spiral, overlapping series. Sutures distinct, limbate, flush becoming depressed on spiral side, obscured on umbilical side. Wall calcareous, coarsely perforate. Aperture interiomarginal, umbilical.

Discussion.—This genus is similar to *Cymbalopora* in test shape and chamber arrangement on the spiral side but differs in having broad platelike umbilical chamber extensions in an overlapping spiral series and indistinct umbilical sutures. The later chambers appear to have been broken away centrally and may never have completely covered the umbilical surface but served instead as

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EXPLANATION OF PLATE 17

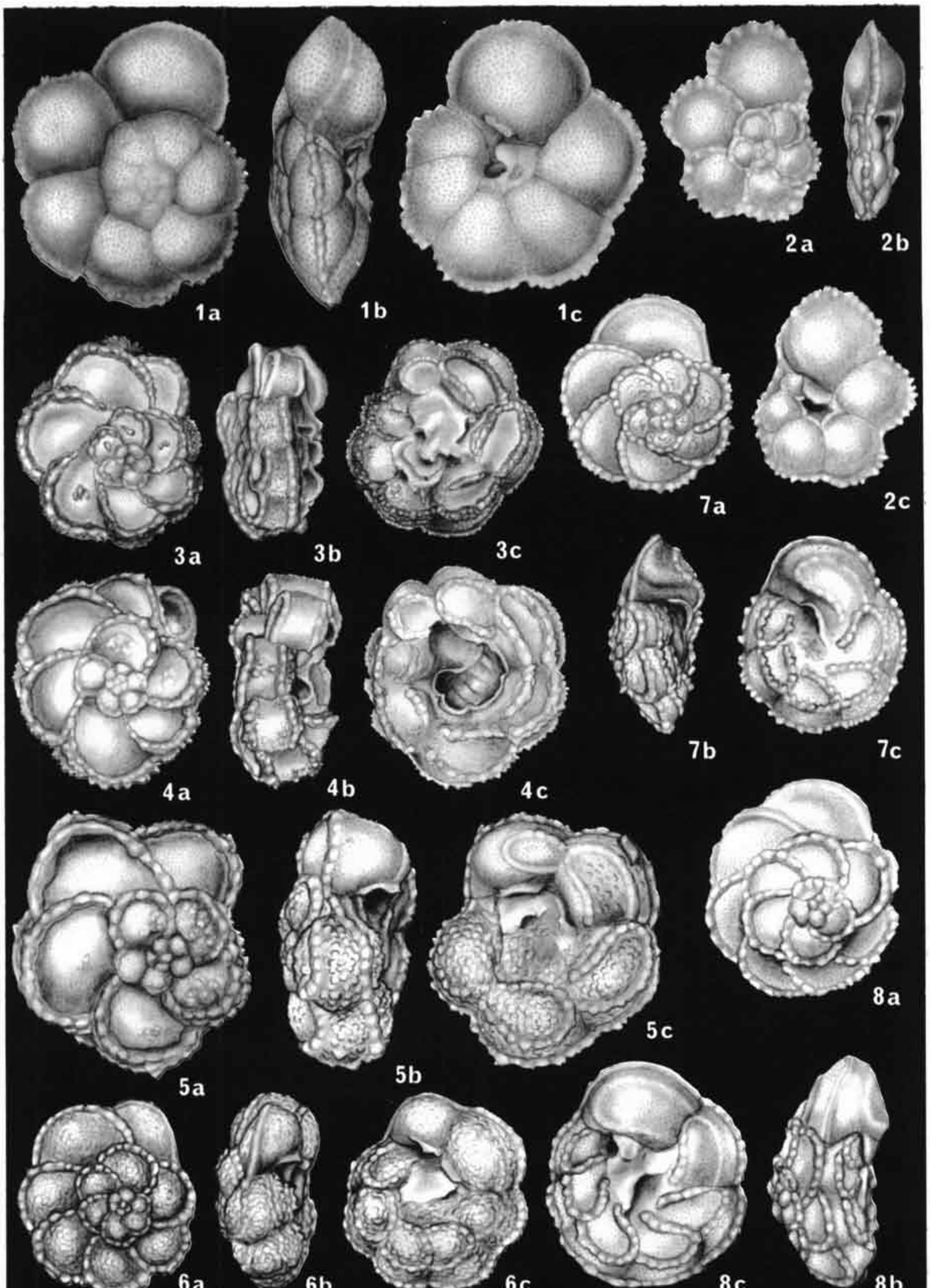
FIGURE

1-2. *Globotruncana havanensis* VOORWIJK; 1a-c, spiral, edge, and umbilical views, ×129; 2a-c, same, ×89 (p. 103).

3-4. *Globotruncana linneiana* (D'ORBIGNY); 3a-c, 4a-c, spiral, edge, and umbilical views, ×66 (p. 104).

5-6. *Globotruncana marginata* (REUSS); 5a-c, spiral, edge, and umbilical views, ×129; 6a-c, same, ×97 (p. 104).

7-8. *Globotruncana mariei* BANNER & BLOW; 7a-c, 8a-c, spiral, edge, and umbilical views, ×97 (p. 105).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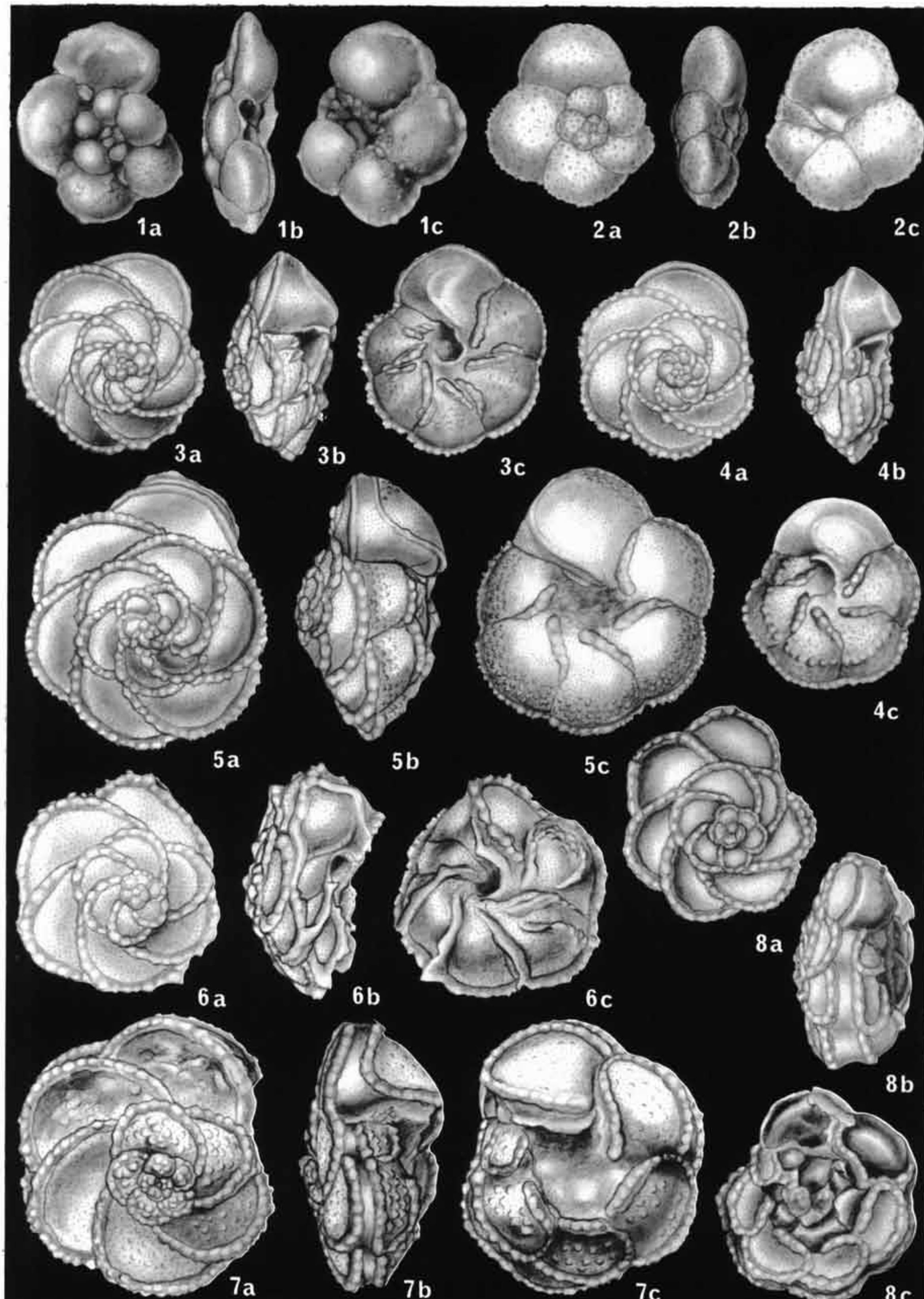
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a peripheral seal for test attachment. The spiral surface is covered by calcareous lamellae which result in a thickened wall and enlarged pores. In thin section the wall structure is obscured by recrystallization and has a granular appearance. This is also common in the specimens studied by HOFKER (1957), which he interpreted as representing an agglutinated wall.

EPITHEMELLA MARTINI (Brotzen)

Plate 19, figure 3

Conorbina martini BROTZEN, 1936, p. 143, fig. 51, pl. 10, fig. 4.
Cyclocibicides triebeli BARTENSTEIN, 1949, p. 213, fig. 1-4.
Cymbalopora martini (Brotzen), HOFKER, 1957, p. 89, fig. 94.

Test attached, large, discoidal, concavo-convex, initial low trochospiral coil followed by elongate, narrow irregular chambers that ultimately become annular, spiral side evolute, gently convex, umbilical side involute, gently concave, chambers broad, overlapping, commonly broken centrally, axial periphery carinate. Sutures distinct, initially limbate, flush, later depressed on spiral side, obscured on umbilical side. Wall calcareous, coarsely perforate except at imperforate chamber margins, surface smooth. Aperture interiomarginal, umbilical, generally obscured.

Maximum diameter of figured hypotype, 1.22 mm.; thickness, 0.34 mm.

Discussion.—The present specimens are found rarely throughout the Carlsbad section. *Epithemella martini* is characteristic of the European Senonian and has previously been recorded from Sweden and Germany.

Types and occurrence.—Figured hypotype (UCLA 44326) from sample C-4, Rosario Formation at Carlsbad (C116).

Genus FALSOCIBICIDES Poignant, 1958

FALSOCIBICIDES BEAUMONTIANUS (d'Orbigny)

Plate 19, figure 5

Truncatulina beaumontiana D'ORBIGNY, 1840, p. 35, pl. 3, fig. 17-19.
Cibicides beaumontianus (d'Orbigny), CUSHMAN, 1946, p. 160, pl. 65, fig. 12.

Test attached, large, trochospiral, asymmetrical, concavo-convex, spiral side generally convex, involute, umbilicate, axial periphery rounded. Chambers 5 to 9 in final whorl, increasing rapidly in size and becoming inflated. Sutures distinct, initially limbate, flush, later depressed on spiral side, depressed on umbilical side, gently curved to radial on both sides. Wall calcareous, coarsely perforate, surface smooth. Aperture an interiomarginal arch, extending onto spiral side from near the periphery on umbilical side.

Maximum diameter of figured hypotype, 0.78 mm.; thickness, 0.43 mm. Other hypotypes range to 1.0 mm. in diameter.

Discussion.—The large, irregular test, strongly convex umbilical side and coarse perforations allow easy recognition of this species. This form is included in the genus *Falsocibicides* on the basis of the noncarinate periphery and the characteristics just noted. In thin sections of specimens of this species as well as of other presently studied members of the superfamily Orbitoidacea, the lamellar character of the wall is obscured by recrystallization. This alteration is shown by the faint traces of lamallae in some of the granular septa and the secondary crystal growth in some chambers. The occasional relict apertures of the Tertiary forms are not observed in this species. *F. beaumontianus*, originally described from the Craie Blanche, is found in the lower parts of the La Jolla and Point Loma sections and throughout the Punta Descanso location. American Gulf Coast occurrences are most characteristic of the Taylor Group.

Types and occurrence.—Figured hypotype (UCLA 44328) from sample S-17, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (J84, L119, D62).

Family PLANORBULINIDAE Schwager, 1877

Genus PLANORBULINA d'Orbigny, 1826

PLANORBULINA PACIFICA Sliter, n. sp.

Plate 19, figure 4

Test attached, discoidal to subglobular, initially a low trochospiral coil, later becoming irregular, adding subglobular chambers. Sutures distinct, depressed. Wall calcareous, coarsely perforate, surface smooth. Aperture a low opening at chamber margin, with bordering lip.

EXPLANATION OF PLATE 18

1-2. *Globotruncana petaloidea* GANDOLFI; 1a-c, spiral edge, and umbilical views, ×129; 2a-c, same, ×97 (p. 105).

3-4. *Globotruncana rosetta* (CARSEY); 3a-c, 4a-c, spiral, edge, and umbilical views, ×66 (p. 105).

5-6. *Globotruncana stuartiformis* DALBIEZ; 5a-c, spiral, edge, and umbilical views, ×89; 6a-c, same, showing flangelike ornamentation on umbilical side, ×89 (p. 106).

7-8. *Globotruncana ventricosa* WHITE; 7a-c, spiral, edge, and umbilical views, ×89; 8a-c, same, ×66 (p. 107).

Maximum length of holotype, 0.51 mm.; breadth, 0.43 mm.; thickness, 0.20 mm.

Discussion.—This species is characterized by a discoidal test and proliferation of irregular, subglobular chambers. The initial trochospiral coil generally is obscured by later chambers. The wall structure of the present speciments is recrystallized, obscuring the lamellar character. The irregular chambers occasionally show a single aperture. *Planorbulina liverovskajae* VASILENKO from the middle Oligocene of Russia is very similar but differs in having more globular and less irregular chambers, more clearly visible trochospiral stage and commonly 2 apertures per chamber. The present occurrences of *P. pacifica* are Campanian.

Types and occurrence.—Holotype (UCLA 44329) from sample C-3; paratype (UCLA 44330) from sample C-4; both from Rosario Formation at Carlsbad (C116).

Family HOMOTREMATIDAE Cushman, 1927

Subfamily VICTORIELLINAE Chapman & Crespin, 1930

Genus CARPENTERIA Gray, 1958

CARPENTERIA sp.

Plate 19, figure 6

Test attached, trochospiral, plano-convex, only chambers of final whorl visible from umbilical side, periphery carinate. Chambers subglobular, increasing rapidly in size, becoming elongated. Sutures distinct, depressed. Wall calcareous, finely perforate, surface smooth. Aperture terminal, rounded.

Maximum diameter of figured specimen, 0.60 mm.; thickness, 0.39 mm.

Discussion.—A single specimen recovered at Punta Descanso is assigned to this genus on the basis of the type of coiling and peripheral keel but it differs in having a terminal aperture. The genus *Biarritzina* has elongated chambers and a terminal aperture but differs in having coarser perforations and chambers arranged in a loose elevated spire. The present specimen apparently represents an irregular form of the genus *Carpenteria.*

Type and occurrence.—Figured specimen (UCLA 44331) from sample E-24, Rosario Formation at Punta Descanso (D153).

Superfamily CASSIDULINACEA d'Orbigny, 1839

Family PLEUROSTOMELLIDAE Reuss, 1860

Subfamily PLEUROSTOMELLINAE Reuss, 1860

Genus PLEUROSTOMELLA Reuss, 1860

PLEUROSTOMELLA SUBNODOSA Reuss

Plate 19, figure 10

Pleurostomella subnodosa REUSS, 1860, p. 204, pl. 8, fig. 2.——CUSHMAN, 1946, p. 132, pl. 55, fig. 1-9.——TRUJILLO, 1960, p. 345, pl. 50, fig. 7.——LOEBLICH & TAPPAN, 1964, p. C727, fig. 594,*1*.

Pleurostomellina sp. GRAHAM & CHURCH, 1963, p. 68, pl. 8, fig. 12.

Nodosarella gracillima Cushman, MARTIN, 1964, p. 75, pl. 8, fig. 6.

Test free, elongate, chambers initially biserially arranged, cuneate, later uniserial. Chambers becoming slightly inflated. Sutures may initially be indistinct, later distinct, depressed. Wall calcareous, finely perforate, granular in structure. Aperture subterminal, with overhanging hood, 2 small apertural teeth.

Maximum length of figured hypotype, 1.02 mm.; diameter, 0.20 mm.

Discussion.—This species is distinguished by its elongate test, cuneate chambers, and apertural modifications. The initial chambers commonly are obscured, whereas others have a chamber arrangement varying from biserial to nearly uniserial. *Pleurostomellina* sp. of GRAHAM & CHURCH (1963) and *Nodosarella gracillima* CUSHMAN of MARTIN (1964), both from the Upper Cretaceous of California, are identical to the present species. *P. subnodosa*, originally described from the Upper Cretaceous of Europe, is indicative of Campanian strata. It presently occurs in the upper portion of the section at La Jolla, throughout the Point Loma and Punta Descanso locations, and rarely at Carlsbad.

Types and occurrence.—Figured hypotype (UCLA 44332) from sample S-35, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Carlsbad, Point Loma and Punta Descanso (C124, J124, L42, D16).

Genus ELLIPSOIDELLA Heron-Allen & Earland, 1910

ELLIPSOIDELLA GRACILLIMA (Cushman)

Plate 19, figure 12

Nodosarella gracillima CUSHMAN, 1933b, p. 64, pl. 17, fig. 14.

Test free, elongate, slightly tapering, initially biserial, later uniserial, rectilinear to very slightly curved. Chambers becoming elongate, inflated, increasing in length as added. Sutures distinct, depressed. Wall calcareous, finely perforate, surface smooth. Aperture subterminal, with overhanging lip.

Maximum length of figured hypotype, 0.60 mm.; diameter, 0.13 mm. Other hypotypes range to 0.72 mm. in length.

Discussion.—This species differs from *Ellipsoidella primitiva* (CUSHMAN) (1938b) in being more slender and in having less overlapping chambers. *E. texana* (CUSHMAN) (1938b) is also similar but differs in having a greater length, test curvature and more numerous elongated chambers. The present forms appear to be somewhat transitional between *E. gracillima* and *E. texana* but nevertheless have more affinities to the former species. The specimen illustrated by MARTIN (1964) as *Nodosarella gracillima* has a crescentic, hooded aperture characteristic of the genus *Pleurostomella,* whereas the form he referred to *N. texana* has many of the characteristics of this species. The present forms are limited to Carlsbad, where they occur rarely throughout the section. American Gulf Coast occurrences range from upper Austin to lower Taylor age strata.

Types and occurrence.—Figured hypotype (UCLA 44333) from sample C-3, Rosario Formation at Carlsbad (C72).

ELLIPSOIDELLA KUGLERI (Cushman & Renz)

Plate 19, figure 9

Nodosarella kugleri CUSHMAN & RENZ, 1946, p. 42, pl. 6, fig. 30, 33.

Test free, elongate, initially biserial, later uniserial, gradually tapering. Chambers subspherical, inflated, overlapping, increasing moderately in size. Sutures distinct, depressed. Wall calcareous, finely perforate, surface smoothly finished. Aperture subterminal, semilunate, with raised lip.

Maximum length of figured hypotype, 0.60 mm.; diameter, 0.21 mm.

Discussion.—This species, originally described from the lower Lizard Springs Formation of Trinidad, differs from *Ellipsoidella gracillima* in being more robust and thicker and in having subspherical, overlapping chambers. The present forms are smaller than those originally illustrated but otherwise are nearly identical. The related California species, *E. coalingensis* (CUSHMAN & CHURCH) (1929), is distinct from this species, being more tapering and having a more definite biserial state, more pronounced lip, and less embracing chambers. The present distribution of *E. kugleri* is limited to Point Loma and the upper samples at La Jolla.

Types and occurrence.—Figured hypotype (UCLA 44334) from sample S-27, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma (J198, L102).

Genus ELLIPSOPOLYMORPHINA Silvestri, 1901

ELLIPSOPOLYMORPHINA sp.

Plate 19, figure 7-8

Ellipsobulimina? sp. CUSHMAN & CHURCH, 1929, p. 514, pl. 40, fig. 1-3.

Ellipsopolymorphina sp. aff. *E. schlichti* (Silvestri), GRAHAM & CHURCH, 1963, p. 67, pl. 8, fig. 7.

?*Ellipsobulimina* sp. GRAHAM & CHURCH, 1963, p. 66, pl. 8, fig. 4.

Test free, spherical to ovate, apical end rounded or pointed. Chambers initially biserial, final chamber uniserial, strongly overlapping to completely enveloping. Sutures generally indistinct, nearly flush. Wall calcareous, finely perforate, surface smooth. Aperture terminal, cresentic, hooded.

Maximum diameter of figured specimens, 0.26 to 0.27 mm.

Discussion.—These specimens are rare in the present material. Broken examples show the early biserial chamber arrangement and final chamber attached to one side. Sutures generally are indistinct or obscured by the final enveloping chamber but may be seen in the initial portion of pointed specimens. Two forms are present, one nearly spherical with the final chamber completely enveloping the test, and the other is initially pointed and shows the early biserial arrangement. These 2 forms represent different stages in the life cycle. Previous California occurrences of this form range from the Santonian to the Campanian. *Ellipsoglandulina* sp. of GRAHAM & CHURCH (1963) may also belong here but differs in having an enlarged initial chamber. The specimen referred to *Ellipsopolymorphina schlichti* (SILVESTRI) by GALLOWAY & MORREY (1931) from the Upper Cretaceous of Mexico is similar in shape but differs in having more pronounced initial chambers and a narrower, more produced aperture and lacks the apical spine. The present form resembles *Ellipsoglandulina velascoensis* CUSHMAN (1926b) from the Velasco Shale of Mexico but differs in being initially biserial. The specimen figured by MARTIN (1964) from the upper Santonian of central California may belong to this genus.

Types and occurrence.—Figured specimen (Fig. 7, UCLA 44335) from sample L-1; figured hypotype (Fig. 8, UCLA 44180) from sample L-10; both from Rosario Formation at Point Loma. Unfigured hypotypes from Rosario Formation at La Jolla (J199, L146).

Subfamily WHEELERELLINAE Petters, 1954

Genus BANDYELLA Loeblich & Tappan, 1962

BANDYELLA GREATVALLEYENSIS (Trujillo)

Plate 19, figure 11

Pleurostomella greatvalleyensis TRUJILLO, 1960, p. 345, pl. 50, fig. 5-6.——MARTIN, 1964, p. 74, pl. 8, fig. 2.

Bandyella greatvalleyensis (Trujillo), LOEBLICH & TAPPAN, 1964, p. C730, fig. 598,2.

Test free, short, chambers initially triserially arranged, later biserial, cuneate. Chambers distinct, inflated. Sutures distinct, depressed. Wall calcareous, finely perforate, granular in structure, surface smoothly finished. Aperture a hooded, subterminal, T-shaped slit.

Maximum length of figured hypotype, 0.31 mm.; diameter, 0.12 mm.

Discussion.—This distinctive species, originally described from the Santonian of northern California, is distinguished by the initial triserial chamber arrangement, short test, and apertural modifications. The present specimens are somewhat smaller and less robust than those of the original illustrations but closely resemble some unfigured paratypes. The final chamber also is less inflated; many specimens, however, are incomplete and may have had this chamber modification. This variation seems due to geographic or stratigraphic differences, or both, and is not a specific difference. The California stratigraphic range of this species is Coniacian to Maastrichtian.

Types and occurrence.—Figured hypotype (UCLA 44336) from sample S-21, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (J156, L151, D105).

Family CAUCASINIDAE Bykova, 1959

Subfamily FURSENKOININAE Loeblich & Tappan, 1961

Genus FURSENKOINA Loeblich & Tappan, 1961

FURSENKOINA NEDERI Sliter, n. sp.

Plate 20, figure 1

Virgulina tegulata Reuss, Bandy, 1951, p. 512, pl. 75, fig. 7.

Test free, elongate, biserial, compressed, periphery rounded. Chambers elongate, inflated, increasing rapidly in size, initial stage strongly twisted, becoming less so toward aperture. Sutures distinct, oblique, depressed. Wall calcareous, finely perforate, granular in structure, surface smooth. Aperture elongate, narrow, extending up apertural face of final chamber.

Maximum length of holotype, 0.67 mm.; breadth, 0.18 mm.; thickness, 0.14 mm.

Discussion.—This species was previously referred to *Cassidella tegulata* (Reuss) (Bandy, 1951), but differs in the more twisted chamber arrangement and chamber shape. *Fursenkoina navarroana* (Cushman) (1933b) from the Navarro Group of Texas is somewhat similar but is distinguished by less elongate chambers, a thicker test, and apical spine. This species is confined to Carlsbad and is rare throughout the section (middle to late Campanian).

Types and occurrence.—Holotype (UCLA 44337) from sample C-3; paratype (UCLA 44338) from sample C-4; both from Rosario Formation at Carlsbad. Unfigured hypotype from Rosario Formation at Point Loma (C50, L148).

Genus CORYPHOSTOMA Loeblich & Tappan, 1962

CORYPHOSTOMA PLAITUM (Carsey)

Plate 19, figure 13

Bolivina plaita Carsey, 1926, p. 26, pl. 5, fig. 2.
Loxostoma plaitum (Carsey), Cushman, 1946, p. 130, pl. 54, fig. 10, 12-14.
Loxstomum plaitum (Carsey), Bandy, 1951, p. 505, pl. 75, fig. 7.
Coryphostoma plaita (Carsey), Loeblich & Tappan, 1964, p. C733, fig. 600,*8*.

Test free, elongate, narrow, slightly compressed, periphery rounded, biserial throughout. Chambers initially subrectangular, later cuneiform, increasing gradually in size. Sutures distinct, slightly depressed, oblique. Wall calcareous, finely perforate, granular in structure, smoothly finished. Aperture subterminal, elongate, with tooth plate.

Maximum length of figured hypotype, 0.87 mm.; breadth, 0.29 mm.; thickness, 0.15 mm.

Discussion.—Originally described from the Navarro of Texas, this species is recognized by the test shape and subterminal aperture. The present specimens are restricted to Carlsbad and occur throughout that section. In the American Gulf Coast, this species is most common in strata of Navarro age but is reported less frequently from beds of Taylor and Austin age.

Types and occurrence.—Figured hypotype (UCLA 44339) from sample C-2, Rosario Formation at Carlsbad. Unfigured hypotypes from Rosario Formation at Punta Descanso (C22, D132).

Family LOXOSTOMIDAE Loeblich & Tappan, 1962

Genus LOXOSTOMUM Ehrenberg, 1852

LOXOSTOMUM ELEYI (Cushman)

Plate 20, figure 2

Bolivinita eleyi Cushman, 1927a, p. 91, pl. 12, fig. 11.——Cushman, 1946, p. 114, pl. 48, fig. 18-20.
Bolivinitella eleyi (Cushman), Brotzen, 1936, p. 122, pl. 9, fig. 5.——Graham & Church, 1963, p. 51, pl. 5, fig. 25.——Martin, 1964, p. 91, pl. 21, fig. 3.
Loxostomum eleyi (Cushman), Loeblich & Tappan, 1964, p. C736, fig. 603,*2-5*.

Test free, elongate, compressed, periphery truncate, sides slightly concave. Chambers biserial, overlapping, elongate. Sutures limbate, curved, forming marginal carinae. Wall calcareous, finely perforate, surface smooth. Aperture terminal, ovate.

Maximum length of figured hypotype, 0.29 mm.; breadth, 0.10 mm.; width, 0.05 mm.

Discussion.—This species is recognized by the flattened sides, truncate periphery, and chamber shape. It occurs rarely in the upper samples at La Jolla and a single location at Punta Descanso. The species ranges throughout the Senonian.

Types and occurrence.—Figured hypotype (UCLA 44340) from sample E-3, Rosario Formation at Punta Descanso. Unfigured hypotypes from Rosario Formation at La Jolla (J188, D85).

Family NONIONIDAE Schultze, 1854

Subfamily CHILOSTOMELLINAE Brady, 1881

Genus CHILOSTOMELLA Reuss in Czjzek, 1849

CHILOSTOMELLA TRINITATENSIS Cushman & Todd

Plate 20, figure 3

Chilostomella trinitatensis Cushman & Todd, 1949b, p. 85, pl. 15, fig. 2.

Test free, elongate, nearly cylindrical, 2 chambers per whorl, last one making up two-thirds of test. Sutures indistinct, flush. Wall calcareous, finely perforate, granular in structure, surface smooth. Aperture an arched opening at base of final chamber, with narrow lip.

Maximum length of figured hypotype, 1.09 mm.; diameter, 0.56 mm.

Discussion.—The present specimens vary considerably in test and apertural size. The aperture ranges from a low narrow slit to a distinct semicircular arch like that shown in the original illustrations. The specimens commonly are pyritized with only the cast remaining. This species is found in all sections except Carlsbad. Originally described from the Paleocene of Trinidad, this form differs from *Chilostomella primitiva* CUSHMAN & TODD (1949b) in being larger and more cylindrical and in having a more distinct and commonly flaring aperture.

Types and occurrence.—Figured hypotype (UCLA 44341) from sample S-17, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (J86, L6, D61).

Genus ALLOMORPHINA Reuss in Czjzek, 1849

ALLOMORPHINA CRETACEA Reuss

Plate 20, figure 4

Allomorphina cretacea REUSS, 1851, p. 42, pl. 5, fig. 6.——CUSHMAN & CHURCH, 1929, p. 517, pl. 41, fig. 12-13.
Allomorphina sp. cf. *A. cretacea* Reuss, MCGUGAN, 1964, p. 947, pl. 152, fig. 11.

Test free, trochospiral, subtriangular in plan, adult stage involute, periphery broadly rounded. Chambers 3 in final whorl, increasing rapidly in size, strongly overlapping. Sutures distinct, generally flush. Wall calcareous, finely perforate, granular in structure, surface smooth. Aperture an arched opening paralleling suture, with narrow bordering lip.

Maximum length of figured hypotype, 0.63 mm.; breadth, 0.53 mm.; thickness, 0.46 mm.

Discussion.—The present specimens are identical to the original illustrations of REUSS from the Upper Cretaceous of Poland. The species is distinguished by the relatively large size, subtriangular and involute test, and wide aperture. Juvenile tests are partly evolute. With increased size, chambers become more overlapping and tend to produce an involute adult test. In this paper, the definition of the closely related genera *Allomorphina* and *Quadrimorphina* presented in the *Treatise on Invertebrate Paleontology*, Part C, is modified as follows: *Allomorphina* includes subtriangular forms having 3 or 4 chambers in the final whorl, the adult stage being involute to partially evolute, with apertural modifications consisting of a bordering lip or umbilical flap; *Quadrimorphina* includes forms that are oval to subspherical in plan view, evolute and more distinctly trochospiral, with 4 or more chambers in the final whorl, and an apertural flap. The relationship of these 2 genera clearly requires further investigation.

Types and occurrence.—Figured hypotype (UCLA 44342) from sample S-20, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Carlsbad, Point Loma, and Punta Descanso (C75, J28, L5, D73).

ALLOMORPHINA HALLI Jennings

Plate 20, figure 8

Allomorphina halli JENNINGS, 1936, p. 34, pl. 4, fig. 5.——BROTZEN, 1948, p. 127, fig. 39-41, pl. 19, fig. 4.——HOFKER, 1957, p. 200, fig. 247.

Test free, trochospiral, biconvex, subtriangular in plan, spiral side partially evolute, with all chambers visible, umbilical side involute, axial periphery broadly rounded. Chambers 3 or 4 in final whorl, increasing rapidly in size, initially globular, later subtriangular, inflated. Sutures distinct, depressed, straight. Wall calcareous, finely perforate, granular in structure, surface smoothly finished. Aperture a low arch at inner margin of final chamber with distinct triangular apertural flap.

Maximum length of figured hypotype, 0.27 mm.; breadth, 0.24 mm.; thickness, 0.17 mm. Other hypotypes range to 0.32 mm. in length.

Discussion.—This species, originally described from the Paleocene of New Jersey, is characterized by its inflated chambers, relatively small size, and triangular apertural flap. It may be differentiated from small specimens of *Allomorphina cretacea* by the greater relative thickness, inflated chambers, less triangular outline, and smaller but more distinct flap. The present specimens differ from *A. minuta* CUSHMAN, described from beds of Austin age in Texas, in being larger and thicker, and in having more globular chambers and a less triangular plan. *A. minuta* probably represents a species ancestral to *A. halli*, giving rise to the latter form by an increase in size and chamber inflation. *A. halli* previously has been recorded in the Paleocene of Sweden (BROTZEN, 1948) and the Maastrichtian of Holland (HOFKER, 1957). In the present samples the species first appears in the lower part of the La Jolla section and continues throughout that locality.

Types and occurrence.—Figured hypotype (UCLA 44343) from sample C-4, Rosario Formation at Carlsbad. Unfigured hypotypes from Rosario Formation at La Jolla, Point Loma and Punta Descanso (C115, J133, L60, D108).

ALLOMORPHINA SUBTRIANGULARIS (Kline)

Plate 20, figure 5-6

Chilostomella subtriangularis KLINE, 1943, p. 56, pl. 6, fig. 3.
Allomorphina subtriangularis (Kline), CUSHMAN & TODD, 1949a, p. 64, pl. 11, fig. 15.

Test free, trochospiral, subtriangular in plan, periphery broadly rounded. Chambers 3 in final whorl, increasing rapidly in size, producing oblique chamber arrangement, inflated, final chamber occupying two-thirds length of test. Sutures distinct, gently depressed. Wall calcareous, finely perforate, granular in structure, surface smooth. Aperture an arched opening at base of final chamber, with bordering lip.

Maximum length of figured hypotypes, 0.75 to 0.90 mm.; diameter, 0.58 to 0.60 mm.

Discussion.—This species, originally described from the Paleocene of Mississippi, is more elongate than *Allomorphina cretacea* and has a reduced initial chamber in the final whorl, and a more flaring aperture. The original description fails to mention the reduced chamber, however, as noted by CUSHMAN & TODD (1949a), the chambers are arranged in a triserial manner. This species may be synonymous to *A. obliqua* Reuss (1851) as both that species and the present examples are associated with *A. cretacea* and are of comparable size. The present forms differ, however, in being more elongate and in having a rounded final chamber and a narrower aperture. Two morphologic types are included within this species. The more common form is oval in plan view, with subglobular chambers and a wide, gently arched aperture. The 2nd form includes subcylindrical specimens with elongate chambers and a hemispherical, flaring aperture. These elongate specimens differ from specimens of *Chilostomella trinitatensis* in having 3 chambers in the final whorl and an oblique chamber arrangement.

Types and occurrence.—Figured hypotype (Fig. 6, UCLA 44344) from sample L-9; figured hypotype (Fig. 5, UCLA 44345) from sample L-8; both from Rosario Formation at Point Loma. Unfigured hypotypes from Rosario Formation at Carlsbad, La Jolla and Punta Descanso (C144, J104, L113, D75).

Genus QUADRIMORPHINA Finlay, 1939

QUADRIMORPHINA ALLOMORPHINOIDES (Reuss)

Plate 20, figure 7

Valvulineria allomorphinoides Reuss, 1860, p. 223, pl. 11, fig. 6.——Brotzen, 1936, p. 153, pl. 11, fig. 1.

Quadrimorphina allomorphinoides (Reuss), Trujillo, 1960, p. 330, pl. 47, fig. 15.

Test free, trochospiral, nearly biconvex, spiral side partially evolute, chambers rather indistinct, umbilical side involute, axial periphery broadly rounded. Chambers 4 or 5 in final whorl, inflated, last chamber much larger and occupying half of test. Sutures somewhat indistinct, gently curved to radial. Wall calcareous, finely perforate, granular in structure, surface smooth. Aperture a broad low arch parelleling the suture, with narrow flap.

Maximum length of figured hypotype, 0.39 mm.; breadth, 0.32 mm.; thickness, 0.26 mm.

Discussion.—This form is rare in the present material and smaller than that originally illustrated from the Cretaceous of Europe. These specimens probably represent juvenile forms. *Quadrimorphina allomorphinoides* is distinguished by the large, inflated final chamber occupying half the test length and by the wide aperture. The species has been reported previously in California by Trujillo (1960) from beds of Santonian age. The specimen illustrated by Graham & Church (1963) from the Campanian of the Stanford University campus may be synonymous; the spiral view, however, has been distorted so as to prevent positive identification. This species is found only in the middle portion of the La Jolla section.

Types and occurrence.—Figured hypotypes (UCLA 44346) from sample S-24, Rosario Formation at La Jolla (J184).

QUADRIMORPHINA CAMERATA (Brotzen)

Plate 20, figure 9

Valvulineria camerata Brotzen, 1936, p. 155, pl. 10, fig. 1-2.

Valvulineria allomorphinoides (Reuss), Cushman, 1946, p. 138, pl. 57, fig. 6.——Bandy, 1951, p. 503, pl. 74, fig. 4.

Valvulineria sp. Graham & Church, 1963, p. 60, pl. 7, fig. 8.

Test free, trochospiral, nearly biconvex, spiral side evolute with all chambers visible, umbilical side involute, umbilicate, axial periphery broadly rounded, ovate in outline. Chambers generally 4, rarely 5 in final whorl, increasing rapidly in size, becoming inflated, last chamber occupying less than half of test length. Sutures distinct, gently curved on spiral side, radial on umbilical side, depressed slightly on both sides. Wall calcareous, finely perforate, granular in structure, surface smooth. Aperture interiomarginal, umbilical, partially covered by triangular apertural flap.

Maximum length of figured hypotype, 0.22 mm.; breadth, 0.19 mm.; thickness, 0.14 mm. Diameter of other hypotypes ranges to 0.43 mm.

Discussion.—The present specimens are identical to the original illustrations from the Senonian of Sweden. The species differs from *Quadrimorphina allomorphinoides* (Reuss) in being smaller and in having a better-developed spire and a smaller final chamber. Previously recorded California occurrences include the upper Campanian of Carlsbad (Bandy, 1951) and the Campanian of the Stanford University campus (Graham & Church, 1963). The broken specimen illustrated by Cushman & Church (1929) as *Discorbis cretacea* (Franke)? also may be synonymous. *Q. camerata* first appears in the lower samples at La Jolla and becomes more common toward the top. It is also abundant in the lower part of both the Point Loma and Punta Descanso sections but is missing entirely at Carlsbad. The Gulf Coast occurrences range from Taylor to Navarro.

Types and occurrence.—Figured hypotype (UCLA 44347) from sample S-28, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (J94, L59, D34).

QUADRIMORPHINA SPIRATA Sliter, n. sp.

Plate 20, figure 10

Test free, trochospiral, spiral side moderately convex with raised spire, evolute, all chambers visible, umbilical side gently convex, involute, with open umbilicus, axial periphery rounded. Chambers 4 to 5 per whorl, increasing moderately in size, inflated. Sutures distinct, oblique, gently curved, depressed on spiral side, radial, depressed on umbilical side. Wall calcareous, finely perforate, granular in structure, surface smoothly finished. Aperture interiomarginal, umbilical, with triangular flap projecting into umbilicus from each chamber.

Maximum length of holotype, 0.41 mm.; breadth, 0.36 mm.; thickness, 0.27 mm.

Discussion.—This species most closely resembles *Quadrimorphina camerata* (Brotzen) but differs in having a more pronounced spire, larger umbilicus, oblique spiral sutures, and less inflated and more slowly enlarging chambers. Many specimens show the remains of a bulla-like, reduced final chamber or umbilical covering. *Q.*

spirata is found only in the lower samples at Carlsbad (middle Campanian).

Types and occurrence.—Holotype (Fig. 10, UCLA 44348) and paratype (UCLA 44349) from sample C-3, Rosario Formation at Carlsbad (C80).

Subfamily NONIONINAE Schultze, 1854

Genus NONIONELLA Cushman, 1926

NONIONELLA AUSTINANA Cushman

Plate 20, figure 11

Nonionella austinana Cushman, 1933b, p. 57, pl. 7, fig. 2.

Test free, small, trochospiral, somewhat compressed, periphery rounded, spiral side evolute, umbilical side involute with final chamber asymmetrically produced toward umbilical side. Chambers 6 in the final whorl, slightly inflated, increasing moderately in size. Sutures gently curved, depressed. Wall calcareous, granular, perforate, surface smooth. Aperture an interiomarginal arch extending onto umbilical side, with small lip.

Maximum length of figured hypotype, 0.19 mm.; breadth, 0.14 mm.; thickness, 0.10 mm.

Discussion.—A few small specimens from the Carlsbad and Punta Descanso sections are referred to this species on the basis of the number of chambers and the rounded periphery. *Nonionella robusta* Plummer (1931) is similar to the present form but has a longer, thinner test and more numerous chambers. *N. austinana* is most characteristic of Austin age strata in the Gulf Coast but also ranges upward into the upper Taylor.

Types and occurrence.—Figured hypotype (UCLA 44350) from sample C-2, Rosario Formation at Carlsbad. Unfigured hypotypes from Rosario Formation at Punta Descanso (C65, D124).

NONIONELLA CRETACEA Cushman

Plate 21, figure 1

Nonionella cretacea Cushman, 1931c, p. 42, pl. 7, fig. 2.——Jennings, 1936, p. 25, pl. 3, fig. 3.

Test free, small, low trochospiral, compressed, periphery rounded, spiral side evolute, umbilical side involute with final chamber produced over umbilicus. Chambers 9 or 10 in the final whorl, increasing rapidly in length. Sutures slightly curved and depressed. Wall calcareous, granular, finely perforate, surface smoothly finished. Aperture a low interiomarginal arch extending onto umbilical side.

Maximum length of figured hypotype, 0.26 mm.; breadth, 0.15 mm.; thickness, 0.09 mm.

Discussion.—This species is distinguished from *Nonionella austinana* by its proportionately longer test, less rounded periphery, and more numerous chambers in the final whorl. *N. cretacea* occurs in Taylor and Navarro age strata in the Gulf and Atlantic coasts. It is rare in the present samples, occurring almost exclusively at Carlsbad, with the related species *N. austinana*.

Types and occurrence.—Figured hypotype (UCLA 44351) from sample C-6, Rosario Formation at Carlsbad. Unfigured hypotypes from Rosario Formation at La Jolla (C62, J63).

Genus PULLENIA Parker & Jones in Carpenter, Parker & Jones, 1862

PULLENIA CRETACEA Cushman

Plate 21, figure 2

Pullenia cretacea Cushman, 1936c, p. 75, pl. 13, fig. 8.——Graham & Church, 1963, p. 68, pl. 8, fig. 13-14.——McGugan, 1964, p. 947, pl. 152, fig. 6.

Pullenia coryelli White, McGugan, 1964, p. 947, pl. 152, fig. 7.

Test free, planispiral, involute, slightly compressed, periphery broadly rounded. Chambers 5 in final whorl, slightly if at all inflated, increasing gradually in size. Sutures distinct, very slightly depressed, radial to gently curved. Wall calcareous, finely perforate, granular in structure, surface smooth. Aperture a low, wide interiomarginal slit at base of a low apertural face.

Maximum diameter of figured hypotype, 0.31 mm.; thickness, 0.27 mm.

Discussion.—*Pullenia cretacea* is the most common species of this genus and occurs in the lower parts of the sections at La Jolla and Point Loma. Specimens range in thickness from 0.20 to 0.27 mm. Subspherical forms resemble *P. coryelli* White (1929) but differ in having fewer chambers, less spherical test, and smaller size. *P. cretacea* is distinguished by its relatively thick test, nonlobate periphery, and flush sutures. This species occurs in the Taylor and Navarro groups of the Gulf Coast and the Upper Cretaceous of Colombia, Venezuela, western Europe, and Australia. West Coast occurrences include the Campanian of the Stanford University campus and Vancouver Island, British Columbia.

Types and occurrence.—Figured hypotype (UCLA 44352) from sample S-23, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma (J44, L103).

PULLENIA JARVISI Cushman

Plate 21, figure 3

Pullenia jarvisi Cushman, 1936c, p. 77, pl. 13, fig. 6.——Martin, 1964, p. 76, pl. 8, fig. 8.——McGugan, 1957, p. 342, pl. 33, fig. 6-7.

Pullenia sp. cf. *P. jarvisi* Cushman, Graham & Church, 1963, p. 69, pl. 8, fig. 15.

Test free, planispiral, involute, compressed, biumbilicate, axial periphery rounded, equatorial periphery lobate. Chambers 5 or 6 in final whorl, inflated, increasing moderately in size as added. Sutures distinct, depressed, curved. Wall calcareous, granular in structure, finely perforate, surface smooth. Aperture a low interiomarginal arch at base of high apertural face.

Maximum diameter of figured hypotype, 0.42 mm.; thickness, 0.24 mm.

Discussion.—*Pullenia jarvisi* differs from *P. cretacea* in its relatively larger size, lobate equatorial periphery, and depressed, curved sutures. Specimens occur at Carlsbad, La Jolla, Point Loma, and Punta Descanso. In the Point Loma section *P. cretacea* appears prior to *P. jarvisi*. From the middle of the section upward, only *P. jarvisi* is present. Originally described from Trinidad, this species also occurs in the Upper Cretaceous of California, Mexico, and Ireland.

Types and occurrence.—Figured hypotype (UCLA 44353) from sample L-4, Rosario Formation at Point Loma. Unfigured hypotypes from Rosario Formation at La Jolla, Carlsbad, and Punta Descanso (C140, J211, L121, D116).

PULLENIA sp. cf. P. MINUTA Cushman
Plate 21, figure 4

Pullenia minuta CUSHMAN, 1936c, p. 77, pl. 13, fig. 7.

Test free, small, planispiral, involute, periphery somewhat angular. Chambers about 6 in final whorl, very slightly inflated. Sutures distinct, slightly depressed and gently curved. Wall calcareous, granular in structure, finely perforate. Aperture a low interiomarginal arch with slight lip, at base of high apertural face.

Maximum diameter of figured hypotype, 0.26 mm.; thickness, 0.15 mm.

Discussion.—This species occurs rarely at Carlsbad and Punta Descanso. The forms are similar to *Pullenia minuta* from the Corsicana Marl of the Gulf Coast but are somewhat larger and lack the distinctly curved sutures. *P. jarvisi* differs in being larger and having distinctly depressed and curved sutures.

Types and occurrence.—Figured hypotype (UCLA 44354) from sample C-5, Rosario Formation at Carlsbad. Unfigured hypotypes from Rosario Formation at Punta Descanso (C141, D123).

Family ALABAMINIDAE Hofker, 1951

Genus ALABAMINA Toulmin, 1941

ALABAMINA DORSOPLANA (Brotzen)
Plate 21, figure 5

Eponides dorsoplana BROTZEN, 1940, p. 31, fig. 8,2.
Alabamina dorsoplana (Brotzen), BROTZEN, 1948, p. 102, fig. 26(E)-27, pl. 16, fig. 3.——HOFKER, 1957, p. 387, fig. 432.

Test free, low trochospiral, spiral side nearly evolute with all chambers showing, umbilical side involute, only final whorl visible around small umbilicus, axial periphery subangular. Chambers 5 or 6 in final whorl, increasing moderately in size, subtriangular with high apertural face. Sutures distinct, curved on spiral side, nearly radial on umbilical side, may become slightly depressed. Wall calcareous, finely perforate, granular in structure, surface smoothly finished. Aperture an interiomarginal slit within sulcus in apertural face, extending from near the periphery to the umbilicus, with narrow lip.

Maximum diameter of figured hypotype, 0.20 mm.; thickness, 0.14 mm.

Discussion.—This species is easily recognized by its small size, subtriangular chambers, and apertural sulcus. *Alabamina dorsoplana* is distinguished by the strongly convex umbilical side, low spiral side, and high apertural face. The species first appears in the middle part of the La Jolla section. Rare occurrences also are recorded at Carlsbad and Point Loma. Originally described from the lower Danian of Sweden, this species extends downward into the upper Campanian.

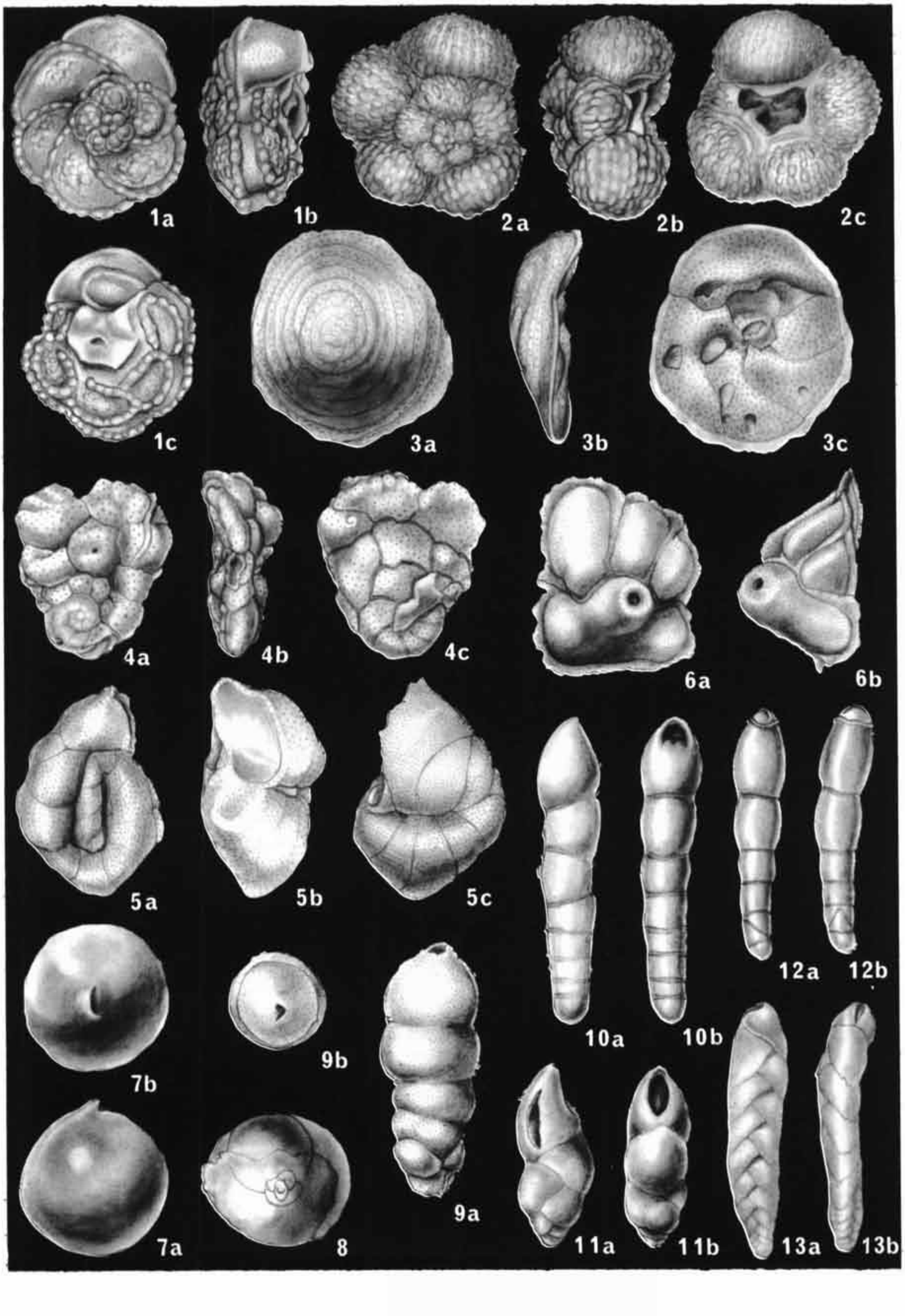
EXPLANATION OF PLATE 19

FIGURE

1. *Globotruncana tricarinata* (QUEREAU); 1a-c, spiral, edge, and umbilical views, ×97 (p. 107).
2. *Rugoglobigerina rugosa* (PLUMMER); 2a-c, spiral, edge, and umbilical views, ×89 (p. 108).
3. *Epithemella martini* (BROTZEN); 3a-c, spiral, edge, and umbilical views, ×33 (p. 109).
4. *Planorbulina pacifica* SLITER, n. sp.; 4a-c, spiral, edge, and umbilical views, ×66 (p. 109).
5. *Falsocibicides beaumontianus* (D'ORBIGNY); 5a-c, spiral edge, and umbilical views, ×52 (p. 109).
6. *Carpenteria* sp.; 6a,b, umbilical and edge views, ×66 (p. 110).

7-8. *Ellipsopolymorphina* sp.; 7a,b, side and apertural views, ×97; 8, basal view, ×97 (p. 111).

9. *Ellipsoidella kugleri* (CUSHMAN & RENZ); 9a,b, side and apertural views, ×66 (p. 111).
10. *Pleurostomella subnodosa* REUSS; 10a,b, side and edge views, ×52 (p. 110).
11. *Bandyella greatvalleyensis* (TRUJILLO); 11a,b, side and edge views, ×97 (p. 111).
12. *Ellipsoidella gracillima* (CUSHMAN); 12a,b, side and edge views, ×66 (p. 110).
13. *Coryphostoma plaitum* (CARSEY); 13a,b, side and edge views, ×52 (p. 112).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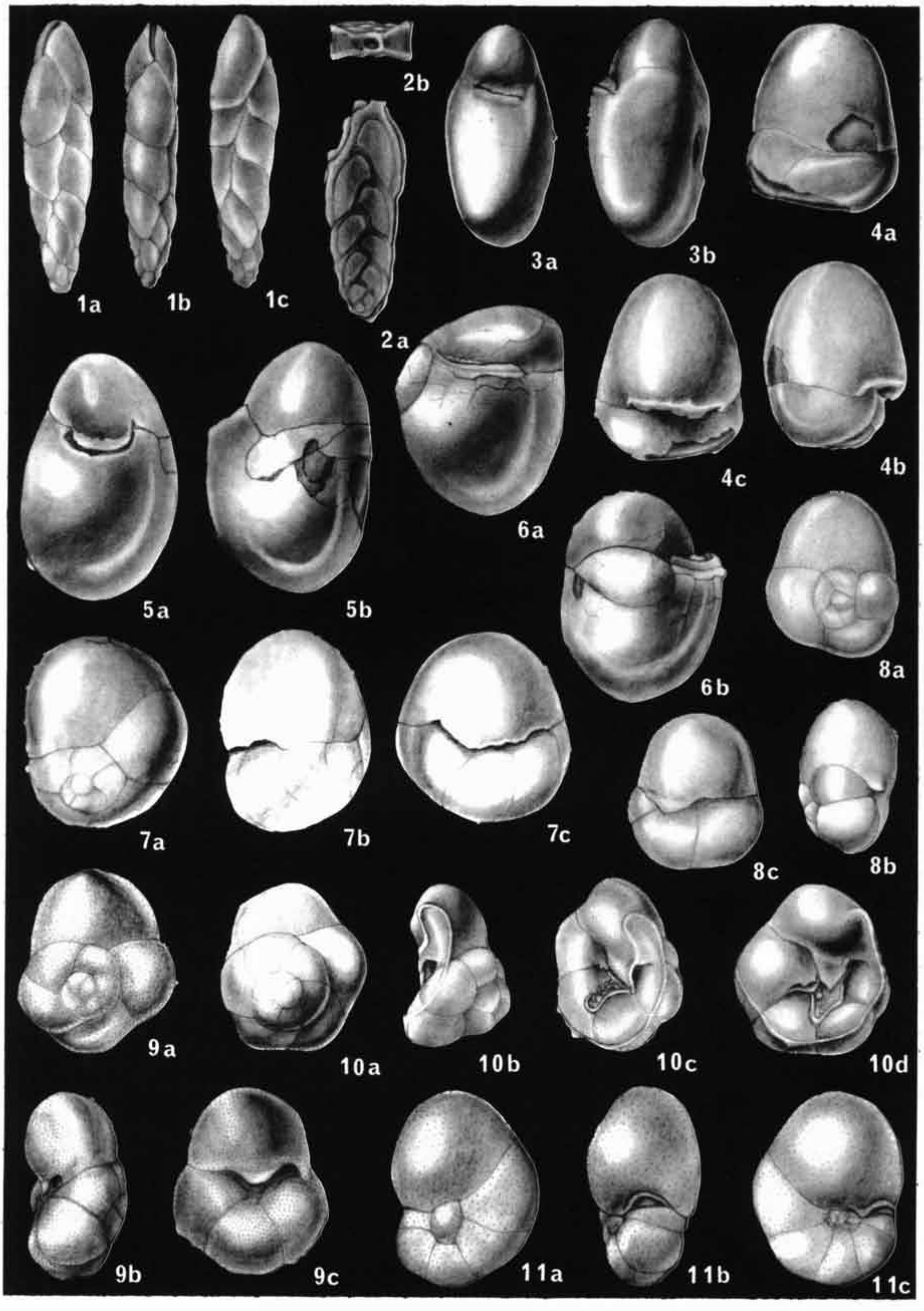
Sliter — Upper Cretaceous Foraminifera, Southern California and Northwestern Mexico.



Types and occurrence.—Figured hypotype (UCLA 44355) from sample S-26, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Carlsbad and Point Loma (C109, J150, L125).

Genus GYROIDINA d'Orbigny, 1826

GYROIDINA CRETACEA (Carsey)
Plate 21, figure 7-8

Rotalia cretacea Carsey, 1926, p. 48, pl. 5, fig. 1.
Valvulineria cretacea (Carsey), Bandy, 1951, p. 504, pl. 74, fig. 1.

Test free, trochospiral, nearly biconvex, umbilical side more convex, axial periphery subacute. Chambers 8 to 12 in final whorl, increasing gradually in size, ultimate chamber inflated. Sutures distinct, gently curved, flush on spiral side, radial, flush, thickened on umbilical side. Wall calcareous, granular, monolamellar, finely perforate, surface smooth. Aperture on elongate slit extending from periphery to umbilicus with umbilical flap.

Maximum diameter of figured hypotypes, 0.22 to 0.35 mm.; thickness, 0.14 to 0.24 mm.

Discussion.—This species, originally described from the Upper Cretaceous of Texas, is distinguished by its numerous chambers, subacute periphery, and umbilical flap. It was previously included in the genus *Valvulineria* because of the umbilical flap, but the wall structure of the present specimens, as well as Texas topotype material, is monolamellar and granular in structure. Following the classification presented in the *Treatise on Invertebrate Paleontology*, Part C, these Cretaceous specimens cannot be included in the Discorbacea, which is composed of forms with radially constructed walls. They correspond most closely to *Gyroidina* of the family Alabaminidae, although the lamellar character of this genus is not definitely known. Until this group is restudied, the present species is tentatively placed in *Gyroidina*. *G. cretacea* is most abundant at Carlsbad. At La Jolla, it first appears in the middle samples and becomes more abundant toward the top. It also occurs scattered throughout the Point Loma and Punta Descanso sections. In the American Gulf Coast, this species is particularly characteristic of the Navarro Group but also is found in Taylor age strata.

Types and occurrence.—Figured hypotype (Fig. 7, UCLA 44356) from sample C-4, Rosario Formation at Carlsbad. Figured hypotype (Fig. 8, UCLA 44357) from sample S-26, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (C15, J141, L97, D76).

GYROIDINA NONIONOIDES (Bandy)
Plate 21, figure 6

Valvulineria sp. cf. *V. umbilicatula* d'Orbigny, Cushman, 1946, p. 139, pl. 57, fig. 9.
Valvulineria nonionoides Bandy, 1951, p. 504, pl. 74, fig. 5.

Test free, trochospiral, nearly biconvex, spiral side gently convex, with central concavity, umbilical side more strongly convex, with distinct umbilical boss, axial periphery broadly rounded. Chambers 5 to 7 in final whorl, increasing rather rapidly in size, inflated. Sutures distinct, radial, depressed. Wall calcareous, finely perforate, granular in structure, monolamellar, surface smooth. Aperture an interiomarginal slit, extending from periphery to umbilicus under umbilical flap.

Maximum diameter of figured hypotype, 0.34 mm.; thickness, 0.19 mm.

Discussion.—Originally described by Bandy (1951) from Carlsbad, this species is easily distinguished by its rounded periphery, nearly biconvex test, and distinct umbilical boss. The species originally was placed in

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EXPLANATION OF PLATE 20

FIGURE

1. *Fursenkoina nederi* Sliter, n. sp.; 1a-c, opposite sides and edge views, ×66 (p. 112).
2. *Loxostomum eleyi* (Cushman); 2a,b, side and apertural views, ×129 (p. 112).
3. *Chilostomella trinitatensis* Cushman & Todd; 3a,b, apertural and edge views, ×33 (p. 112).
4. *Allomorphina cretacea* Reuss; 4a-c, side, edge and apertural views, ×52 (p. 113).
5-6. *Allomorphina subtriangularis* (Kline); 5a,b, 6a,b, apertural and edge views, ×52 (p. 113).
7. *Quadrimorphina allomorphinoides* (Reuss); 7a-c, opposite sides and edge view, ×89 (p. 114).
8. *Allomorphina halli* Jennings; 8a-c, side, edge, and apertural views, ×97 (p. 113).
9. *Quadrimorphina camerata* (Brotzen); 9a-c, opposite sides and edge view, ×129 (p. 114).
10. *Quadrimorphina spirata* Sliter, n. sp.; 10a-d, opposite sides, edge, and oblique views, ×66 (p. 114).
11. *Nonionella austinana* Cushman; 11a-c, opposite sides and edge view, ×187 (p. 115).

Valvulineria, but examination shows the wall structure to be granular and thus distinct from that of that genus. The species is here tentatively assigned to *Gyroidina*, which is characterized by forms with umbilical flaps but undetermined wall structure. Thin sections have shown the umbilical boss to be composed of thickened, overlapping umbilical flaps. *G. nonionoides* occurs characteristically in the Carlsbad section with a rare occurrence at La Jolla. The recorded stratigraphic range of this species is from upper Campanian to Maastrichtian.

Types and occurrence.—Figured hypotype (UCLA 44358) from sample C-2, Rosario Formation at Carlsbad. Unfigured hypotypes from Rosario Formation at La Jolla (C87, J187).

Genus SVRATKINA Pokorný, 1956

SVRATKINA LAJOLLAENSIS Sliter, n. sp.

Plate 21, figure 10

Test free, small trochospiral, biconvex, spiral side covered by tubercules obscuring chambers, umbilical side involute, only last whorl visible, with small umbilicus, axial periphery rounded. Chambers 6 in final whorl, increasing rapidly in size, becoming somewhat inflated. Sutures obscured on spiral side, initially flush, limbate, later depressed on umbilical side. Wall calcareous, perforate, granular in structure, surface tuberculate, final chamber becoming smooth. Aperture a narrow slit located midway between periphery and umbilicus in sulcus of final chamber.

Maximum diameter of holotype, 0.26 mm.; thickness, 0.17 mm.

Discussion.—This species is easily distinguished by its apertural and surface characteristics. These forms most closely resemble *Svratkina* sp. aff. *S. australiensis* Chapman, Parr & Collins described by Pokorný (1956) from the Eocene of Czechoslovakia but differ in being more evenly biconvex, thicker, more strongly tuberculate, and having an even equatorial periphery. *S. lajollaensis* is very rare in the present samples, occurring in the upper La Jolla and Point Loma sections (late Campanian).

Types and occurrence.—Holotype (UCLA 44359) from sample S-22, Rosario Formation at La Jolla. Paratype (UCLA 44360) from sample L-1, Rosario Formation at Point Loma (J171, L175).

Family OSANGULARIIDAE Loeblich & Tappan, 1964

Genus OSANGULARIA Brotzen, 1940

OSANGULARIA CORDIERIANA (d'Orbigny)

Plate 21, figure 9

Rotalina cordieriana d'Orbigny, 1840, p. 33, pl. 3, fig. 9-11.

Osangularia cordieriana (d'Orbigny), Martin, 1964, p. 102, pl. 15, fig. 2.

Osangularia sp. cf. *O. cordieriana* (d'Orbigny), McGugan, 1964, p. 946, pl. 152, fig. 2.——Graham & Church, 1963, p. 59, pl. 7, fig. 4.

Test free, trochospiral, biconvex, biumbonate, periphery carinate. Chambers commonly 8 in final whorl, increasing gradually in size. Sutures distinct, curved on spiral side, radial to gently curved on umbilical side. Wall calcareous, granular in structure, finely perforate, surface smooth. Aperture a V-shaped opening at base of final chamber or may be 2 isolated slits, one interiomarginal, the other areal.

Maximum diameter of figured hypotype, 0.37 mm.; thickness, 0.10 mm.

Discussion.—*Osangularia cordieriana* is recognized by its biumbonate test, carinate periphery, and characteristic aperture. Specimens occur commonly at La Jolla, Point

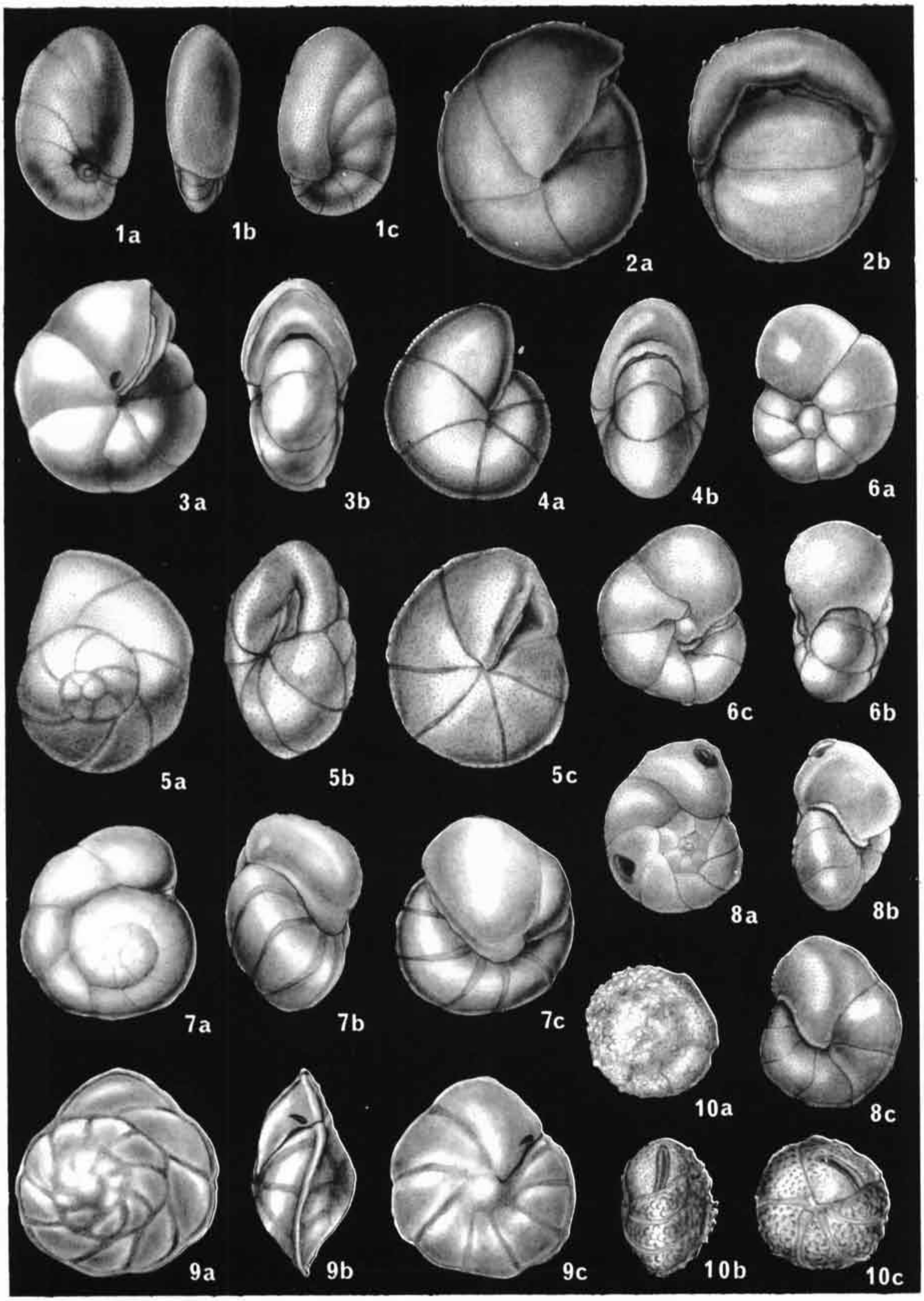
EXPLANATION OF PLATE 21

FIGURE

1. *Nonionella cretacea* Cushman; 1a-c, opposite sides and edge views, ×66 (p. 115).
2. *Pullenia cretacea* Cushman; 2a,b, side and edge views, ×129 (p. 115).
3. *Pullenia jarvisi* Cushman; 3a,b, side and edge views, ×33 (p. 115).
4. *Pullenia* sp. cf. *P. minuta* Cushman; 4a,b, side and edge views, ×52 (p. 116).
5. *Alabamina dorsoplana* (Brotzen); 5a-c, spiral, edge, and umbilical views, ×187 (p. 116).
6. *Gyroidina nonionoides* (Bandy); 6a-c, spiral, edge, and umbilical views, ×97 (p. 117).

7-8. *Gyroidina cretacea* (Carsey); 7a-c, spiral, edge, and umbilical views, ×97; 8a-c, same, ×129 (p. 117).

9. *Osangularia cordieriana* (d'Orbigny); 9a-c, spiral, edge, and umbilical views, ×97 (p. 118).
10. *Svratkina lajollaensis* Sliter, n. sp.; 10a-c, spiral, edge, and umbilical views, ×97 (p. 118).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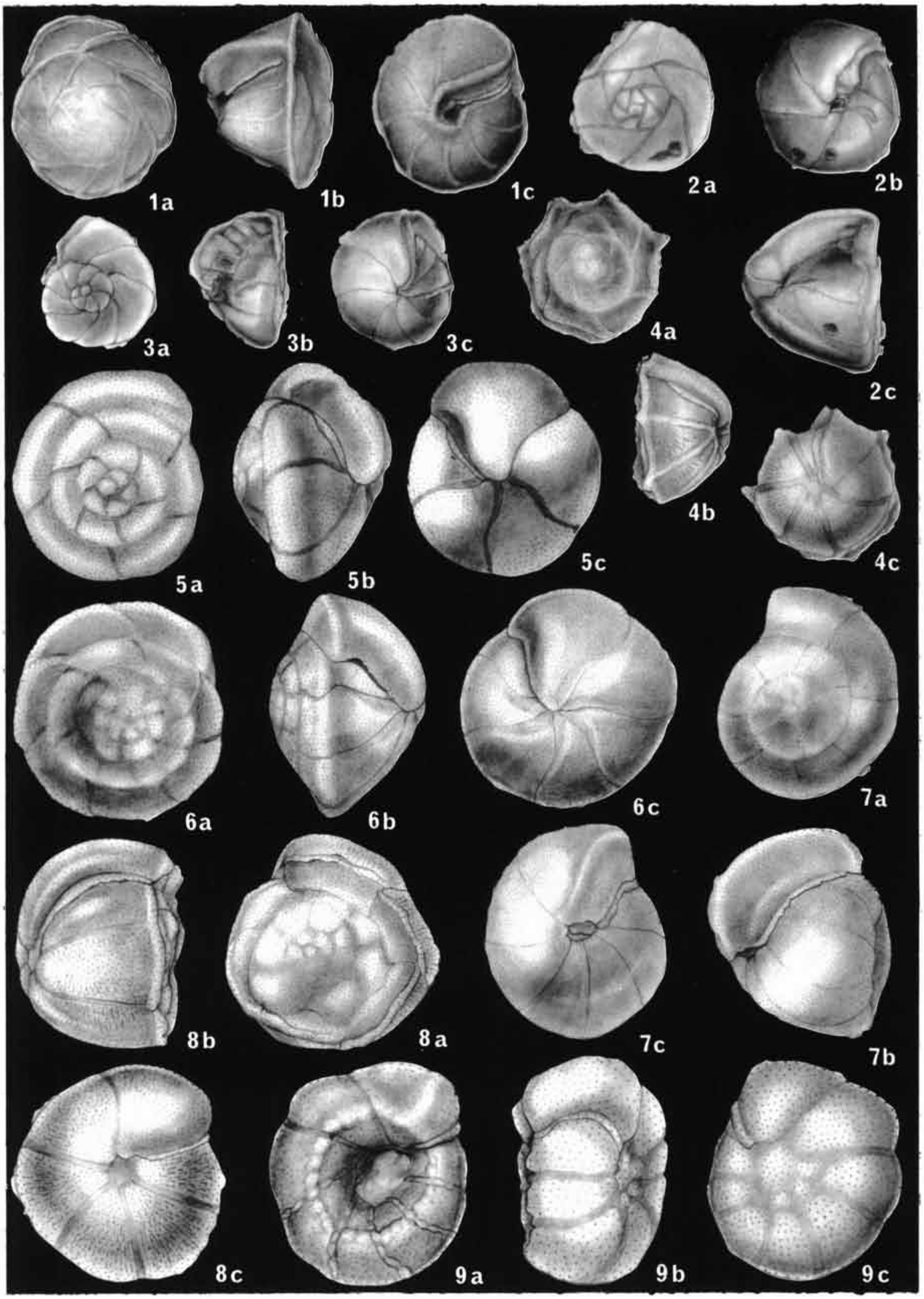
Sliter – Upper Cretaceous Foraminifera, Southern California and Northwestern Mexico.



Loma, and Punta Descanso. Faunal sequences of this species show either gradational or rapid fluctuations in size. In the La Jolla section, early forms are 0.17 mm. in diameter and gradually increase to the typical size by the middle of the section. In the upper part, a reversal of the trend is noted, specimens again becoming reduced in size. Point Loma and Punta Descanso sections are characterized by sudden fluctuations in size between samples. The West Coast range of this species is Santonian to Maastrichtian.

Types and occurrence.—Figured hypotype (UCLA 44361) from sample E-6, Rosario Formation at Punta Descanso. Unfigured hypotypes from Rosario Formation at La Jolla and Point Loma (J8, L96, D17).

Genus GLOBOROTALITES Brotzen, 1942

GLOBOROTALITES MICHELINIANUS (d'Orbigny)

Plate 22, figure 1

Rotalina micheliniana D'ORBIGNY, 1840, p. 31, pl. 3, fig. 1-3.
Globorotalia micheliniana (d'Orbigny), CUSHMAN, 1946, p. 152, pl. 63, fig. 2-3.
Gyroidina micheliniana (d'Orbigny), SCHIJFSMA, 1946, p. 87, pl. 5, fig. 2.
Globorotalites michelinianus (d'Orbigny), MARTIN, 1964, p. 99, pl. 14, fig. 4.

Test free, trochospiral, planoconvex, spiral side flat, umbilical side strongly convex, with prominent pseudoumbilicus, periphery acute, carinate. Chambers 7 or 8 in final whorl, increasing gradually in size. Sutures oblique, limbate, flush on spiral side, gently curved, limbate and becoming slightly depressed on umbilical side. Wall calcareous, granular in structure, finely perforate, surface smooth. Aperture an interiomarginal slit at base of final chamber.

Maximum diameter of figured hypotype, 0.44 mm.; thickness, 0.29 mm.

Discussion.—This species is distinguished by the oblique spiral sutures, acutely carinate periphery, and prominent pseudoumbilicus. It occurs rarely in all locations, whereas the most robust specimens are encountered at Carlsbad. *Globorotalites michelinianus*, originally described from the Campanian of France, ranges from Cenomanian to Campanian.

Types and occurrence.—Figured hypotype (UCLA 44362) from sample C-3, Rosario Formation at Carlsbad. Unfigured hypotypes from the Rosario Formation at La Jolla, Point Loma and Punta Descanso (C79, J182, L93, D147).

GLOBOROTALITES SPINEUS (Cushman)

Plate 22, figure 4

Truncatulina spinea CUSHMAN, 1926a, p. 22, pl. 2, fig. 10.
Eponides? spinea (Cushman), CUSHMAN, 1946, p. 142, pl. 57, fig. 16.——GRAHAM & CHURCH, 1963, p. 57, pl. 6, fig. 19.
Eponides spinea (Cushman), MARTIN, 1964, p. 98, pl. 13, fig. 8.
Globorotalites spinea (Cushman), McGUGAN, 1964, p. 949, pl. 152, fig. 13.

Test free, trochospiral, plano-convex, spiral side gently convex to concave, umbilical side gently to strongly convex, axial periphery carinate, with short spines at each suture. Chambers 7 or 8 in final whorl, increasing gradually in size. Sutures gently curved, flush, limbate on spiral side, radial, limbate, flush to slightly depressed on umbilical side. Wall calcareous, finely perforate, granular in structure, surface smoothly finished. Aperture an interiomarginal slit at base of final chamber, extending from pseudoumbilicus nearly to periphery, with small lip.

Maximum diameter of figured hypotype, 0.37 mm.; thickness, 0.24 mm. Other hypotypes range from 0.18 mm. in thickness.

Discussion.—This species is easily distinguished by its trochoid test and peripheral spines. The present specimens are identical to the original description, size, and

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EXPLANATION OF PLATE 22

FIGURE

1. *Globorotalites michelinianus* (D'ORBIGNY); 1a-c, spiral, edge, and umbilical views, ×66 (p. 119).
2-3. *Globorotalites tappanae* SLITER, n. sp.; 2a-c, spiral, edge, and umbilical views of holotype, ×97; 3a-c, same views of paratype, ×97 (p. 120).
4. *Globborotalites spineus* (CUSHMAN); 4a-c, spiral, edge, and umbilical views, ×66 (p. 119).
5. *Gyroidinoides bandyi* (TRUJILLO); 5a-c, spiral, edge, and umbilical views, ×133 (p. 120).
6. *Gyroidinoides goudkoffi* (TRUJILLO); 6a-c, spiral, edge, and umbilical views, ×66 (p. 120).
7. *Gyroidinoides nitidus* (REUSS); 7a-c, spiral, edge, and umbilical views, ×97 (p. 121).
8. *Gyroidinoides quadratus* (CUSHMAN & CHURCH); 8a-c, spiral, edge, and umbilical views, ×129 (p. 121).
9. *Gyroidinoides quadratus martini* SLITER, n. ssp.; 9a-c, spiral, edge, and umbilical views, ×187 (p. 121).

illustrations. First representatives of *Globoratalites* occur in the middle portion of the La Jolla section, and the species gradually increases in size and test convexity with time. The species also occurs throughout the Point Loma section and less frequently at Punta Descanso and Carlsbad. Originally described from Mexico, it is reported from upper Santonian to Maastrichtian.

Types and occurrence.—Figured hypotype (UCLA 44363) from sample S-27, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Carlsbad, Point Loma and Punta Descanso (C146, J145, L87, D81).

GLOBOROTALITES TAPPANAE Sliter, n. sp.
Plate 22, figure 2-3

Test free, trochospiral, plano-convex, spiral side flat, partially evolute, umbilical side strongly convex, involute, only last whorl visible around small pseudoumbilicus, axial periphery subacute. Chambers 5 or 6 in final whorl, increasing rapidly in size, apertural face high with angular shoulder. Sutures distinct, flush, somewhat limbate, tangential to gently curved on spiral side, flush, oblique, gently curved on umbilical side. Wall calcareous, finely perforate, granular in structure, surface smooth. Aperture an interiomarginal slit at base of apertural face on last chamber, extending from near periphery almost to umbilicus, with small bordering lip.

Maximum diameter of holotype, 0.26 mm.; thickness, 0.24 mm. Diameter of figured paratype, 0.22 mm.; thickness, 0.14 mm.

Discussion.—This species is easily recognized by its plano-convex test, subacute periphery, and commonly tangential sutures. These characteristics also serve to distinguish clearly this form from the larger, carinate *Globorotalites michelinianus.* Two morphologic forms present seem to represent different stages in the life cycle. The most abundant form is strongly umbilico-convex, with limbate, tangential spiral sutures. The other is represented by less strongly convex forms with gently curved sutures on the spiral side. Both have approximately the same stratigraphic distribution. This species first appears in the middle part of the La Jolla section but does not become abundant until near the top. There are rare, scattered occurrences throughout the Point Loma and Punta Descanso sections, but the species is lacking at Carlsbad. Stratigraphic range Campanian to Maastrichtian.

Types and occurrence.—Holotype (Fig. 2, UCLA 44364) from sample S-36; figured paratype (Fig. 3, UCLA 44365) from sample S-12; both from Rosario Formation at La Jolla. Unfigured paratypes from Rosario Formation at Point Loma and Punta Descanso (J131, L114, D77).

Genus GYROIDINOIDES Brotzen, 1942

GYROIDINOIDES BANDYI (Trujillo)
Plate 22, figure 5

Eponides bandyi TRUJILLO, 1960, p. 332, pl. 48, fig. 3.——MARTIN, 1964, p. 97, pl. 13, fig. 7.

Test free, trochospiral, nearly biconvex with umbilical side more strongly developed, equatorial periphery somewhat lobate, axial periphery subrounded. Chambers 5 or 6 in final whorl, more commonly 5, increasing gradually in size, becoming slightly inflated. Sutures distinct, spiral sutures curved, becoming slightly depressed at final chamber, umbilical sutures sigmoidal, limbate, more so toward the umbilical region. Aperture a low interiomarginal slit extending from the umbilical area almost to periphery.

Maximum diameter of figured hypotype, 0.27 mm.; thickness, 0.20 mm. Additional hypotypes range in diameter from 0.12 to 0.29 mm.

Discussion.—The present specimens are smaller than those of the original illustrations but are otherwise identical. This species differs from *Gyroidinoides goudkoffi* (TRUJILLO) in being smaller and more nearly biconvex and in having a more rounded periphery and slightly inflated chambers. The California stratigraphic range is from Coniacian to Campanian.

Types and occurrence.—Figured hypotype (UCLA 44367) from sample L-12, Rosario Formation at Point Loma. Unfigured hypotypes from Rosario Formation at La Jolla and Punta Descanso (J148, L105, D144).

GYROIDINOIDES GOUDKOFFI (Trujillo)
Plate 22, figure 6

Eponides goudkoffi TRUJILLO, 1960, p. 333, pl. 48, fig. 6.
Gyroidina sp. GRAHAM & CHURCH, 1963, p. 59, pl. 6, fig. 23.
Gyroidina goudkoffi (Trujillo), MARTIN, 1964, p. 96, pl. 13, fig. 3.
Eponides sp. cf. *beisseli* Schijfsma, MCGUGAN, 1964, p. 944, pl. 151, fig. 4.
Eponides sp. cf. *simplex* (White), MCGUGAN, 1964, p. 945, pl. 151, fig. 7.

Test free, trochospiral, spiral side gently convex, umbilical side strongly convex, axial periphery subacute. Chambers 5 to 7 in final whorl, increasing gradually in size. Sutures distinct, curved, limbate, flush on spiral side, sigmoidal, limbate, often somewhat depressed in later chambers on umbilical side. Wall calcareous, granular, finely perforate, surface smooth. Aperture a low interiomarginal arch extending from the umbilical area to just short of the periphery.

Maximum diameter of figured hypotype, 0.60 mm.; thickness, 0.42 mm.

Discussion.—Originally described from the Santonian of northern California, this species is distinguished from *Gyroidinoides trujilloi* by the less numerous chambers, larger size, and more strongly limbate sutures. The present specimens show a gradational morphologic change in test thickness, size, and strength of the limbate sutures. Sutures of the smaller specimens commonly are more strongly limbate than those of larger individuals. The first forms in the basal La Jolla and Punta Descanso sections are nearly biconvex, with an acute axial periphery. These grade rapidly into more typical representatives by an increase in the umbilical convexity. Intergradational specimens are identical to the types of Trujillo. This species has been recorded from Coniacian to Campanian of California. The forms referred to *Eponides* sp. cf. *E. beisseli* Schijfsma and *E.* sp. cf. *E. simplex* (White) by McGugan (1964) from the Upper Cretaceous of Vancouver Island, British Columbia appear to be identical. Within the present samples, *G. goudkoffi* occurs in all locations except Carlsbad.

Types and occurrences.—Figured hypotype (UCLA 44368) from sample S-23, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (J129, L36, D2).

GYROIDINOIDES NITIDUS (Reuss)

Plate 22, figure 7

Rotalina nitida Reuss, 1845, p. 35, pl. 8, fig. 52, pl. 12, fig. 8, 20.
Gyroidina nitida (Reuss), Brotzen, 1936, p. 157, fig. 58, pl. 11, fig. 3.——Schijfsma, 1946, p. 85, pl. 5, fig. 1.
Gyroidinoides nitida (Reuss), Loeblich & Tappan, 1964, p. C753, fig. 615,6.

Test free, trochospiral, subglobular, spiral side gently convex, umbilical side strongly convex, axial periphery rounded, umbilicus open. Chambers 7 or 8 in final whorl, increasing gradually in size, slightly inflated. Sutures distinct, slightly curved and depressed on spiral side, nearly radial, slightly depressed on umbilical side. Wall calcareous, granular in structure, finely perforate, surface smooth. Aperture a low interiomarginal slit at base of flattened apertural face, extending from umbilicus nearly to periphery.

Maximum diameter of figured hypotype, 0.42 mm.; thickness, 0.35 mm. Additional hypotypes range from 0.18 to 0.45 mm. in diameter.

Discussion.—This widespread foraminifer is easily distinguished from associated species by its subglobular test, rounded periphery, and open umbilicus. *Gyroidinoides nitidus* occurs at all 4 localities studied.

Types and occurrence.—Figured hypotype (UCLA 44369) from sample S-26, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Carlsbad, Point Loma and Punta Descanso (C76, J147, L88, D113).

GYROIDINOIDES QUADRATUS (Cushman & Church)

Plate 22, figure 8

Gyroidina quadrata Cushman & Church, 1929, p. 516, pl. 41, fig. 7-9.——Graham & Church, 1963, p. 58, pl. 7, fig. 2.——Martin, 1964, p. 97, pl. 13, fig. 5.

Test free, trochospiral, spiral side concave, umbilical side strongly convex, umbilicate, axial periphery rounded with acute shoulder on spiral side. Chambers 6 or 7 in final whorl, increasing gradually in size, in some slightly inflated on umbilical side. Sutures distinct, radial, may become depressed in later chambers. Wall calcareous, granular in structure, finely perforate, surface smooth. Aperture a low interiomarginal slit at base of final chamber, with slight lip, extending from umbilicus nearly to periphery.

Maximum diameter of figured hypotype, 0.31 mm.; thickness, 0.22 mm.

Discussion.—This species, originally described from the Upper Cretaceous of central California, is easily distinguished by its concave spiral side and acute peripheral shoulder. *Gyroidinoides quadratus* first appears in the middle samples at La Jolla and continues throughout the section. The species also is present at Point Loma and Punta Descanso. To date, this species is limited to the West Coast, but *G. girardanus* (Reuss), reported by Cushman (1946) from the Gulf Coast, appears to be a closely related form. The recorded stratigraphic range is from upper Santonian to Maastrichtian.

Types and occurrence.—Figured hypotype (UCLA 44370) from sample S-36, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (J146, L37, D35).

GYROIDINOIDES QUADRATUS MARTINI Sliter, n. subsp.

Plate 22, figure 9

Gyroidina globosa (Hagenow), Martin, 1964, p. 95, pl. 12, fig. 12.

Test free, small, trochospiral, spiral side concave, umbilical side strongly convex, umbilicate, periphery broadly rounded, spiral shoulder acute with small spines. Chambers 7 to 9 in final whorl, increasing gradually in size. Sutures indistinct on spiral side, distinct, radial on umbilical side. Wall calcareous, granular in structure, finely perforate, surface granular on spiral side, smoothly finished on umbilical side. Aperture a low interiomarginal arch at base of final chamber.

Maximum diameter of holotype, 0.22 mm.; thickness, 0.14 mm.

Discussion.—This form differs from typical *Gyroidinoides quadratus* in being smaller, less umbilico-convex, and in having a greater spiral convexity, small peripheral shoulder spines, and a granular spiral surface. The subspecies appears in the lower part of the La Jolla section prior to the advent of *G. quadratus*. The specimens present in 2 samples containing both forms show no apparent intergradation of test size or spiral surface modification. The 2 types nevertheless are very similar in chamber shape and number, overall test shape, pore size, and type of aperture. For these reasons, the smaller forms are given subspecific rather than specific rank. The specimen illustrated by Martin (1964) as *Gyroidina globosa* (Hagenow) is regarded as synonymous to the present subspecies because of the general test morphology and stratigraphic occurrence in relation to *G. quadratus*. Martin, however, did not mention the presence of a granular spiral surface or peripheral spines, although these may be obscured in preservation. Stratigraphic range middle to upper Campanian.

Types and occurrence.—Holotype (UCLA 44371) and paratype (UCLA 44372) from sample S-13, Rosario Formation at La Jolla (J128).

GYROIDINOIDES TRUJILLOI Sliter, n. sp.
Plate 23, figure 1

Test free, trochospiral, spiral side gently convex, umbilical side strongly convex, centrally umbilicate, axial periphery subacute. Chambers numerous, 10 or 11 in final whorl, increasing gradually in size. Sutures gently curved, flush on spiral side, sinuate and somewhat limbate on umbilical side commonly producing an umbilical thickening. Wall calcareous, granular in structure, finely perforate, surface granular. Aperture a low interiomarginal slit extending from umbilicus to periphery.

Maximum diameter of holotype, 0.29 mm.; thickness, 0.20 mm.

Discussion.—This species is characterized by numerous chambers, slightly limbate sutures, a small central umbilicus, and granular surface texture. It is somewhat similar to *Gyroidinoides birdi* (TRUJILLO) but differs in having a more strongly biconvex test, a more rounded periphery, and less limbate sutures. *G. trujilloi* is restricted to the basal part of the La Jolla section (middle Campanian) where it last occurs at the faunal break just prior to the first appearance of *G. goudkoffi* (TRUJILLO).

Types and occurrence.—Holotype (UCLA 44373) and paratype (UCLA 44374) from sample S-5, Rosario Formation at La Jolla (J49).

Family ANOMALINIDAE Cushman, 1927

Subfamily ANOMALININAE Cushman, 1927

Genus GAVELINELLA Brotzen, 1942

GAVELINELLA COMPRESSA Sliter, n. sp.
Plate 24, figure 2

Test free, compressed, low trochospiral, spiral side partially evolute, all chambers visible through low central boss, umbilical side partially evolute, with small spiralling umbilical boss, axial periphery initially rounded, later subacute. Chambers 11 to 13 in final whorl, crescentic to lobate in plan, becoming slightly inflated. Sutures distinct, limbate, strongly curved on both sides, initially elevated but later depressed on spiral side, flush on umbilical side. Wall calcareous, finely perforate, granular in structure, surface smooth. Aperture a low interiomarginal arch extending from periphery to umbilicus, with narrow lip that forms triangular flap extending over umbilicus from each chamber, aperture continuous beneath earlier flaps.

Maximum diameter of holotype, 0.60 mm.; thickness, 0.12 mm.

Discussion.—This species superficially resembles the Recent *Planulina ariminensis* D'ORBIGNY (1826) but has a granular wall structure, a subacute periphery on the final chambers, finer pores, initially elevated spiral sutures, and both a spiral and umbilical boss. All of the numerous specimens studied show the same wall structure and subacute peripheral margin. This species is placed in *Gavelinella* on the basis of its wall structure, type of coiling, umbilical boss, and apertural characteristics. *G. compressa* first appears in the lower part of the La Jolla section and extends nearly to the top. The species also is present at Point Loma but is missing at the Punta Descanso and Carlsbad localities. Stratigraphic range middle to upper Campanian.

Types and occurrence.—Holotype (UCLA 44384) from sample S-8; paratype (UCLA 44385) from sample S-9; both from Rosario Formation at La Jolla (J106, L129).

EXPLANATION OF PLATE 23

FIGURE

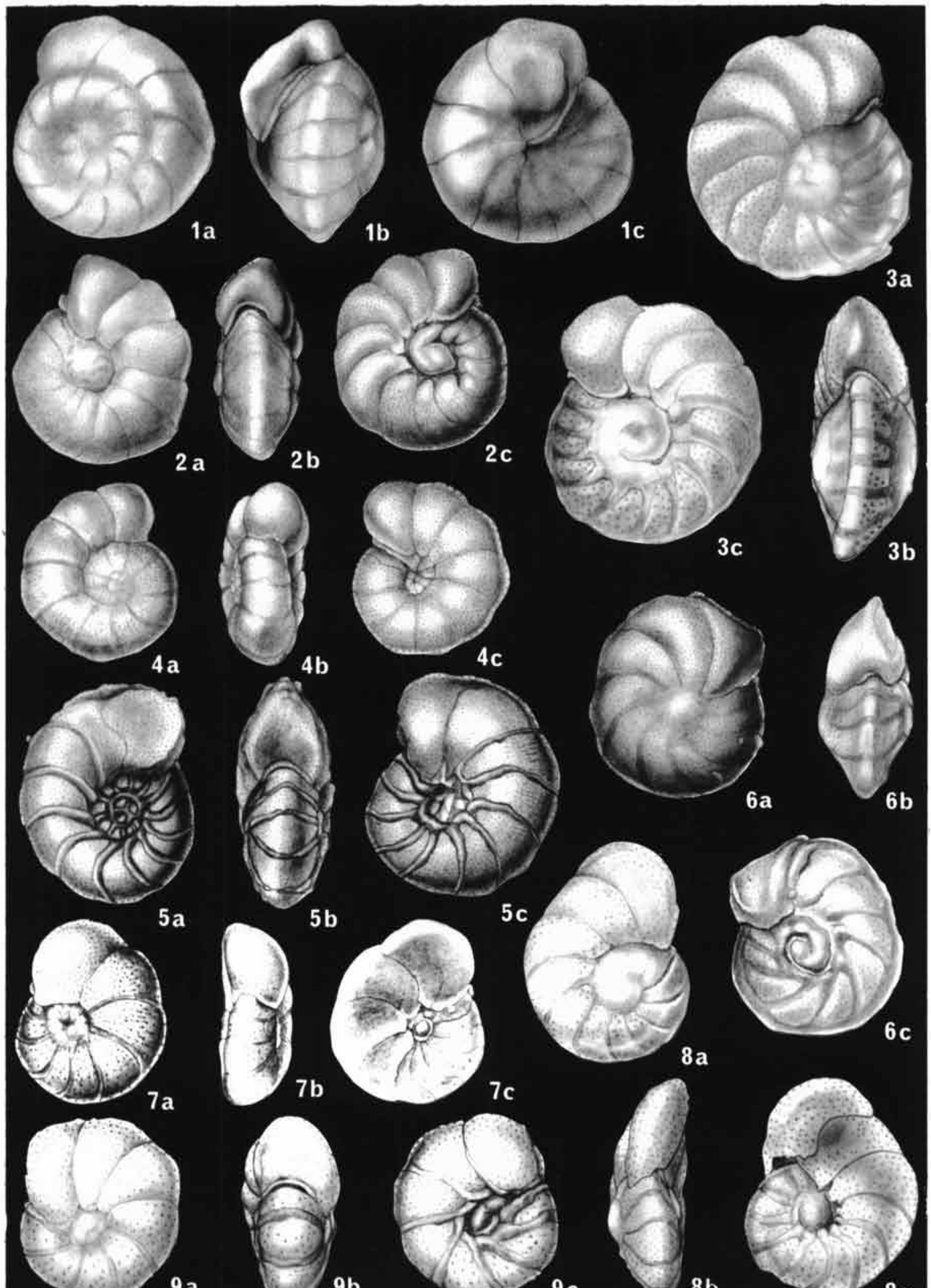
1. *Gyroidinoides trujilloi* SLITER, n. sp.; 1a-c, spiral, edge, and umbilical views, ×129 (p. 122).
2. *Gavelinella henbesti* (PLUMMER); 2a-c, spiral, edge, and umbilical views, ×45 (p. 123).
3. *Gavelinella stephensoni* (CUSHMAN); 3a-c, spiral, edge, and umbilical views, ×97 (p. 125).

4-5. *Gavelinella nacatochensis* (CUSHMAN); 4a-c, spiral, edge, and umbilical views, ×66; 5a-c, same, ×97 (p. 124).

6. *Gavelinella eriksdalensis* (BROTZEN); 6a-c, spiral, edge, and umbilical views, ×66 (p. 123).

7-8. *Gavelinella sandidgei* (BROTZEN); 7a-c, 8a-c, spiral, edge, and umbilical views, ×66 (p. 124).

9. *Gavelinella velascoensis* (CUSHMAN); 9a-c, spiral, edge, and umbilical views, ×66 (p. 125).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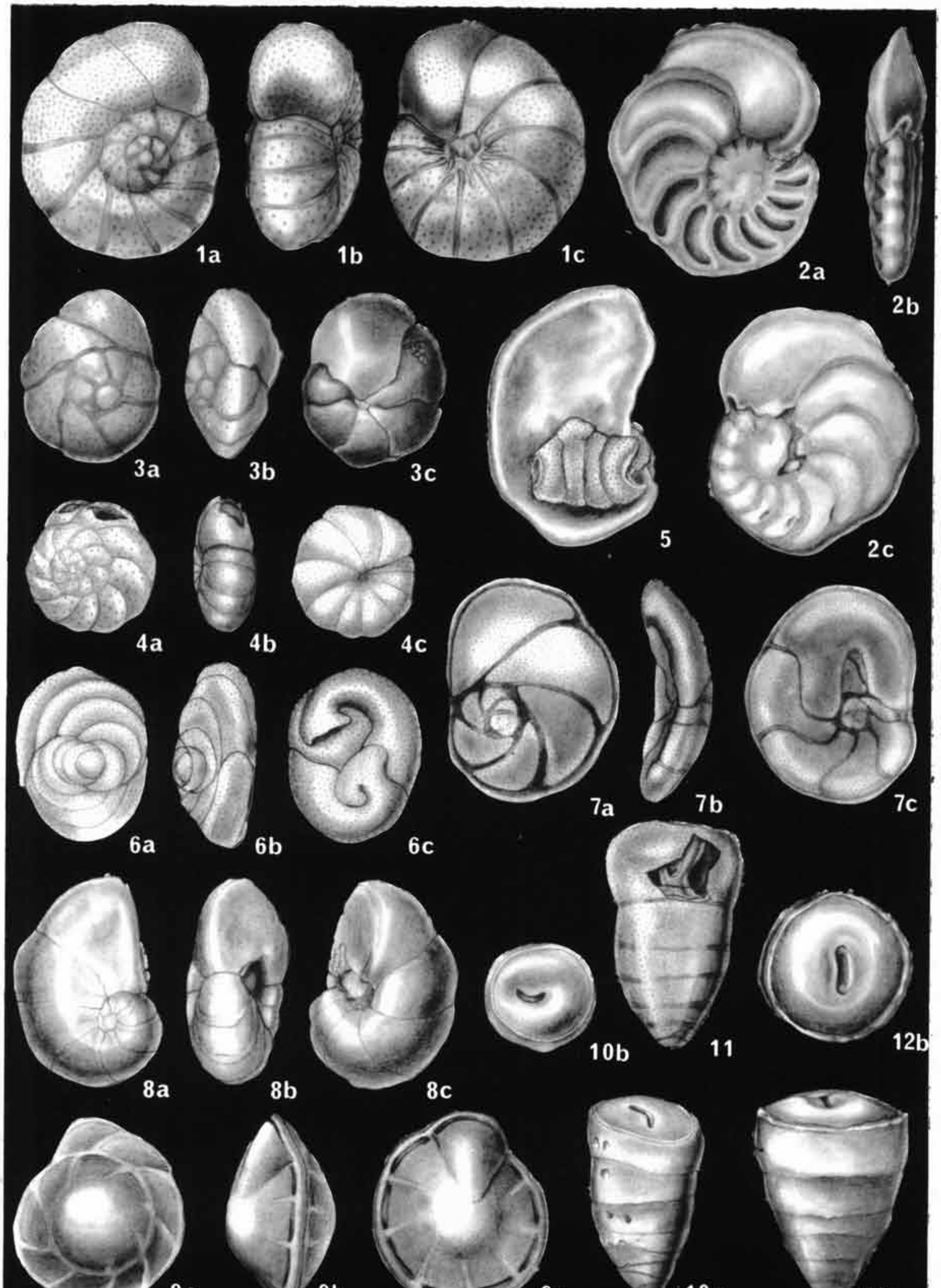
Sliter — Upper Cretaceous Foraminifera, Southern California and Northwestern Mexico.



GAVELINELLA ERIKSDALENSIS (Brotzen)
Plate 23, figure 6

Cibicides (Cibicidoides) eriksdalensis BROTZEN, 1936, p. 193, fig. 69, pl. 14, fig. 5.
Gavelinopsis eriksdalensis (Brotzen), HOFKER, 1957, p. 322, fig. 370-371.
Anomalinoides eriksdalensis (Brotzen), BELFORD, 1960, p. 108, pl. 34, fig. 1-11.

Test free, trochospiral, nearly biconvex, spiral side more strongly convex, with small umbonate boss, umbilical side shows only chambers of last whorl, with spiralling umbilical boss, axial periphery subacute. Chambers 10 or 11 in final whorl, increasing gradually in size. Sutures gently curved, initially limbate, flush, later depressed on spiral side, curved, limbate, flush to somewhat elevated on umbilical side. Wall calcareous, finely perforate, granular in structure, surface smooth to granular. Aperture a low equatorial, interiomarginal slit, at base of last-formed chamber, extending to umbilicus, with slight lip.

Maximum diameter of figured hypotype, 0.49 mm.; thickness, 0.24 mm.

Discussion.—This species, originally described from the Senonian of Sweden, varies both in the convexity of the spiral side as noted by BROTZEN (1936) and also in thickness of the spiral boss and degree of elevation and curvature of the umbilical suture. The European Campanian and Maastrichtian forms referred to *Cibicides voltzianus* (D'ORBIGNY) (1840) differ in being higher-spired and in having a more acute periphery, fewer chambers, and less limbate sutures. BROTZEN (1945) stated that only typical forms of *C. voltzianus* occur in the Campanian. The present specimens appear distinct from the latter species and closer to the concept of *G. eriksdalensis*, thus extending the stratigraphic range of this species into the Campanian as recognized by HOFKER (1957). Another similar form, *C. succedens* BROTZEN (1948) from the Paleocene of Sweden, differs in having a larger spiral boss and in lacking the umbilical boss and sutural characters. *Gavelinella eriksdalensis* is found throughout the La Jolla and Point Loma sections, less frequently at Punta Descanso, and is missing at Carlsbad.

Types and occurrence.—Figured hypotype (UCLA 44375) from sample S-2, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (J15, L120, D78).

GAVELINELLA HENBESTI (Plummer)
Plate 23, figure 2

Anomalina henbesti PLUMMER, 1936, p. 290, pl. 5, fig. 7-10.——CUSHMAN & GOUDKOFF, 1944, p. 63, pl. 10, fig. 11.——CUSHMAN, 1946, p. 155, pl. 64, fig. 2.——BANDY, 1951, p. 506, pl. 74, fig. 6.

EXPLANATION OF PLATE 24

FIGURE

1. *Gavelinella whitei* (MARTIN); 1a-c, spiral, edge, and umbilical views, ×97 (p. 126).
2. *Gavelinella compressa* SLITER, n. sp.; 2a-c, spiral, edge, and umbilical views, ×66 (p. 122).
3. *Heterolepa carlsbadensis* SLITER, n. sp.; 3a-c, spiral, edge, and umbilical views, ×129 (p. 126).
4. *Heterolepa minuta* SLITER, n. sp.; 4a-c, spiral, edge, and umbilical views, ×187 (p. 126).
5. *Karreria* sp.; side view, ×45 (p. 127).
6. *Pseudopatellinella cretacea* TAKAYANAGI; 6a-c, spiral, edge, and umbilical views, ×187 (p. 127).
7. *Pseudopatellinella minuta* SLITER, n. sp.; 7a-c, spiral, edge, and umbilical views, ×187 (p. 127).
8. *Ceratobulimina (Ceratolamarckina) cretacea* CUSHMAN & HARRIS; 8a-c, spiral, edge, and umbilical views, ×97 (p. 127).
9. *Hoeglundina supracretacea* (TEN DAM); 9a-c, spiral, edge, and umbilical views, ×52 (p. 128).

10-12. *Colomia californica* BANDY; 10a,b, side and apertural views, ×97; 11, interior hemicylindrical columella, ×97; 12a,b, side and apertural views, ×66 (p. 128).

Test free, robust, nearly biconvex, partially evolute on both sides, compressed, spiral side with small umbo, umbilical side with spiral umbilical boss, axial periphery subacute. Chambers numerous, 10 to 13 in final whorl, increasing gradually in size, becoming inflated in final stage. Sutures distinct, flush and limbate in early stage, later depressed. Wall calcareous, rather coarsely perforate, surface smooth. Aperture a low interiomarginal, equatorial arch, extending from periphery to umbilicus, with slight lip that forms small triangular flaps at interior margins projecting into umbilicus.

Maximum diameter of figured hypotype, 0.77 mm.; thickness, 0.31 mm. Other hypotypes range to 0.91 mm. in diameter.

Discussion.—This species is distinguished by the subacute periphery, numerous chambers, and large size. The present specimens differ from the original illustrations in being somewhat thicker. The local distribution is limited entirely to Carlsbad, where it occurs rather commonly. This species is here referred to the genus *Gavelinella* on the basis of the umbilical apertural extension and small apertural flaps. Previous West Coast records include the Upper Cretaceous of Stanislaus County (Cushman & Goudkoff, 1944) and Carlsbad (Bandy, 1951). *Anomalina becki* Martin (1964) from the Coniacian of Fresno County, California, is slightly smaller and may represent an ancestral form. The reported stratigraphic range of *G. henbesti* is restricted to the Campanian.

Types and occurrence.—Figured hypotype (UCLA 44376) from sample C-3, Rosario Formation at Carlsbad (C53).

GAVELINELLA NACATOCHENSIS (Cushman)

Plate 23, figure 4-5

Planulina nacatochensis Cushman, 1938b, p. 50, pl. 8, fig. 9.——McGugan, 1964, p. 946, pl. 152, fig. 3.
Planulina mascula Bandy, 1951, p. 506, pl. 74, fig. 8.——Martin, 1964, p. 107, pl. 16, fig. 7.
Planulina sp. cf. *P. mascula* Bandy, Graham & Church, 1963, p. 66, pl. 8, fig. 3.

Test free, low trochospiral, commonly nearly planispiral, spiral side partially evolute with earlier whorls visible, umbilical side nearly involute, umbilicate, axial periphery rounded. Chambers 9 to 11 in final whorl, increasing gradually in size, may become slightly inflated. Sutures gently curved, initially may be limbate, flush to slightly elevated, later depressed. Wall calcareous, distinctly perforate, granular in structure, surface smooth. Aperture a low interiomarginal arch at base of final chamber, extending from periphery to umbilicus, with small lip.

Maximum diameter of figured hypotypes, 0.36 to 0.44 mm.; thickness, 0.14 to 0.20 mm.

Discussion.—*Gavelinella nacatochensis* differs from associated species in being compressed, commonly nearly planispiral, and having a rounded periphery. It lacks the spiral umbonate thickening characteristic of most gavelinellids. Bandy (1951) proposed the species *Planulina mascula* to include the somewhat thicker, more inflated forms at Carlsbad. Based on the current study, however, these appear synonymous. The majority of specimens occurring throughout the La Jolla, Point Loma and Punta Descanso sections are identical to Gulf Coast material but differ from those at Carlsbad in being more compressed and in having more limbate sutures, commonly coalescing in a periumbilical thickening. Occasional specimens within the La Jolla population approach the degree of chamber and suture modification of those at Carlsbad. Differences between these 2 populations seems the result of an environmental variation, most likely a variation in depth, with the Carlsbad locality representing a more shallow-water environment. The occurrence of *G. nacatochensis* reported by Cushman & Goudkoff (1944) from California seems correct, although illustrations fail to provide the needed taxonomic information; hence this reference is not included in the present synonymy. The stratigraphic range is Campanian to Maastrichtian.

Types and occurrence.—Figured hypotype (Fig. 5, UCLA 44377) from sample S-23, Rosario Formation at La Jolla. Figured hypotype (Fig. 4, UCLA 44378) from sample C-3, Rosario Formation at Carlsbad. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (C11, J27, L35, D91).

GAVELINELLA SANDIDGEI (Brotzen)

Plate 23, figure 7-8

Cibicides sandidgei Brotzen, 1936, p. 191, pl. 14, fig. 2-4.
Cibicidina californica Bandy, 1951, p. 505, pl. 74, fig. 7.
Planulina multipunctata Bandy, 1951, p. 506, pl. 74, fig. 9.——Olsson, 1960, p. 55, pl. 12, fig. 22-24.

Test free, low trochospiral, plano-convex, spiral side convex, partially evolute, earlier whorls commonly obscured by umbonate boss, umbilical side flat to gently concave, involute, with umbilical boss, axial periphery subacute. Chambers 9 to 11 in final whorl, increasing gradually in size, becoming slightly inflated. Sutures distinct, curved, generally more strongly curved on umbilical side, initially limbate, flush to gently elevated, later depressed. Wall calcareous, perforate, umbilical perforations commonly obscured by secondary calcitic lamellae, wall structure granular, surface smooth to granular. Aperture a low interiomarginal arch at base of final chamber, extending from periphery to umbilicus, with narrow lip forming umbilical flaps.

Maximum diameter of figured hypotypes, 0.44 to 0.56 mm.; thickness, 0.20 to 0.29 mm. Other convex hypotypes range from 0.24 to 0.48 mm. in diameter, whereas compressed forms range from 0.24 to 0.70 mm.

Discussion.—This species, originally described from the Senonian of Sweden, is separated from *Gavelinella eriksdalensis* by the plano-convex test, reduced spiral, and umbilical thickenings and more strongly curved sutures.

As originally described by BROTZEN (1936), test dimorphism in this species represents different stages in the life cycle. One form is generally plano-convex, with a small spiral umbo and smooth equatorial periphery. The other is more compressed, umbilically convex, with a distinct spiral and umbilical boss, a lobate periphery, is somewhat more coarsely perforate, and may have irregular ultimate chambers. These two forms were described by BANDY (1951) as belonging to differing genera and species, but the present study shows them to have the same general stratigraphic range and similar morphologic characteristics in the initial stages of the test. Based on these data and the remarks by BROTZEN, they are here regarded as conspecific. Certain specimens in the population resemble *Cibicides voltzianus* (D'ORBIGNY) (1840) from the Campanian-Maastrichtian of Europe and the biconvex *C. succedens* BROTZEN (1948), from the Paleocene of Sweden, but differ in having a granular wall structure, a flat umbilical side, less produced spiral boss and coarser pores. *C. burlingtonensis* JENNINGS (1936) from the Upper Cretaceous of New Jersey is also similar but has fewer chambers in the final whorl.

Types and occurrence.—Figured hypotype (Fig. 7, UCLA 44379) from sample C-3; figured hypotype (Fig. 8, UCLA 44380) from sample C-2; both from Rosario Formation at Carlsbad. Unfigured hypotypes from Rosario Formation at La Jolla, Point Loma and Punta Descanso (C12, J34, L133, D66).

GAVELINELLA STEPHENSONI (Cushman)

Plate 23, figure 3

Cibicides stephensoni CUSHMAN, 1938c, p. 70, pl. 12, fig. 5.——CUSHMAN & GOUDKOFF, 1944, p. 63, pl. 10, fig. 15.

Anomalina sp. GRAHAM & CHURCH, 1963, p. 65, pl. 8, fig. 1.

Cibicides voltziana (d'Orbigny), MCGUGAN, 1964, p. 946, pl. 152, fig. 1.

Cibicidoides validus MARTIN, 1964, p. 107, pl. 16, fig. 5.

Test free, trochospiral, biconvex, compressed, nearly involute on both sides, umbilical side commonly more strongly convex with spiral umbilical boss, spiral side flat to convex with smooth umbonate boss, axial periphery subacute. Chambers numerous, distinct, narrow, increasing gradually in size, 13 or 14 in final whorl. Sutures curved, initially limbate, flush to elevated, later depressed. Wall calcareous, distinctly perforate, granular in structure, surface smooth, polished. Aperture an equatorial, interiomarginal slit extending to umbilicus, with slight lip.

Maximum diameter of figured hypotype, 0.46 mm.; thickness, 0.17 mm. Other hypotypes range from 0.29 to 0.60 mm. in diameter.

Discussion.—*Gavelinella stephensoni* differs from *G. eriksdalensis* in being more nearly biconvex and compressed and having limbate, commonly elevated sutures, and a polished surface. The present specimens are very similar to Pecan Gap material but are less robust and generally less flat spirally. The upper Taylor trend toward thicker, spirally concave tests and more inflated chambers is not recognized on the West Coast. Gulf Coast specimens of *G. stephensoni* may represent morphovariants of *G. henbesti* (CUSHMAN), inasmuch as their stratigraphic ranges and general morphologic characteristics are nearly identical. CUSHMAN distinguished *G. stephensoni* from *G. henbesti* by its somewhat thicker test, flattened to slightly concave spiral side, umbilical plug and surrounding groove and more limbate, commonly raised spiral sutures. The present classification follows that of CUSHMAN until the relationship of these two species is better defined. At that time it may be shown that the California specimens represent *G. validus* MARTIN, here placed in synonymy with *G. stephensoni*. Originally described from the Campanian of Alabama, West Coast representatives of this form range from upper Santonian to Maastrichtian. MCGUGAN (1964) referred this species to *Cibicides voltziana* (D'ORBIGNY), but the latter is characterized by its plano-convex test, prominent spiral umbo, and less limbate sutures. *G. stephensoni* occurs in the lower samples at La Jolla and continues throughout the section. Likewise, the species is present at Point Loma and Punta Descanso but missing at Carlsbad.

Types and occurrence.—Figured hypotype (UCLA 44381) from sample S-35, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (J111, L22, D4).

GAVELINELLA VELASCOENSIS (Cushman)

Plate 23, figure 9

Anomalina velascoensis CUSHMAN, p. 21, pl. 3, fig. 3.——CUSHMAN, 1940a, p. 32, pl. 5, fig. 10.

Anomalinoides pinguis (Jennings), GRAHAM & CHURCH, 1963, p. 65, pl. 8, fig. 2.

Test free, nearly biconvex to plano-convex, spiral side convex commonly with rounded spiral boss of clear test material, umbilical side flattened with distinct spiral umbonal boss, axial periphery broadly rounded. Chambers 8 to 10 in final whorl, increasing rather rapidly in size, becoming slightly inflated. Sutures distinct in final whorl, initially limbate, flush, later depressed on spiral side, limbate, elevated, commonly coalescing at umbilical spire and peripherally thickening on umbilical side. Wall calcareous, distinctly punctate in later chambers, may be obscured by wall thickening on earlier chamber on both sides. Aperture a low interiomarginal arch extending from periphery to umbilicus, with narrow lip that joins sutural thickening.

Maximum diameter of figured hypotype, 0.44 mm.; thickness, 0.22 mm. Other hypotypes range to 0.60 mm. in diameter.

Discussion.—This species, originally described from the upper Paleocene of Mexico, is distinguished by its broadly convex spiral side, rounded periphery, raised umbilical sutures, and spiral umbilical boss. The species differs from *Gavelinella eriksdalensis* in being more plano-convex, with a broadly rounded spiral side and more highly developed ornamentation on the umbilical side. The species is here placed in the genus *Gavelinella* on the basis of the umbilical apertural extensions. Specimens from the lower part of the La Jolla section are less highly ornamented and more equally biconvex. These somewhat resemble *Anomalinoides pinguis* (Jennings) (1936). In the upper samples the specimens gradually become more spiro-convex with a thickened umbo, while the umbilical surface is strongly ornamented. *A. pinguis* (Jennings) of Graham & Church (1963) is here regarded as synonymous to the present species. Present specimens range throughout the La Jolla and Point Loma locations, occur rarely at Punta Descanso and are missing at Carlsbad. *G. velascoensis* ranges from upper Campanian to Paleocene.

Types and occurrence.—Figured hypotype (UCLA 44382) from sample S-36, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma and Punta Descanso (J21, L112, D135).

GAVELINELLA WHITEI (Martin)

Plate 24, figure 1

Rotalia beccariiformis var. White, 1928b, p. 287, pl. 39, fig. 4.
Anomalina whitei Martin, 1964, p. 106, pl. 16, fig. 4.

Test free, trochospiral, nearly biconvex, spiral side evolute, all chambers visible, flattened, umbilical side involute, only last whorl visible, slightly more convex, umbilicate, axial periphery broadly rounded. Chambers 9 to 11 in final whorl, becoming slightly inflated. Sutures distinct, curved, initially limbate, later depressed on spiral side, indistinct, radial, flush on umbilical side. Wall calcareous, rather coarsely perforate, granular in structure, surface smooth to granular, umbilical area with small pustules arranged in radial pattern from umbilicus. Aperture a low interiomarginal slit extending from periphery to umbilicus with small lip.

Maximum diameter of figured hypotype, 0.39 mm.; thickness, 0.20 mm.

Discussion.—This species differs from *Gavelinella nacatochensis* in being thicker, with a more broadly rounded periphery, and in having a deeper, more prominent umbilicus with radiate ornamentation. The present specimens are identical with those illustrated by Martin from central California. This species first appears in the upper portion of the La Jolla section and gradually increases in size in younger material. Specimens are also found at Point Loma but are missing at Punta Descanso and Carlsbad. The stratigraphic range is upper Santonian to Maastrichtian.

Types and occurrence.—Figured hypotype (UCLA 44383) from sample S-35, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Point Loma (J179, L104).

Genus HETEROLEPA Franzenau, 1884

HETEROLEPA CARLSBADENSIS Sliter, n. sp.

Plate 24, figure 3

Test free, trochospiral, nearly biconvex, spiral side gently convex, evolute, all chambers visible, umbilical side more strongly convex, involute, with only chambers of last whorl visible around small umbilicus, axial periphery subrounded. Chambers 6 or 7 in final whorl, broadly petaloid on spiral side, subtriangular on umbilical side, increasing rapidly in size, becoming slightly inflated. Sutures distinct, tangential, gently curved, limbate, flush on spiral side, sinuate to gently curved, depressed on umbilical side. Wall calcareous, coarsely perforate on spiral side, finely perforate on umbilical side, granular in structure, surface smooth, polished. Aperture a low interiomarginal slit extending from periphery nearly to umbilicus.

Maximum diameter of holotype, 0.20 mm.; thickness, 0.12 mm.

Discussion.—This species is distinguished by the nearly biconvex test, subrounded periphery, and coarsely perforate spiral side. It is included in the genus *Heterolepa* because of the granular wall structure and apertural characteristics. *Heterolepa*, however, should be restricted to plano-convex forms, whereas forms with biconvex tests, granular walls, and a spiral and umbilical pore differentiation should be generically separated. This latter genus (e.g., *Pninaella, Gemellides, Hollandina*) would include such forms as *H. pegwellensis* Haynes, *H. toulmini* (Brotzen) (1948), *H. minuta* Sliter, n. sp., the present species, and possible *H. lunata* (Brotzen) (1948). *H. carlsbadensis* most closely resembles *H. toulmini*, described from the Swedish Paleocene, but differs in having fewer whorls, higher chambers, a subrounded periphery, and sinuate umbilical sutures. The present occurrences are limited to the Carlsbad locality where it is found rarely throughout the section (middle to late Campanian).

Types and occurrence.—Holotype (UCLA 44386) and paratype (UCLA 44387) from sample C-6, Rosario Formation at Carlsbad (C97).

HETEROLEPA MINUTA Sliter, n. sp.

Plate 24, figure 4

Test free, small, trochospiral, nearly biconvex, lenticular, spiral side generally flattened, evolute, all chambers visible, umbilical side more strongly convex, involute, only chambers of final whorl visible, with small umbilicus, axial periphery subrounded. Chambers numerous, 9 to 11 in final whorl, increasing gradually in size, becoming somewhat inflated. Sutures distinct, gently curving, depressed. Wall calcareous, spiral side commonly more strongly perforate, granular in structure, surface finely pitted to smooth. Aperture an interiomarginal slit, extending from periphery to umbilicus, bordered by thin lip.

Maximum diameter of holotype, 0.12 mm.; thickness, 0.07 mm.

Discussion.—This small form is assigned to *Heterolepa* on the basis of test shape, wall structure, and pore differentation. The extremely thin walls are generally indistinct in thin sections but some specimens show what may be bilamellar septa. This would further substantiate the present taxonomic assignment. The species is distinguished from juvenile forms of other nearly biconvex species by its lenticular shape, numerous chambers, pore differentiation, and light brown, translucent walls. *H. minuta* first appears in the lower samples at La Jolla and is a persistent membeı of the fauna throughout the section. The species also occurs at Point Loma and Punta Descanso but is not present at Carlsbad. Stratigraphic range Campanian to Maastrichtian.

Types and occurrence.—Holotype (UCLA 44388) and paratype (UCLA 44389) from sample T-28, Rosario Formation at La Jolla (J87, L58, D33).

Genus KARRERIA Rzehak, 1891

KARRERIA sp.
Plate 24, figure 5

Test attached, initial portion trochospiral, later uncoiling and rectilinear, periphery subrounded. Chambers of rectilinear portion low, broad, subequal. Sutures distinct, depressed, transverse. Wall calcareous, coarsely perforate, surface smooth. Aperture terminal, rounded, with bordering lip.

Maximum length of figured specimen, 0.49 mm.; breadth, 0.39 mm.

Discussion.—A single irregular specimen with 2 apertures was found at Point Loma attached to a pelecypod fragment. It has the characteristic subrounded periphery of *Karreria* and the coarse perforations of *Stichocibicides*. Based on the peripheral character, the species is placed in *Karreria*.

Types and occurrence.—Figured specimen (UCLA 44390) from sample L-14, Rosario Formation at Point Loma (L127).

Genus PSEUDOPATELLINELLA Takayanagi, 1960

PSEUDOPATELLINELLA CRETACEA Takayanagi
Plate 24, figure 6

Pseudopatellinella cretacea TAKAYANAGI, 1960, p. 122, pl. 8, fig. 4.

Test free, small trochospiral, spiral side flattened, convex, evolute, umbilical side flattened, involute, umbilicate, equatorial outline oval, axial periphery subrounded. Chambers 2 per whorl, initially subglobular, later crescentic, becoming slightly inflated. Sutures distinct, initially flush, later depressed, umbilical sutures arranged in scroll-like fashion, with median septa. Wall calcareous, finely perforate, granular in structure, surface smooth. Aperture a low arch at exterior margin of median septa.

Maximum diameter of figured hypotype, 0.17 mm.; minimum diameter, 0.14 mm.; thickness, 0.09 mm.

Discussion.—*Pseudopatellinella cretacea* is easily distinguished by its small size, oval outline, chamber arrangement, and umbilical characteristics. The present specimens are identical to the original illustrations with the exception of apertural details. These illustrations show a linear, median, slit aperture, probably representing the umbilical depression, into which the arched aperture opens. TAKAYANAGI (1960) failed to mention the wall structure; but as the present specimens are granular, they are here included in the Anomalinidae. This species, originally described from the Coniacian of Japan, occurs rarely throughout the Carlsbad section and in a single sample at La Jolla.

Types and occurrence.—Figured hypotype (UCLA 44391) from sample C-7, Rosario Formation at Carlsbad. Unfigured hypotype from Rosario Formation at La Jolla (C103, J121).

PSEUDOPATELLINELLA MINUTA Sliter, n. sp.
Plate 24, figure 7

Test free, small, trochospiral, compressed, spiral side slightly convex, evolute, showing globular proloculus and all remaining chambers of single whorl, umbilical side gently convex, involute, showing only final 4 or 5 chambers, umbilicate, axial periphery subacute. Chambers few, 5 or 6 in adult test, increasing rapidly in size, petaloid. Sutures distinct, strongly arched, becoming gently depressed on spiral side, strongly sinuate, gently depressed on umbilical side. Wall calcareous, finely perforate, granular in structure, surface smoothly finished. Aperture a low interiomarginal, umbilical arch at end of final chamber, opening into elongate umbilical depression.

Maximum length of holotype, 0.20 mm.; breadth, 0.17 mm.; thickness, 0.07 mm.

Discussion.—This species has an apertural arrangement somewhat similar to *Pseudopatellinella cretacea* but differs in being compressed, more circular in plan, and in lacking the alternating spiral chambers and the scroll-like umbilical septa. *P. minuta* is restricted to Carlsbad (middle to late Campanian) and occurs throughout the section in association with *P. cretacea*.

Types and occurrence.—Holotype (UCLA 44392) and paratype (UCLA 44393) from sample C-3, Rosario Formation at Carlsbad (C54).

Superfamily ROBERTINACEA Reuss, 1850

Family CERATOBULIMINIDAE Cushman, 1927

Subfamily CERATOBULIMININAE Cushman, 1927

Genus CERATOBULIMINA Toula, 1915

CERATOBULIMINA (CERATOLAMARCKINA) CRETACEA Cushman & Harris
Plate 24, figure 8

Ceratobulimina cretacea CUSHMAN & HARRIS, 1927, p. 173, p. 29, fig. 1.——PLUMMER, 1936, p. 460, fig. 5.——BANDY, 1951, p.

507, pl. 73, fig. 20.——TRUJILLO, 1960, p. 338, pl. 49, fig. 2. ——MCGUGAN, 1964, p. 947, pl. 152, fig. 5.

Test free, trochospiral, umbilicate, axial periphery broadly rounded. Chambers about 7 in final whorl, increasing rapidly in size, ultimate chamber commonly inflated. Sutures distinct, curved, flush to slightly depressed. Wall calcareous, aragonitic, finely perforate, surface smooth and polished. Aperture an umbilical, arched opening in final chamber, with tooth plate and apertural lip.

Maximum length of figured hypotype, 0.39 mm.; breadth, 0.25 mm.; thickness, 0.19 mm.

Discussion.—The present specimens compare favorably with those from the Kemp Clay (loc. 19 of CUSHMAN, 1946). This species occurs commonly at Carlsbad and rarely at La Jolla and Punta Descanso. This classification follows that of MCGOWRAN (1966) whose recent study of the Ceratobuliminidae has confirmed the desirability of re-evaluating the subgenera proposed by TROELSEN (1954) (i.e., *Ceratolamarckina, Ceratocancris, Ceratobulimina ss.*).

Originally described from the Corsicana Marl of Texas, this species is characteristic of Navarro age strata in the Gulf Coast. West Coast occurrences include the Campanian of Carlsbad (BANDY, 1951), the Coniacian of northern California (TRUJILLO, 1960), and the Senonian of Vancouver Island, British Columbia (MCGUGAN, 1964).

Types and occurrence.—Figured hypotype (UCLA 44394) from sample C-3, Rosario Formation at Carlsbad. Unfigured hypotypes from Rosario Formation at La Jolla and Punta Descanso (C95, J120, D120).

Subfamily EPISTOMININAE Wedekind, 1937

Genus HOEGLUNDINA Brotzen, 1948

HOEGLUNDINA SUPRACRETACEA (ten Dam)

Plate 24, figure 9

Epistomina supracretacea TEN DAM, 1948, p. 163, pl. 1, fig. 8.——GRAHAM & CHURCH, 1963, p. 70, pl. 8, fig. 20.——MCGUGAN, 1964, p. 945, pl. 151, fig. 10.

Hoeglundina supracretacea (ten Dam), BANDY, 1951, p. 507, pl. 74, fig. 3.——TRUJILLO, 1960, p. 338, pl. 49, fig. 3.——TAKAYANAGI, 1960, p. 127, pl. 9, fig. 2.——MARTIN, 1964, p. 104, pl. 15, fig. 7.

Test free, trochospiral, biconvex, axial periphery acute. Chambers 7 to 9 in final whorl, gradually increasing in size. Sutures limbate, flush, gently curved on spiral side, radial to slightly tangential on umbilical side, fusing at central umbo. Wall calcareous, aragonitic, finely perforate, surface smooth, polished, characteristically white. Aperture interiomarginal, earlier apertures open or secondarily closed.

Maximum diameter of figured hypotype, 0.67 mm.; thickness, 0.37 mm.

Discussion.—This widespread species is easily distinguished by its accessory apertures, size, and wall material which imparts the characteristic white color. Specimens occur abundantly in all present locations. The La Jolla and Point Loma faunal sequences show opposite size gradations with time. The first La Jolla specimens average 0.32 mm. in diameter and rapidly increase to the normal dimensions. Point Loma specimens, on the other hand, diminish in size in the upper portion of the section and approach the size of the first La Jolla forms. *Hoeglundina supracretacea* ranges throughout the Senonian and is reported from Europe, Japan, the Gulf Coast, Western Interior, and West Coast of America and from British Columbia, Canada.

Types and occurrence.—Figured hypotype (UCLA 44395) from sample S-30, Rosario Formation at La Jolla. Unfigured hypotypes from Rosario Formation at Carlsbad, Point Loma and Punta Descanso (C14, J93, L86, D18).

Family ROBERTINIDAE Reuss, 1850

Genus COLOMIA Cushman & Bermúdez, 1948

COLOMIA CALIFORNICA Bandy

Plate 24, figure 10-12

Colomia californica BANDY, 1951, p. 512, pl. 75, fig. 11.

Colomia californica BANDY var. *mundula* BANDY, 1951, p. 512, pl. 75, fig. 12.

Test free, conical, may become cylindrical, initial portion triserial, followed by reduced biserial portion, later uniserial portion comprising major portion of test length. Chambers of uniserial stage low, cylindrical, may ultimately become inflated. Sutures flush to slightly depressed, generally transverse. Wall calcareous, aragonitic, finely perforate, surface smoothly finished. Aperture a terminal, crescentic opening, with hemicylindrical columella extending to previous aperture.

Maximum length of figured hypotypes, 0.36 to 0.48 mm.; diameter, 0.20 to 0.34 mm.

Discussion.—The present forms were originally described as new species and a variety of that species by BANDY (1951). The variety was distinguished by its greater test length and diameter and by being conical throughout. Examination of topotype material and hypotypes from the other present locations, however, indicated that the 2 forms are conspecific, probably representing different stages in the life cycle. Their stratigraphic occurrences are nearly identical and the minor apparent differences result from relative abundance. The smaller, narrower, specimens are by far the most common. Both occur in the upper portion of the La Jolla section, the middle of the Punta Descanso section, and throughout the Carlsbad locality. *Sagrina conulus* LIEBUS (1927) (= *Colomia*), described from reworked Eocene strata in Austria, appears to be closely related if not identical to *Colomia californica*. The illustrated specimen, however, contains more uniserial chambers and the author states that the sutures are commonly raised. As these characteristics are lacking in the present specimens, *C. californica* is here retained pending further investigation.

The specimen illustrated as *Colomia* sp. by GRAHAM & CHURCH (1963) differs from the present species in the greater length of the triserial stage. The significance of this feature remains to be determined.

Types and occurrence.—Figured hypotypes (Fig. 11-12, UCLA 44396-44398) from sample S-25, Rosario Formation at La Jolla. Figured hypotype (Fig. 10, UCLA 44397) from sample C-3, Rosario Formation at Carlsbad. **Unfigured hypotypes from Rosario** Formation at Punta Descanso (C26, J185, D114).

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