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**VIII**  
**FORAMINIFERA FROM THE EOCENE**  
**NEAR COALINGA, CALIFORNIA**

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AND  
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It has been known for many years that some of the Eocene rocks on the west side of the San Joaquin Valley near Coalinga, California, contain large numbers of Foraminifera. F. M. Anderson was apparently the first to publish a note on the occurrence. In 1905<sup>1</sup> he listed seven genera, *Nodosaria*, *Lagena*(?), *Sagrina*, *Vaginulina*, *Cyclammia*, *Pulvulina* [*Pulvinlina*], and *Polymorphina*(?), most of these having come from one block of rock in Sec. 9, T. 19 S., R. 15 E., nine miles north of Coalinga. This block passed through the San Francisco fire of 1906, is still in a well preserved condition and registered as No. 607 of the Academy's series of types. The material considered in the present paper came from about two miles south of Anderson's locality and is unquestionably from the same formation.

He called this formation "Kreyenhagen," correlation having been made with the type locality of that formation on Canoas Creek several miles to the southward. This apparently stood uncontested until 1915 when Robert Anderson and R. W.

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<sup>1</sup>"A Stratigraphic study in the Mount Diablo Range of California." Proc. Calif. Acad. Sci., 3rd Ser., Vol. 2, 1905, p. 192-193, pl. 13, figs. 9-29.

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Pack<sup>2</sup> referred certain overlying, diatomaceous shales, probably Miocene in age, to the Kreyenhagen and called it doubtfully "Oligocene". The true Eocene shales here being considered were referred to the Tejon formation, upper Eocene. The present junior author endeavored to clear up the confusion surrounding the name "Kreyenhagen" in 1925<sup>3</sup> when an attempt was made to show that the formation at the type locality was Eocene, not Oligocene, and that its equivalent north of Coalinga was the Eocene formation from which F. M. Anderson took his Foraminifera. Studies since that date have tended to strengthen that contention.

Therefore, the Kreyenhagen Shale, as now understood, is an important lithologic unit, widely distributed on the west side of the San Joaquin Valley and often about 1000 feet thick. In most cases it consists of a fairly uniform, soft, muddy shale. Localized lenses or thin strata are highly fossiliferous and a considerable molluscan fauna has been described<sup>4</sup> from them or from immediately adjacent sandstones. Regarding the Eocene age of the formation there can be no question but there has been some difference of opinion as to the stratigraphic position in the column. It is of course the uppermost definitely recognized Eocene exposed in the region and is obviously not to be compared to the Martinez, lower Eocene. The Mollusca are similar in many ways to the Tejon which has been considered by all recent geologists to be very near the top, if not actually the top, of the Eocene. Yet there are some notable differences in the faunas and these are so pronounced that some have considered the Fresno County deposits about middle Eocene.<sup>5</sup> Here we encounter a maze of formation-names in the literature, with many differences of opinion; in fact a complicated problem is presented.

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<sup>2</sup> U. S. Geol. Surv. Bull. 603, 1915.

<sup>3</sup> Hanna, "The Age and Correlation of the Kreyenhagen Shale in California." Bull. Amer. Assoc. Petrol. Geol., Vol. 9, No. 6, 1925, pp. 990-998.

<sup>4</sup> See Dickerson, "Stratigraphy and Fauna of the Tejon Eocene of California." Univ. of Calif. Publ. Geol., Vol. 9, No. 17, 1916, pp. 363-524, pls. 36-46.

<sup>5</sup> Clark, B. L. "Meganos Group", a newly recognized division of the Eocene of California". Bull. Geol. Soc. Amer. Vol. 29, 1918, pp. 281-296. Also "The stratigraphic and faunal relationships of the Meganos Group, middle Eocene of California." Journ. of Geol. Vol. 29, 1921, pp. 125-165. See especially pp. 143-145. Also, "The Domengine horizon, middle Eocene of California. Univ. Calif. Publ. Geol. Vol. 16, No. 5, pp. 99-118, 1926.



Professor Clark's latest contribution to the subject shows that he considers the mass of muddy shales to be of "Meganos," middle Eocene age. These lie mostly below the Eocene sandstone reef, used as a guide in this section, and it is from them that many of our species of Foraminifera have come. Evidently "Meganos" used in this connection is exactly synonymous with the earlier name "Kreyenhagen." Sands overlying these shales have been named "Domijean" by F. M. Anderson,<sup>6</sup> the name being modified to "Domengine" by some later writers. Clark recognized the distinctness of this formation and likewise classified it as middle Eocene. Former writers have considered it to be upper Eocene, the equivalent of the typical Tejon. He considered the Tejon to be missing in that section.

Unfortunately, Foraminifera have not been found at the type locality of the Tejon. The present collection, however, includes samples from a few feet above the sandy reef to several hundred feet below and into the muddy shales and the organisms in them are so distributed that it appears we are dealing with one formational unit. This fauna is very closely related to that of the upper Eocene of the Gulf Coastal Plain region of the United States and Mexico. The relationship with the Mexican region is perhaps a little closer than with that of the Coastal Plain of the United States. This relationship amounts to identity of species in some cases. There are several species, however, which have apparently not been found heretofore and are described herein as new.

On account of this study having been based on a single section it is hardly safe to form positive conclusions therefrom; nevertheless, the evidence we have indicates that the exposure at this locality is well up in the Eocene and probably the equivalent of at least a part of the Tejon. The earliest name applied to the lower, muddy-shale phase is "Kreyenhagen"; and the earliest name applied to the upper, sandy phase is "Domijean."

One species of Foraminifera, *Orthophragmina clarki* Cushman<sup>7</sup> has been described from what appears to be an extension northward of the shales from which the present collection was

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<sup>6</sup> Proc. Calif. Acad. Sci. 3rd ser., Vol. 2, No. 2, 1905, p. 167.

<sup>7</sup> Cushman, J. A. "The American Species of *Orthophragmina* and *Lepidocyclina*", U. S. Geol. Surv. Prof. ppr. 125-D, 1920, p. 41, pl. 7, figs. 4-5.



derived. It came from the "northeast side of Domengine Creek near the corner of the SW  $\frac{1}{4}$  Sec. 29, T. 18 S., R. 15 E., M. D. M." from strata classified as "Meganos", (middle Eocene) by Dr. Clark. What is probably the same species was figured by Arnold & Anderson,<sup>8</sup> as "*Orbitolites* sp. a" from the southwest flank of Reef Ridge, north of McLure Valley, Sec. 27, T. 23 S., R. 17 E. This locality can hardly be other than an extension of the exposure southward from the type locality of the Kreyenhagen Shale. The species occurs sparingly throughout the 1000 feet of muddy shales at the locality here being considered, (873 C.A.S.).

The present collection came from a section across the Eocene exposure southeast of the old camp of "Oil City" which was run in 1924 by J. A. Taff, E. G. Gaylord, and G. D. Hanna. It is in the NW  $\frac{1}{4}$  Sec. 20, T. 19 S., R. 15 E. A conspicuous feature of the landscape there is a high sandstone reef or ridge, as seen from Oil City, looking southeast. This Eocene reef contains many molluscan fossils and was used as a base for measurement. The collections came from 10 feet above the reef, 100, 200 and 1000 feet below the reef on the exposure facing northwest. The latter depth is near the shale contact between the Eocene "Kreyenhagen" and the Cretaceous "Moreno" below. This contact is very difficult to follow satisfactorily at that point except by means of the Foraminifera; faunal differences are very pronounced.

Above the Eocene reef at the point indicated, the muddy shales gradually become more and more siliceous. No evident unconformity was seen at that point and there appeared to be continuous sedimentation. These siliceous shales become highly organic and are the source-rock of most of the petroleum of the Coalinga district. They contain what has been called "*Pecten peckhami* Gabb" and in the upper part a very considerable number of micro-organisms which have been reported from deposits definitely known to be of Miocene age. They lie below a sandstone reef which is often called "Vaqueros" but may not be extreme basal Miocene. Only four species of Mollusca have been reported from this huge body of shale, throughout its extent and these are hardly suf-

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<sup>8</sup> U. S. Geol. Surv. Bull. 396, 1909, p. 13, pl. 3, fig. 6; Bull. 398, p. 70, pl. 25, fig. 6.



ficient to identify the formation as either Miocene, Oligocene or Eocene; in all of these it has been variously placed in the past. It overlies Eocene without unconformity and upper Eocene is reported missing in the region.<sup>9</sup> Therefore, it might be contended that these shales are Tejon. Being between known Miocene and known Eocene, they can also be called Oligocene. And being, in large part, highly siliceous like some basal Miocene elsewhere, they can be called Miocene. Since they contain a large fauna of Foraminifera in some parts and Radiolaria, Silicoflagellata and Diatomaceæ in many places and through a considerable vertical range, the safest procedure seems to be to consider the age in doubt until some of these groups of organisms are critically studied. Stratigraphy seems to be incapable of furnishing a means of age determination in this case and molluscan paleontology is equally deficient. It is possible, even probable, that the point of separation between Eocene and higher strata is a shale contact and will have to be based on the micro-organisms as does the Eocene-Cretaceous contact below.

1. *Rhabdammina eocenica* Cushman & Hanna, new species

Plate 13, figure 1

Test cylindrical, slightly irregular, open at both ends; wall arenaceous with some sand grains but a large percentage of fine amorphous material, the whole firmly cemented; apertures at the ends of the chambers which are somewhat constricted. Length 3 mm., breadth 0.5 mm.

*Holotype*: No. 2522, *paratype* No. 2523, Mus. Calif. Acad. Sci., from **seven miles north of Coalinga, California**; fairly common, 10 feet above the Eocene sandstone reef.

The specimens vary somewhat in diameter but the ratio of diameter to length is rather constant indicating that the specimens may perhaps be considered reasonably complete. They are usually slightly compressed, probably due to fossilization and later stresses. The amount of fine material is relatively larger than in most recent species.

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<sup>9</sup> See Clark, Univ. Calif. Publ. Geol., Vol. 16, 1926, No. 5, pp. 99-118.



2. *Bathysiphon eocenica* Cushman & Hanna, new species

Plate 13, figures 2, 3

Test elongate, compressed cylindrical; wall made of fine white amorphous material and rather soft; wall thick but the tubular chamber several times as broad as the thickness of the wall; outer surface with traces of a reddish coating. Length of short pieces 1 mm., breadth 0.5 mm.

*Holotype*: No. 2524, *paratypes* Nos. 2525, 2526, Mus. Calif. Acad. Sci., from **seven miles north of Coalinga, California**; specimens from 10 feet above the Eocene sandstone reef; also from 100 feet below.

In some respects this species resembles *Bathysiphon taurinensis* Sacco, especially as figured by Schubert from the lower Oligocene of Austria. Both species are apparently constricted at intervals and a line of weakness develops there causing the specimens in the samples when washed to be broken up into relatively short pieces. It is apparently a larger and thicker walled species than *B. taurinensis*.

3. *Haplophragmoides coalingensis* Cushman & Hanna, n. sp.

Plate 13, figure 4

Test comparatively large, coarsely arenaceous but the surface smoothly finished due to the considerable amount of whitish cement, close coiled, planospiral, involute, very slightly umbilicate, last-formed coil composed of ten to twelve chambers; sutures very indistinct but slightly depressed in the later portion; aperture narrow, curved, at the base of the last-formed chamber. Length 1 mm., breadth 0.8 mm., thickness 0.45 mm.

*Holotype*: No. 2527, Mus. Calif. Acad. Sci., from **seven miles north of Coalinga, California**; fairly common 10 feet above the Eocene sandstone reef; also 100 feet and 200 feet below it.

The relatively large size, very smooth surface due to the



abundance of cement into which the relatively large sand grains are stuck, together with the large number of chambers in the involute test should make this species easily recognized.

#### 4. *Textularia mississippiensis* Cushman

Plate 13, figure 5

*Textularia mississippiensis* CUSHMAN, U. S. Geol. Survey Prof. Paper 129, 1922, pp. 90, 125; Prof. Paper 133, 1923, p. 16.—CUSHMAN & APPLIN, Bull. Amer. Assoc. Petr. Geol., Vol. 10, No. 2, 1926, p. 166, pl. 6, figs. 10, 11.

Test elongate, compressed, broad, thickest in the median line, thence thinning toward the periphery, in end view biconvex, central portion curved, lens shaped; chambers low and broad, especially in the early stages, somewhat higher in the adult; sutural region covered by a coarsely arenaceous layer, meeting along the central portion and periphery, leaving the central portion of each chamber uncovered; periphery thin and irregular not definitely or regularly spinose, chamber-walls finely arenaceous, smoothly finished except as noted.

*Plesiotype*: No. 2528, Mus. Calif. Acad. Sci., from **seven miles north of Coalinga, California**; rare, 10 feet above the Eocene sandstone reef.

This species is characteristic of the upper Eocene and lower Oligocene of the United States and Mexico.

#### 5. *Textularia* cf. *distortio* Cushman & Applin

Plate 13, figure 6

There is a single incomplete specimen which strongly resembles this species described from the upper Eocene of Texas. It may be simply an eroded specimen of *T. mississippiensis* but seems worthy of note for the information of future workers.

*Plesiotype*: No. 2529, Mus. Calif. Acad. Sci., from **seven miles north of Coalinga, California**; rare, 100 feet below the Eocene sandstone reef.



## 6. *Gaudryina jacksonensis coalingensis*

Cushman & Hanna, new subspecies

Plate 13, figure 7

Test slightly curved, triangular in section, early portion triserial, later adult portion biserial, chambers and sutures rather indistinct in most specimens due to the unusually rough texture of the exterior. Length 1.25 mm., breadth 0.80 mm.

*Holotype*: No. 2530, *paratype* No. 2531, Mus. Calif. Acad. Sci., from seven miles north of Coalinga, California; common in the material collected 10 feet above the Eocene sandstone reef, but not found in the lower samples.

This variety differs from typical *Gaudryina jacksonensis* Cushman in the somewhat shorter form and the very rough exterior. *G. jacksonensis* is found in the upper Eocene of the United States and Mexico.

## 7. *Bulimina* sp.?

*Bulimina* sp.?, CUSHMAN, Bull. Amer. Assoc. Petr. Geol., Vol. 9, No. 2, 1925, p. 301, pl. 7, fig. 9.

In the collection are a very few small smooth *Buliminas* which are apparently identical with the specimen figured as cited above. It was from upper Eocene material collected on the Moctezuma River in the State of Vera Cruz, Mexico. Other species of this Mexican locality occur in the California samples and when sufficient material is available it may be found that this is a definite upper Eocene species.

Specimens were found 100 feet and 200 feet below the Eocene Reef.

## 8. *Nodosaria latejugata* Gümbel

Plate 13, figures 15-17

*Nodosaria latejugata* GÜMBEL, Abhandl. Kon. bay. Akad. Wiss. München, Vol. 18, 1868 (1870), p. 619, pl. 1, fig. 32.—HANTKEN, A. magy. Kir. földt. int. Evkön., Vol. 4, 1875 (1876), p. 21, pl. 2, figs. 6a-d.—CUSHMAN, Contrib. Cushman Lab. Foram. Res., Vol. 1, pt. 3, 1925, p. 66, pl. 10, fig. 7.

*Nodosaria budensis* HANTKEN, A. magy. Kir. földt. int. Evkön., Vol. 4, 1875 (1876), p. 23, pl. 2, fig. 10; pl. 16, fig. 4.



Test elongate, subcylindrical, initial end with a single spine; chambers distinct, slightly inflated; sutures distinct, of clear shell material, slightly depressed; surface ornamented with a few very prominent longitudinal costæ, continuous from initial to apertural ends, except occasionally the final chamber smooth; apertural end slightly prolonged; aperture radiate. Length up to 2 mm.; breadth up to 0.60 mm.

*Plesiotypes*: Nos. 2532-2534, Mus. Calif. Acad. Sci., from **seven miles north of Coalinga, California**; there are numerous specimens from 10 feet above and 100 feet below the Eocene sandstone reef.

This species was originally described by Gümbel from the upper Eocene of Bavaria. Hantken figures it from the upper Eocene of Hungary. It is common in the American upper Eocene of the Gulf Coastal Plain region of the United States and Mexico in both microspheric and magalospheric forms. This is one of the species belonging to the general *Nodosaria raphanus* group, various species of which are known from the Cretaceous to the Recent ocean.

#### 9. *Nodosaria aculeata* d'Orbigny (?)

*Nodosaria aculeata* D'ORBIGNY, Foram. Foss. Bass. Tert. Vienné, 1846, p. 35, pl. 1, figs. 26, 27.

There is a single broken fragment consisting of two globular chambers from the middle portion of a test with prominent radiating spines that may be placed under this species. It came from 10 feet above the Eocene Reef.

#### 10. *Nodosaria (Dentalina) adolphina* d'Orbigny

Plate 13, figures 8, 9

*Dentalina adolphina* D'ORBIGNY, Foram. Foss. Bass. Tert. Vienné, 1846, p. 51, pl. 2, figs. 18-20.

*Nodosaria adolphina* SCHWAGER, *Novara-Exped.*, Geol. Theil., 1866, p. 235, pl. 6, figures 72, 73.

Test elongate, slightly curved, the chambers rounded, increasing gradually in size as added, each connected by short



slender necks with the adjacent ones; wall smooth except near the base where there is a ring of sharp, backwardly pointing spines.

*Plesiotypes*: Nos. 2535, 2536, Mus. Calif. Acad. Sci., from **seven miles north of Coalinga, California**; specimens occur at 10 feet above and 200 feet below the Eocene sandstone reef.

Originally described by d'Orbigny from the Miocene of the Vienna Basin this species has been widely recorded. It occurs in the upper Eocene of Mexico.

### 11. *Nodosaria (Dentalina) consobrina* d'Orbigny

Plate 13, figures 12, 13

*Dentalina consobrina* d'ORBIGNY, Foram. Foss. Bass. Tert. Vienné, 1846, p. 46, pl. 2, figs. 1-3.

Test elongate, slightly curved, the chambers elliptical, somewhat constricted at the sutures, increasing in size and length as added, initial end usually with a spine, wall smooth, matte.

*Plesiotypes*: Nos. 2537, 2538, Mus. Calif. Acad. Sci., from **seven miles north of Coalinga, California**; numerous fragments occur in the collection from 10 feet above the Eocene sandstone reef.

This species originally described by d'Orbigny from the Miocene of the Vienna Basin occurs in the Eocene of Mexico. It is a delicate species; on account of the weakness developed at the constricted sutures fossil specimens are usually broken.

### 12. *Nodosaria (Dentalina) communis* (d'Orbigny)

Plate 13, figure 10

*Dentalina communis* d'ORBIGNY, Ann. Sci. Nat., Vol. 7, 1826, p. 254.—  
Mém. Soc. Géol. France, ser. 1, Vol. 4, 1840, p. 13, pl. 1, fig. 4.  
*Nodosaria communis* REUSS, Verstein Böhm. Kreide, 1845, 6, p. 28, pl. 12, fig. 21.

Test stout, tapering, slightly curved, initial end pointed, sometimes ending in a short spinose projection, chambers numerous, very slightly depressed at the sutures, increasing



gradually in height as added; wall smooth, aperture radiate, eccentric. Length 1.10 mm., breadth 0.20 mm.

*Plesiotype*: No. 2539, Mus. Calif. Acad. Sci., from **seven miles north of Coalinga, California**; specimens occur in the collection from 10 feet above the Eocene sandstone reef.

### 13. *Nodosaria arundinea* Schwager

Plate 13, figure 14

*Nodosaria arundinea* SCHWAGER, *Novara-Exped.*, Geol. Theil., pt. 2, 1866, p. 211, pl. 5, figs. 43-45.—SHERBORN & CHAPMAN, *Journ. Roy. Micr. Soc.*, 1886, p. 747, pl. 14, figs. 28, 29.

Test very long and slender, chambers long cylindrical, many times as long as wide; sutures very slightly depressed; wall thin, smooth.

*Plesiotype*: No. 2540, Mus. Calif. Acad. Sci., from **seven miles north of Coalinga, California**; rare at 10 feet above the Eocene sandstone reef.

The species is recorded from the Eocene of Europe and occurs in considerable numbers in the upper Eocene of Mexico. Schwager's types were from the Pliocene of Kar Nicobar.

### 14. *Nodosaria (Glandulina) lævigata ovata* Cushman & Applin

Plate 14, figure 1

*Nodosaria (Glandulina) lævigata* D'ORBIGNY, var. *ovata* CUSHMAN & APPLIN, *Bull. Amer. Assoc. Petr. Geol.*, Vol. 10, 1926, p. 169, pl. 7, figs. 12, 13.

Test ovate, longer than broad, circular in transverse section, widest toward the apertural end, initial end subacute, chambers overlapping, few, indistinct; sutures indistinct; aperture radiate, slightly projecting; wall smooth, matte. Length 0.75 mm., breadth 0.40 mm.

*Plesiotype*: No. 2541, Mus. Calif. Acad. Sci., from **seven miles north of Coalinga, California**; a single specimen from 10 feet above the Eocene sandstone reef.



This variety, described from the upper Eocene of Texas, is widely distributed in the deposits of the same age of the Gulf Coastal Plain of the United States and Mexico.

### 15. *Marginulina subbullata* Hantken

Plate 13, figure 11

*Marginulina subbullata* HANTKEN, A Magy. Kir. földt. int. Evkön., Vol. 4, 1875 (1876), p. 39, pl. 4, figs. 9, 10; pl. 5, fig. 9.—CUSHMAN, Contrib. Cushman Lab. Foram. Res., Vol. 1, pt. 3, 1925, p. 62, pl. 10, figs. 3a, b.

Test subcylindrical, initial end broadly rounded, the first three chambers arranged in a loose coil, the last two or three chambers uniserial in a straight line; chambers few, inflated; sutures distinct, slightly depressed; wall smooth and polished; apertural end produced with a small tapering neck and radiate aperture. Length of immature specimen 0.50 mm., breadth 0.25 mm.

*Plesiotype*: No. 2542, Mus. Calif. Acad. Sci., from **seven miles north of Coalinga, California**; a single specimen, 200 feet below the Eocene sandstone reef.

Hantken described this species from the upper Eocene of Central Europe. It also occurs in the upper Eocene of Mexico.

### 16. *Cristellaria mexicana nudicostata*

Cushman & Hanna, new subspecies

Plate 14, figure 2

Test differing from the typical in having the raised limbate sutures smooth instead of beaded, the portion toward the inner margin from the middle slightly more swollen; aperture radiate with a supplementary robuline aperture below on the apertural face.

*Holotype*: No. 2543, *paratype* No. 2544, Mus. Calif. Acad. Sci., from **seven miles north of Coalinga, California**; several



specimens at 10 feet above and 100 feet below the Eocene sandstone reef.

This same form occurs in the Tantoyuca formation of Mexico.

### 17. *Cristellaria truncana* Gümbel

Plate 14, figure 6

*Cristellaria truncana* GÜMBEL, Abhandl. Bay. Akad. Wiss. München, Cl. II, Vol. 10, 1868 (1870), p. 639, pl. 1, figs. 68a, b.

Test much compressed, slightly uncoiled, two or three times as long as broad, sides nearly parallel, periphery truncate; chambers very distinct; sutures distinct, transparent, limbate, curved especially toward the periphery; wall smooth, polished; aperture radiate with a small rounded supplementary robuline aperture just below on the apertural face. Length 0.85 mm., breadth 0.40 mm.

*Plesiotype*: No. 2545, Mus. Calif. Acad. Sci., from **seven miles north of Coalinga, California**; rare in collection 100 feet below Eocene sandstone reef.

This is apparently identical with Gümbel's species described from the upper Eocene of Bavaria.

### 18. *Cristellaria inornata* (d'Orbigny)

Plate 14, figure 5

*Robulina inornata* D'ORBIGNY, Foram. Foss. Bass. Tert. Vienné, 1846, p. 102, pl. 4, figs. 25, 26.

*Cristellaria inornata* SHERBORN & CHAPMAN, Journ. Roy. Micr. Soc., ser. 2, Vol. 6, 1886, p. 754, pl. 15, figs. 27a, b.

Test closely coiled, thick, periphery acute, six or seven chambers in the last formed coil, chambers distinct but not inflated: sutures distinct, slightly limbate, strongly curved, flush with the surface; wall smooth, matte; aperture radiate with an elongate supplementary robuline chamber just below on the triangular apertural face. Length 0.95 mm., breadth 0.80 mm.



*Plesiotype*: No. 2546, Mus. Calif. Acad. Sci., from **seven miles north of Coalinga, California**; a number of specimens occur in the collection made 100 feet below the Eocene sandstone reef.

D'Orbigny described this species from the Miocene of the Vienna Basin and Sherborn & Chapman record it from the Eocene of England. There are a number of specimens from the same material near Coalinga that may be variants of this species.

### 19. *Cristellaria convergens* Bornemann

Plate 14, figure 3

*Cristellaria convergens* BORNEMANN, Zeitschr. deutsch. geol. Ges., Vol. 7, 1855, p. 327, pl. 13, figs. 16, 17.

Test oval, biconvex, close coiled; chambers triangular, the last-formed one drawn out to a point at the apertural end; sutures hardly visible, the chambers embracing to the umbo; wall smooth and thick, aperture radiate. Length 0.65 mm.; breadth 0.55 mm.

*Plesiotype*: No. 2547, Mus. Calif. Acad. Sci., from **seven miles north of Coalinga, California**; specimens occur in the collection made 100 feet below the Eocene sandstone reef.

Bornemann's type was from the Oligocene of Germany. Specimens from Jurassic to Recent have been referred to this species but a comparison of the published figures shows a considerable difference in the forms.

### 20. *Cristellaria subaculeata* Cushman

*Cristellaria aculeata* H. B. BRADY (not d'Orbigny), Rep. Voy. *Challenger*, Zoology, Vol. 9, 1884, p. 555, pl. 71, figs. 4, 5.

*Cristellaria subaculeata* CUSHMAN, Bull. 104, U. S. Nat. Mus., pt. 4, 1923, p. 123, pl. 34, fig. 2.

Test somewhat longer than broad, somewhat compressed, periphery with a narrow, thin keel, test becoming slightly uncoiled in the later portion; chambers comparatively few, about



8 in the last-formed coil, distinct but not inflated; sutures limbate, raised, with bead-like prominences, wall between the sutures also spinose or beaded, apertural face triangular, truncate, the sides with a raised keel; aperture projecting, radiate, with a supplementary robuline opening below on the apertural face. Length 0.85 mm., breadth 0.60 mm.

Specimens occur in the collection from 200 feet below the Eocene sandstone reef, seven miles north of Coalinga, California. The specimens are very close indeed to the species now living in the western Atlantic.

#### 21. *Cristellaria subaculeata glabrata* Cushman

Variety differing from the typical in the larger proportion of the uncoiled part, the greater development of spines on the periphery and the lack of ornamentation of the wall between the sutures.

This variety occurs with the typical form in the material collected 200 feet below the Eocene sandstone reef, seven miles north of Coalinga, California.

#### 22. *Globigerina bulloides* d'Orbigny

*Globigerina bulloides* D'ORBIGNY, Ann. Sci. Nat., Vol. 7, 1826, p. 277, No. 1; Modèles, No. 76.

A few specimens came from 200 feet below the Eocene sandstone reef, seven miles north of Coalinga, California.

#### 23. *Globigerina coalingensis* Cushman & Hanna, new species

Plate 14, figures 4a, b

Test subglobular, the last three chambers making up nearly the whole periphery of the test, early chambers largely concealed by the ornamentation which is greatest over the early chambers; consisting of large projecting bosses with a spinose surface, the succeeding chambers covered with a progressively



decreasing ornamentation, the last-formed chamber with only a few short slender spines; aperture small, in the slightly open umbilicus of the ventral side. Diameter 0.60 mm.

*Holotype*: No. 2548, Mus. Calif. Acad. Sci., from **seven miles north of Coalinga, California**; rare at 200 feet below the Eocene sandstone reef.

This species is peculiar in its ornamentation but in this respect strongly resembles *Globigerina topilensis* Cushman described from the upper Eocene of Mexico. The California species has rounded instead of angled, truncated chambers and the ornamentation decreases much more rapidly.

#### 24. *Truncatulina pseudoungeriana* Cushman

*Truncatulina ungeriana* H. B. BRADY (not *Rotalina ungeriana* D'ORBIGNY), Rep. Voy. Challenger, Zoology, Vol. 9, 1884, pl. 94, figs, 9a-c.

*Truncatulina pseudoungeriana* CUSHMAN, U. S. Geol. Survey Prof. Paper 129, 1922, pp. 97, 136, pl. 20, fig. 9; Prof. Pap. 133, 1923, p. 40.

Test almost equally biconvex, periphery subacute; chambers nine to eleven in the last-formed whorl, those of the earlier whorls not showing on either the ventral or the dorsal side, being hidden on the dorsal side by the roughness of the surface and on the ventral side by the involute character; periphery lobulate; sutures distinct above the last whorl and very distinct below, as they are somewhat tumid on the ventral side; umbilical region filled nearly flush with the chambers by clear shell material, last few chambers on the dorsal side slightly above the surface on the inner margin; surface dorsally with coarse punctæ, below smooth and more finely punctate; aperture at the periphery. Diameter 1 mm. or less.

Specimens, evidently this species, occurred at 10 feet above and 200 feet below the Eocene sandstone reef.

This species is common in the Oligocene and upper Eocene of the Gulf Coastal Plain of the United States and Mexico.



25. **Truncatulina coalingensis** Cushman & Hanna, new species

Plate 14, figures 7-9

Test comparatively large, dome shaped, ventral side slightly concave, dorsal-side strongly convex, the central portion umbonate, periphery with a strong blunt keel; chambers about eight in the last-formed coil, somewhat indistinct on the dorsal side but much more distinct on the ventral side; sutures on the ventral side rather indistinct, very slightly curved; on the ventral side distinct, only slightly curved, limbate; wall thick, dorsal side irregularly pitted, except on the peripheral keel which is nearly smooth; ventral side finely but very distinctly perforate, toward the umbilical area with several large confluent boss-like, smooth projections; aperture narrow, on the ventral side of the last-formed chamber. Diameter 1.15 mm.

*Holotype*: No. 2549, *paratype* No. 2550, Mus. Calif. Acad. Sci., from **seven miles north of Coalinga, California**; common in the collection made 10 feet above the Eocene sandstone reef.

This is a peculiar species in its shape and especially in the character of the ornamentation.

26. **Anomalina coalingensis** Cushman & Hanna, new species

Plate 14, figures 10-12

Test plano-convex, ventral side convex, dorsal side nearly flat, periphery bluntly keeled; chambers very distinct, eleven to thirteen in the last-formed coil, on the dorsal side with the border of each chamber with a distinct thickened border, the inner end roundly pointed and distinctly free from the preceding coil; the earlier coils forming a flat coarsely pitted disc, ventral side involute with the chambers ending in a central raised boss, the sutures slightly curved, wall coarsely perfor-



ate; aperture short, at the periphery and extending slightly over onto the ventral side. Diameter 0.60 mm.

*Holotype*: No. 2551, *paratypes* Nos. 2552, 2553, Mus. Calif. Acad. Sci., from **seven miles north of Coalinga, California**; fairly common at 10 feet above and 200 feet below the Eocene sandstone reef.

The ventral side is distinctly raised in the middle, the figure showing about the maximum; other specimens are more compressed. This is related to *Anomalina umbonata* Cushman described from the Eocene of Mexico.

## 27. *Pulvinulina mexicana* Cushman

Plate 14, figures 13-15

*Pulvinulina mexicana* CUSHMAN, Bull. Amer. Assoc. Petr. Geol., Vol. 9, 1925, p. 300, pl. 7, figs. 7, 8.

Test unequally biconvex, dorsal side forming a low cone, ventral side only slightly biconvex, periphery subacute, subcarinate, last-formed coil with eight to ten chambers, only those of the last-formed coil visible from the ventral side, which is umbonate; sutures distinct, very slightly limbate on the dorsal side, ventrally very slightly depressed near the periphery, becoming limbate near the umbilicus, and often fusing on the inner margin and forming a ring; wall distinctly but rather finely perforate; aperture elongate on the middle part of the inner margin of the ventral side of the last-formed chamber. Diameter, 0.60 mm.

*Plesiotype*: No. 2554, Mus. Calif. Acad. Sci., from **seven miles north of Coalinga, California**; specimens were common at 100 feet below the Eocene sandstone reef.

This species was originally described from the Eocene of Mexico.



### 28. *Pulvinulina crassata* Cushman

*Pulvinulina crassata* CUSHMAN, Bull. Amer. Assoc. Petr. Geol., Vol. 9, 1925, p. 300, pl. 7, fig. 4.

Test small, plano-convex, the dorsal side nearly flat, ventral side strongly convex, last-formed coil with five or six chambers; periphery subacute; chambers inflated, especially on the ventral side; sutures distinct, slightly depressed on the dorsal side, strongly so on the ventral side; periphery and surface closely set with short spinose processes; aperture elongate, on the inner edge of the ventral face of the last-formed chamber. Diameter, 0.45-0.55 mm. Rare at 200 feet below the Eocene sandstone reef.

This species occurs with the above in the Eocene of Mexico.

### 29. *Gyroidina soldanii* d'Orbigny, *octocamerata* Cushman & Hanna, new subspecies

Plate 14, figures 16-18

Test small, dorsal side flattened, ventral side very convex, composed of about three coils, the last formed one consisting of eight chambers, periphery broadly rounded, ventral side with the umbilical region strongly depressed; chambers distinct, sutures distinct, slightly depressed, on the dorsal side somewhat oblique, on the ventral side radial; wall finely perforate, smooth and polished; aperture elongate, arched, from the periphery at least half way to the umbilicus along the ventral border of the last formed chamber, with a very slightly developed lip. Length 0.50 mm., breadth 0.45 mm., thickness 0.35 mm.

*Holotype*: No. 2555, Mus. Calif. Acad. Sci., from **seven miles north of Coalinga, California**; rare at 10 feet above the Eocene sandstone reef.

This variety occurs frequently in the upper Eocene of the Gulf Coastal Plain of the United States and Mexico.



30. *Discocyclina clarki* (Cushman)

*Orthophragmina clarki* CUSHMAN, U. S. Geol. Survey, Prof. Pap. 125, 1920, p. 41, pl. 7, figs. 4, 5.

This species is abundant in parts of the muddy shale for several hundred feet below the sandstone reef. Except where there has been local consolidation, the preservation is not good.

31. *Nonionina* cf. *umbilicatula* (Montagu)

There are a very few specimens from 100 feet below the Eocene reef near Coalinga, which may be referred to this species, at least temporarily. Such specimens are widely distributed and need special study to determine the extent of range in the various species. They are very common in the Eocene of the Gulf Coastal Plain of the United States and Mexico.

32. *Nonionina* cf. *scapha* (Fichtel and Moll)

Plate 14, figures 19, 20

A very few specimens in the collection may be doubtfully referred to this species.

*Plesiotype*: No. 2556, Mus. Calif. Acad. Sci., from 100 and 1000 feet below the Eocene reef, **seven miles north of Coalinga, California.**

33. *Massilina decorata* Cushman

*Massilina decorata* CUSHMAN, U. S. Geol. Survey Prof. Paper 129, 1922, p. 143, pl. 34, fig. 7; Prof. Paper 133, 1923, p. 55.

Test much flattened, elliptical or oval, slightly longer than broad, basal and apertural ends projecting, the apertural end narrowing to a small cylindrical neck, nearly in the longi-  
tudi-



nal axis of the test; sutures rather indistinct; surface dull white; periphery rounded, the wall ornamented by very fine pits, giving a finely granular, matte appearance to the test. Maximum length 1 mm.

A single specimen came from 200 feet below the Eocene sandstone reef, seven miles north of Coalinga, California.

This species is widely distributed in the lower Oligocene and upper Eocene of the Gulf Coastal Plain of the United States and Mexico.

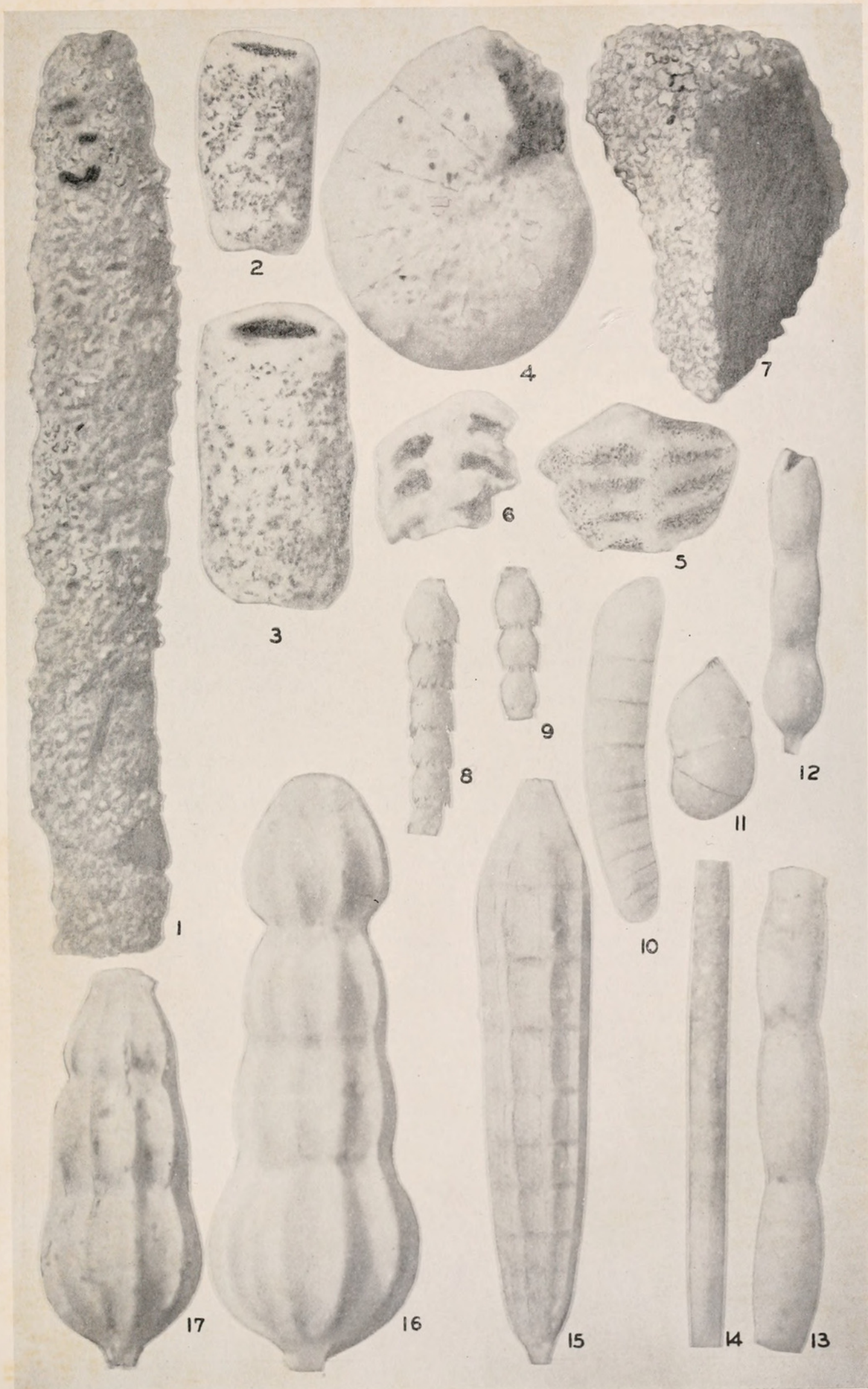


## PLATE 13

- Fig. 1. *Rhabdammina eocenica* Cushman & Hanna, n. sp. Holotype, No. 2522, C. A. S.; from seven miles north of Coalinga, Calif.; Eocene, 10 feet above sandstone reef; p. 209.
- Figs. 2, 3. *Bathysiphon eocenica* Cushman & Hanna, n. sp. Fig. 2, paratype, No. 2525; fig. 3, holotype, No. 2524, C. A. S.; from seven miles north of Coalinga, Calif.; Eocene, 10 feet above sandstone reef; p. 210.
- Fig. 4. *Haplophragmoides coalingensis* Cushman & Hanna, n. sp. Holotype, No. 2527, C. A. S.; from seven miles north of Coalinga, Calif.; Eocene, 10 feet above sandstone reef; p. 210.
- Fig. 5. *Textularia mississippiensis* Cushman. Plesiotype, No. 2528, C. A. S.; from seven miles north of Coalinga, Calif.; Eocene, 10 feet above sandstone reef; p. 211.
- Fig. 6. *Textularia* cf. *distortio* Cushman & Applin. Plesiotype, No. 2529, C. A. S.; from seven miles north of Coalinga, Calif.; Eocene, 100 feet below sandstone reef; p. 211.
- Fig. 7. *Gaudryina jacksonensis coalingensis* Cushman & Hanna, n. s. sp. Holotype, No. 2530, C. A. S.; from seven miles north of Coalinga, Calif.; Eocene, 10 feet above sandstone reef; p. 212.
- Figs. 8, 9. *Nodosaria (Dentalina) adolphina* d'Orbigny. Plesiotypes, Nos. 2535, 2536, C. A. S.; from seven miles north of Coalinga, Calif.; Eocene, 10 feet above sandstone reef; p. 213.
- Fig. 10. *Nodosaria (Dentalina) communis* d'Orbigny. Plesiotype, No. 2539, C. A. S.; from seven miles north of Coalinga, Calif.; Eocene, 10 feet above sandstone reef; p. 214.
- Fig. 11. *Marginulina subbullata* Hantken. Plesiotype, No. 2542, C. A. S.; from seven miles north of Coalinga, Calif.; Eocene, 200 feet below sandstone reef; p. 216.
- Figs. 12, 13. *Nodosaria (Dentalina) consobrina* d'Orbigny. Plesiotypes, Nos. 2537, 2538, C. A. S.; from seven miles north of Coalinga, Calif.; Eocene, 10 feet above sandstone reef; p. 214.
- Fig. 14. *Nodosaria arundinea* Schwager. Plesiotype, No. 2540, C. A. S.; from seven miles north of Coalinga, Calif.; Eocene, 10 feet above sandstone reef; p. 215.
- Fig. 15. *Nodosaria latejugata* Gümbel, microspheric form. Plesiotype, No. 2534, C. A. S.; from seven miles north of Coalinga, Calif.; Eocene, 10 feet above sandstone reef; p. 212.
- Figs. 16, 17. *Nodosaria latejugata* Gümbel, megalospheric forms, Plesiotypes, Nos. 2532, 2533, C. A. S.; from seven miles north of Coalinga, Calif.; Eocene, 10 feet above sandstone reef; p. 212.

All figures on this plate are enlarged approximately 50 diameters; see foregoing text for accurate measurements of the specimens. The carinate appearance of some of the figures is due to the method of engraving the plate.





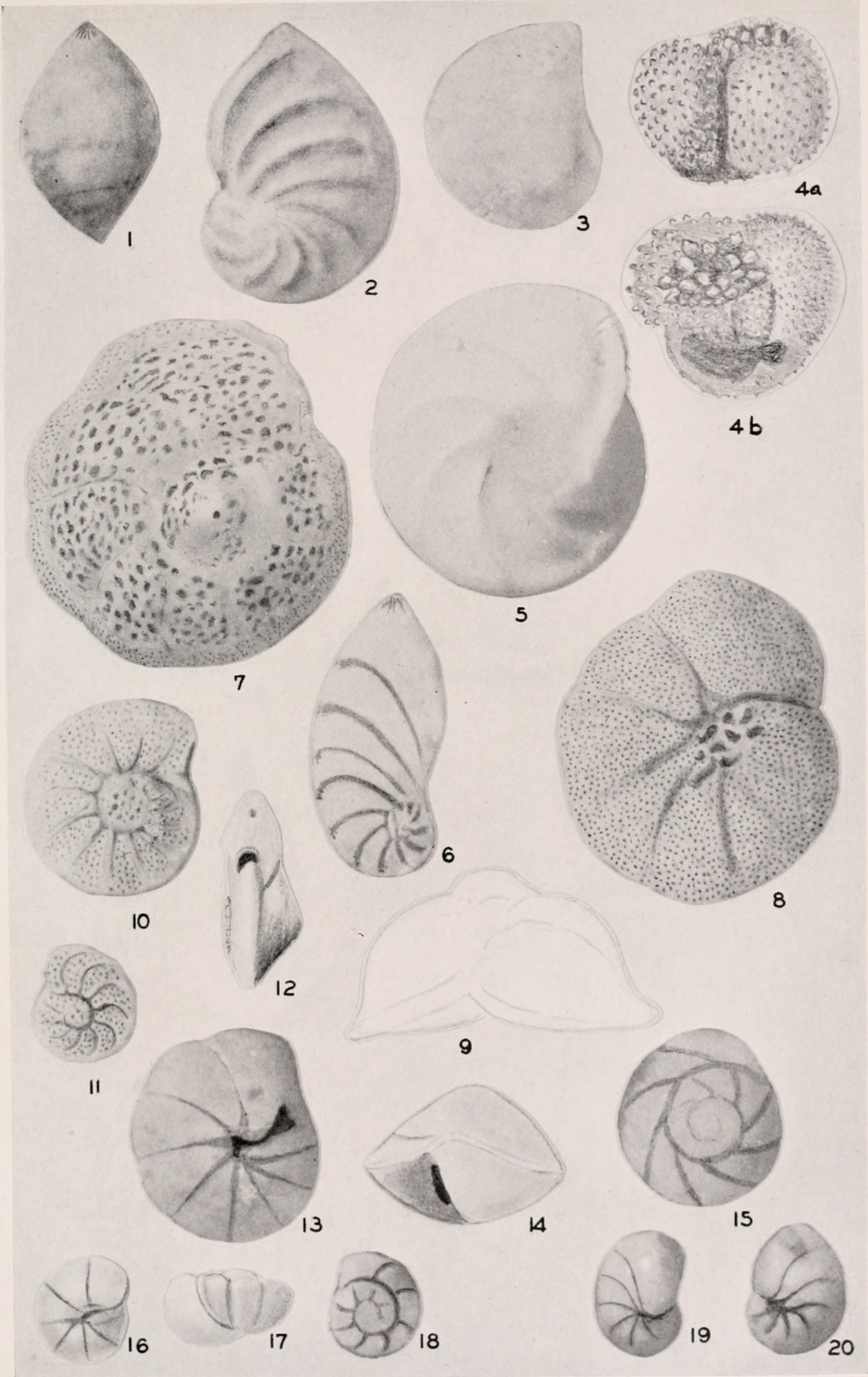


## PLATE 14

- Fig. 1. *Nodosaria (Glandulina) laevigata ovata* Cushman & Applin. Plesiotype, No. 2541, C. A. S.; from seven miles north of Coalinga, Calif.; Eocene, 10 feet above sandstone reef; p. 215.
- Fig. 2. *Cristellaria mexicana nudicostata* Cushman & Hanna, n. s. sp. Holotype, No. 2543, C. A. S.; from seven miles north of Coalinga, Calif.; Eocene, 10 feet above sandstone reef; p. 216.
- Fig. 3. *Cristellaria convergens* Bornemann. Plesiotype, No. 2547, C. A. S.; from seven miles north of Coalinga, Calif.; Eocene, 10 feet above sandstone reef; p. 218.
- Fig. 4a, 4b. *Globigerina coalingensis* Cushman & Hanna, n. sp.; a, side view; b, dorsal view. Holotype, No. 2548, C. A. S.; from seven miles north of Coalinga, Calif.; Eocene, 200 feet below sandstone reef; p. 219.
- Fig. 5. *Cristellaria inornata* d'Orbigny. Plesiotype, No. 2546, C. A. S.; from seven miles north of Coalinga, Calif.; Eocene, 10 feet above sandstone reef; p. 217.
- Fig. 6. *Cristellaria truncana* Gümbel. Plesiotype, No. 2545, C. A. S.; from seven miles north of Coalinga, Calif.; Eocene, 100 feet below sandstone reef; p. 217.
- Figs. 7, 8, 9. *Truncatulina coalingensis* Cushman & Hanna, n. sp. Holotype, (fig. 7) No. 2549; paratype, (figs. 8, 9) No. 2550, C. A. S.; from seven miles north of Coalinga, Calif.; Eocene, 10 feet above sandstone reef; p. 221.
- Figs. 10, 11, 12. *Anomalina coalingensis* Cushman & Hanna, n. sp. Holotype, (figs. 10, 12) No. 2551; paratype, (fig. 11) No. 2552, C. A. S.; from seven miles north of Coalinga, Calif.; Eocene, 10 feet above sandstone reef; p. 221.
- Figs. 13, 14, 15. *Pulvinulina mexicana* Cushman. Plesiotype, No. 2554, C. A. S.; from seven miles north of Coalinga, Calif.; Eocene, 10 feet above sandstone reef; p. 222.
- Figs. 16, 17, 18. *Gyroidina soldanii octocamerata* Cushman & Hanna, n. s. sp. Holotype, No. 2555, C. A. S.; from seven miles north of Coalinga, Calif.; Eocene, 10 feet above sandstone reef; p. 223.
- Figs. 19, 20. *Nonionina* cf. *scapha* (Fichtel & Moll.) Plesiotype, No. 2556, C. A. S.; from seven miles north of Coalinga, Calif.; Eocene, 100 feet below sandstone reef; p. 224.

All figures on this plate are enlarged approximately 50 diameters; see foregoing text for accurate measurements of the specimens. The carinate appearance of some of the figures is due to the method of engraving the plate.









Cushman, Joseph A. and Hanna, G Dallas. 1927. "Foraminifera from the Eocene near Coalinga, California." *Proceedings of the California Academy of Sciences, 4th series* 16, 205–229.

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