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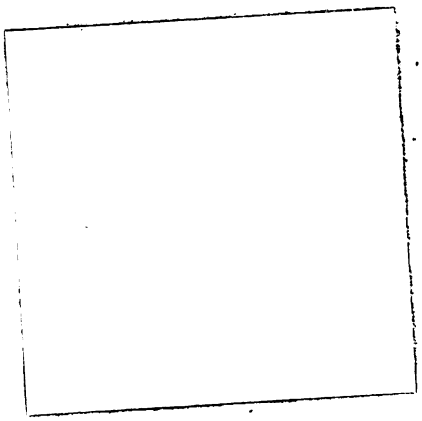

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DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

BULLETIN 396

PALEONTOLOGY

OF THE

COALINGA DISTRICT

FRESNO AND KINGS COUNTIES

CALIFORNIA

BY

RALPH ARNOLD

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PALEONTOLOGY OF THE COALINGA DISTRICT, FRESNO AND KINGS COUNTIES, CALIFORNIA.

By RALPH ARNOLD.

INTRODUCTION.

General statement.—The material on which this paper is based was collected during two separate investigations in the Coalinga district and adjacent regions. The first was made in the summer of 1905, under the direction of William H. Dall, of the United States Geological Survey, in connection with a paleontologic reconnaissance of the southern Coast Ranges. During this trip, on which the writer was assisted by H. R. Johnson and Frank Stokes, jr., nearly a month was spent in the region from Coalinga southward to the vicinity of Dudley. The second examination of the district was carried on during the whole of the summer of 1907, at which time a detailed geologic map of the district was made. This map was primarily prepared to accompany a report on the oil resources of the district, but incidentally the detailed mapping threw much light on various stratigraphic and paleontologic problems, several of which are discussed in this paper.

Acknowledgments.—Mr. Robert Anderson collaborated in the work carried on in 1907 and in the preparation of the geologic reports relative to the district, and Mr. Earl Stonebarger assisted in some of the paleontologic field work in 1907. The writer wishes also to return thanks to Mrs. Hugo Kreyenhagen, Mr. James H. Pierce, Prof. Orlando D. Barton, Judge W. H. Kerr, Mr. K. W. Jones, and many others in the district for kindly assistance and interest in the paleontologic work. He is especially indebted to Mr. Homer Hamlin and Mr. Frank M. Anderson for notes relating to many fossiliferous localities, not only in this district but elsewhere in the southern Coast Ranges, which have expedited the collection of much of the material on which this and other papers have been based; and to Mr. S. G. Mason, of the United States Geological Survey, for assistance in the preparation of the tables of fossils and fossiliferous localities contained in this bulletin.

The discussion relating to the topography and geology of the district is largely copied from Bulletin No. 357, United States Geological Survey.[a]

Previous paleontologic work in the district.—Practically no paleontologic or geologic data concerning the Coalinga district were available until 1894, when W. L. Watts published geologic descriptions accompanied by lists of fossils collected by himself at various localities throughout the district and identified by the late J. G. Cooper.[b] In 1900 Mr. Watts gave supplemental notes on the geology of the district.[c]

The most important contribution to the paleontology of the district is by Frank M. Anderson,[d] who in 1905 mapped and described the formations of the local Coalinga field and described and figured many new and several old species of fossils. The original descriptions and figures of all the Tertiary species accredited to Mr. Anderson occur in this paper. His report was supplemented by a later one,[e] in which he revises some of his opinions concerning the age of certain of the formations and gives additional notes on others.

On November 23, 1908, a report[f] issued by the writer in collaboration with Robert Anderson gave a geologic map and a brief description of the geology of the region, but contained only the briefest mention of the paleontology, although the classification of the formations described is based primarily on their contained fossils.

Mention is also made directly or indirectly of the paleontology and stratigraphy of the Coalinga district in the following publications, among others:

1865. Whitney, J. D., Geol. Survey California, Geology, vol. 1, xxxii+498 pp., 1 pl.
1869. Gabb, W. M., Geol. Survey California, Pal. California, vol. 2, Cretaceous and Tertiary fossils, xiv+299 pp., 36 pls.
1888. Cooper, J. G., Catalogue of California fossils, pt. 1: Seventh Ann. Rept. California State Mineralogist for 1887.
1894. Cooper, J. G., Catalogue of California fossils, parts 2, 3, 4, and 5: Bull. California State Min. Bureau, No. 4. Describes *Cancellaria irelaniana* and *Potamides carbonicola*.
1894. Cooper, J. G., On some Pliocene fresh-water fossils of California: Proc. California Acad. Sci., 2d ser., vol. 4, pp. 166–172, pl. 14. Describes fresh-water deposits of Kettleman Hills, and the new species *Margaritana subangulata*.
1903. Eldridge, Geo. H., The petroleum fields of California: Bull. U. S. Geol. Survey No. 213, pp. 306–321. Gives an outline of the stratigraphy.

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[a] Arnold, Ralph, and Anderson, Robert, Preliminary report on the Coalinga district, 1908.

[b] The gas and oil yielding formations of the central valley of California: Bull. California State Min. Bureau No. 3, 1894, pp. 53–67.

[c] Oil and gas yielding formations of California: Bull. California State Min. Bureau No. 19, 1900, pp. 131–142.

[d] A stratigraphic study in the Mount Diablo Range of California: Proc. California Acad. Sci., 3d ser. Geology, vol. 2, No. 2, 1905, pp. 156–243, pls. 13–35.

[e] A further stratigraphic study on the Mount Diablo Range of California: Proc. California Acad. Sci., 4th ser., vol. 3, 1908, pp. 1–40.

[f] Preliminary report on the geology and oil resources of the Coalinga district, Fresno and Kings counties, California: Bull. U. S. Geol. Survey No. 357, 1908, 142 pp., 3 pls.

1906. Arnold, Ralph, The Tertiary and Quaternary pectens of California: Prof. Paper U. S. Geol. Survey No. 47, 264 pp., 53 pls., 2 figs. Describes *Pecten coalingaensis*, *P. nutteri*, and *P. wattsi*.

1908. Weaver, Chas. E., New echinoids from the Tertiary of California: Bull. Dept. Geology Univ. California, vol. 5, No. 17, pp. 271–274, pls. 21–22. Describes *Scutella perrini*.

1908. Rathbun, Mary J., Descriptions of fossil crabs from California: Proc. U. S. Nat. Mus., vol. 35, pp. 341–349, pls. 45–49. Describes *Cancer fissus* and *Branchiolambrus altus*, new species, and *Loxorhynchus grandis* Stimpson from Coalinga district.

1909. Weaver, Chas. E., Stratigraphy and paleontology of the San Pablo formation in middle California: Bull. Dept. Geology Univ. California, vol. 5, No. 16, pp. 243–269.

Notes on the stratigraphy of the general region also occur in some of the other publications of the California State Mining Bureau, especially in those relating to the San Joaquin coal mine.

Location and topography.—The region mapped and referred to in the reports of the United States Geological Survey[a] as the Coalinga district is situated in the southern part of Fresno County and the western part of Kings County, Cal., and is bounded on the south by the Kern County line. It forms a long strip of territory extending from 119° 50′ west longitude and 35° 47′ north latitude at its southeast corner to 120° 37′ west longitude and 36° 20′ north latitude at its northwest corner, along the foot of the Diablo Range. This is the easternmost member of the Coast Ranges on the border of the San Joaquin Valley of California. The district as mapped is roughly 50 miles long and 15 miles wide and includes about 700 square miles.

The Coalinga district owes its broader topographic features to its position along the border between the Coast Ranges and the San Joaquin Valley. It is largely a region of foothills that rise on the west into the mountains and merge on the east with the wide level plain. The foothills form several groups around the base of spurs descending southeastward from the Diablo Range, the groups being separated from each other by reentrant valleys that open out to the San Joaquin Valley.

The Diablo Range in this latitude is a rugged mountain group made up of various component members, some of which, owing to a complication of structures, run at angles oblique to the main trend of the range northwest and southeast. The crest of the range has a general altitude varying between 2,500 and 5,000 feet, and declines in height from the region northwest of the Coalinga district toward the region southwest of it, where it has been assumed as coming to a stop and giving place on the southwest to the Temblor Range. The northwest corner of the district is marked by a peak nearly 5,000 feet high that

[a] Bull. No. 357, p. 11.

stands at the head of Joaquin Ridge; in the southwest corner, the much lower Avenal Ridge, the southernmost spur of the range, appears. In the intermediate region the ridges are in general separated from the main divide of the range by a region of lower relief determined by the presence of transverse structural valleys, of which Waltham Valley is the principal example. The general topographic development is youthful, but there is evidence in certain localities of different stages of development up to advanced youth. A feature of the relief of the whole region is the topographic reflection of the geologic structure, a feature that is especially pronounced in the foothills belt, with which this report particularly deals.

GEOLOGIC FORMATIONS.

GENERAL STATEMENT.

The eastern slope of the mountains bordering the San Joaquin Valley is formed by a great thickness of strata dipping toward the valley. The oldest rocks exposed appear in the axis of the mountain range at the base of the monocline, and successively younger formations appear eastward as the edge of the valley is approached. The different formations that may be recognized as units in this series, with the time divisions to which they correspond, are as follows, from the oldest to the youngest: Franciscan (Jurassic?), Knoxville (Lower Cretaceous), Chico (Upper Cretaceous), Tejon (Eocene), Vaqueros (lower Miocene), Santa Margarita(?) (upper middle Miocene), Jacalitos (early upper Miocene), Etchegoin (uppermost Miocene), Tulare (Pliocene and lower Pleistocene), and late Quaternary alluvium and terrace deposits. These formations, with the exception of certain igneous and metamorphic rocks associated with the Franciscan, are of sedimentary origin, and, with the exception of minor portions of the Miocene series and most of the Tulare and later beds, are of marine deposition. They indicate that the greater portion of the area included within the Coalinga district was beneath the sea during intervals occupying probably the major portion of the time from the Jurassic to the end of the Miocene. The latest movements of the land, which produced the features of topographic relief now to be seen, did not take place until Quaternary time.

In the following table is given a tentative correlation of these formations with those of other localities in California:

Tentative correlation of the formations of the Coalinga district with the standard California Coast Range section and with those of other localities in California.

Era.	System.	Series.	Standard Coast Range section.	Coalinga district section.	Santa Maria district section.	Santa Clara Valley (Ventura County) section.	Los Angeles and Puente Hills section.	Santa Cruz Mountains section.
Cenozoic.	Quaternary.	Recent.	Alluvium.	Alluvium.	Alluvium.	Alluvium.	Alluvium.	Alluvium.
		Pleistocene.	San Pedro.	Stream deposits, valley fillings, and raised beaches.	Terrace deposits and dune sand.	Terrace deposits, sand, and gravel.	Terrace deposits, sand, and gravel.	Terrace deposits, sand, and gravel.
			—Unc.—	—Unconformity—	—Unconformity—	—Unconformity—	—Unconformity—	—Unconformity—
	Tertiary.	Pliocene.	Merced.	Tulare.				Merced. / Santa Clara.
			San Diego.	—Unconformity—	Coronado.			
		Miocene.	San Pablo.	Etchegoin.	~~Fernando.~~	Fernando.	Fernando.	Purisima.
			—Unconformity—	—Unconformity—	Pliocene			
			Santa Margarita.	Jacalitos.				Santa Margarita.
			—Unconformity—	—Unconformity—	—Unconformity—	—Unconformity—	—Unconformity—	—Unconformity—
			Monterey.	Santa Margarita(?) / Lacking (with possible exception of a small part).	Monterey.	Modelo: Shale. / Upper sandstone. / Shale. / Lower sandstone.	Puente: Upper shale. / Sandstone. / Lower shale.	Monterey.
			—Unconformity—	—Unconformity—	—Unconformity—	—Unconformity—	—Unconformity—	—Unconformity—
			Vaqueros.	Vaqueros.	Vaqueros.	Vaqueros.	Vaqueros.	Vaqueros.
			—Unconformity—	—Unconformity—	—Unconformity—	—Unconformity—	—Unconformity—	—Unconformity—
		Oligocene.	San Lorenzo.	Lacking.	Sespe and Tejon, undifferentiated.	Sespe: Upper Sespe. / Red beds. / Lower Sespe.		San Lorenzo. / Butano.
			—Unconformity?—	—Unconformity—	—Unconformity—	—Unconformity—	—Unconformity—	—Unconformity?—
		Eocene.	Tejon.	Tejon.		Topatopa.		Undifferentiated Eocene, probably Martinez.
			Martinez.	—Unconformity—	—Unconformity—	—Unconformity—	—Unconformity—	—Unconformity?—
Mesozoic.	Cretaceous.		Chico.	Chico.	(?)	—Unconformity—	—Unconformity—	Chico.
			—Unconformity—	—Unconformity—	—Unconformity—	Granitic rocks, gneiss, etc.	Granitic rocks, gneiss, etc.	—Unconformity—
			Horsetown.	—Unconformity—	—Unconformity—	—Unconformity—	—Unconformity—	—Unconformity—
			—Unconformity—	—Unconformity—	—Unconformity—	—Unconformity—	—Unconformity—	—Unconformity—
			Knoxville.	Knoxville.	Knoxville.	—Unconformity—	—Unconformity—	Knoxville.
			—Unconformity—	—Unconformity—	—Unconformity—	—Unconformity—	—Unconformity—	—Unconformity—
	Jurassic?		Franciscan.	Franciscan.				Franciscan.
			—Unconformity—	—Unconformity—	—Unconformity—	—Unconformity—	—Unconformity—	—Unconformity—
			Granitic rocks, etc.	—Unconformity—	—Unconformity—	—Unconformity—	—Unconformity—	Granitic rocks.
	?		—Unconformity—	—Unconformity—	—Unconformity—	—Unconformity—	—Unconformity—	—Unconformity—
			Schist and limestone.				Black schist.	Schist and limestone.

FRANCISCAN FORMATION (JURASSIC?).

General description.—The Franciscan formation occupies the central portion of the Diablo Range and comprises the oldest, most altered, and most distorted rocks in the district. The original sedimentary rocks of the Franciscan are sandstone, shale, and jasper, with which are associated glaucophane, actinolite, and related schists, serpentine, and other metamorphosed rocks, and, in one area, soda-bearing hornblende syenite. The serpentine is by far the most important of the rocks in or associated directly with the Franciscan.

Age.—No fossils have been found in the Franciscan formation in the Coalinga district, and similar conclusive evidence as to its age is also lacking in other districts where it is known throughout the Coast Ranges. It antedates the Knoxville (Lower Cretaceous) and is usually considered Jurassic, but further than this little can be said regarding its age.

KNOXVILLE-CHICO ROCKS (CRETACEOUS).

General description.—The next oldest rocks exposed in the Coalinga district comprise a thick succession of sandstone, shale, and conglomerate overlying with probable unconformity the Franciscan formation and covering a wide belt for the most part west of the foothill region. They form the high hills north and south of Los Gatos and Waltham creeks and may be easily recognized by the dark, thin-bedded, compact shale and sandstone of the lower portion and the massive drab concretionary sandstone of the upper portion. These rocks are of Cretaceous age and comprise part or all of the two formations well known elsewhere on the west coast as Knoxville (Lower Cretaceous) and Chico (Upper Cretaceous). Owing to the lack of fossil or stratigraphic evidence in the Coalinga district sufficient to form the basis for a separation between these two formations, they are described together for the present.

The rocks, however, may be separated lithologically into three divisions. A marked distinction between the lower and upper portions has already been noted, and the thin-bedded shale and sandstone making up the lower portion is further divided into two parts by a conformably interbedded zone of coarser sediments and in places by several hundred feet of coarse massive conglomerate, as along Alcalde Canyon and on Juniper Ridge.

The beds above and below the conglomerate zone are the same in character, consisting of predominantly dark argillaceous shale in thin layers with partings of sandstone, but it is possible that the conglomerate zone represents an important stratigraphic separation. Chico (Upper Cretaceous) fossils have been found north of White Creek and near Alcalde in the shale at horizons higher than the conglomerate, and it is possible that the zone of coarsening in the sediments represents the base of the Chico. The beds below the conglomerate are at least 3,000 feet thick, and probably belong to the Knoxville (Lower Cretaceous).

Knoxville fossils.—No fossils of Knoxville age have been found in the Coalinga district proper, but in the Devils Den region, a short distance southeast of the Kern-Kings County line, the following characteristic Knoxville fossils have been found in a dark greenish shale, believed to be the equivalent of a part of the lower portion of the Knoxville-Chico of the Coalinga district: Pelecypoda, *Aucella crassicollis* Keyserling; Cephalopoda, *Belemnites impressus* Gabb. In addition to these two species, F. M. Anderson[a] reports a species of *Ammonites* (*Hoplites*) from the Knoxville portion of the Cretaceous in the Coalinga district or adjacent regions.

Chico fossils.—The Chico, or upper portion of the Knoxville-Chico rocks, has yielded a number of fairly representative fossils, but in most instances in a poor state of preservation. The following species, all believed to be characteristic of the Chico, have been found at one place or another within the district:

List of Chico (Upper Cretaceous) fossils from the Coalinga district.

Name.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
PELECYPODA.											
Anomia lineata Gabb		×									
Anomia lineata? Gabb					×	×					
Arca vancouverensis Meek		×									
Avicula linguæformis Evans and Shumard										×	×
Inoceramus sp. indet				×						×	
Mactra ashburneri Gabb			×								
Meekia sella Gabb			×								
Meekia sella? Gabb		×									
Nucula sp. indet										×	
Pelecypod sp	×										
Solen? sp		×									
Tellina? ooides Gabb			×								
Venus varians Gabb		×									
GASTEROPODA.											
Lunatia sp			×								
Perissolax brevirostris Gabb				×							
Volutoderma gabbi (White)			×								
CEPHALOPODA.											
Ammonites[b]				×							
Baculites chicoensis Trask	×			×				×	×		
Pachydiscus n. sp.[b]							×				

[a] Proc. California Acad. Sci., 3d ser., Geology, vol. 2, p. 161.

[b] Fragments of indeterminate ammonoids have been found by several persons in the hills northwest of Coalinga.

1. Ten miles N. 27° W. of Coalinga, at elevation of 2,600 feet, on summit of long ridge north of Los Gatos Creek; in center of SW. ¼ sec. 15, T. 19 S., R. 14 E. About 1,000 feet stratigraphically above base of Chico concretionary sandstone series in a bed of conglomerate and pebbly micaceous sandstone.
2. Hills north of Los Gatos Creek; probably same locality as 1.
3. About one-fourth mile north of 1, on the same ridge. About 600 feet stratigraphically above base of Chico concretionary sandstone series in a conglomerate bed through massive sandstone.
4. On long ridge, 3¾ miles north of junction of White and Los Gatos creeks, on north side of summit of 2,654-foot hill. Several hundred feet stratigraphically below base of Chico concretionary sandstone series in a coarse conglomerate through sandstone and shale.
5. Two miles north of White Creek, at elevation of 3,100 feet, one-fourth mile southeast of summit of 3,425-foot hill; southeast corner sec. 10, T. 19 S., R. 13 E. About 2,000 feet stratigraphically below base of concretionary sandstone series in a bed of pebbly sandstone through the shale series.
6. Two miles north of White Creek, at elevation of about 2,800 feet, on long ridge, three-fourths mile south of 3,300-foot hill; east side of NE. ¼ sec. 14, T. 19 S., R. 13 E. About 2,000 feet stratigraphically below base of Chico concretionary sandstone series in a pebbly sandstone through shale series. Probably the same horizon as 5.
7. Hills northwest of Coalinga; locality indefinite. Specimens owned by J. H. Webb.
8. Float in creek 6 miles northwest of Coalinga, north of White Creek.
9. In Alcade Hills, 3½ miles west-southwest of Coalinga in Anticline Canyon, central part of sec. 2, T. 21 S., R. 14 E. At contact of Cretaceous and Miocene in a thin bed of pebbly sandstone through thinly bedded sandstone and shale.
10. Alcalde Canyon, one-half mile southwest of Alcalde. In shale.
11. Head of Canoas Creek outside of the area mapped. About 1 to 2 miles east of the southeast end of Castle Mountain. In sandstone and shale.

The following additional species are reported by F. M. Anderson[a] from the nodular limestone in the shales below the concretionary sandstones at different points throughout the Coalinga district:

PELECYPODA.

Glycymeris veatchii Gabb+Pectunculus id.
Inoceramus whitneyi Gabb.

GASTEROPODA.

Architectonica sp.
Cinulia obliqua Gabb.
Gyrodes sp.

CEPHALOPODA.

Baculites sp.
Desmoceras sp., related to D. hoffmanni Gabb.
Lytoceras sacya Forbes.

TEJON FORMATION (EOCENE).

General description.—The Knoxville-Chico rocks are overlain unconformably by beds belonging to the Tejon (Eocene) formation. This is a marine sedimentary formation, which was named from the locality near Fort Tejon, in Kern County, where it occurs typically. It forms a belt along the western edge of the San Joaquin Valley and is exposed intermittently in the region between the type locality and the Coalinga district. No sharp line of demarcation is to be drawn between the Tejon and the underlying Chico in the northern part of the district, and in places there appears to be a gradation from the beds of the former into those of the latter, as if they had been formed during a continuous period of sedimentation.

The Tejon formation in the Coalinga district is made up entirely of sedimentary strata that dip toward the San Joaquin Valley in the monocline along the eastern flank of the mountains, and are exposed on the surface in a narrow discontinuous belt between the beds of Cretaceous which underlie them and those of the overlying Miocene. Broadly speaking, the Tejon formation here may be divided into a lower sandstone portion and an upper shale portion, but no sharp division can be made that will be applicable throughout the district under discussion. The most important and distinctive feature of the formation is the predominantly fine-grained nature of the beds toward the top as compared with those below. Where most completely exposed the Tejon comprises a thickness of 1,400 to 2,300 feet, the upper half of which is made up of thin beds of whitish and purplish, siliceous, argillaceous, and locally calcareous shale which is easily recognizable and which lends individuality to the formation. The lowermost few hundred feet are of variable sandy beds, locally fossiliferous. The upper shale is very similar—especially so in some places, as north of Coalinga—to the siliceous shale of the formation along Reef Ridge described later as the Santa

[a] Proc. California Acad. Sci., 3d ser., Geology, vol. 2, No. 2, 1905, p. 161.

Margarita(?), and the two must not be confused. Where the Tejon formation is thick the shale portion forms a greater proportion of the whole than does the sandstone, the middle beds being chiefly of fine grain. The middle beds differ from those at the top in being more argillaceous, of a darker color, less prominent, and more frequently interbedded with sandy beds.

There are three separate areas in which the Tejon is exposed; one in the oil field north of Pleasant Valley, another on the eastern border of the Alcalde Hills just west of Coalinga, and the third along Reef Ridge. Between the Alcalde Hills and Reef Ridge it is covered, as is the Cretaceous below, by the overlapping Miocene beds.

Fossils.—As indicated by the following list, the Tejon formation is well represented by fossils, which in several localities are in a fairly good or even an excellent state of preservation. Among the species collected by Robert Anderson and the writer within the Coalinga district are the following:

List of Tejon (Eocene) fossils from the Coalinga district.

Name.	4613.	4614.	4615.	4616.	4617.	4619.	4620.	4621.	4622.	4801.	5013.	5014.
FORAMINIFERA.												
Orbitolites sp. *a*					×							
ECHINODERMATA.												
Cassidulus californicus F. M. Anderson									×			
PELECYPODA.												
Barbatia morsei Gabb			×				×		×	×		
Cardium breweri Gabb			×					×	×			
Cardium cooperi Gabb					×	×						
Cardium sp. indet			×									
Corbula parilis Gabb			×			×				×		
Crassatellites grandis Gabb	×					×						
Leda gabbi Conrad						×						×
Meretrix gabbi n. sp		×						×		×		
Meretrix hornii Gabb					×		×		×			
Meretrix ovalis Gabb										×		
Meretrix uvasana Conrad			×			×						
Meretrix sp	×											
Ostrea aviculiformis F. M. Anderson										×		
Ostrea idriaensis Gabb		×						×	×	×		
Ostrea sp. indet						×	×					
Ostrea very large			×									
Petricola? n. sp										×		
Pecten interradiatus Gabb				×							×	
Pecten peckhami Gabb				×								
Placunanomia inornata Gabb			×						×	×		
Septifer dichotomus Gabb							×	×		×		
Solen parallelus Gabb					×	×						
Spondylus carlosensis F. M. Anderson		×			×							
Tellina hornii Gabb					×							
Tellina joaquinensis n. sp										×		
Tellina sp. indet						×						
Venericardia alticostata Gabb								×				
Venericardia planicosta Lamarck						×						
Venericardia sp. (small)			×									
Venericardia sp. indet		×	×									
GASTEROPODA.												
Actæon sp. indet			×									
Amauropsis alveata Conrad						×				×		
Amauropsis oviformis? Gabb					×							
Cancellaria irelaniana Cooper						×						
Cylichna costata Gabb					×							
Dentalium cooperi Gabb						×						
Fusus remondii Gabb								×				

List of Tejon (Eocene) fossils from the Coalinga district—Continued.

Name.	4613.	4614.	4615.	4616.	4617.	4619.	4620.	4621.	4622.	4801.	5013.	5014.
GASTEROPODA—continued.												
Galerus excentricus Gabb						×		×	×	×		
Loxotrema turrita Gabb							×			×		
Lunatia hornii Gabb										×		
Lunatia sp. *a*										×		
Nerita triangulata Gabb										×		
Pleurotoma domenginei n. sp						×						
Pleurotoma fresnoensis n. sp						×						
Pleurotoma gulbersoni n. sp						×						
Potamides carbonicola Cooper										×		
Rimella canalifera Gabb		×				×						
Serpulorbis sp. *a*					×							
Spiroglyphus? tejonensis n. sp					×	×						
Tritonidea kreyenhageni n. sp										×		
Tritonium californicum Gabb						×						
Turritella pachecoensis Stanton					×							
Turritella uvasana Conrad		×			×	×		×	×			
Xenophora? sp					×							

4613. About 11 miles north of Coalinga, on west side of sec. 4, T. 19 S., R. 15 E.

4614. East flank of Alcalde Hills, 3 to 4 miles northwest of Coalinga, along ridge within three-fourths mile of San Joaquin Valley coal mine, in northwest corner of sec. 26 and SE. ¼ sec. 22, T. 20 S., R. 14 E. Prominent medium-grained sandstone bed about 200 feet above contact with concretionary sandstone beds mapped as Cretaceous.

4615. High point on Reef Ridge about 1 mile south of sharp turn in Zapato Creek and 1 mile east of Sulphur Spring Canyon, in sec. 25, T. 22 S., R. 15 E. Basal conglomerate of Tejon.

4616. Eight miles due north of Coalinga, one-half mile east of Oil Canyon road, and just north of Laval grade, near center of SE. ¼ sec. 20, T. 19 S., R. 15 E. Siliceous shale in upper portion of Tejon.

4617. On southwest flank of Reef Ridge north of McLure Valley, 2½ miles south-southeast of El Cerrito oil well, in sec. 27, T. 23 S., R. 17 E.

4619. Fifteen miles north of Coalinga, southwest of Domengine's ranch.

4620. Coal mine 4½ miles northwest of Coalinga, about 1 mile north of San Joaquin mine, SW. ¼ NE. ¼ sec. 22, T. 20 S., R. 14 E. In very gypsiferous variable sand and clay overlying coal seams, 200 to 300 feet above base of formation.

4621. About 5½ miles northwest of Coalinga on point of hills (elevation 1,100 feet) south of mouth of Los Gatos Creek, in center of NE. ¼ sec. 15, T. 20 S., R. 14 E. In hard calcareous sandstone bed about 150 feet above contact with concretionary sandstone mapped as Cretaceous.

4622. Four miles west-northwest of Coalinga, on top of hill north of road and one-half mile south of San Joaquin Valley coal mine, west of center of SW. ¼ sec. 26, T. 22 S., R. 14 E. Prominent sandstone bed about 150 feet above concretionary sandstone mapped as Cretaceous.

4801. Three miles northwest of Coalinga, at San Joaquin Valley coal mine, in NW. ¼ sec. 26, T. 20 S., R. 14 E.

5013. Eight miles northwest of Coalinga, in white siliceous shale at top of Tejon formation east of center of sec. 25, T. 19 S., R. 14 E.

5014. About 13 miles north of Coalinga, on east side of sec. 29, T. 18 S., R. 15 E., in dark-colored shale just under Miocene oil sand.

To the above list of species should be added the following, among others collected by F. M. Anderson[a] in the same region:

FORAMINIFERA.

Cyclammina sp.
Lagena? sp.
Nodosaria sp.
Polymorphina sp.
Pulvulina sp.
Sagrina sp.
Vaginulina sp.

ANTHOZOA.

Ellipsosmilia granulifera Gabb (4).
Trochocyathus striatus Gabb + Trochosmilia id. (4).

BRACHIOPODA.

Terebratella sp. (2).

PELECYPODA.

Gari texta? Gabb (4).
Modiola ornata Gabb (3).

GASTEROPODA.

Cancellaria elongata Gabb (1).
Architectonica hornii Gabb (1).
Fusus diaboli Gabb (1).
Fusus martinez Gabb (1, 3).
Morio tuberculatus Gabb (4).
Neverita globosa Gabb (1, 3).

[a] Proc. California Acad. Sci., 3d ser., Geology, vol. 2, No. 2, 1905, pp. 164–166.

LOCALITIES.

1. Region southeast of Big Tar Canyon.
2. Conglomerate and coarse sandstone near base of Eocene at San Joaquin coal mine and northward to Los Gatos Creek.
3. Sandy beds associated with the carbonaceous strata above 2.
4. North of Los Gatos Creek.

Faunal relations and age.—With the exception of the new Eocene species described in this paper, certain species described by J. G. Cooper and F. M. Anderson from this region, and a few forms that occur in the Martinez or lower Eocene, the fauna of the Eocene of the Coalinga district consists of species heretofore known only from Tejon localities.

The new forms discovered by F. M. Anderson and the writer have so far escaped observation in other localities, but some of them, at least, may eventually be found elsewhere. The species occurring in the Coalinga district and also found at the type locality of the Martinez[a] are as follows:

Cardium cooperi Gabb.
Cylichna costata Gabb.
Dentalium cooperi Gabb.
Leda gabbi Conrad.
Lunatia hornii Gabb.
Morio tuberculatus Gabb.
Tellina hornii Gabb.
Turritella pachecoensis Stanton.
Venericardia planicosta Lamarck (V. hornii Gabb).

According to Merriam[a] *Cardium cooperi* is common in the Martinez and rarer in the Tejon; *Cylichna costata* is rare in the Martinez and common in the Tejon; *Dentalium cooperi* is common in the Chico (Cretaceous), Martinez, and Tejon; *Leda gabbi* is common in both the Martinez and Tejon; *Lunatia hornii* is rare in the Martinez and common in the Tejon; the occurrence of *Morio tuberculatus* is questionable in the Martinez; *Tellina hornii* is common in both the Martinez and Tejon; and *Venericardia planicosta* is common throughout the Martinez and Tejon and all through the Eocene for that matter. The *Turritella pachecoensis* from the Coalinga district is much smaller than the typical form from the Martinez. *Pecten peckhami* Gabb extends to the Miocene or even higher.

Of a total fauna of 52 recognizable species, in the Tejon of the Coalinga district, 10 are species so far known only from the district, 1 has heretofore been known only in the Martinez; 8 are found both in the Martinez and the Tejon (but all except 1 are species of which the individuals are as common or commoner in the latter than in the former); and 33 are known almost exclusively in the Tejon. It is obvious, therefore, that the bulk of the Eocene in the Coalinga district is of Tejon age, which probably represents a part of the middle Eocene. There is also evidence favoring the correlation of the fauna with the Jackson formation of Mississippi.

The faunas of all of the localities in the Tejon in the Coalinga district, with the exception of those found associated with the carbonaceous beds west of Coalinga, indicate a marine origin for the

[a] Merriam, J. C., Jour. Geology, vol. 5, 1897, p. 773.

deposits. The fauna of the carbonaceous beds (locality 4801, etc.), indicate brackish water at this locality during a part of the Tejon. This agrees with evidence from other parts of the west coast where the middle Eocene is characterized by brackish and even fresh water deposits, usually containing more or less coal. The brackish water deposits in the Coalinga district are characterized by such species as *Barbatia morsei* Gabb, *Placunanomia inornata* Gabb, *Ostrea avicularis* Anderson, and *Potamides carbonicola* Cooper.

The molluscan fauna of the white diatomaceous and foraminiferal shale at the top of the Tejon in the Coalinga district consists of *Pecten interradiatus* Gabb, *Pecten peckhami* Gabb, and *Leda gabbi* Conrad. *Leda gabbi* is a common Tejon species, while *Pecten peckhami* is so far known elsewhere only in the Oligocene, Miocene, and possibly Pliocene. *Pecten interradiatus* is known elsewhere only in shales occupying a similar stratigraphic position to the shales in which it occurs in the Coalinga district. The stratigraphic evidence is in favor of the diatomaceous shales being a part of the Tejon. The faunal evidence is about equally divided; therefore, it seems most logical that the rocks in question be assigned to the Tejon, at least until the securing of further and more definite evidence.[a]

VAQUEROS FORMATION (LOWER MIOCENE).

Distribution and character.—The unconformity at the top of the Tejon (Eocene) marks an important lapse of time before the beginning of the Miocene epoch. In the early Miocene there was deposited in the Coalinga district a sedimentary formation that is the correlative of the formation known as the Vaqueros sandstone in the region nearer the coast.

The Vaqueros sandstone in the area under discussion forms an elongated belt east of the belt of Tejon in the hills bordering the San Joaquin Valley. It consists of hard and soft sandstone, shale, and conglomerate, varying from 550 feet in the Coalinga field to 900 feet in the Kreyenhagen field, and may be easily distinguished from all other formations by the protruding tendency of the hard sandstone, known as the "reef beds," in its central portion. These beds outcrop prominently in the northern portion of the district, and in the southern portion, in the bold face of Reef Ridge, assume such prominence as to dominate the landscape. They are much more resistant to erosion than the soft associated beds, and, dipping toward the valley on the northeast at angles varying from 50° to 80° they form the scarp and double row of pinnacles with which Reef Ridge fronts the foothills.

An important distinguishing feature of the Vaqueros is that the beds at its base are the chief oil sands of the Coalinga district. In many places they are saturated and discolored with petroleum. They rest upon the eroded surface of the shale of the Tejon through-

[a] See also Anderson, F. M., Proc. California Acad. Sci., 4th ser., vol. 3, 1908, p. 16.

out most of their extent, but overlap in the Alcalde and Jacalitos hills upon the Knoxville-Chico (Cretaceous) rocks, thus hiding the Tejon (Eocene) from view. Where such overlapping occurs, the basal beds lose their petroliferous character at a distance from the Tejon.

Fossils.—Throughout the Coalinga district the Vaqueros sandstone is usually fossiliferous at one horizon or another, and yields a fauna of many species, sometimes in a fairly good state of preservation. The following species have been found by Robert Anderson and the writer in or immediately adjacent to the Coalinga district:

List of Vaqueros (lower Miocene) fossils from the Coalinga district.

Name.	4024.	4625.	4627.	4628.	4629.	4631.	4633.	4634.	4635.	4637.	4655.	4667.
PELECYPODA.												
Arca obispoana Conrad												
Arca osmonti Dall												
Cardium vaquerosensis Arnold						×						
Chione conradiana F. M. Anderson						×	×					
Chione temblorensis F. M. Anderson		×				×						
Corbicula dumblei F. M. Anderson				×	×							
Dosinia mathewsonii Gabb												
Dosinia ponderosa Gray						×						
Macoma aff. secta Conrad							×					
Macoma piercei n. sp						×						
Metis aff. alta Conrad			×			×						
Mulinia densata Conrad		×										
Mulinia densata Conrad var. minor n. var		×	×									×
Mytilus mathewsoni Gabb var. expansus Arnold												
Ostrea titan Conrad										×		
Pecten andersoni Arnold						×			×			
Pecten crassicardo Conrad												
Pecten estrellanus? Conrad											×	
Pecten miguelensis Arnold												
Phacoides acutilineatus Conrad						×						
Phacoides (Miltha) sanctæcrucis n. sp												
Saxidomus vaquerosensis n. sp			×			×						
Septifer coalingensis n. sp								×				
Tivela inezana? Conrad		×										
Venus pertenuis Gabb						×						
Yoldia impressa Conrad												
Zirphæa dentata Gabb		×	×				×					

Name.	4764.	4770.	4771.	4772.	4773.	4774.	4775.	4777.	4803.	4859.	4860.	4861.
PELECYPODA.												
Arca obispoana Conrad									×			×
Arca osmonti Dall										×		
Cardium vaquerosensis Arnold											×	
Chione conradiana F. M. Anderson												
Chione temblorensis F. M. Anderson									×		×	×
Corbicula dumblei F. M. Anderson												
Dosinia mathewsonii Gabb									×			
Dosinia ponderosa Gray												
Macoma aff. secta Conrad												
Macoma piercei n. sp												×
Metis aff. alta Conrad										×	×	×
Mulinia densata Conrad									×			
Mulinia densata Conrad var. minor n. var		×						×				
Mytilus mathewsoni Gabb var. expansus Arnold									×			×
Ostrea titan Conrad	×				×				×		×	×
Pecten andersoni Arnold	×		×	×					×		×	×
Pecten crassicardo Conrad											×	×
Pecten estrellanus? Conrad												
Pecten miguelensis Arnold	×											
Phacoides acutilineatus Conrad									×	×	×	×
Phacoides (Miltha) sanctæcrucis n. sp												×
Saxidomus vaquerosensis n. sp												
Septifer coalingensis Arnold												
Tivela inezana? Conrad												
Venus pertenuis Gabb												×
Yoldia impressa Conrad										×		
Zirphæa dentata Gabb									×			

List of Vaqueros (lower Miocene) fossils from the Coalinga district—Continued.

Name.	4624.	4625.	4627.	4631.	4633.	4764.	4770.	4772.	4774.	4775.	4803.	4859.	4860.	4861.
ECHINODERMATA.														
Scutella merriami F. M. Anderson	....	....	....	....	....	....	....	×	×	×	×	....	×	×
GASTEROPODA.														
Agasoma kernianum Cooper	....	....	....	×	×	....	....	....	....	....	....	....	....	....
Agasoma santacruzana Arnold	....	....	....	×	....	....	....	....	....	....	....	....	....	....
Bathytoma piercei n. sp	....	....	....	×	....	....	....	....	....	....	....	....	....	....
Cancellaria vetusta Gabb	....	....	....	×	....	....	....	....	....	....	....	....	....	....
Cancellaria andersoni n. sp	....	....	....	×	....	....	....	....	....	....	....	....	....	....
Conus owenianus F. M. Anderson	....	....	....	×	....	....	....	....	....	....	....	....	....	....
Conus hayesi n. sp	....	....	....	....	....	....	....	....	....	....	....	....	....	×
Crepidula sp	....	....	....	×	....	....	....	....	....	....	....	....	....	....
Ficus pyriformis Gabb	....	....	....	....	×	....	....	....	....	....	....	....	....	....
Neverita callosa Gabb	....	....	....	×	....	....	....	....	....	....	×	....	....	×
Ocinebra topangensis Arnold	....	....	....	×	....	....	....	....	....	....	....	....	×	....
Trochita filosa Gabb	....	....	×	....	....	....	....	....	....	....	×	....	....	....
Trochita sp. indet	....	....	....	×	....	....	....	....	....	....	....	....	....	×
Trophon (Forreria) bartoni n. sp	....	....	....	....	....	....	....	....	....	....	×	....	....	×
Trophon (Forreria) gabbianum F. M. Anderson	....	....	....	....	....	....	....	....	....	....	×	....	×	×
Trophon (Forreria) gabbianum F. M. Anderson var. cancellarioides n. var	....	....	....	....	....	....	....	....	....	....	....	....	....	×
Turritella ocoyana Conrad	×	×	×	×	×	....	×	....	....	....	....	....	....	×
Xylotrya sp. *a*	....	....	....	....	....	....	....	....	....	....	....	....	×	....
CIRRIPEDIA.														
Balanus sp	....	....	....	....	....	×	....	....	....	....	....	....	×	×
CRUSTACEA.														
Branchiolambrus altus Rathbun	....	....	....	....	....	....	....	....	....	....	....	×	....	....

4624. *Turritella* bed, or lower one of "reef beds," in Garza Creek gorge through Reef Ridge, southwest corner of SE. ¼ sec. 3, T. 23 S., R. 16 E.
4625. Sulphur Spring Canyon, in "reef beds," in sec. 23, T. 22 S., R. 15 E.
4627. "Reef beds" just west of Big Tar Canyon, in north part of sec. 18, T. 23 S., R. 16 E.
4628. Oil sand series, in west fork of canyon west of well 3 miles southwest of Coalinga, in sec. 12, T. 21 S., R. 14 E.
4629. Anticline Canyon, about 3 miles southwest of Coalinga, in roughly bedded gypsiferous sand overlying fossiliferous Chico, in center of sec. 2, T. 21 S., R. 14 E.
4631. *Turritella* bed on east flank of high hill northeast of Oil City, in SE. ¼ NE. ¼ sec. 16, T. 19 S., R. 15 E.
4633. *Turritella* bed about 11 miles north-northeast of Coalinga, below Big Blue, on ridge in sec. 10, T. 19 S., R. 15 E.
4634. Hill south of well about 3 miles southwest of Coalinga, in sec. 12, T. 21 S., R. 14 E.
4635. Bed just below Big Blue 1½ miles northeast of Oil City, near SE. ¼ SE. ¼ sec. 16, T. 19 S., R. 15 E.
4637. Six miles northwest of Coalinga, about 500 feet south of contact of Tejon and Miocene, in center of NE. ¼ sec. 2, T. 20 S., R. 14 E.
4655. About 3¾ miles due west of Coalinga. From prominent sandstone bed about 100 feet stratigraphically above contact of concretionary sandstone (Chico) beds with Vaqueros.
4667. "Reef beds," on Reef Ridge about 1½ miles east of Jasper Canyon, one-half mile west of 2,710-foot hill, 5½ miles south-southwest of Alcalde, in east central part of sec. 18, T. 22 S., R. 15 E., 125 feet above Cretaceous.
4764. Stone Canyon coal mine, Monterey County, Cal., 40 feet stratigraphically above the coal.
4770. *Turritella ocoyana* bed in Canoas Canyon, 1½ miles southwest of Hugo Kreyenhagen's NE. ¼ SE. ¼ sec. 32, T. 22 S., R. 16 E.
4771. *Pecten andersoni* bed in Canoas Canyon, 200 feet stratigraphically above 4770.
4772. *Scutella merriami* bed ("button beds") in Canoas Canyon, 600 feet stratigraphically above 4770.
4773. On Laval grade, 8½ miles north of Coalinga, in "oyster bed" of variable sand, just above oil sand at base of Vaqueros.
4774. On hill just east of Laval grade, 8½ miles north of Coalinga, in "button bed" about 100 feet stratigraphically above 4773; NW. ¼ sec. 21, T. 19 S., R. 15 E.
4775. Garza Creek gorge in Reef Ridge, in hard sandstone "button bed" 225 feet stratigraphically above 4624, in southeast corner of sec. 3, T. 23 S., R. 16 E.
4777. Jasper Canyon through Reef Ridge, 1½ miles southwest of fork of Jacalitos Creek, in hard sandstone and conglomerate "reef beds."
4803. On Laval grade, 8½ miles north of Coalinga, in "button bed" 200± feet above Eocene unconformity, in SW. ¼, sec. 21, T. 19 S., R. 15 E. (Practically same as 4774.)
4859. Wagonwheel Mountain, Devils Den District, Kern County, Cal., dark gypsum-bearing shale 50 feet stratigraphically below "reef" or "button bed," NW. ¼ sec. 36, T. 25 S., R. 18 E.
4860. Same locality as 4859, in hard sandstone "reef" or "button bed."
4861. Devils Den District, Kern County, Cal., in "reef beds," ¼ mile south and southeast of Barton's cabin, which is in the NW. ¼ sec. 23, T. 25 S., R. 18 E.

To this list should be added the following species, among others, collected by F. M. Anderson[a] from the Vaqueros in the Coalinga district: Gasteropoda, *Agasoma gravida* Gabb, *Crepidula prærupta*

[a] Proc. California Acad. Sci., 3d ser., Geology, vol. 2, No. 2, 1905, pp. 171–172.

Conrad, *Hemifusus wilkesana* F. M. Anderson (may possibly be same as *Ocinebra topangensis* Arnold).

Faunal relations and age.—Three distinct fossiliferous horizons are recognizable in the Vaqueros section north of Coalinga. The lower one is but a short distance above the base of the formation and is represented entirely by *Ostrea titan* Conrad (locality 4773). The middle horizon, that of the "reef beds," is about 200 feet above the base and is characterized by *Pecten andersoni* Arnold, *Arca osmonti* Dall, and *Scutella merriami* F. M. Anderson (localities 4774 and 4803). The upper horizon, which lies at the top of the Vaqueros and just below the Big Blue sandy shale, is characterized by a unique fauna, in which occur such forms as *Agasoma santacruzana* Arnold, *Cancellaria vetusta* Gabb, and *Turritella ocoyana* Conrad. The fauna at locality 4631 is characteristic of the last horizon.

In the Coalinga district the correlation of the sandstone formation of which the "reef beds" are a part, with the Vaqueros formation of the outer Coast Ranges, is based on the large number of species common to the two. At one point in particular on the northeastern flank of the Temblor Range, near Antelope Valley, in sec. 36, T. 26 S., R. 17 E., a few miles south of the south line of the district, the "reef beds" contain a typical Vaqueros fauna with such forms as *Pecten magnolia* Conrad, *Turritella inezana* Conrad, *Pecten bowersi* Arnold, and many other typical Vaqueros species. The region from which this fauna comes is believed by the writer to mark an old lower Miocene strait joining the water of the San Joaquin lower Miocene sea with the lower Miocene sea which once covered much of the territory now occupied by the outer Coast Ranges.

F. M. Anderson[a] gave the name "Temblor beds" to the lower Miocene in the northeast side of the Coast Ranges, from the Temblor Ranch north to Coalinga, but has since[b] recognized the correlation of these beds with those of the Vaqueros (lower Miocene) of the outer Coast Ranges.

The Vaqueros fauna that is characterized particularly by *Turritella ocoyana* Conrad is best developed in the San Joaquin Valley[c] and in the region of the Santa Monica[d] and Santa Ana ranges of southern California. The Vaqueros fauna that is characterized by *Turritella inezana* Conrad is best developed in the Santa Cruz,[e] Santa Lucia[f] and Santa Ynez[g] mountains.

The assignment of a lower Miocene age to the Vaqueros formation is based on the general similarity of certain members of its fauna to

[a] Proc. California Acad. Sci., 3d ser., Geology, vol. 2, p. 170.

[b] Proc. California Acad. Sci., 4th ser., vol. 3, p. 39.

[c] Anderson, F. M., Proc. California Acad. Sci., 3d ser., Geology, vol. 2, p. 188, lists of Vaqueros fossils from Kern River.

[d] Arnold, Ralph, Proc. U. S. Nat. Mus., vol. 32, pp. 525–526.

[e] Haehl, H. L., and Arnold, Ralph, Proc. Am. Philos. Soc., vol. 43, 1904, p. 20; Arnold, Ralph, Proc. U. S. Nat. Mus., vol. 34, 1908, p. 350.

[f] Hamlin, Homer, Water-Supply Paper U. S. Geol. Survey No. 89, 1904, p. 14.

[g] Arnold, Ralph, Smithsonian Misc. Coll., vol. 50, pt. 4, p. 421.

species in the lower Miocene of the Atlantic States and on its relative position in the geologic column of the Pacific coast. This correlation, first made by Conrad, has, so far as the writer is aware, never been questioned.

SANTA MARGARITA (?) FORMATION (UPPER ~~MIDDLE~~ MIOCENE).

General description.—A zone of beds full of very large fossil oysters and barnacles runs through the midst of the developed oil territory in the Eastside Coalinga oil field and is well known to those familiar with the region. Its fossils show that it belongs in the same portion of the geologic column as the Santa Margarita formation[a] in San Luis Obispo County, nearer the coast. This formation belongs in the upper part of the middle Miocene. No fossils have been found in the beds immediately below or above the *Tamiosoma* zone (as the fossil beds referred to may be termed from the typical occurrence in them of the large barnacle of that genus); but these beds, for a thickness of several hundred feet, are mapped in the same formation with the fossil beds, because they are closely associated with them and to all appearances form a part of the same succession.

The beds carrying Santa Margarita fossils are traceable only as far south as the San Joaquin coal mine. Beyond that the beds are either lacking or are unfossiliferous, so that it can not positively be stated that they are the same. In a region such as this, where the beds are so variable from place to place and the different formations are so similar, the fossils furnish the only evidence of contemporaneity that holds good. In the Kreyenhagen field, therefore, where the portion of the succession between the Vaqueros (lower Miocene) and Jacalitos (upper Miocene), corresponding to the portion occupied by beds carrying Santa Margarita fossils farther north, is made up of unfossiliferous, hard, largely white, siliceous shales, it can not be stated definitely whether or not these beds belong to the same formation. The break in the geologic column between the Vaqueros (lower Miocene) and Jacalitos (upper Miocene) is great, covering the whole of middle Miocene time, and is represented only in its later part by the *Tamiosoma* zone and associated beds. The Monterey formation (early middle Miocene) of the region nearer the coast is lacking. It is possible that the beds overlying the Vaqueros in the two parts of the Coalinga district represent different divisions of the later part of the middle Miocene period, that in the Kreyenhagen Hills being perhaps the younger.

The Santa Margarita(?) formation in the region 9 miles north of Coalinga is about 900 feet thick, consisting of 300 feet of soft fine sand and clay at the base called the Big Blue, above this 175 feet of fossiliferous sand of varying consistency called the *Tamiosoma* zone, and still farther up 400 or 500 feet of alternating beds of sand and

[a] Fairbanks, H. W., Geol. Atlas U. S., San Luis folio (No. 101), U. S. Geol. Survey, 1904.

gravelly sand. In the region of Reef Ridge the Santa Margarita(?) (believed to be a somewhat higher portion than that just described) consists of 400 feet of fairly hard purplish shale at the base, 250 feet of hard siliceous thinly bedded shale in the middle, and 400 feet of brownish shale and intercalated sands at the top.

Fossils.—The Santa Margarita(?) formation, from a point 8 or 9 miles north of Coalinga northwestward for a distance of at least 6 or 8 miles, is exceedingly fossiliferous, the principal species being the big oyster *Ostrea titan* Conrad, the big barnacle-like *Tamiosoma gregaria* Conrad, and the scallop shell *Pecten estrellanus* Conrad. The names *Tamiosoma* zone and "big oyster beds" have been locally applied to these fossiliferous strata. Among the species found in this bed by James H. Pierce, Robert Anderson, and the writer are the following, which comprise the fauna for this formation in the district.

List of Santa Margarita (upper middle Miocene) fossils from the Coalinga district.

Name.	4632.	4651.	4766.	4805.	4841.	4842.	4848.
ECHINODERMATA.							
Astrodapsis whitneyi Rémond			×				
PELECYPODA.							
Chione conradiana F. M. Anderson							×
Cryptomya ovalis ? Conrad	×						
Dosinia ponderosa Gray	×						
Hinnites giganteus Gray		×	×				
Macoma nasuta Conrad	×	×					
Ostrea titan Conrad	×	×	×	×	×	×	
Pecten crassicardo Conrad			×			×	
Pecten estrellanus Conrad		×	×		×	×	
Solen sicarius Gould	×						
Zirphæa dentata Gabb	×						
GASTEROPODA.							
Trophon (Forreria) carisaensis F. M. Anderson			×			×	
CIRRIPEDIA.							
Tamiosoma gregaria Conrad	×	×	×			×	

4632. At and northwest of San Joaquin Valley coal mine near Miocene-Eocene contact.
4651. *Tamiosoma* zone or "big oyster bed" in canyon between old Standard Oil Company and California Oil fields Limited camps, sec. 28, T. 19 S., R. 15 E., 8 miles north-northeast of Coalinga.
4766. *Tamiosoma* zone or "big oyster bed" above Big Blue, NE. ¼ sec. 21, T. 19 S., R. 15 E., west of Peerless Oil property, 9 miles north of Coalinga.
4805. Waltham Valley, 13 miles southwest of Coalinga; oyster bed 2 miles west of Elmer Frame's house; sandstone under shale.
4841. Sandstone next to serpentine, at head of Bray and Secords canyon, 3 miles south of Waltham Valley.
4842. Sandstone at mouth of Bray and Secords Canyon, south side of Waltham Valley, 15 miles west of Coalinga. This sandstone underlies the shale in this vicinity.
4848. Nine miles north-northeast of Coalinga, just above *Tamiosoma* zone or "big oyster bed," one-fourth mile northwest of Peerless wells.

Faunal relations and age.—The fauna of these beds, though small, is one of the most characteristic in the southern Coast Ranges. The association and abundance of certain unique species, such as *Tamiosoma gregaria* Conrad, *Trophon (Forreria) carisaensis* F. M. Anderson, and *Pecten estrellanus* Conrad, suggest correlation with the Santa Margarita formation of the Salinas Valley and Carrizo Plain. The correlation of the siliceous shale in Reef Ridge with the Santa Margarita is based upon the similar stratigraphic position of

these shales to beds on the west side of Waltham Valley, near the mouth of Bray and Secords Canyon, which overlie sandstones at locality 4842, containing the following Santa Margarita fauna:

Mytilus aff. mathewsonii Gabb.
Ostrea titan Conrad.
Pecten crassicardo Conrad.
Pecten estrellanus Conrad.
Tamiosoma gregaria Conrad.
Trophon (Forreria) carisaensis F. M. Anderson.

For a number of years the Santa Margarita formation was believed to be the equivalent of the San Pablo formation of the Mount Diablo region, but the stratigraphic work in the Coalinga district has shown it to be older. It is quite evident that the Etchegoin formation represents at least a considerable part of the San Pablo, and as the Etchegoin lies well above the beds containing the Santa Margarita fossils it seems likely that the Santa Margarita formation is, in part, of greater age than the San Pablo.

With the Etchegoin and Jacalitos formations classified as upper Miocene it seems most logical to place the Santa Margarita in the upper part of the middle Miocene, thus confining the Monterey to the lower part of the middle Miocene. Such an arrangement would consign the far-reaching post-Monterey diastrophic period to the middle of the Miocene. This classification and correlation is of course more or less arbitrary and necessarily tentative, but it seems to best fit the information now in hand.

JACALITOS FORMATION (EARLY ~~UPPER MIOCENE~~ Pliocene).

At most localities along the flanks of the Diablo and Temblor ranges south of the Coalinga district it is impossible to separate the post-Santa Margarita(?) Tertiary formations, and to these beds—the equivalent of the Jacalitos, Etchegoin, and possibly Tulare formations of the Coalinga district—the name McKittrick formation[a] has been given in the McKittrick district. This name was chosen because of the importance of the beds in that district, the basal members yielding the petroleum found in the productive McKittrick field.

General description.—The formation overlying the Santa Margarita(?) in the Kreyenhagen Hills, which consists of about 3,600 feet of sand, gravel, clay, and sandstone, in places very fossiliferous, was formed in earlier upper Miocene time. It has been named the Jacalitos formation, owing to its characteristic exposures both north and south of the creek of that name. Abundant and well-preserved fossils, by means of which its age is determined, occur in the type locality. It is probably the equivalent of parts of one or more of the upper Miocene formations known in other parts of the State, but its definite relations to these have not yet been worked out. It is in part represented in the northern portion of the district by similar beds aggregating a much smaller thickness.

[a] Arnold, Ralph, and Johnson, H. R., Preliminary report on the McKittrick-Sunset oil region, California: Bull. U. S. Geol. Survey No. 406 (in press).

In the field this formation does not stand out prominently as a lithologic or stratigraphic unit and is not readily distinguishable by itself. On the contrary, it forms merely a portion of the great thickness of apparently conformable Tertiary beds that are exposed in the great monocline, dipping at medium and high angles toward the valley. The formation may be roughly distinguished as that portion of the series between the shale of the Santa Margarita(?) below and the major beds of blue sand that characterize the lower part of the formation above it (the Etchegoin) throughout the district. The Jacalitos, however, includes a great thickness of blue sand beds at its summit in the southeastern part of the Kreyenhagen Hills. A feature of this formation is the occurrence in it at intervals of hard zones that project like saw teeth and by their resistance protect the beds immediately above and below them, thus forming long parallel ridges. The same feature is in a greater measure characteristic of the Vaqueros sandstone and Santa Margarita (?) formation below and less so of the Etchegoin (uppermost Miocene) formation above. Another feature of the Jacalitos is the great number of sand and pebble beds, full of sea urchins, that are found in all parts of the formation. This feature is likewise one belonging to the formation above. The most important features, however, and the only ones that can be relied on to separate the Jacalitos from the other sandy formations, are its stratigraphic position and its fossils.

The Jacalitos in the Kreyenhagen Hills is probably unconformable with the Santa Margarita (?) below, although the two formations appear conformable at the contact, and the line between them is arbitrarily drawn where the beds that are predominantly shale (Santa Margarita ?) give place to beds that are sandy (Jacalitos). In the northern part of the district the relation of these two formations appears also to be one of conformity, although the overlap of the Jacalitos on the Vaqueros near Oil Canyon indicates that it is the opposite. The line there also is drawn arbitrarily at the base of the prominent pebble zone full of fossil wood. The Jacalitos is likewise conformable to all appearances with the later Miocene (Etchegoin) beds which rest above it and are largely similar to it in composition, the line between these two formations being likewise drawn somewhat arbitrarily, chiefly on the basis of the fossil contents. There is a possibility that an unconformity between these two formations exists in the hills surrounding Pleasant Valley.

From its locality of typical occurrence in the Kreyenhagen and Jacalitos hills the Jacalitos formation extends southwestward into McLure Valley, where it occupies a similar position between the underlying Santa Margarita (?) and the overlying Etchegoin sands. Toward the northwest it reaches into the interior of the Diablo Range through the depression formed by the Waltham syncline and toward the north it extends across Alcalde Canyon into the region around Pleas-

ant Valley. North of Jacalitos Creek it no longer rests upon the shale of the Santa Margarita (?), that formation being lacking, and the Jacalitos ceases to be completely represented. The relations of the beds of this age in the northern and southern portions of the district are complex and can be deciphered only on the basis of detailed paleontologic evidence. The formation will be considered separately for the areas lying to the south and to the north of Waltham Creek.

Although the major part of the Jacalitos formation is known by its fossils to be of marine origin, the evidence offered by the fossilized wood and extinct horse teeth and bones found abundantly in certain of the conglomeratic layers leads to the conclusion that at least some of the beds are probably of terrestrial or fluviatile origin.

During the past summer H. R. Johnson and the writer discovered a characteristic Jacalitos fauna in soft sandstones exposed in the low hills in sec. 34, T. 31 S., R. 21 E., 1 mile south of White's, at the northwest end of the Elkhorn Plain, eastern San Luis Obispo County. This region is about 75 miles southeast of the type locality, thus showing that the Jacalitos has at least fairly widespread distribution.

Fossils.—Like the Etchegoin, which lies above it and with which it is closely allied, the Jacalitos is fossiliferous in many localities in the Coalinga district and vicinity, especially in the Waltham Valley, 13 miles southwest of Coalinga. In the upper part of the formation the fossils are usually in a very good state of preservation; in the lower part the original shell has usually been leached out and replaced by other material and some of the fossils are simply casts.

The following species have been found in the Jacalitos formation in the Coalinga district or in the Waltham Valley:

List of Jacalitos (upper Miocene) fossils from the Coalinga district.

Name.	4636.	4638.	4639.	4640.	4642.	4644.	4645.	4646.	4647.	4649.	4650.
ECHINODERMATA.											
Astrodapsis jacalitosensis n. sp.											
Echinarachnius gibbsii Rémond		×	×		×					×	
PELECYPODA.											
Arca trilineata Conrad				×							
Cardium meekianum Gabb											
Cardium sp. *a*											
Cardium sp.			×								
Chione securis Shumard					×						
Chione sp. indet.											
Cryptomya ovalis? Conrad		×									
Diplodonta harfordi? F. M. Anderson											
Diplodonta parilis Conrad											
Diplodonta sp. indet.	×										
Dosinia jacalitosana n. sp.											
Glycymeris sp. indet.	×										
Macoma secta Conrad											
Macoma jacalitosana n. sp.											
Macoma vanvlecki n. sp.											
Macoma sp. *a*											
Metis alta? Conrad				×							
Metis sp.											
Monia macroschisma Deshayes					×						
Mulinia densata Conrad								×			
Mytilus (Mytiloconcha) coalingensis n. sp.											
Ostrea atwoodi Gabb											
Panopea generosa Gould			×							×	

List of Jacalitos (upper Miocene) fossils from the Coalinga district—Continued.

Name.	4636.	4638.	4639.	4640.	4642.	4644.	4645.	4646.	4647.	4649.	4650.
PELECYPODA—continued.											
Panopea estrellana Conrad											
Paphia staleyi? Gabb (+ Tapes id.)		×	×								
Paphia jacalitosensis n. sp											
Paphia aff. tenerrima Carpenter											
Pecten estrellanus Conrad				×	×	×			×		×
Pecten crassicardo Conrad					×						
Pecten oweni Arnold									×		
Saxidomus nuttalli Conrad				×				×			
Schizodesma abscissa Gabb											
Schizothærus pajaroanus Conrad		×	×	×						×	
Tellina aragonia Dall											
Thracia jacalitosensis n. sp											
Zirphæa dentata Gabb											
GASTEROPODA.											
Chrysodomus imperialis Dall											
Chrysodomus portolaensis Arnold											
Crepidula princeps Conrad											
Lunatia lewisii? Gould									×		
Margarita johnsoni n. sp											
Melongena sp. *a*											
Neverita recluziana Petit											
Neverita sp											
Thais crispatus Chemnitz											
Thais kettlemanensis n. sp											
Trophon (Forreria) ponderosum Gabb		×			×		×			×	
CIRRIPEDIA.											
Balanus sp											
Tamiosoma gregaria? Conrad											
PISCES.											
Fish vertebræ											
MAMMALIA.											
Pliohippus sp. *a*											

Name.	4652.	4653.	4654.	4745.	4745a.	4746.	4747.	4763.	4765.	4767.	4784.	5015.
ECHINODERMATA.												
Astrodapsis jacalitosensis n. sp			×	×								
Echinarachnius gibbsii Rémond					×	×	×		×	×		
PELECYPODA.												
Arca trilineata Conrad								×	×			
Cardium meekianum Gabb								×	×			
Cardium sp. *a*									×	×		
Cardium sp												
Chione securis Shumard		×						×				
Chione sp. indet												
Cryptomya ovalis? Conrad												
Diplodonta harfordi ? F. M. Anderson				×								
Diplodonta parilis Conrad								×	×			
Diplodonta sp. indet												
Dosinia jacalitosana n. sp								×				
Glycymeris sp. indet												
Macoma secta Conrad									×			
Macoma jacalitosana n. sp									×			
Macoma vanvlecki n. sp								×	×			
Macoma sp. *a*								×				
Metis alta? Conrad								?				
Metis sp				×								
Monia macroschisma Deshayes										×		
Mulinia densata Conrad								×	?			
Mytilus (Mytiloconcha) coalingensis n. sp	×											
Ostrea atwoodi Gabb										×		
Panopea generosa Gould		×						×	×			
Panopea estrellana Conrad									×			
Paphia staleyi? Gabb (+ Tapes id.)												
Paphia jacalitosensis n. sp									×			
Paphia aff. tenerrima Carpenter									×			
Pecten estrellanus Conrad	×			×		×			×	×		
Pecten crassicardo Conrad												
Pecten oweni Arnold		×								×		
Saxidomus nuttalli Conrad												

List of Jacalitos (upper Miocene) fossils from the Coalinga district—Continued.

Name.	4652.	4653.	4654.	4745.	4745a.	4746.	4747.	4763.	4765.	4767.	4784.	5015.
PELECYPODA—continued.												
Schizodesma abscissa Gabb									×			
Schizothærus pajaroanus Conrad												
Tellina aragonia Dall									×			
Thracia jacalitosensis n. sp								×				
Zirphæa dentata Gabb				×								
GASTEROPODA.												
Chrysodomus imperialis Dall										×		
Chrysodomus portolaensis Arnold								×	×	×		
Crepidula princeps Conrad								×				
Lunatia lewisii? Gould								×				
Margarita johnsoni n. sp									×			
Melongena sp. *a*				×								
Neverita recluziana Petit								×				
Neverita sp									×			
Thais crispatus Chemnitz								×				
Thais kettlemanensis n. sp								×	×			
Trophon (Forreria) ponderosum Gabb				×					×			
CIRRIPEDIA.												
Balanus sp				×					×	×		
Tamiosoma gregaria? Conrad										?	×	
PISCES.												
Fish vertebræ		×										
MAMMALIA.												
Pliohippus sp. *a*												×

4636. Hill 4 miles N. 85° W. of Coalinga, not far from contact with concretionary sandstone beds mapped as Cretaceous (Chico); on west side of sec. 35, T. 20 S., R. 14 E. Lower beds.

4638. Three hundred feet east of nose of 1,300-foot ridge, three-fourths mile southeast of Alcalde; in center of sec. 24, T. 21 S., R. 14 E. Olive-gray gypsiferous sand overlying white shale bed, about 700 or 800 feet stratigraphically below top of the Jacalitos formation as mapped. Upper beds.

4639. About 2 miles south of Alcalde on south side of 1,548-foot hill; in sand immediately above and below white shale bed; in sec. 25, T. 21 S., R. 14 E. Same horizon as 4638, upper beds.

4640. Near Commercial Petroleum well, 3 miles southwest of Coalinga. Upper beds.

4642. About 20 miles south of Coalinga, in Kreyenhagen Hills. Gray sand 500 feet southwest of top of 1,053-foot hill, four-fifths mile southwest of El Cerrito oil well; in NW. ¼ SW. ¼ sec. 15, T. 23 S., R. 17 E. *Pecten estrellanus* zone, or upper beds.

4644. Southeast base of 1,300-foot hill, on north side of Jacalitos Creek, just north of old adobe house two-thirds mile above fork of Salt Creek, in center of south side of sec. 31, T. 21 S., R. 15 E. Upper beds.

4645. One mile west of Garza Creek on top of ridge north of Clark's place, in NW. ¼ NE. ¼ sec. 3, T. 23 S., R. 16 E.; "big *Trophon* zone," about 900 or 1,000 feet stratigraphically above shale of Santa Margarita (?) formation. Lower beds.

4646. About 3 miles west of Coalinga, just north of Commercial Petroleum well No. 1, in canyon. Upper beds.

4647. On top of ridge between Salt Creek and Jacalitos Creek, about 5 miles south-southeast of Alcalde, at elevation of 1,300 feet, on north line of sec. 6, T. 22 S., R. 15 E., hard sandstone layer through pebbly olive-gray sand. "*Pecten estrellanus* zone" about 700 to 800 feet stratigraphically below summit of formation. One of the typical Jacalitos localities. Upper beds.

4649. West point of 1,308-foot ridge three-fourths mile southeast of Alcalde, SW. ¼ NE. ¼ sec. 24, T. 21 S. R. 14 E. Middle beds.

4650. Lowest fossil bed on west face of 1,900-foot hill southeast of Alcalde. Middle beds.

4652. On point of ridge three-fourths mile south-southwest of Alcalde, one-fourth mile south of south bend in road, SE. ¼ sec. 23, T. 21 S., R. 14 E. Middle beds.

4653. Nearly 4 miles southwest of Coalinga, one-third mile south of Commercial Petroleum well at point of hills on north side of Waltham Creek, just east of Anticline Canyon road, in very southwest corner of sec. 7, T. 21 S., R. 15 E. Upper beds.

4654. On Jacalitos Creek, one-half mile above confluence with Jasper Canyon, on south side of sec. 1, T. 22 S., R. 14 E. Lower beds.

4745. On ridge south of Garza Creek, 1 mile southeast of Clark's place, NE. ¼ SW. ¼ sec. 2, T. 23 S., R. 16 E.; "big *Trophon* zone" about 800 feet stratigraphically above shale of the Santa Margarita (?) formation. Lower beds.

4745*a*. "Big *Echinarachnius gibbsii* zone" about 800 feet stratigraphically above 4745, in NW. ¼ SE. ¼ sec. 2, T. 23 S., R. 16 E. Middle beds.

4746. Sixteen hundred feet stratigraphically above 4745 on ridge east of Garza Creek, NE. ¼ sec. 2, T. 23 S., R. 16 E. Upper beds.

4747. Same locality as 4746, 150 feet stratigraphically higher. "*Pecten estrellanus* bed," or upper beds.

4763. Southwest of Coalinga district, on little ridge 200 yards north of Stone Canyon–Waltham Creek road where it crosses a little stream before reaching Waltham Valley from the west. Undifferentiated zone.

4765. "Big *Trophon* zone" on Jasper Creek just above fork of confluence with Jacalitos Creek, on west side of center of SW. ¼ sec. 6, T. 22 S., R. 15 E. About 2,000 feet stratigraphically below summit of formation. One of the typical Jacalitos localities. Lower beds.

4767. On southeast side of Canoas Creek, three-eighths mile above Hugo Kreyenhagen's house, in NW. ¼ SW. ¼ sec. 27, T. 22 S., R. 16 E. *Pecten estrellanus* zone, or upper beds. Abundance of beautifully preserved specimens.

4784. On Jacalitos Creek, about 7 miles south of Coalinga; shaly sandstone a few hundred feet stratigraphically above "big *Trophon* zone" of 4765.

5015. Basal Jacalitos gravel bed, SE. ¼ sec. 15, T. 19 S., R. 15 E., northeast of Octave oil wells.

Faunal zones.—Three fairly easily distinguishable fossiliferous zones occur in the Jacalitos. The lowest one of these, sometimes called the "big *Trophon* zone," is characterized by such forms as *Trophon* (*Forreria*) *ponderosum* Gabb, *Macoma vanvlecki* n. sp., *Panopea estrellana* Conrad, *Dosinia jacalitosana* n. sp., and *Astrodapsis jacalitosensis* n. sp. The fauna of this zone is typically developed at locality 4765. The same zone is also represented at localities 4636, 4645, 4654, 4745, 4763, 4765, and 5015.

The middle zone has a less well characterized fauna but usually yields very large specimens of *Echinarachnius gibbsii* Rémond, and *Panopea generosa* Gould, and *Schizothærus pajaroanus* Conrad. It is represented by localities 4646 (?), 4649, 4650, 4652, 4653 (?), and 4745*a*.

The upper zone, or "*Pecten estrellanus* zone" as it is sometimes referred to, is characterized by large specimens of *Pecten estrellanus* Conrad, *Pecten oweni* Arnold, and large individuals of *Echinarachnius gibbsii* Rémond. The species common to this zone are beautifully preserved at locality 4767. The zone is also represented at localities 4638, 4639, 4640, 4642, 4644, 4646, 4647, 4653, 4746, 4747, and 4767.

Faunal relations and age.—The fauna of the Jacalitos formation not only contains a considerable number of unique species, but the association in it of species known elsewhere in other formations is peculiar.

Species characteristic of or found more commonly in the Jacalitos, in addition to the new species described from it in the present paper, are *Chione securis* Shumard, *Echinarachnius gibbsii* Rémond, large variety, *Melongena* sp. *a*, *Schizodesma abscissa* Gabb, *Tellina aragonia* Dall, and *Trophon* (*Forreria*) *ponderosum* Gabb.

Species which are found in the Jacalitos and in the Santa Margarita formation and which, it is believed, do not extend into the overlying Etchegoin, except possibly in rare instances, are *Pecten estrellanus* Conrad, *Pecten crassicardo* Conrad, *Tamiosoma gregaria?* Conrad, and *Zirphæa dentata* Gabb.

Species which are common to the Jacalitos and the overlying Etchegoin but which are not found in the Santa Margarita are *Arca trilineata* Conrad, *Cardium meekianum* Gabb, *Cryptomya ovalis?* Conrad, *Diplodonta harfordi* F. M. Anderson, *Diplodonta parilis* Conrad, *Echinarachnius gibbsii* Rémond, *Chrysodomus portolaensis* Arnold, *Macoma secta* Conrad, *Monia macroschisma* Deshayes, *Mytilus* (*Mytiloconcha*) *coalingensis* n. sp., *Ostrea atwoodi* Gabb, *Pecten oweni* Arnold, *Schizothærus pajaroanus* Conrad, *Paphia staleyi?* Gabb, and *Paphia tenerrima* Carpenter.

Thais kettlemanensis n. sp. should properly belong in the list of those species unique to the Jacalitos, as it occurs in the Etchegoin only at the type locality of the species (locality 4780, which is included in the general locality 4779), on the axis of the Coalinga anticline and in beds below the lowest fossiliferous Etchegoin horizon. It is, however, abundant toward the base of the Jacalitos.

The Jacalitos may be defined as a formation embracing about 3,600 feet of sand, gravel, clay, and sandstone, lying between the Santa Margarita (?) below and the Etchegoin above, and containing in its fauna among others at least 15 species which are unique, 4 which are common to it and the Santa Margarita but do not extend up into the Etchegoin, and 15 which are common to it and to the Etchegoin but are not found in the Santa Margarita. In age the Jacalitos is believed to belong to the lower part of the upper Miocene. It has a known range of about 75 miles along the Diablo and Temblor ranges, from Coalinga to the Elkhorn plain. Whether it will be possible to recognize the fauna outside of this area is not known; for the present it seems advisable to use the name only in a local way, and in the general geologic column to place it tentatively as an equivalent for the upper part of the Santa Margarita and the lower part of the San Pablo.

ETCHEGOIN FORMATION (~~UPPERMOST MIOCENE~~).

General description.—The Etchegoin formation is the succession of slightly consolidated beds of sand, gravel, and clay occurring on the summit and flanks of Anticline Ridge and on the southeast end of Joaquin Ridge north of Coalinga, above the base of the hill-forming sandstone beds (referred to for convenience as the *Glycymeris* zone), and below the beds described as the Tulare formation. Strata in other portions of the Coalinga district are referred to the Etchegoin formation on the basis of paleontologic correlation with the beds on Anticline Ridge.

The *Glycymeris* zone is an extremely fossiliferous bed of somewhat indurated sand that forms the summit of the hill at the northwest end of Anticline Ridge (in the NW. ¼ SW. ¼ sec. 34, T. 19 S., R. 15 E.) and extends continuously from that point along the line mapped [a] as the base of the Etchegoin formation. It is underlain at the locality referred to by clay that is classed in the Jacalitos formation and is overlain by a thick succession of bluish-gray sand beds interbedded with dark-gray sand. The zone affords almost perfect specimens of many species of fossils that make up a distinctive fauna. It is called the *Glycymeris* zone for ease of reference, because it is an important datum line that may be recognized by the association of fossils contained in it.

There are various reasons for assuming this zone to be the base of the formation. First, an unconformity is known to occur below it in the synclinal basin north of White Creek, for there a zone containing the same fauna rests directly upon Cretaceous (Chico) sandstone; and somewhere between Oil Canyon and the Cretaceous area an overlap of the *Glycymeris* zone upon the underlying Cretaceous beds must exist. It is therefore appropriate to consider the beds above the base of the *Glycymeris* zone as a distinct formation,

[a] Bull. U. S. Geol. Survey No. 357, 1908, Pl. I.

although on Anticline Ridge and in the greater portion of their extent in the region north of Coalinga, as well as to the south as far as they have been studied, they appear to rest conformably upon the beds below. A further reason for assuming this zone as the base is that it is at the bottom of a succession of bluish sand beds on Anticline Ridge and at some other places in the Coalinga district, thus marking a sharp and easily recognizable variation in lithology between the beds below and above it. At other places, however, especially in the southern portion of the Kreyenhagen Hills, the blue sands occur also far below the *Glycymeris* zone, so that the lithologic feature can not be relied upon everywhere as a basis of separation.

In the description of the Jacalitos (early upper Miocene) frequent reference has been made to the overlying Etchegoin (late upper Miocene). In fact, these formations are so closely related and so similar that the one can not well be described without reference to the other. In places they seem to have originated as a chronologically continuous succession of marine deposits and are only arbitrarily separable, whereas in other places an overlap of the latter upon the Cretaceous has taken place. Many of the features of structure, influence on topography, and lithologic variability mentioned in connection with the former exist also in the latter.

The Etchegoin formation consists of slightly consolidated sand, clay, and gravel, interbedded with occasional indurated beds, and is characterized by an abundance of invertebrate fossils, among which a few forms, like sand dollars (*Echinarachnius*), barnacles (*Balanus*), *Mulinia*, *Arca*, *Mya*, small oysters, *Neverita*, etc., are particularly prevalent. It reaches a thickness of over 3,500 feet in the southern portion of the district, but in the northern portion it is at most only half as thick. It may be most easily recognized by the dominant grayish-blue color of the massive sand beds that comprise a thickness of several hundred feet at its base, but an examination of its characteristic fossils is the only means of distinguishing it accurately from the associated formations.

One of the most important of its broad features in the Coalinga district is the usual predominance of coarse material, such as sand and pebbly deposits, in its lower portion, and of finer material, such as extremely fine sand and clay, in its upper portion; but this feature varies with the locality, and in some places is hardly noticeable.

Fossils.—Fossils are more or less abundant and usually in an excellent state of preservation throughout the Etchegoin formation in the Coalinga district. Several recognizable horizons, each carrying a more or less distinctive fauna, occur between the base and top of the formation, but these faunas are so closely related and of such local extent that they have not been deemed worthy of recognition in the mapping of the formation. The following species have been found by Robert Anderson and the writer in the district under discussion:

List of fossils from the Etchegoin (uppermost Miocene) formation, Coalinga district.

Name.	3849.	4643.	4648.	4656.	4657.	4658.	4659.	4660.	4661.	4662.	4663.	4664.	4665.	4669.	4670.	4671.	4672.	4673.	4674.	4675.	4676.	4677.	4678.	4679.	4681.	4682.	4683.	4684.	4688.	4690.
ANTHOZOA.																														
Astrangia coalingensis Vaughan																														
ECHINODERMATA.																														
Astrodapsis cf. tumidus Rémond																														
Astrodapsis sp. *a*																														
Echinarachnius gibbsii Rémond	×	×			×				×	×						×		×	×				×					×	×
Scutella perrini Weaver																														
BRACHIOPODA.																														
Terebratalia occidentalis Dall																														
Terebratalia smithi Arnold																														
PELECYPODA.																														
Arca trilineata Conrad			×	×				×		×		×	×		×			×		×			×	×						
Arca sp. *a*																														
Cardium coosense Dall								×												×										
Cardium meekianum Gabb								×					×								×		×	×						
Cardium sp. indet																														
Chama pellucida Broderip																														
Clidiophora punctata Conrad																														
Cryptomya ovalis Conrad																														
Cryptomya quadrata n. sp													×																	
Cumingia californica Conrad				×																										
Diplodonta harfordi F. M. Anderson																														
Diplodonta parilis Conrad																														
Glycymeris coalingensis n. sp				×					×			×					×												
Glycymeris septentrionalis Middendorf					×		×	×		×								×										×	
Glycymeris sp. indet																			×											
Macoma inquinata Deshayes				×												×		×					×	×						
Macoma nasuta Conrad				×									×																	
Macoma secta Conrad																														
Macoma sp. *a*																														
Mactra albaria Conrad													×																	
Mactra coalingensis n. sp													×																	
Metis sp. indet															×															
Modiolus directus Dall																														
Modiolus rectus Conrad				×																										
Mulinia densata Conrad		×		×	×		×																×	×	×	×	×	×		
Mya japonica Jay													×								×	×	×							
Mytilus (Mytiloconcha) coalingensis n. sp				×		×		×				×				×	×							×					×	

Nucula castrensis Hinds																															
Ostrea atwoodi Gabb		×	×									×												×	×						
Ostrea lurida Carpenter																															
Ostrea vespertina Conrad																															
Ostrea vespertina Conrad var. sequens n. var.																															
Ostrea sp.												×																			
Panopea generosa Gould						×								×																	
Paphia staleyi? Gabb		×		×	×	×						×													×						
Paphia tenerrima Carpenter				×				×		×		×	×																		
Paphia truncata? Gabb				×																											
Pecten coalingaensis Arnold																															
Pecten deserti Conrad																															
Pecten nutteri Arnold																															
Pecten oweni Arnold				×			×	×		×	×	×		×																	
Pecten wattsi Arnold												×																			
Pecten wattsi Arnold var. etchegoini F. M. Anderson																															
Phacoides acutilineatus Conrad												×																			
Pholadidea ovoidea Gould																															
Placunanomia californica n. sp.																															
Saxidomus nuttalli Conrad				×		×										×															
Schizothærus nuttalli Conrad					×	×																			×						
Schizothærus pajaroanus Conrad													×																		
Semele rubropicta Dall																															
Siliqua cf. nuttalli Conrad																									×						
Siliqua sp. indet.																															
Solen sicarius Gould		×											×					×			×									
Solen sp. indet.																															
Transennella californica n. sp.																															
Zirphæa gabbi Tryon																															
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Bathytoma carpenteriana Gabb var. fernandoana Arnold																															
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Cancellaria tritonidea Gabb																			×												
Chrysodomus imperialis Dall																															
Chrysodomus portolaensis Arnold												×	×																		
Crepidula princeps Conrad												×	×																		
Goniobasis kettlemanensis n. sp.																															
Littorina mariana n. sp. and var. alta n. var.																															
Lunatia lewisii Gould			×									×												×						
Margarita sp.																															
Nassa californiana Conrad												×								×									×	
Nassa californiana Conrad var. coalingensis n. var.					×		×							×			×														
Natica?																				×											
Neverita recluziana Petit																															

List of fossils from the Etchegoin (uppermost Miocene) formation, Coalinga district—Continued.

Name.	3849.	4643.	4648.	4656.	4657.	4658.	4659.	4660.	4661.	4662.	4663.	4664.	4665.	4666.	4670.	4671.	4672.	4673.	4674.	4675.	4676.	4677.	4678.	4679.	4681.	4682.	4683.	4684.	4688.	4690.
GASTEROPODA—continued.																														
Neverita recluziana Petit var. alta Dall																				×										
Olivella biplicata Conrad																														
Olivella pedroana Conrad																														
Opalia sp. indet																														
Pisania fortis Carpenter var. angulata Arnold																	×													
Pleurotoma coalingensis n. sp																														
Sigaretus scopulosus Conrad										×																				
Thais crispatus Chemnitz																														
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Thais etchegoinensis n. sp																														
Thais sp																								×						
Trochita filosa Gabb																×		×			×									
Trophon (Forreria) coalingense n. sp																														
Trophon (Forreria) ponderosum Gabb																								×						
Trophon (Boreotrophon) stuarti Smith																														
Turritella vanvlecki n. sp						×				×																				
Xylotrya sp																														
CIRRIPEDIA.																														
Balanus sp				×					×			×				×	×													
Balanus large sp																													×	
Balanus concavus Bronn																														
Tamiosoma gregaria? Conrad					(?)					×																				
CRUSTACEA.																														
Cancer fissus Rathbun																														
Loxorhynchus grandis Stimpson																														
PISCES.																														
Fish bones of various kinds																														
Carcharodon arnoldi Jordan																														
Fish, bulbous growths																														
Fish spines																														
Fish vertebræ																														
CETACEA.																														
Cetaceæ (vertebræ)																														

3849. Point where road from Coalinga to Stone Canyon crosses the Waltham Creek Sheep property. Spur of sandstone. Probably middle beds.

4643. Upper *Mulinia* zone on main ridge of Kettleman Hills, 1 mile southeast of 1,370-foot hill, in SE. ¼ sec. 20, T. 22 S., R. 18 E. Lower middle beds.

4648. Seventy-five feet below summit on south side of 1,375-foot hill just west of Mr. Orr's house in Big Tar Canyon. In NE. ¼ NW. ¼ sec. 8, T. 23 S., R. 17 E. Basal beds.

4656. At northwest end of Anticline Ridge, 6 miles north-northeast of Coalinga, SW. ¼ sec. 34, T. 19 S., R. 15 E. Lowest Etchegoin bed or *Glycymeris* zone, just below bed of 4657.

4657. At northwest end of Anticline Ridge, 6 miles north-northeast of Coalinga, bed just above 4656, near south side of SW. ¼ sec. 34, T. 19 S., R. 15 E. Basal beds.

4658. Near northwest end of Anticline Ridge at southeast end of long 1,200-foot hill, in NE. ¼ sec. 3, T. 20 S., R. 15 E., near base of Etchegoin.

4659. At northwest end of Anticline Ridge on 1,200-foot hill, and for 1 mile northwest of that hill along *Glycymeris* zone. Basal beds. See 4656.

4660. About 2½ miles southwest of Coalinga, northeast of West Coalinga well. *Glycymeris* zone, or basal beds. See locality 4674.

4661. Eight miles north of Coalinga, in NW. ¼ sec 29, T. 19 S., R. 15 E. *Glycymeris* zone or basal beds.

4662. At north edge of Etchegoin area in White Creek basin, one-half mile east of road up White Creek and three-fourths mile southeast of Michigan well, center of NW. ¼ sec. 16, T. 19 S., R. 13 E. *Glycymeris* zone, 100 feet above base of Etchegoin.

4663. At north edge of Etchegoin area in White Creek basin, on summit of ridge one-half mile west of road up White Creek and three-fourths mile southwest of Michigan well, about ¼ mile northwest of 4662, in basal sandstone of the Etchegoin.

4664. On north side of White Creek about 5 miles northwest of junction with Los Gatos Creek, in basal Etchegoin beds on south side of synclinal basin.

4665. On south side of White Creek about 6 miles northwest of junction with Los Gatos Creek. Basal beds.

4669. At south end of Kettleman Hills, on summit of 540-foot hill in very southwest corner of map, in center of sec. 2, T. 25 S., R. 19 E., and for 1 mile S. 15° E. of that hill; probably about the lowest Etchegoin beds exposed south of Avenal Gap.

4670. At southernmost end of Kettleman Hills, 5½ miles south-southeast of Light's house in Avenal Gap, on knob of vertical angle bench mark (elevation 505 feet), in center of sec. 10, T. 25 S., R. 19 E. Prominent bed of yellowish limestone in uppermost portion of Etchegoin.

4671. On northeast flank of Anticline Ridge, about 6½ miles northeast of Coalinga and about 2 miles north-northeast of bench mark 947 feet, several hundred feet above base of Etchegoin, in the lower middle beds.

4672. South of Waltham Creek, 3½ miles southwest of Coalinga, on northeast nose of 1,200-foot ridge four-fifths mile north-northwest of 1,900-foot hill, center of SE. ¼ sec. 13, T. 21 S., R. 14 E. Basal beds.

4673. One mile southeast of Alcalde, at elevation of 1,600 feet on ridge west of 1,900-foot hill, center of NE. ¼ sec. 24, T. 21 S., R. 14 E. Basal beds.

4674. Halfway between West Coalinga and Commercial Petroleum wells, about 3 miles southwest of Coalinga. *Glycymeris* zone, or basal beds. See locality 4660.

4675. Two and one-half miles due west of Coalinga, at elevation of about 1,200 feet on road, north line of sec. 1, T. 21 S., R. 14 E. Lower middle beds.

4676. Six miles southeast of northwest end of Kettleman Hills, where old road crosses main ridge one-half mile east of 1,332-foot hill. Lower *Mya* zone, or lower middle beds.

4677. Ten miles southeast of northwest end of Kettleman Hills on northeast side of summit of 1,370-foot hill, west side of NW. ¼ sec. 20, T. 22 S., R. 18 E. Lower *Mya* zone, or lower middle beds.

4678. On road north of locality 4676, one-half mile east-northeast of 1,332-foot hill. Lower middle beds.

4679. Area about 10 to 12 miles southeast of northwest end of Kettleman Hills; *Mulinia* beds on both sides of anticline, between 1,370-foot and 1,277-foot hills on main ridge and within 1 mile northeast of those hills on opposite side of anticline. Lower middle beds.

4681. On east side of Kettleman Hills 3 miles northeast of Light's place in Avenal Gap, on southwest side of long, low ridge near axis of anticline; middle of west side of NE. ¼ sec. 4, T. 24 S., R. 19 E. Upper (?) *Mulinia* zone, or lower middle beds.

4682. One-third mile west of locality 4681, north-central part of NW. ¼ sec. 4, T. 24 S., R. 19 E. Upper *Mulinia* zone, or lower middle beds.

4683. South of Avenal Gap in Kettleman Hills; extremely fossiliferous sand on summit of 500-foot knob just north of old house, 2½ miles S. 45° E. of Light's place, northern part of NW. ¼ sec. 27, T. 24 S., R. 19 E. Upper *Mulinia* zone, or lower middle beds.

4684. South-central part of Kettleman Hills, about 5 miles northwest of Dudley-Lemoore road, in second main canyon 1½ miles N. 45° E. of 1,030-foot hill, center of SW. ¼ sec. 35, T. 22 S., R. 18. E. Lower *Mulinia* zone, about 3,000 feet below top of Etchegoin; lower middle or basal beds.

4688. On Anticline Ridge, southwest of Turner well No. 2, middle of S. ½ sec. 2, T. 20 S., R. 15 E. Several hundred feet above base of Etchegoin in the lower middle beds.

4690. Two miles southwest of Coalinga, south of Lucile well, SW. ¼ sec. 6. Lower middle beds.

List of fossils from the Etchegoin (uppermost Miocene) formation, Coalinga district—Continued.

Name.	4693.	4695.	4696.	4697.	4698.	4699.	4700.	4701.	4702.	4703.	4704.	4705.	4706.	4707.	4708.	4709.	4710.	4711.	4712.	4713.	4714.	4715.	4716.	4717.	4718.	4720.	4722.	4723.	4724.	4725.
ANTHOZOA.																														
Astrangia coalingensis Vaughan																	×													
ECHINODERMATA.																														
Astrodapsis cf. tumidus Rémond																														
Astrodapsis sp *a*																×	×		×											
Echinarachnius gibbsii Rémond	×						×						×	×	×		×		×	×	×	×								
Scutella perrini Weaver																			×	×										
BRACHIOPODA.																														
Terebratalia occidentalis Dall																														
Terebratalia smithi Arnold																			×		×									
PELECYPODA.																														
Arca trilineata Conrad	×	×						×							×	×	×		×		×			×	×					×
Arca sp. *a*																														
Cardium coosense Dall																×														
Cardium meekianum Gabb																														
Cardium sp. indet																														
Chama pellucida Broderip																×	×													
Clidiophora punctata Conrad																														
Cryptomya ovalis Conrad	×																													
Cryptomya quadrata n. sp																														
Cumingia californica Conrad																														
Diplodonta harfordi F. M. Anderson																														
Diplodonta parilis Conrad																														
Glycymeris coalingensis n. sp																														
Glycymeris septentrionalis Middendorf																														
Glycymeris sp. indet																														
Macoma inquinata Deshayes																						×			×	×	×	×		×
Macoma nasuta Conrad												×					×					×								
Macoma secta Conrad																														
Macoma sp. *a*																														
Mactra albaria Conrad																														
Mactra coalingensis n. sp																														
Metis sp. indet																														
Modiolus directus Dall																														
Modiolus rectus Conrad					×																									
Mulinia densata Conrad		×		×	×																									
Mya japonica Jay		×																			×				×	×	×	×		×
Mytilus (Mytiloconcha) coalingensis n. sp	×																					×								

Nucula castrensis Hinds														×																
Ostrea atwoodi Gabb														×	×															
Ostrea lurida Carpenter														×			×	×				×								
Ostrea vespertina Conrad														×																
Ostrea vespertina Conrad var. sequens n. var								×				×																		
Ostrea sp								×				×																		
Panopea generosa Gould																														
Paphia staleyi Gabb																														
Paphia tenerrima Carpenter																														
Paphia truncata? Gabb																														
Pecten coalingaensis Arnold															×	×		×				×								
Pecten deserti Conrad																		×				×								
Pecten nutteri Arnold																		×		×										
Pecten oweni Arnold				×																										
Pecten wattsi Arnold																		×												
Pecten wattsi Arnold var. etchegoini F. M. Anderson																		×												
Phacoides acutilineatus Conrad																														
Pholadidea ovoidea Gould																														
Placunanomia californica n. sp																						×								
Saxidomus nuttalli Conrad																														
Schizothærus nuttalli Conrad																														
Schizothærus pajaroanus Conrad																														
Semele rubropicta Dall																														
Siliqua cf. nuttalli Conrad																														
Siliqua sp. indet																														
Solen sicarius Gould												×			×															×
Solen sp. indet																														
Transennella californica n. sp																						×								
Zirphæa gabbi Tryon															×															
GASTEROPODA.																														
Astyris richthofeni Gabb																														
Bathytoma carpenteriana Gabb var. fernandoana Arnold								×																						
Calliostoma coalingensis n. sp															×															
Calliostoma kerri n. sp	×																	×												
Cancellaria tritonidea Gabb								×																						
Chrysodomus imperialis Dall																														
Chrysodomus portolaensis Arnold																														
Crepidula princeps Conrad														×				×												
Goniobasis kettlemanensis n. sp			×																			×								
Littorina mariana n. sp. and var. alta n. var								×														×			×	×	×	×	×	
Lunatia lewisii Gould				×														×												
Margarita sp																														
Nassa californiana Conrad															×															
Nassa californiana Conrad var. coalingensis n. var																		×												
Natica?																														
Neverita recluziana Petit	×			×				×	×	×	×	×			×	×		×												

List of fossils from the Etchegoin (uppermost Miocene) formation, Coalinga district—Continued.

Name.	4693.	4695.	4696.	4697.	4698.	4699.	4700.	4701.	4702.	4703.	4704.	4705.	4706.	4707.	4708.	4709.	4710.	4711.	4712.	4713.	4714.	4715.	4716.	4717.	4718.	4720.	4722.	4723.	4724.	4725.
GASTEROPODA—continued.																														
Neverita recluziana Petit var. alta Dall																×														
Olivella biplicata Conrad																														
Olivella pedroana Conrad																	×													
Opalia sp. indet																			×											
Pisania fortis Carpenter var. angulata Arnold																														
Pleurotoma coalingensis n. sp																														
Sigaretus scopulosus Conrad																														
Thais crispatus Chemnitz				×											×															
Thais crispatus Chemnitz nearly smooth var.																														
Thais etchegoinensis n. sp		×		×															×											
Trochita filosa Gabb	×														×										×		×			
Trophon (Forreria) coalingense n. sp																														
Trophon (Forreria) ponderosum Gabb																														
Trophon (Boreotrophon) stuarti Smith																			×											
Turritella vanvlecki n. sp																														
Xylotrya sp																						×								
CIRRIPEDIA.																														
Balanus sp																														
Balanus large sp																			×											
Balanus concavus Bronn																	×													
Tamiosoma gregaria? Conrad																														
CRUSTACEA.																														
Cancer fissus Rathbun																														
Loxorhynchus grandis Stimpson																														
PISCES.																														
Fish bones of various kinds						×										×												×	×	
Carcharodon arnoldi Jordan																×				×										
Fish, bulbous growths		×	×	×		×																×								
Fish spines			×																											
Fish vertebræ																														
CETACEA.																														
Cetaceæ (vertebræ)				×																										

4693. South-central part of Kettleman Hills, about 9 miles northwest of Avenal Gap, 1,000 feet northeast of 1,030-foot hill, SW. ¼ NE. ¼ sec. 3, T. 23 S., R. 18 E., 950 feet stratigraphically below summit of Etchegoin. About same as *Pecten coalingaensis* zone, or upper middle beds.

4695. East side of Kettleman Hills, south of Avenal Gap, from gravelly surface of ground, NE. ¼ SE. ¼ sec. 27, T. 24 S., R. 19 E. Lower middle beds.

4696. About 2,000 feet east of main ridge of Kettleman Hills, 1 mile southeast of Light's place, SW. ¼ NW. ¼ sec. 21, T. 24 S., R. 19. E. In dark gypsiferous sand and clay about 750 feet stratigraphically below top of Etchegoin; probably the equivalent of the *Pecten coalingaensis* zone, or upper middle beds.

4697. Near south end of Kettleman Hills, along summit of ridge (elevation 592 feet) 4 miles S. about 20° E. of Light's place in Avenal Gap, on west side of sec. 3, T. 25 S., R. 19 E. Prominent pebble bed 1,600 to 2,000 feet below summit of Etchegoin. Probably same horizon as 4695, in lower middle beds.

4698. North of White Creek syncline, about three-fourths mile north of White Creek and 3½ miles northwest of junction with Los Gatos Creek, in center of sec. 23, T. 19 S., R. 13 E. Upper middle beds.

4699. Eastern border of southernmost group of Kettleman Hills, in gray and blue sand on northeastern side of knoll in western part of sec. 26, T. 24 S., R. 19 E. About same horizon as 4695 and 4697, in lower middle beds.

4700. Kettleman Hills. Float. Undifferentiated lower or middle beds.

4701. East side of Kettleman Hills, at base of upper *Mya* zone or uppermost beds on Dudley-Lemoore road, in east-central part of sec. 17, T. 23 S., R. 19 E.

4702. South-central part of Kettleman Hills, on northwest side of 813-foot hill 4½ miles northwest of Avenal Gap, 400 feet east of main ridge where old road crosses, NW. ¼ NW. ¼ sec. 25, T. 23 S., R. 18 E. Gypsiferous sand and pebble bed about 900 feet stratigraphically below summit of Etchegoin. Probably equivalent to *Pecten coalingaensis* zone, or upper middle beds.

4703. Central part of Kettleman Hills, 10 miles northwest of Avenal Gap, three-fourths mile N. 30° W. of 1,030-foot hill, SW. ¼ SW. ¼ sec. 34, T. 22 S., R. 18 E. About 900 feet stratigraphically below summit of Etchegoin. Probably equivalent of *Pecten coalingaensis* zone, or upper middle beds.

4704. Central part of Kettleman Hills, 11 miles northwest of Avenal Gap, on south base of 1,145-foot hill, in very southeast corner of sec. 28, T. 22 S., R. 18 E. Just above upper *Mulinia* zone, in lower middle beds.

4705. One-third mile south of bench mark 923 feet on Zapato Creek, from hard layers in sand forming a ridge that runs along 1 mile from there on south side of road to Canoas Creek, on west side of NW. ¼ sec. 17, T. 22 S., R. 16 E. About 450 feet below summit of Etchegoin. *Pecten coalingaensis* zone, or upper middle beds.

4706. Just across the gully east of the Call well, 7 miles north-northwest from Coalinga, in northwest corner of sec. 32, T. 19 S., R. 15 E. Lower middle beds (?).

4707. About one-fourth mile northeast of Hugo Kreyenhagen's house between two roads that run east from Canoas Creek, center of sec. 27, T. 22 S., R. 16 E. Sea-urchin bed immediately above upper *Mulinia* zone, about 900 feet stratigraphically above base of Etchegoin, in lower middle beds.

4708. On 1,245-foot hill 4 miles southeast of northwest end of Kettleman Hills, east side of sec. 32, T. 21 S., R. 17 E. *Arca* bed in upper *Mya* zone, or uppermost beds.

4709. East side of Kettleman Hills, on summit of ridge in center of SE. ¼ sec. 6, T. 22 S., R. 18 E. Drab sand with hard sandstone layers, 750 to 800 feet stratigraphically below summit of Etchegoin. *Pecten coalingaensis* zone, or upper middle beds.

4710. Three-fourths mile northwest of Zapato Creek bench mark, 806 feet, on north side of ravine, west-central part of NE. ¼ sec. 5, T. 22 S., R. 16 E. *Pecten coalingaensis* zone, or upper middle beds.

4711. West side of 1,245-foot hill, 4 miles southeast of northwest end of Kettleman Hills, central part of sec. 32, T. 21 S., R. 17 E. Oyster bed 50 feet above *Arca* bed of locality 4708; upper *Mya* zone, or uppermost beds.

4712. East of Zapato Creek, one-half mile south of Adolph Kreyenhagen's house, SW. ¼ SE. ¼ sec. 8, T. 22 S., R. 16 E. Variable pebbly sand, very fossiliferous. *Pecten coalingaensis* zone, or upper middle beds.

4713. On top of 1,332-foot hill, 5½ miles southeast of northwest end of Kettleman Hills, in south-central part of sec. 3, T. 22 S., R. 17 E. Sand dollar bed of drab sand overlying blue and gray sand of lower *Mya* zone, both being in the lower middle beds.

4714. Two miles southwest of Coalinga, at elevation of 900 feet near edge of Alcalde Hills, on ridge descending east from prominent hill (elevation 1,410 feet). Just east of center of SW. ¼ sec. 6, T. 21 S., R. 15 E. Coarse sand and pebble conglomerate about 650 feet stratigraphically above base of Etchegoin. *Pecten coalingaensis* zone, or upper middle beds.

4715. South end of Kettleman Hills, sec. 10, T. 25 S., R. 19 E. Upper middle and uppermost Etchegoin beds.

4716. Near northwest end of Kettleman Hills, 2 miles north-northwest of 1,245-foot hill, east of center of SW. ¼ sec. 20, T. 21 S., R. 17 E. In sand just below flinty white shale bed that marks top of Etchegoin. Just below 4740. Upper *Mya* zone, or uppermost beds.

4717. Near northwest end of Kettleman Hills, 1¾ miles northwest of 1,244-foot hill, just east of old house, northwest corner of sec. 29, T. 21 S., R. 17 E. *Arca* sand below white shale at top of Etchegoin. Upper *Mya* zone, or uppermost beds.

4718. Main ridge of Kettleman Hills, 4 miles north of Dudley-Lemoore road, on summit of 1,020-foot hill, east side of sec. 11, T. 23 S., R. 18 E. Upper *Mya* zone, or uppermost beds.

4720. One mile due north of Light's place in Avenal Gap on south side of hill (elevation 555 feet), in center of SW. ¼ sec. 8, T. 24 S., R. 19 E. Very gypsiferous sand at base of upper *Mya* zone, or uppermost beds.

4722. Three-fourths mile southeast of Adolph Kreyenhagen's on Zapato Creek, northwest corner of sec. 16, T. 22 S., R. 16 E. Upper *Mya* zone, or uppermost beds.

4723. South group of Kettleman Hills, on point of main ridge facing Avenal Gap one-half mile east-southeast of Light's place, south side of SE. ¼ sec. 17, T. 24 S., R. 19 E. Upper *Mya* zone, or uppermost beds.

4724. Main ridge of south group of Kettleman Hills, 1 mile south of Avenal Gap, NW. ¼ SE. ¼ sec. 20, T. 24 S., R. 19 E. Upper *Mya* zone, or uppermost beds.

4725. East side of Kettleman Hills, on 500-foot ridge at contact of Etchegoin and Tulare north of sharp turn in Dudley-Lemoore road, southwest corner of sec. 8, T. 23 S., R. 19 E. Upper *Mya* zone, or uppermost beds.

List of fossils from the Etchegoin (uppermost Miocene) formation, Coalinga district—Continued.

Name.	4728.	4729.	4730.	4736.	4741.	4744.	4749.	4750.	4751.	4752.	4753.	4754.	4755.	4756.	4757.	4758.	4759.	4760.	4761.	4762.	4763.	4769.	4778.	4780.	4781.	4782.	4783.	4799.	4806.	4857.
ANTHOZOA.																														
Astrangia coalingensis Vaughan																×														
ECHINODERMATA.																														
Astrodapsis cf. tumidus Rémond																	×													
Astrodapsis sp. *a*																														
Echinarachnius gibbsii Rémond							×	×	×		×		×	×	×	×	×		×									×	×	
Scutella perrini Weaver																														
BRACHIOPODA.																														
Terebratalia occidentalis Dall			×																											
Terebratalia smithi Arnold																×														
PELECYPODA.																														
Arca trilineata Conrad				×			×	×							×	×	×	×		×	×	×		×	×				×	×
Arca sp. *a*																												×		
Cardium coosense Dall																					×									
Cardium meeklanum Gabb								×							×				×										×	
Cardium sp. indet																						×								
Chama pellucida Broderip																														
Clidiophora punctata Conrad																													×	
Cryptomya ovalis Conrad			×													×														
Cryptomya quadrata n. sp																														
Cumingia californica Conrad																×														
Diplodonta harfordi F. M. Anderson																													×	
Diplodonta parilis Conrad														×		×					×								×	
Glycymeris coalingensis n. sp								×						×		×					×								×	
Glycymeris septentrionalis Middendorf																													×	
Glycymeris sp. indet																														
Macoma inquinata Deshayes				×		×	×	×		×				×		×										×				
Macoma nasuta Conrad														×		×														
Macoma secta Conrad																													×	
Macoma sp. *a*														×						×										
Mactra albaria Conrad																														
Mactra coalingensis n. sp																				×									×	
Metis sp. indet																						×								
Modiolus directus Dall																		×												
Modiolus rectus Conrad						×										×								×						
Mulinia densata Conrad							×	×			×	×		×		×						×						×		
Mya japonica Jay		×		×		×				×		×														×				
Mytilus (Mytiloconcha) coalingensis n. sp				?			×	×								×													×	

Nucula castrensis Hinds																														
Ostrea atwoodi Gabb																						×								
Ostrea lurida Carpenter																							×							
Ostrea vespertina Conrad	×														×								×							
Ostrea vespertina Conrad var. sequens n. var.	×																													
Ostrea sp																														
Panopea generosa Gould														×	×															
Paphia staleyi Gabb														×							×									
Paphia tenerrima Carpenter																														
Paphia truncata? Gabb						×																								
Pecten coalingaensis Arnold															×															
Pecten deserti Conrad																														
Pecten nutteri Arnold																														
Pecten oweni Arnold						×																						×	×	×
Pecten wattsi Arnold															×								×							
Pecten wattsi Arnold var. etchegoini F. M. Anderson																														
Phacoides acutilineatus Conrad																														
Pholadidea ovoidea Gould							×																							
Placunanomia californica n. sp																														
Saxidomus nuttalli Conrad						×	×							×	×						×									
Schizothærus nuttalli Conrad																														
Schizothærus pajaroanus Conrad																														
Semele rubropicta Dall															×															
Siliqua cf. nuttalli Conrad							×																							
Siliqua sp. indet															×															
Solen sicarius Gould			×		×									×	×							×								
Solen sp. indet						×																								
Transennella californica n. sp																														
Zirphæa gabbi Tryon															×															
GASTEROPODA.																														
Astyris richthofeni Gabb															×															
Bathytoma carpenteriana Gabb var. fernandoana Arnold															×														×	
Calliostoma coalingensis n. sp															×															
Calliostoma kerri n. sp															×															
Cancellaria tritonidea Gabb															×															
Chrysodomus imperialis Dall							×																							
Chrysodomus portolaensis Arnold																														×
Crepidula princeps Conrad							×								×															×
Goniobasis kettlemanensis n. sp																														
Littorina mariana n. sp. and var. alta n. var.			×																											
Lunatia lewisii Gould							×							×					×				×						×	×
Margarita sp																														
Nassa californiana Conrad						×								×	×							×							×	×
Nassa californiana Conrad var. coalingensis n. var															×															
Natica?																														
Neverita recluziana Petit					×					×					×		×													

List of fossils from the Etchegoin (uppermost Miocene) formation, Coalinga dstirict—Continued.

Name.	4728.	4729.	4730.	4736.	4741.	4744.	4749.	4750.	4751.	4752.	4753.	4754.	4755.	4756.	4757.	4758.	4759.	4760.	4761.	4762.	4763.	4769.	4778.	4780.	4781.	4782.	4783.	4799.	4806.	4857.
GASTEROPODA—continued.																														
Neverita recluziana Petit var. alta Dall																														
Olivella biplicata Conrad																×														
Olivella pedroana Conrad																						×								
Opalia sp. indet																														
Pisania fortis Carpenter var. angulata Arnold																	×													
Pleurotoma coalingensis n. sp																													×	
Sigaretus scopulosus Conrad																														
Thais crispatus Chemnitz																														
Thais crispatus Chemnitz nearly smooth var							×																							
Thais etchegoinensis n. sp														×																
Trochita filosa Gabb															×	×	×							×						
Trophon (Forreria) coalingense n. sp							×																							×
Trophon (Forreria) ponderosum Gabb																												×	×	
Trophon (Boreotrophon) stuarti Smith																														
Turritella vanvleckl n. sp																														
Xylotrya sp																														
CIRRIPEDIA.																														
Balanus sp																														×
Balanus large sp														×																
Balanus concavus Bronn																														
Tamiosoma gregaria? Conrad																														×
CRUSTACEA.																														
Cancer fissus Rathbun														×																
Loxorhynchus grandis Stimpson																											×			
PISCES.																														
Fish bones of various kinds																														
Carcharodon arnoldi Jordan																														
Fish, bulbous growths					×																									
Fish spines																														
Fish vertebræ																														
CETACEA.																														
Cetaceæ (veretbræ)																														

4728. On northeast border of Kettleman Hills, on southwest flank of 900-foot hill just east of old road, in north part of sec. 35, T. 21 S., R. 17 E. Upper *Mya* zone at top of Etchegoin immediately underlying Tulare fresh-water beds of 4731.

4729. At west foot of hill (elevation 1,174 feet), 1½ miles east of Garza Creek, just north of road, southeast corner of NE. ¼ sec. 36, T. 22 S., R. 16 E. Upper *Mya* zone, or uppermost beds.

4730. Central part of Kettleman Hills, on summit of 1,030-foot hill on main ridge 9¾ miles northwest of Light's place in Avenal Gap, center of sec. 3, T. 23 S., R. 18 E. Upper *Mya* zone, or uppermost beds.

4736. East side of Kettleman Hills, east of Dudley-Lemoore road, NE. ¼ SW. ¼ sec. 17, T. 23 S., R. 19 E. Upper *Mya* zone just below fresh-water bed (Tulare) of locality 4737, uppermost beds.

4741. In Kettleman Hills, 3¼ miles north of Dudley-Lemoore road on little hill (elevation 600+ feet), northeast corner sec. 12, T. 23 S., R. 18 E. In lower middle beds just above lower *Mya* zone.

4744. West of Canoas Creek, north of road leading to Zapato Creek, SW. ¼ NW. ¼ sec. 22, T. 22 S., R. 16 E. Upper *Mya* zone, uppermost beds.

4749. On ridge east of Garza Creek, in NE. ¼ sec. 1, T. 23 S., R. 16 E. Lower *Mulinia* zone, basal beds of Etchegoin.

4750. On ridge east of Garza Creek, about 1,200 feet stratigraphically above 4749, SW. ¼ sec. 36, T. 22 S., R. 16 E. Lower middle beds.

4751. On ridge east of Garza Creek and immediately west of road from Garza Creek to Big Tar Canyon, NW. ¼ sec. 36, T. 22 S., R. 16 E. About 1,000 feet stratigraphically above 4750, or in upper middle beds.

4752. On ridge east of Garza Creek and immediately northeast of road connecting Garza Creek and Big Tar Canyon, NE. ¼ sec. 36, T. 22 S., R. 16 E. Upper *Mya* zone, about 1,000 feet stratigraphically above 4751, uppermost beds.

4753. On Waltham Creek 13 miles southwest of Coalinga, 200 yards north of Elmer Frame's house. In gray sandstone well up in Etchegoin formation, probably in middle beds.

4754. Waltham Creek, 13 miles southwest of Coalinga, three-fourths mile east of Elmer Frame's place. Gray sandstone 200 feet stratigraphically below 3849; also probably in middle beds.

4755. About 4 miles south of Coalinga in Jacalitos Hills, SW. ¼ sec. 21, T. 21 S., R. 15 E. Undifferentiated lower or middle beds.

4756. Vicinity of Henry Spring, 4 miles south-southwest of Coalinga, on east side of 1,900-foot hill, SW. ¼ sec. 18, T. 21 S., R. 15 E. Lower middle or basal beds.

4757. Same locality, but 150 feet stratigraphically above 4756. Lower middle or basal beds.

4758. Same locality, but 490 feet stratigraphically above 4756. Upper middle beds.

4759. Same locality, but 500 to 900 feet stratigraphically above 4756. Upper middle beds.

4760. On old road crossing north end of Kettleman Hills, three-fourths mile northeast of 1,332-foot hill, SE. ¼ NW. ¼ sec. 2, T. 22 S., R. 17 E. In lower middle beds, 1,900 feet stratigraphically below summit of Etchegoin, about equivalent of lower *Mya* zone.

4761. On ridge one-half mile south of junction of Jacalitos and Salt creeks, southeast corner of sec. 31, T. 21 S., R. 15 E. *Cardium* bed at base of Etchegoin, about equivalent of *Glycymeris* zone, basal beds.

4762. Southwest of Coalinga district, in Waltham Valley three-fourths mile east of Elmer Frame's house. *Arca* and *Mactra* bed, probably basal beds.

4763. Southwest of Coalinga district, on Stone Canyon-Waltham Creek road just west of Waltham Valley. Probably middle beds.

4769. On east side of Canoas Creek, just south of Hugo Kreyenhagen's home, northwest corner of SW. ¼ sec. 27, T. 22 S., R. 16 E. Lower *Mulinia* zone, at contact between Etchegoin and Jacalitos.

4778. About three-fourths mile east of Adolph Kreyenhagen's house on Zapato Creek, west side of sec. 9, T. 22 S., R. 16 E. Small *Ostrea* bed, about 100 feet stratigraphically below *Mya* bed at top of Etchegoin formation in upper *Mya* zone.

4780. One-fourth mile west of locality 4778. *Arca* bed about 350 feet below summit of Etchegoin, in uppermost beds.

4781. *Arcas* from north-central part of Kettleman Hills. Basal *Mulinia* beds.

4782. On southwest flank of high hill (elevation 1,458 feet) east of lower part of Canoas Creek, at elevation of 1,200 feet, SW. ¼ SW. ¼ sec. 23, T. 22 S., R. 16 E. Upper *Mya* zone, or uppermost beds.

4783. On the southeast bank of Canoas Creek, three-fourths mile below H. Kreyenhagen's, 16 miles southeast of Coalinga, northeast corner SW. ¼ sec. 22, T. 22 S., R. 16 E.; 125 feet stratigraphically below top of Etchegoin formation, in uppermost beds.

4799. Coalinga district. Exact locality unknown.

4806. Two miles southeast of Coalinga, on north side of Alcalde Canyon, center of SW. ¼ sec. 7, T. 21 S., R. 15 E. *Glycymeris* zone, near base of Etchegoin.

4857. Extreme southeast end of Kettleman Hills, in secs. 11, 12, T. 25 S., R. 19 E. *Pecten oweni* bed, probably lowest Etchegoin.

Faunal zones.—The lowest fossiliferous bed in the Etchegoin is in a zone in which *Glycymeris coalingensis* n. sp. and *G. septentrionalis* Middendorf are exceedingly abundant; this zone is called the *Glycymeris* zone; above this are beds in which *Mulinia densata* Conrad is very abundant; this is the *Mulinia* zone; still higher in certain parts of the field *Echinarachnius gibbsii* Rémond is very common, but other fossils rare, and this is sometimes called the *Echinarachnius* zone. A few hundred feet below the top of the Etchegoin is an exceedingly fossiliferous horizon in which *Pecten coalingaensis* Arnold is a common species, and this is called the *Pecten coalingaensis* zone; above it and practically at the top of the Etchegoin is the upper *Mya* zone, characterized by numerous *Mya japonica* Jay. In the Kettleman Hills is another horizon, between the *Mulinia* and *Pecten coalingaensis* zones, in which *Mya japonica* is practically the only fossil; this horizon is called the lower *Mya* zone.

The *Glycymeris* zone, or zone of the basal beds, is characterized by the two species of this genus previously mentioned and by *Diplodonta harfordi* F. M. Anderson, *D. parilis* Conrad, *Cardium meekianum* Gabb, and *Pecten oweni* Arnold. Locality 4806 is typical of this zone. Localities representative of this zone are 4648, 4656, 4657, 4658, 4659, 4660, 4661, 4662, 4663, 4664, 4665, 4669, 4672, 4673, 4674, 4684, 4749, 4756, 4757, 4761, 4762, 4769, 4781, 4806, and 4857.

The *Mulinia* zone, or zone of the lower middle beds, contains numerous *Mulinia densata* Conrad, *Ostrea atwoodi* Gabb, and *Arca trilineata* Conrad. It is represented by localities 4643, 4671, 4675, 4676, 4677, 4678, 4679, 4681, 4682, 4683, 4688, 4690 (?), 4695, 4697, 4699, 4704, 4706 (?), 4707, 4713, 4741, 4750, and 4760.

The *Pecten coalingaensis* zone, or zone of the upper middle beds, is characterized by *Pecten coalingaensis* Arnold, *P. wattsi* Arnold and its variety *etchegoini* F. M. Anderson, *Terebratalia smithi* Arnold, and *Ostrea vespertina* Conrad. Locality 4712 yields a fauna typical of this horizon. It is also represented at localities 4693, 4696, 4698, 4702, 4703, 4705, 4709, 4710, 4712, 4714, 4715, 4751, 4758, and 4759.

The upper *Mya* zone, or zone of the uppermost Etchegoin beds, carries *Mya japonica* Jay, *Littorina mariana* n. sp., and its variety *alta* n. var., *Trochita filosa* Gabb, and *Solen sicarius* Gould. Just above the upper *Mya* zone is usually found a bed in which are numerous *Ostrea vespertina* Conrad var. *sequens* n. var. This zone is represented at localities 4670, 4701, 4708, 4711, 4716, 4717, 4718, 4720, 4722, 4723, 4724, 4725, 4728, 4729, 4730, 4736, 4744, 4752, 4778, 4780, 4782, and 4783.

Localities 3849, 4700, 4753, 4754, 4755, 4763, and 4799 are undifferentiated.

Conditions of deposition.—A study of the faunas of the various zones of the Etchegoin leads to some interesting conclusions concern-

ing the physical conditions which surrounded the deposition of the strata at various times throughout the Etchegoin epoch, and also to some important correlations, not only with formations in other parts of the Coast Ranges but with horizons of the Tertiary of the Eastern States.

The abundance of *Arca* in the *Glycymeris* and *Mulinia* zones leads to the conclusion that the water in which the lower part of the Etchegoin was laid down was somewhat warmer than that now prevalent on the Pacific coast at the latitude of Coalinga.

Following the deposition of the two lower zones came a period in which estuarine conditions prevailed over at least a part of the Coalinga shore line, for in the Kettleman Hills is a bed in which is to be found large numbers of *Mya japonica* Jay, a noted cold-water species preferring mud flats. This *Mya* bed in turn is followed by strata containing a fauna having many characteristics in common with the fauna of the Gulf of California, a province that has been subject to tropical conditions at least since the beginning of Miocene time. It is therefore reasonable to suppose that a subsidence and change of conditions to those favoring the immigration of warmer water species took place some time after the deposition of the middle Etchegoin. These conditions were suddenly altered near the close of the Etchegoin epoch, as is indicated by the fauna of the upper *Mya* zone, which contains *Mya japonica* Jay, *Macoma inquinata* Deshayes, and *Littorina mariana* n. sp. (closely allied to the northern *L. grandis* Midd.), species supposed to have been best suited to cold and possibly estuarine conditions. It is a noteworthy fact in connection with this late Etchegoin cold-water invasion that it exterminated most of the species found in the subjacent beds, at least for the local Coalinga province, and that the only important species of the preceding fauna, *Ostrea vespertina* Conrad, which persisted into the last part of the Etchegoin, was so adversely influenced by the new conditions that it became a dwarf of its former self and took up new characteristics of at least varietal importance. The uppermost Etchegoin representative of the beautiful well-developed *Ostrea vespertina* is the dwarfed, thin variety *sequens*.

Other evidence showing the varying conditions which prevailed during the latter half of the Etchegoin is to be found in the occurrence within the formation of curious bulbous growths of fishes, such as are later mentioned as occurring associated with the fresh-water fossils in the basal Tulare. The lowest horizon at which they were found is at locality 4697, which is 1,600 to 2,000 feet below the summit of the formation. These growths occur alone, with marine fossils, or with fresh-water fossils. At one horizon, about 900 below the summit of the Etchegoin, along the eastern foot of the main ridge in the southern portion of the Kettleman Hills, abundant specimens of

Goniobasis, a fresh-water (?) genus, were found in gypsiferous beds associated with the curious fish bones. This horizon is represented by locality 4696, and is about equivalent to that of *Pecten coalingaensis*. These bones and shells indicate that a close connection existed between salt-water areas and nearly if not entirely fresh-water areas during much of the Etchegoin period, and that especially in the later portion of the period conditions were on the verge of becoming such as existed during early Tulare time. The great thickness of inky-blue fine clay in the upper portion of the Etchegoin of the Kettleman Hills below the sands of the upper *Mya* zone is believed to have originated as fine delta deposits, possibly subaerially and above the reach of the tide.

The presence of enormous quantities of *Echinarachnius*, accompanied by no other forms of fossils, in some of the middle or upper middle Etchegoin sands, and somewhat similar deposits in the upper Jacalitos, indicate that at various periods throughout the upper Miocene extensive, shallow sand flats prevailed along the edge of the San Joaquin sea.

Correlation.—F. M. Anderson [a] correlates the lower portion of the Etchegoin with the typical San Pablo beds of the Mount Diablo province, and this correlation agrees in general with that made by the writer. To be more exact it is believed that the upper Jacalitos and lower Etchegoin are probably the equivalent of the typical San Pablo and that the upper Etchegoin is possibly younger than the latest San Pablo, and agrees in age more nearly with the lower part of the fossiliferous Purisima beds on the southwestern flanks of the Santa Cruz Mountains.[b]

The resemblance of the fauna of the upper Etchegoin to the fauna of the latest marine formation in the Carrizo Creek district of eastern San Diego County and to similar beds at Santa Rosalia and other points in lower California, has led the writer to correlate it with these latter, and on the basis of this correlation to suppose that the upper Miocene sea occupied the upper end of the Gulf of California depression. This last correlation agrees with that of Gabb and Cooper, who considered the beds at Carrizo Creek to be Pliocene (some of their Pliocene is now recognized as upper Miocene by the writer). The number of species common to the two faunas is not large but the abundance of the individuals and the uniqueness of the forms compensate for this. Among the forms common to the two faunas are *Ostrea vespertina* Conrad, *Pecten deserti* Conrad, and *Neverita recluziana* Petit.

The similarity between *Ostrea vespertina* Conrad, *Mytilus* (*Mytiloconcha*) *coalingensis* n. sp., and *Pecten deserti* Conrad of the Etche-

[a] Proc. California Acad. Sci., 3d ser., Geology, vol. 2, p. 180.
[b] Arnold, Ralph, Proc. U. S. Nat. Mus., vol. 34, 1908, p. 353.

goin fauna and *Ostrea sculpturata* Conrad, *Mytilus* (*Mytiloconcha*) *incurvus* Conrad, *Pecten gibbus* Linnæus var. *concentricus* Say of the Miocene and Pliocene of the Atlantic States, points strongly to a direct connection between the Atlantic and Pacific provinces during the Miocene. If such a connection existed it was possibly through southern Arizona and New Mexico and thence along the course of the Rio Grande to the Gulf of Mexico, although it might have been farther south.

Age.—The age of the Etchegoin in terms of the standard time scale is now, and probably will for some time to come, be a question on which opinions differ. F. M. Anderson and the writer agree on the general correlation of the San Pablo and Etchegoin; about this there can be very little doubt. But when it comes to assigning the San Pablo and Etchegoin to the Pliocene, the writer differs with Anderson[a] and also with Weaver.[b]

According to the list given in this paper the Etchegoin is represented by 84 recognizable species. Of these, 55 species or varieties (65 per cent) are extinct, while but 29 species (35 per cent) are still living in the Pacific Ocean. According to Lyell's classification this would place the formation decidedly in the Miocene. Furthermore, of the fauna of 18 recognizable species at locality 4712, a fauna typical of the upper part of the Etchegoin, 16 species and varieties (89 per cent) are extinct and only 2 species (11 per cent) are now living.

In addition to the line of evidence presented above, which at best is largely dependent on the personal interpretation of the meaning of species, there is the evidence of the position of the Etchegoin in the geologic series of California. An examination of its fauna indicates that its upper portion is equivalent to the lowest Purisima of the western side of the Santa Cruz Mountains, and there is no question but that in places at least 4,000 or 5,000 feet[c] of strata separate this lower Purisima fauna from the lower Merced fauna and that between 3,000 and 5,000 feet of Merced (both Pliocene and Pleistocene) overlie the lower Merced fauna. Therefore it is evident that since the deposition of the Etchegoin enough time has elapsed for the deposition of between 7,000 and 10,000 feet of strata on the California coast. Taking 25,000 feet as a conservative estimate of the total maximum thickness of the Tertiary on the west coast, this 7,000 to 10,000 feet of strata above the Etchegoin would place the top of the Etchegoin at least a third of the way down toward the base of the Tertiary. Arguing along this line it seems to the writer more consistent to place the Etchegoin in the Miocene rather than in the Pliocene.

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[a] Proc. California Acad. Sci., 3d ser., Geology, vol. 2, pp. 180 et seq.; 4th ser., vol. 3, pp. 28 et seq.

[b] Bull. Dept. Geology, Univ. California, vol. 5, p. 269.

[c] See Santa Cruz folio (No. 163), Geol. Atlas U. S., U. S. Geol. Survey, 1909.

TULARE FORMATION (PLIOCENE-LOWER PLEISTOCENE).

General description.—The Etchegoin in the Coalinga district is overlain along the border of the San Joaquin Valley by a thick succession of beds of gravel, sand, clay, sandstone, conglomerate, and some limestone, which forms the uppermost member of the upturned formations exposed in the monocline on the eastern flank of the Diablo Range. It differs materially from the formations so far described in that its origin is doubtful, being in part fresh water, in part marine, and in large part probably of subaerial origin. In the Kettleman Hills, where these beds are best exposed, the basal sand, which appears to lie conformably upon the marine bed at the top of the Etchegoin, contains many fresh-water fossils. The beds above this have a thickness of several thousand feet, and as far as observed are unfossiliferous except at one horizon near the summit, at which a few marine fossils have been found. Along the foothills of the Diablo Range in the Coalinga district the basal fresh-water beds have not been recognized and may be lacking. Gravel and sand beds belonging to the same succession overlie the Etchegoin with local appearances of unconformity.

The whole series of tilted beds overlying the Etchegoin is referred to as one formation, the Tulare, for the reason that it appears to be continuous and can not be consistently subdivided in different regions. It was formed without doubt under varying conditions of deposition, but it may or may not represent a continuous period. It began to be formed in some portion (probably the earlier portion) of the Pliocene epoch, and probably represents a continuation of deposition well into the Pleistocene. Its summit may be considered as the highest bed markedly affected by the great uplift that took place early in Pleistocene time throughout the Coast Range region, and as unconformably overlain by the more recent horizontal terrace deposits and alluvium.

The highest part of the formation exposed is near the edge of Kettleman Plain in the south-central part of the Kettleman Hills, but the summit of the formation as above defined is not exposed, though it is probable that the edge of the Kettleman Hills marks the approximate summit of the tilted beds. The maximum thickness of the Tulare at this locality is a little over 3,000 feet. The formation may be recognized most easily by the fresh-water fossils and strange bone beds at its base, by its position overlying all the other formations and bordering the valley, and by the prevalence in it of prominent beds of bowlder gravel, which is much coarser and more abundant than in any of the other Tertiary formations. Otherwise this formation resembles some of the others closely, and it is frequently difficult to differentiate them.

This formation was first described by F. M. Anderson,[a] the section in the Kettleman Hills being his type. Lists of fossils accompanied

[a] Proc. California Acad. Sci., 3d ser., Geology, vol. 2, 1902, p. 181.

his original description. In Bulletin 357 of the United States Geological Survey the beds now called Tulare were correlated with Fairbanks's Paso Robles formation.[a] Late work by Robert Anderson has shown the Paso Robles to be composed in part of various marine strata extending from the upper Miocene upward. F. M. Anderson's later name, Tulare, is therefore adopted for the formation to which it was originally given.

Fossils.—The only important fossiliferous zone in the Tulare lies near its base and is called the *Anodonta* zone because of the abundance in it of fresh-water mussels of this genus. Commonly there is but one fossil bed in the zone, but toward the south-central part of the Kettleman Hills, two, and locally three, beds carrying fresh-water shells are found. The following species have been found in the Tulare formation in the Coalinga district by Robert Anderson and the writer:

List of Tulare (Pliocene-lower Pleistocene) fossils from the Coalinga district.

Name.	4715.	4721.	4731.	4732.	4735.	4737.	4738.	4739.	4740.	4743.
PELECYPODA.										
Anodonta kettlemanensis n. sp	....	×	×	×	×	×	....	....	....	....
Gonidea coalingensis n. sp., and var. cooperi n. var	....	×	×	....	....	....	....	×	....	....
Ostrea lurida Carpenter	....	....	....	....	....	....	....	....	....	×
Sphærium cooperi n. sp	....	....	×	×	....	....	....	....	....	....
Sphærium kettlemanensis n. sp	....	....	×	×	....	....	....	....	....	....
GASTEROPODA.										
Amnicola andersoni n. sp	....	....	....	×	....	....	....	....	....	....
Amnicola sp	×	....	....	....	....	....	....	....	....	....
Carinifex marshalli n. sp	....	....	....	×	....	....	....	....	....	....
Goniobasis kettlemanensis n. sp	×	....	....	....	×	....	....	....	....	....
Goniobasis nigrina? Lea	....	....	....	×	....	....	....	....	....	....
Littorina cf. mariana n. sp	....	....	....	....	....	....	....	....	....	×
Physa humerosa Gould	....	....	....	×	....	....	....	....	....	....
Physa wattsi n. sp	....	....	....	×	....	....	....	....	....	....
Planorbis vanvlecki n. sp	×	....	×	×	....	....	....	....	....	....
PISCES.										
Fish, bulbous growths	....	....	×	....	....	....	×	×	×	....
Fish spines	....	....	....	....	....	....	....	....	×	....

[a] San Luis folio (No. 101), Geol. Atlas U. S., U. S. Geol. Survey, 1904.

4715. South end of Kettleman Hills, sec. 10, T. 25 S., R. 19 E.

4721. Northeast border of Kettleman Hills, 4 miles west of Tulare Lake, on summit of 758-foot hill, NE. ¼ sec. 15, T. 22 S., R. 18 E. Fresh-water zone at base of Tulare.

4731. Northeast border of Kettleman Hills, near northwest end, on top of hill (elevation 905 feet) just east of old road and cabin, NW. ¼ NE. ¼ sec. 35, T. 21 S., R. 17 E. Fresh-water zone just above oyster bed of locality 4728.

4732. About 2 miles from northwest end of Kettleman Hills, on south side of main ridge 1½ miles northwest of 1,245-foot hill, SW. ¼ NE. ¼ sec. 30, T. 21 S., R. 17 E. Fresh-water zone at base of Tulare.

4735. Central part of Kettleman Hills, on southwest side, 1 mile southwest of 1,370-foot hill and one-third mile northwest of oil derrick, in center of south line of SW. ¼ sec. 19, T. 22 S., R. 18 E. Fresh-water zone at base of Tulare.

4737. East side of Kettleman Hills, east of Dudley-Lemoore road, NE. ¼ SW. ¼ sec. 17, T. 23 S., R. 19 E. Fresh-water zone overlying upper Etchegoin bed of locality 4736.

4738. In Kreyenhagen Hills, 20 miles southeast of Coalinga, one-fourth mile east of bench mark 872 feet, just south of El Cerrito well, SE. ¼ NW. ¼ sec. 14, T. 23 S., R. 17 E. In white shale zone at base of Tulare as mapped.

4739. Same general locality as 4738, on point of 900-foot hill, nearly 1 mile northwest of bench mark 872 feet, SE. ¼ sec. 10, T. 23 S., R. 17 E. At contact of Etchegoin and Tulare.

4740. Near northwest end of Kettleman Hills, 2 miles north-northwest of 1,245-foot hill, east of center of SW. ¼ sec. 20, T. 21 S., R. 17 E. Fresh-water zone just above Etchegoin oyster beds and white shale of locality 4716.

4743. On west side of Kettleman Hills, along Dudley-Lemoore road, in steeply dipping beds of pebbly sand exposed in bed of arroyo, 1,000 feet up gully from edge of plain, north part of SW. ¼ sec. 35, T. 23 S., R. 18 E. About 2,500 feet above fresh-water zone at base of formation.

The marine and fresh-water fossils at locality 4715, in the southern part of the Kettleman Hills, are more or less mixed, owing to their scattered occurrence over the surface of the eroded upturned beds, and it is uncertain whether the marine forms *Echinarachnius* and *Paphia*, listed from this locality, originally occurred with the fresh-water *Amnicola*, *Goniobasis*, and *Planorbis*.

Faunal relations and age.—A comparison of the above list with the list of species from the same locality prepared by Dr. J. G. Cooper[a] shows a marked discrepancy between the two. This is caused by the different identifications of Doctor Cooper and the writer. Cooper identified the Kettleman Hill species, with the exception of two forms, as species now living, while the writer, after a careful comparison of the fossils with the series of recent fresh-water mollusks in the United States National Museum, concluded that with three exceptions the fossils were new, although in most cases allied to recent forms. A comparison of the two lists discloses the following relations:

Cooper's identification.	*Arnold's identification.*
Anodonta decurtata Conrad	Anodonta kettlemanensis n. sp.
Anodonta nuttalliana Lea	Probably same as above.
Amnicola turbiniformis Tryon	Amnicola andersoni n. sp.
Carinifex newberryi Lea	Carinifex marshalli n. sp.
Goniobasis occata Hinds	Goniobasis kettlemanensis n. sp.
	Goniobasis nigrina? Lea.
Margaritana subangulata Cooper	Gonidea coalingensis n. sp.
	Gonidea coalingensis var. cooperi n. var.
Physa costata Newcomb	Physa wattsi n. sp.
	Physa humerosa Gould.
Planorbis tumens Carpenter	Planorbis vanvlecki n. sp.
Sphærium dentatum Haldeman	Sphærium cooperi n. sp.
	Sphærium kettlemanensis n. sp.

This fauna, as interpreted by the writer, indicates that the basal Tulare in the Coalinga district is possibly older than the lowest known fossiliferous beds in the Santa Clara formation of the Santa Cruz region, and certainly very much older than the fresh-water fossils from the Colorado Desert of southern California. In fact, the basal Tulare is believed to be the fresh-water equivalent of the San Diego formation and lower Pliocene in age. About 2,500 feet above the base of the Tulare, *Ostrea lurida* Carpenter, a species so far known outside of this district only from Pleistocene and recent faunas, has been found. This fact is interpreted as indicating a recurrence of marine or estuarine conditions during upper Tulare time and the extension of the Tulare into the Pleistocene.

[a] Proc. California Acad. Sci., 2d ser., vol. 4, May 26, 1894, p. 167; Bull. California State Min. Bureau, No. 3, p. 55; Proc. California Acad. Sci., 3d ser., Geology, vol. 2, p. 180.

DESCRIPTIONS OF SPECIES.

TEJON (EOCENE) SPECIES.

PELECYPODA.

Genus TELLINA Linnæus.

TELLINA JOAQUINENSIS n. sp.

Plate II, figure 11.

Description.—Shell attaining a length of 22 millimeters, oblong, compressed, inequivalve, inequilateral. Beaks slightly posterior, small; anterior extremity regularly rounded; posterior extremity more attenuated than anterior, the posterior dorsal margin sloping from beaks at a somewhat steeper angle than the anterior dorsal margin; posterior fold practically obsolete. Surface smooth, except for numerous very fine lines of growth. Hinge and interior unknown.

Dimensions.—Longitude 22 mm.; latitude 15 mm.; diameter of single valve, 1.1 mm.

Notes.—This small species reminds one somewhat of *Angulus*, but is more nearly equilateral and has a less attenuated posterior extremity. *T. joaquinensis* is characterized and may be distinguished from other California Eocene species by its small size, approximate bilateral symmetry, and the moderately steep slopes of its dorsal margins. It is apparently closest allied to the Chico (upper Cretaceous) *T. parilis* Gabb, but may be distinguished from the latter by its slightly more posterior beaks and broader outline. It is named for the San Joaquin coal mine, near Coalinga.

Type.—Left valve; catalogue No. 165619, U.S.N.M.

Locality.—United States Geological Survey locality 4801; hard, fine sandstone at San Joaquin coal mine, 3 miles west of Coalinga, in NW. ¼ sec. 26, T. 20 S., R. 14 E. (Ralph Arnold and Robert Anderson).

Horizon.—Tejon formation, Eocene.

Genus MERETRIX Lamarck.

MERETRIX GABBI n. sp.

Plate III, figure 4.

Description.—Shell attaining a length of 30 millimeters, inequilaterally trigonal in outline, gibbous, finely concentrically striated.

Beaks prominent, turbid, bent forward, situated well toward the front of the shell; anterior dorsal margin sloping abruptly down to the narrow, sharply rounded extremity; posterior dorsal margin only slightly curved except near beak and near extremity, where it bends abruptly down, obliquely truncating the end; lower angle of extremity sharper than upper; base regularly rounded, lunule not large; sculpture consisting of numerous sharp, fine, close-set concentric lines and a few lines of interrupted growth, the latter appearing closer together on the later stages of growth. Hinge and interior unknown.

Dimensions.—Longitude 29 mm.; latitude 24 mm.; diameter of single valve, 11 mm.

Notes.—*Meretrix gabbi* differs from *M. uvasana* Conrad (Pl. III, fig. 13), from the Tejon by its much finer surface sculpture and much more abruptly truncated anterior extremity. It differs from *M. horni* Gabb (Pl. III, fig. 9), from the Tejon, by the same characters. It differs from *M. ovalis* Gabb (Pl. III, fig. 5), from the Tejon, by its more trigonal outline, more abrupt anterior end, and rougher surface. It is named in honor of the late W. M. Gabb, the Nestor of California paleontology.

Type.—Catalogue No. 165640, U.S.N.M., from locality 4801.

Localities.—United States Geological Survey locality 4614, in low hills 3½ miles northwest of Coalinga and between the two coal mines; locality 4621, about 150 feet above Chico (Cretaceous) contact, in hills just south of Los Gatos Creek, 5½ miles north 45° west of Coalinga; locality 4801, San Joaquin coal mine, 3 miles west of Coalinga (Ralph Arnold and Robert Anderson).

Horizon.—Tejon formation, Eocene.

Genus OSTREA Linnæus.

OSTREA AVICULIFORMIS F. M. Anderson.

Plate II, figure 12.

1905. *Ostrea aviculiformis* F. M. Anderson, Proc. California Acad. Sci., 3d ser., Geology, vol. 2, December, 1905, p. 194, pl. 13, figs. 3, 4, and 5.

This species is very closely allied to, if not the same as, *Ostrea (Gryphostrea) subeversa* Conrad from the Jackson formation of Alabama. This close relationship between the Jackson formation and the Tejon, also shown by many other species, leads to the conclusion that the two formations are practically contemporaneous.

Figured specimen.—Catalogue No. 165627, U.S.N.M.

Locality.—United States Geological Survey locality 4801, San Joaquin coal mine, 3 miles west of Coalinga, in NW. ¼ sec. 26, T. 20 S., R. 14 E. (Ralph Arnold); west and north of Coalinga (F. M. Anderson).

Horizon.—Tejon formation, Eocene.

GASTEROPODA.

Genus SPIROGLYPHUS Daudin.

SPIROGLYPHUS? TEJONENSIS n. sp.

Plate IV, figure 18.

Description.—Shell attaining a diameter of over 7 millimeters, discoidal coil, with no spire. Whorls three, circular in cross section, the first one impressed slightly below plane of periphery; sculpture consisting of numerous fine, sharp lines of growth and a more or less prominent revolving sulcation near suture on the inner side of the top of the whorl.

Dimensions.—Maximum diameter, 7.5 mm.; height of coil, 1 mm.

Notes.—Owing to the uncertainty attending the identification of forms belonging to this group, it is impossible to assign the species definitely to this genus. Its common occurrence and apparent restriction to the Eocene fauna has, in the writer's opinion, warranted a name. It is named for the Tejon formation, in which it is common in the Coalinga district.

Type.—Catalogue No. 165658, U.S.N.M., from locality 4617.

Localities.—United States Geological Survey locality 4617, hills just northwest of the headwaters of Little Tar Canyon, north of Dudley; locality 4619, west part of sec. 29, T. 18 S., R. 15 E., 15 miles north of Coalinga (James H. Pierce and Ralph Arnold).

Horizon.—Tejon formation, Eocene.

Genus TRITONIDEA Swainson.

TRITONIDEA KREYENHAGENI n. sp.

Plate IV, figure 10.

Description.—Shell attaining a length of over 15 millimeters, fusiform, apex acute, canal short; axially ribbed and spirally sculptured. Whorls about five or six, moderately convex, angulate and tabulate above middle of whorl; a wavy sulcated sutural line or riblet adorns top of whorl. Sculpture consisting of several (11 on penultimate whorl) prominent, bulging, close set varices extending from suture to suture, but becoming obsolete, or nearly so, on the body whorl; spiral sculpture consists of three prominent rounded, raised lines separated by interspaces, somewhat wider than the lines, in each of which is a minor line, and sometimes a threadlet or two; between the uppermost prominent line, which usually adorns the angle, and the sutural riblet are two or three minor riblets; body whorl tapering rapidly in front and sculptured in a similar manner to the lower parts of the upper whorls. Aperture ovate, narrowed in front, canal short, curved; outer lip thin, describing a compound curve bowing from and below

middle; inner lip smooth; columella with external, rather smooth fold.

Dimensions.—Longitude, of slightly décolleté type, 16 mm.; latitude 9.5 mm.; longitude of body whorl 12 mm.; longitude of aperture and canal 9 mm.

This species is characterized by its numerous close-set bulging varices and well-defined spiral lines. It is named in honor of Adolph and Hugo Kreyenhagen, to whom the writer is under obligations for many favors received during the course of work in the region of their ranches south of Coalinga.

Type.—Catalogue No. 165657, U.S.N.M.

Locality.—United States Geological Survey locality 4801, San Joaquin coal mine, 3 miles northwest of Coalinga, in NW. ¼ sec. 26, T. 20 S., R. 14 E. (Ralph Arnold).

Horizon.—Tejon formation, Eocene.

Genus CANCELLARIA Lamarck.

CANCELLARIA IRELANIANA Cooper.

Plate IV, figure 22.

1894. *Cancellaria* (*Narona*) *irelaniana* Cooper, California State Min. Bureau, Bull. No. 4, p. 42, pl. 1, fig. 5.

Notes.—The specimen from the Coalinga locality has less prominent tubercles on the body whorl, has a higher angle on each whorl, and shows more spiral sculpture, especially below the angle, than is indicated by Cooper's original description and figure. These differences are easily accounted for by the individual variability usually encountered in species of this genus. Cooper reports only a single specimen, the type, from the Marysville Buttes, Sutter County, collected by W. L. Watts. A single specimen only was found in the Coalinga locality. The species was named after William Irelan, jr., former state mineralogist of California.

Figured specimen.—No. 165645 U.S.N.M.

Locality.—United States Geological Survey locality 4619, west part of sec. 29, T. 18 S., R. 15 E., 15 miles north of Coalinga (James H. Pierce and Ralph Arnold).

Horizon.—Tejon formation, Eocene.

Genus PLEUROTOMA Lamarck.

PLEUROTOMA DOMENGINEI n. sp.

Plate IV, figure 16.

Description.—Perfect shell about 15 millimeters in length, spindle-shaped, whorls angulated, sculpture largely spiral. Whorls about six,

sharply angulated posterior to middle, tabulate above with a prominent nearly vertical revolving sutural ridge or carina just below suture. The sculpture on the sutural ridge consists of numerous sharp, more or less regular incremental lines bowing backward in conformity with the curvature of the posterior sinus at each period of growth; a small rugose spiral thread runs along the base of the sutural ridge and another along the top in certain of the whorls; the sculpture of the rest of the whorl consists of several (four on the lower part of the penultimate whorl) rather prominent rugose revolving threadlets; the lower part of the body whorl is nearly straight or only slightly convex and is sculptured by lines similar to those on the basal parts of the other whorls. Aperture and columella of type are missing, so these can not be characterized.

Dimensions.—Of broken type, longitude 11 mm.; latitude 6.5 mm.

Notes.—This beautifully sculptured little species is characterized by its tabulate whorls, prominent sutural ridge, and the peculiar sculpture of the ridge and lower part of whorl. Only the type is known. It is named for the Domengine ranch, near which the type was found.

Type.—Catalogue No. 165647, U.S.N.M.

Locality.—United States Geological Survey locality 4619, in the west part of sec. 29, T. 18 S., R. 15 E., 15 miles north of Coalinga (Jas. H. Pierce and Ralph Arnold).

Horizon.—Tejon formation, Eocene.

PLEUROTOMA FRESNOENSIS n. sp.

Plate IV, figure 23.

Description.—Shell attaining a length of over 20 millimeters, spindle-shaped, very slender, apex acute, whorls nodose and spirally sculptured. Whorls 10, convex and sharply angulated in middle; about eight sharp, spirally elongated nodes adorn the angle of each whorl, becoming obsolete toward sutures; upper surface of whorls flat to concave and strongly sculptured by backward bowing incremental lines which record shape of sinus; lower portion of whorl sculptured by two or three subequal spiral lines; lower part of body whorl with alternating rugose spiral lines. Suture wavy, distinct. Aperture elliptical; canal unknown; posterior sinus well developed; outer lip sharp, bowing forward in middle; inner lip smooth.

Dimensions.—Longitude of type from which the canal is broken, 21 mm.; latitude 8 mm.; longitude of spire 11 mm.; longitude of aperture 7 mm.

Notes.—This beautiful species is at once distinguishable by its slender form, peculiar spirally elongated sharp nodes and strong spiral sculpture below angle, and strong incremental sculpture above

angle. The species reminds one somewhat of *P.* (*Drillia*) *torosa* Carpenter. Named for Fresno County, in the western part of which is the type locality.

Type.—Catalogue No. 165631, U.S.N.M.

Locality.—United States Geological Survey locality 4619, west part of sec. 29, T. 18 S., R. 15 E., 15 miles north of Coalinga (James H. Pierce and Ralph Arnold).

Horizon.—Tejon formation, Eocene.

PLEUROTOMA GUIBERSONI n. sp.

Plate IV, figure 20.

Description.—Shell attaining a length of at least 14 millimeters, narrowly spindle-shaped, prominently nodose. Whorls seven, regularly convex, each whorl carrying five or six very prominent, slightly oblique rounded varices; the spiral sculpture consists of a small sutural riblet or wavy line just below the suture, three or four prominent sharp, equidistant, widely separated spiral lines, and between each pair of these four to six microscopic revolving lines; suture deeply impressed, distinct. Canal broken and aperture covered up in type.

Dimensions.—Longitude 13.5 mm.; latitude 5.8 mm.; longitude of spire above body whorl 6 mm.

Notes.—This species is characterized by its moderately small size, very convex whorls, very prominent bulging varices and few distinct widely separated spiral lines. It is named in honor of Mr. S. A. Guiberson, jr., superintendent of the Associated Oil Company, Coalinga, Cal., to whom the writer is indebted for favors while working in the Coalinga district.

Type.—Catalogue No. 165648, U.S.N.M.

Locality.—United States Geological Survey locality 4619, in the west part of sec. 29, T. 18 S., R. 15 E., 15 miles north of Coalinga (James H. Pierce and Ralph Arnold).

Horizon.—Tejon formation, Eocene.

VAQUEROS (LOWER MIOCENE) SPECIES.

PELECYPODA.

Genus MULINIA Gray.

MULINIA DENSATA Conrad var. MINOR n. var.

Plate V, figure 6. (See also Pl. XVII, figs. 3 and 4, and Pl. XXI, fig. 3.)

Notes.—This variety is characterized by its smaller size, and more inequilateral form than the typical *M. densata* Conrad. (Pacific Railroad Repts., vol. 6, p. 71, pl. 3, fig. 12.) The typical *M.*

densata is found most abundantly in the upper Miocene; var. *minor* is commoner in the lower Miocene (Vaqueros), although specimens indistinguishable from the Vaqueros forms are found in the Etchegoin. *Mulinia densata* is also known as *Pseudocardium gabbi* Rémond.

Type.—Catalogue No. 165601 U.S.N.M., from locality 4777.

Localities.—United States Geological Survey locality 4625, "reef bed" in Sulphur Spring branch of Zapato Creek, in sec. 23, T. 22 S., R. 15 E.; locality 4627, "reef bed" just west of Tar Canyon, in north part of sec. 18, T. 23 S., R. 16 E.; locality 4667, "reef bed" 1½ miles east of Jacalitos Creek, 5½ miles southwest of Alcalde, in east-central part of sec. 18, T. 22 S., R. 15 E.; locality 4770, *Turritella ocoyana* bed in Canoas Creek, 1½ miles southwest of Hugo Kreyenhagen's place, NE. ¼ SE. ¼ sec. 32, T. 22 S., R. 16 E.; locality 4777, "reef bed" on Jasper Creek, above Ramirez place at forks of Jacalitos Creek (Ralph Arnold and Robert Anderson); also several localities in Etchegoin formation (Arnold and Anderson).

Horizon.—Vaqueros formation, lower Miocene, to Etchegoin formation, upper Miocene.

Genus MACOMA Leach.

MACOMA PIERCEI n. sp.

Plate VII, figure 6.

Description.—Shell attaining a length of 75 millimeters, oval, compressed, inequivalve, inequilateral, concentrically sculptured and with a prominent posterior dorsal ridge or fold. Beaks small, turned slightly forward, situated somewhat anterior to middle; anterior dorsal margin straight for a short distance and sloping at a moderate steep angle away from the beak, then curving gently around the regularly convex anterior extremity; posterior extremity straight, moderately angulated at juncture with rounded posterior extremity; in the left valve the surface is flexed downward dorsally in the rear, a sharply defined anterior dorsal ridge or carina marking the border; in the right valve the disk flexes upward dorsally in the rear, a sharp ridge or carina joining the beak and posterior extremity a short distance below the dorsal margin. Surface sculptured by fine, sharp, regular incremental lines.

Dimensions.—Longitude 75 mm.; latitude 55 mm.; diameter of both valves together 14 mm.

Notes.—*M. piercei* is more closely allied to *M. secta* Conrad (living from Strait of Fuca to Lower California) than to any other west coast form, but is readily distinguished from the latter by its longer and narrower outline, more compressed disk, more advanced position of the beak, and sharper anterior dorsal ridge; the sculpture of the

former is also apparently sharper and more regular than that of the latter species. It is named in honor of James H. Pierce, Coalinga, Cal.

Type.—A rather poorly preserved pair, catalogue No. 165595, U.S.N.M., from locality 4631.

Locality.—U. S. Geological Survey locality 4631, *Turritella ocoyana* bed, SE. ¼ NE. ¼ sec. 16, T. 19 S., R. 15 E., 10 miles north of Coalinga (Ralph Arnold; James H. Pierce); locality 4633, same horizon as last, sec. 10, T. 19 S., R. 15 E. (Ralph Arnold); locality 4861, "reef bed," NW. ¼ sec. 23, T. 25 S., R. 18 E., Devils Den District, near Barton's cabin (O. D. Barton; H. R. Johnson; Ralph Arnold).

Horizon.—Vaqueros formation, lower Miocene.

Genus SAXIDOMUS Conrad.

SAXIDOMUS VAQUEROSENSIS n. sp.

Plate VII, figure 7.

Description.—Shell averaging about 70 millimeters in length, transversely oval, equivalve, inequilateral, moderately gibbous. Beak tumid, situated about two-fifths of the distance from anterior to posterior extremity, turned slightly forward; posterior dorsal margin nearly straight, posterior extremity oblique and meeting dorsal margin in a faint angle, lower part of posterior extremity rounded; base slightly but regularly rounded; anterior extremity regularly rounded, excavated immediately in front of beak. Surface sculptured by sharp, subequal incremental laminæ. There is no lunule, but an impressed line runs part way from beak to anterior extremity and a broad, shallow groove extends from the beak to the posterior angle.

Dimensions.—Longitude 69 mm.; latitude 45 mm.; diameter, both valves together, 31 mm.

Notes.—This beautiful species is closely allied and is probably the precursor of *S. nuttalli* Conrad, which is found in the upper Miocene, Pliocene, Pleistocene, and Recent faunas. It is distinguished from the latter by its narrower outline and more regular and finer concentric sculpture. It is named for the Vaqueros formation, of which it is believed to be characteristic.

Type.—Catalogue No. 165570, U.S.N.M., from locality 4631.

Localities.—United States Geological Survey locality 4627, "reef bed" just west of Tar Canyon, in north part of sec. 18, T. 23 S., R. 16 E. (Ralph Arnold and Robert Anderson); locality 4631, *Turritella ocoyana* bed, SE. ¼ NE. ¼ sec. 16, T. 19 S., R. 15 E. (James H. Pierce; Ralph Arnold).

Horizon.—Vaqueros formation, lower Miocene.

Genus CARDIUM (Linnæus) Lamarck.

Subgenus TRACHYCARDIUM Mörch.

CARDIUM (TRACHYCARDIUM) VAQUEROSENSIS Arnold.

Plate IX, figure 2.

1908. *Cardium (Trachycardium) vaquerosensis* Arnold, Proc. U. S. Nat. Mus., vol. 34, August 8, 1908, p. 378, pl. 34, fig. 3.

Notes.—The specimen figured in this report has four more (33) ribs than the type of the species, thus approaching more closely to the recent, *C. quadrigenarium* Conrad, which has about 10 more (40) ribs than the typical *C. vaquerosensis*. This fact is accounted for by the higher stratigraphic position of the beds from which the Coalinga specimen comes, namely, from the top of the Vaqueros; the type locality of the species is well down in the formation.

Figured specimen.—Catalogue No. 165598, U.S.N.M., from locality 4631.

Localities.—United States Geological Survey locality 4631, *Turritella ocoyana* bed, in SE. ¼ NE. ¼ sec. 16, T. 19 S., R. 15 E., 10 miles north of Coalinga (James H. Pierce and Ralph Arnold); locality No. 4860, "reef bed," Wagon Wheel Mountain, Kern County, 9 miles southeast of Dudley, NW. ¼ sec. 36, T. 25 S., R. 18 E. (O. D. Barton; H. R. Johnson; Ralph Arnold); Santa Cruz quadrangle, San Mateo County; locality 12, Mindego Creek, 1 mile above its confluence with Alpine Creek (Ralph Arnold; H. H. Holly; L. C. Mills).

Horizon.—Vaqueros formation, lower Miocene.

Genus PHACOIDES Blainville.

Subgenus MILTHA H. & A. Adams.

PHACOIDES (MILTHA) SANCTÆCRUCIS n. sp.

Plate VI, figure 6.

Description.—Shell averaging about 75 millimeters in altitude, circular in outline, compressed, concentrically striate. Beaks central, prominent, turned sharply toward the front. Both margins faintly angulated at a point down about one-fourth the distance from beak to base; the posterior dorsal margin the higher and more regularly curved; the anterior dorsal margin shorter and less regular; anterior extremity and base evenly rounded; posterior extremity somewhat truncate. Lunule rather narrow, separated from disk by impressed line and a more or less elevated carina; posterior area broadly grooved, extending from beak to extremity, separated from disk by

a faint carina and groove. Surface sculptured by fine regular incremental lines and a few faint irregularities of growth. Hinge not exposed in type but believed to be similar to *P. childreni* Gray.

Dimensions.—Longitude 75 mm.; latitude 75 mm.; diameter of both valves 28 mm.

Notes.—This species, which is not rare in many of the Vaqueros (lower Miocene) faunas of the Coast Ranges and is believed to extend to the upper Miocene and possibly lower Pliocene, is characterized by its large size, circular outline, slight angulation dorsally, compressed disk, prominent lunule and dorsal areas, and finely concentrically striate but otherwise unsculptured surface. It is closely allied to *P. childreni* Gray, the type of the subgenus, from the Gulf of California, but may be distinguished by its shorter lunule and relatively greater breadth. The species is named in honor of the Santa Cruz Mountains, where it is quite abundant in the Vaqueros formation.

Type.—Catalogue No. 165569, U.S.N.M., from locality 4861, Coalinga district.

Localities.—Mindego Creek (L. S. J. U. locality 12) Santa Cruz Mountains, San Mateo County (Ralph Arnold); United States Geological Survey locality 4861, sec. 23, T. 25 S., R. 18 E., in "reef bed" one-fourth of a mile southeast of Barton's cabin, Devils Den district, Kern County (O. D. Barton; Ralph Arnold). Lower Miocene.

Fernando and Newhall, Los Angeles County (Ralph Arnold). Upper Miocene or lower Pliocene.

Horizon.—Lower Miocene to upper Miocene and possibly lower Pliocene.

Genus SEPTIFER Recluz.

SEPTIFER COALINGENSIS n. sp.

Plate V, figure 4.

Description.—Shell averaging about 45 millimeters in length, wedge-shaped, slender, convex, radially striate. Beaks subterminal, curved, sharp, anterior margin moderately concave, slightly angular at about middle; posterior margin considerably more curved than the anterior, slightly angulated opposite angle in anterior margin; base slightly convex, moderately abruptly truncated at right angles to margins on both sides. Surface sculptured by numerous regular, close-set small rounded radiating ribs and a considerable number of prominent lines of growth; all of the specimens examined are more or less decorticated and show the radial sculpture around the periphery only; the sculpture in the younger stages of growth is believed to be coarser than that in the later stages. Hinge without teeth, furnished with a lamellar septum; ligamental pits linear, marginal.

Dimensions.—Longitude 45 mm.; latitude 18.5 mm.; diameter of both valves together, 18 mm.

Notes.—This unique species is characterized by its slender form, regularly convex surface, and fine radial sculpture. It is closely allied to the recent *S. bifurcatus* Reeve (range, San Francisco to Lower California), but is narrower, more falcate, and more regularly but less markedly convex. It is much larger, narrower, less angulate, and finer sculptured than the Tejon (Eocene) *S. dichotomus* Gabb.

Type.—Catalogue No. 165580, U.S.N.M.

Locality.—United States Geological Survey locality No. 4634, hill south of oil well in the NE. ¼ sec. 12, T. 21 S., R. 14 E., 3 miles southwest of Coalinga (Ralph Arnold and Robert Anderson).

Horizon.—Vaqueros formation, lower Miocene.

GASTEROPODA.

Genus TROPHON Montfort.

Subgenus FORRERIA Jousseaume, 1880.

TROPHON (FORRERIA) BARTONI n. sp.

Plate VII, figure 3.

Description.—Shell averaging about 50 millimeters in length, spire elevated, canal long and narrow, whorls angular and prominently spinose. Whorls three or four, sharply angular a short distance below middle; upper surface smooth and nearly flat, lower surface vertical or sloping slightly inward, suture distinct and wavy. Sculpture consists of about seven prominent, straight, sharp spines on the angle of each whorl; each spine is continued below into a more or less prominently forward-flexing nodose varix, the nodes being formed by the crossing of several (seven on the body whorl of the type) ridges; faint lines of growth and minor spiral ridges also adorn the shell. Aperture ovate; canal moderately long and slightly recurved.

Dimensions.—Of imperfect type, altitude 33 mm.; latitude 40 mm.; altitude of aperture, not including canal, 17 mm.

Notes.—This species is doubtless closely allied to *T.* (*Forreria*) *kernensis* F. M. Anderson, described from the Vaqueros formation on Kern River. It may, however, be distinguished from the latter by its longer and sharper varices, broader outline, and more prominent varices and spiral ridges. It is named in honor of Prof. Orlando D. Barton, Dudley, Cal., to whom the writer is under the deepest obligations for assistance rendered during various expeditions in the region of his home.

Type.—Catalogue No. 165571, U.S.N.M., from locality 4861.

Localities.—United States Geological Survey locality 4803, "reef bed" about 200 feet stratigraphically above the Eocene unconformity on Laval grade, 9 miles north of Coalinga, SW. ¼ sec. 21, T. 19 S., R. 15 E. (Ralph Arnold; H. R. Johnson; Frank Stokes, jr.); locality 4861, "reef bed" in NW. ¼ sec. 23, T. 25 S., R. 18 E., near Barton's cabin (O. D. Barton; Ralph Arnold).

Horizon.—Vaqueros formation, lower Miocene.

TROPHON (FORRERIA) GABBIANUM F. M. Anderson var. CANCELLARIOIDES n. var.

Plate VI, figure 5.

Notes.—As is indicated by the figures, *T. gabbianum*[a] is a most variable species. The specimen from Wagon Wheel Mountain (Pl. V, fig. 5) superficially resembles a *Siphonalia*, exhibits practically spineless upper whorls, a prominent overlapping carina on the upper portion of the whorl and the characteristic spiral sculpture, best developed below the angle. The individual obtained near Barton's cabin (Pl. VI, fig. 5) suggests a *Cancellaria*, has numerous sharply angular, well-defined spiny whorls, in addition to the peculiar spiral sculpture. This latter characteristic, together with certain other points of detail, at once disclose the identity of the various mutations. In recognition of the resemblance of the extremely nodose or spiny form to a *Cancellaria* the varietal name *cancellarioides* is proposed.

Type of variety.—Catalogue No. 165605, U.S.N.M., locality 4861.

Figured specimen of typical form.—Catalogue No. 165572, locality 4860.

Localities.—United States Geological Survey locality 4860, "reef bed," Wagon Wheel Mountain, Devils Den district, Kern County, NW. ¼ sec. 36, T. 25 S., R. 18 E.; locality 4861, "reef bed" in NW. ¼ sec. 23, T. 25 S., R. 18 E., near Barton's cabin, 6 miles south of Dudley (Ralph Arnold; O. D. Barton; H. R. Johnson); type locality, Laval grade, 9 miles north of Coalinga (F. M. Anderson).

Horizon.—Vaqueros formation, lower Miocene.

Genus CANCELLARIA Lamarck

CANCELLARIA ANDERSONI n. sp.

Plate IX, figure 5.

1905. *Purpura lima* F. M. Anderson (not of Martyn), Proc. California Acad. Sci., 3d ser., Geology, vol. 2, December 4, 1905, p. 202, pl. 15, figs. 62–63.

Description.—Shell attaining a length of over 20 millimeters, broadly oval in outline, the last whorl much larger than the antecedent ones, surface cancellate. Whorls four, convex and angular, with

[a] Anderson, F. M., Proc. California Acad. Sci., 3d ser., Geology, vol. 2, p. 203, pl. 16, figs. 79, 80.

exception of body whorl, which is, with the exception of a faint tabulation, regularly ventricose and relatively smooth. Penultimate and earlier whorls sculptured by several (10 in the penultimate whorl) prominent rounded varices which become obsolete above angle; the body whorl is only faintly axially ribbed, if at all, but is spirally sculptured, the latter sculpture becoming subdued or obsolete in the upper whorls; suture distinct. Aperture oblong; outer lip simple; inner lip incrusted, smooth, with a prominent callus posteriorly; columella with two prominent oblique spiral plaits.

Dimensions.—Longitude 21 mm.; latitude 12 mm.; longitude of spire above body whorl, 3.5 mm.

Notes.—This species is characterized by its inornate body whorl and strongly sculptured upper whorls, and is easily distinguished by these characters from the other west coast species. Mr. Anderson was probably unable to uncover the columella of his specimen, else his generic determination would not have been as quoted.

Named in honor of Mr. Frank M. Anderson, Berkeley, Cal., to whom we are indebted for so many paleontologic data concerning both the Cretaceous and Tertiary formations of the Pacific coast.

Type.—Catalogue No. 165607, U.S.N.M., from locality 4631.

Localities.—United States Geological Survey locality 4631, *Turritella ocoyana* bed in SE. ¼ NE. ¼ sec. 16, T. 19 S., R. 15 E., 10 miles north of Coalinga (James H. Pierce and Ralph Arnold); Kern River, Vaqueros locality, Kern County (F. M. Anderson).

Horizon.—Vaqueros formation, lower Miocene.

Genus PLEUROTOMA Lamarck.

Subgenus BATHYTOMA.

PLEUROTOMA (BATHYTOMA) PIERCEI n. sp.

Plate IX, figure 7.

Description.—Shell averaging about 50 millimeters in length, turriculated, fusiform. Whorls probably about six (type décolleté) moderately prominently angulated about middle of whorl; posterior surface slightly concave, anterior surface prominently convex; the convexity of the posterior portion of the body whorl is most pronounced just back of the angle; body whorl regularly rounded below. Surface of whorls faintly spirally sculptured below; lines of growth are also visible in well-preserved specimens. Suture impressed, distinct. Aperture and canal imperfect but believed to be similar to *B. carpenteriana.*

Dimensions.—Longitude of imperfect type 38 mm.; latitude 19.5 mm.; longitude of restored spire above body whorl about 16 mm.

Notes.—*B. piercei* at once suggests the group of which *B. carpenteriana* Gabb is by far the commonest west coast representative; it

may be distinguished from the latter by its relatively shorter whorls, much higher angle, and consequently shorter posterior portion of whorl; the suture is usually better marked in *B. piercei* than in *B. carpenteriana*, owing to the greater convexity of the basal portion of the whorl in the former species. *B. piercei* may be distinguished from *B. carpenteriana* var. *fernandoana* Arnold, from the Fernando formation (probably Pliocene portion), by its more acute spire and the higher position of the revolving angle on each whorl. *B. piercei* bears practically the same relation to *B. carpenteriana* that *B. keepi* Arnold, from the Vaqueros (lower Miocene) of the Santa Monica Mountains, bears to the recent *B. tryoniana* Gabb.

The species is named in honor of James H. Pierce, superintendent Standard Oil Company, Coalinga, Cal., whose work among the fossiliferous localities of the Coalinga district has been of the utmost assistance to the writer.

Type.—Specimen from which lower portion of body whorl has been broken, catalogue No. 165578, U.S.N.M.

Locality.—United States Geological Survey locality 4631, *Turritella ocoyana* bed in the SE. ¼ NE. ¼ sec. 16, T. 19 S., R. 15 E., 10 miles north of Coalinga (James H. Pierce and Ralph Arnold).

Horizon.—Near top of Vaqueros formation, lower Miocene.

Genus CONUS Linnæus.

CONUS HAYESI n. sp.

Plate VI, figure 3.

Description.—Shell averaging over 60 millimeters in length, obconic, whorls enrolled upon themselves, the spire short, tapering slightly more acutely in the younger stages of growth, shell thick. Spire elevated about one-twelfth of the length of shell above body whorl; whorls about seven, nearly flat, but showing a faint carina posteriorly next to suture; the type shows faint traces of three or four spiral lines; body whorl moderately sharply angulated and carrying a faint sutural carina, sides straight. Aperture long and narrow; the imperfect condition of the type prevents a full description of the aperture and canal.

Dimensions.—Longitude 60 mm.; latitude 44 mm.; altitude of spire 5 mm.

Notes.—*C. hayesi* closely resembles both the recent Gulf of California species *C. fergusoni* Sowerby and the tropical west American *C. purpuraceus* Broderip. It is relatively broader and slightly less sharply angulated than the former and is spirally sculptured above, while it has a less elevated spire and more sharply angulated body whorl than the latter. The species is supposed to be characteristic of the Vaqueros or lower Miocene horizon. It is named in honor of C. Willard Hayes, chief geologist, United States Geological Survey.

Localities.—United States Geological Survey locality 4626, "reef bed" on Wagon Wheel Mountain, Kern County, 10 miles south of Dudley; locality 4861, "reef bed" in sec. 23, T. 25 S., R. 18 E., near Barton's cabin, which is in the NW. ¼ sec. 23, Kings County (O. D. Barton; Ralph Arnold); (?)El Toro, Orange County (Delos Arnold; Stephen Bowers).

Horizon.—Vaqueros sandstone, lower Miocene.

JACALITOS (EARLY UPPER MIOCENE) SPECIES.

ECHINODERMATA.

Genus ASTRODAPSIS Conrad.

ASTRODAPSIS JACALITOSENSIS n. sp.

Plate XV, figure 5.

Description.—Specimen similar in general aspects to *A. whitneyi* Rémond, but distinguished by its larger size (sometimes 80 millimeters in maximum diameter), and oblong instead of circular outline; the petals are also less prominently elevated and broader in *jacalitosensis* than in the latter.

Dimensions.—Maximum diameter 80 mm.; minimum diameter 70 mm.; maximum latitude of petals 12 mm.

Notes.—As this form has a definite stratigraphic value, being so far as known confined to the Jacalitos formation, it has been deemed worthy of a specific name, although its close relationship to the previously described *A. whitneyi* is freely admitted. In the Coalinga district *A. whitneyi* (see Pl. XI, fig. 1) is found in the Santa Margarita(?) formation (upper middle Miocene), while *A. jacalitosensis* occurs in the Jacalitos formation, which lies stratigraphically above the Santa Margarita(?). Merriam[a] states that in the Mount Diablo region *A. whitneyi* probably occurs in the upper beds of the San Pablo formation, which would correspond to the Etchegoin of the Coalinga district. This discrepancy between the horizons in which *A. whitneyi* occurs in the two regions is worthy of further study. For a fuller discussion of the stratigraphic relations of the various west American sea urchins the reader is referred to papers on this subject by J. C. Merriam,[b] C. E. Weaver,[c] and R. W. Pack.[d]

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[a] Proc. California Acad. Sci., 3d ser., Geology, vol. 1, p. 167.

[b] The distribution of the Neocene sea urchins of middle California and its bearing on the classification of the Neocene formations: Bull. Dept. Geology Univ. California, vol. 2, May, 1898, pp. 109-118. The Tertiary sea urchins of middle California: Proc. California Acad. Sci., 3d ser., Geology, vol. 1, March 6, 1899, pp. 161-174, pls. 21-22.

[c] New echinoids from the Tertiary of California: Bull. Dept. Geology Univ. California, vol. 5, 1909, pp. 271-274, pls. 21-22.

[d] Notes on echinoids from the Tertiary of California: Bull. Dept. Geology Univ. California, vol. 5, July, 1909, pp. 275-283, pls. 23-24.

Type.—Catalogue No. 165610, U.S.N.M., from locality 4745.

Localities.—U. S. Geological Survey locality 4654, on Jacalitos Creek, one-half mile above the junction with Jasper Creek, on south side of sec. 1, T. 22 S., R. 14 E. (A. E. Preston; Ralph Arnold); locality 4745, on ridge southeast of Garza Creek, in sec. 2, T. 23 S., R. 16 E., Kings County (Ralph Arnold).

Horizon.—Jacalitos formation, lower part of upper Miocene.

PELECYPODA.

Genus PANOPEA Menard.

PANOPEA ESTRELLANA Conrad.

Plate XV, figure 1.

1857. *Glycymeris estrellana* Conrad, Pacific R. R. Repts., vol. 7, 1857, p. 194, pl. 7, figs. 5, 5*a*.

1869. *Glycymeris generosa* Gould, Gabb, Pal. California, vol. 2, p. 89, California Miocene records only.

1888. *Glycymeris generosa* Gould, Cooper, Seventh Ann. Rept. California State Mineralogist, 1888, p. 241, California Miocene records only.

1898. *Panopea estrellanus* Conrad, Dall, Trans. Wagner Free Inst. Sci., vol. 3, pt. 4, 1898, p. 830, California Miocene records only.

Notes.—Comparisons of the type of this species (catalogue 13320 U.S.N.M.) with specimens from the Coalinga district show the type to be smaller, relatively narrower, and with the beaks much more anterior to the middle of the shell than in *P. generosa* Gould; *P. estrellana* may be distinguished from *P. abrupta* Conrad by its longer posterior extremity and more steeply sloping dorsal anterior margin.

Figured specimen.—Catalogue No. 165568, U.S.N.M., from locality 4765.

Localities.—United States Geological Survey locality 4765, just east of Ramirez place at forks of Jacalitos Creek, Coalinga district, Fresno County, on west side of center of SW. ¼ sec. 6, T. 22 S., R. 15 E. (Ralph Arnold); Estrella Valley, San Luis Obispo County, California (Pacific R. R. Expl. Exped.); ?Walnut Creek, Contra Costa County, ?Foxin's, Santa Barbara County (Cooper).

Horizon.—Upper half of the Miocene.

Genus MACOMA Leach.

MACOMA sp. *a*.

Plate XV, figure 3.

Notes.—This species, which is characterized by its short form, steeply sloping dorsal margins, and angulated anterior extremity, is believed to be characteristic of the Jacalitos. The material is in too

poor a state of preservation to permit a specific diagnosis warranting a name.

Specimen figured.—Catalogue No. 165588, U.S.N.M.

Locality.—United States Geological Survey locality 4763, 200 yards north of Jacalitos Creek crossing on Stone Canyon and Coalinga road 14 miles southwest of Coalinga (Ralph Arnold and Frank Stokes, jr.).

Horizon.—Jacalitos formation, lower part of upper Miocene.

MACOMA JACALITOSANA n. sp.

Plate XVI, figure 2.

Description.—Shell attaining a length of 70 millimeters, oblong, attenuated posteriorly, inflated, inequivalve, inequilateral, surface smooth. Beaks slightly anterior to middle, small, tumid, curved slightly forward; anterior extremity regularly rounded; posterior dorsal margin only slightly curved, sloping more steeply from beak than anterior dorsal margin; posterior extremity moderately sharply truncated near base of shell, posterior surface of right valve flexed into a prominent carina or fold which extends from the beak to the posterior angle at base; the carina being separated from the dorsal margin by a space equal in width to nearly one-third the width of the shell; base line curved to conform to flexure of disk, otherwise nearly straight; left valve flexed downward and with carina less prominent and nearer dorsal margin than in right. Surface sculptured by fine sharp incremental lines and occasional lines of interrupted growth.

Dimensions.—Longitude 70 mm.; latitude 46 mm.; diameter of right valve, 15 mm.

Notes.—*M. jacalitosana* belongs to the same general group as *M. nasuta* Conrad (range lower Miocene to Recent) but is very much more inflated, narrower posteriorly, and carries the posterior carina or fold much farther below the dorsal margin than the latter. It is named for the Jacalitos formation, of which it is believed to be characteristic.

Type.—Nearly perfect right valve, catalogue No. 156613, U.S.N.M.

Locality.—United States Geological Survey locality 4765, just east of Ramirez place at junction of Jacalitos Creek and Jasper Creek, east of Reef Ridge, on west side of center of SW. ¼ sec. 6, T. 22 S., R. 15 E., about 2,000 feet stratigraphically below summit of formation (Ralph Arnold; H. R. Johnson; W. H. Kerr).

Horizon.—Jacalitos formation, lower part of upper Miocene.

MACOMA VANVLECKI n. sp.

Plate XII, figure 2; Plate XVI, figure 1.

Description.—Shell averaging between 50 and 60 millimeters in length, elongate oval, attenuated anteriorly, beaks anterior, inequi-

valve, tumid, the left valve much more tumid than the right and having the anterior extremity flexed upward instead of downward. Beak, small and not prominent, located a little over two-fifths the length of shell from anterior extremity; anterior dorsal margin faintly angulated in middle, sloping steeply downward from beak toward extremity which is sharply angulated at a point somewhat below the horizontal medial line of the valve; posterior extremity nearly straight; posterior extremity curved, the point of greatest convexity occurring above middle line of valve; base slightly curved and practically parallel with posterior dorsal margin except for faint convex curve caused by the flexing of the valve; a prominent angle joins the beaks and the anterior extremity; in the left valve this angle flexes upward, in the right valve downward. Surface smooth except for fine incremental lines. Hinge unknown.

Dimensions.—Longitude 54 mm.; latitude 31.5 mm.; diameter, right valve, 7 mm.; left valve, 12 mm.

Notes.—*M. vanvlecki* is more closely related to *M. indentata* Carpenter (living from San Pedro to San Diego), than to any other member of this genus from the west coast, but may be distinguished by its narrower outline, relatively longer anterior extremity, and less show of flexuosity on the anterior ventral margin. It is believed to be a characteristic species of the Jacalitos formation. It is named in honor of Robert Van Vleck Anderson, Menlo Park, Cal., the writer's collaborator in the Coalinga and Santa Maria oil districts.

Type.—Catalogue No. 165576, U.S.N.M. from locality 4763.

Localities.—United States Geological Survey locality 4763, 200 yards north of Jacalitos Creek crossing on Stone Canyon-Coalinga road, 14 miles southwest of Coalinga (Ralph Arnold; Frank Stokes, jr.); locality No. 4765, just east of Ramirez place on forks of Jacalitos Creek, a short distance below Reef Ridge, on west side of center of SW. ¼ sec. 6, T. 22 S., R. 15 E., about 2,000 feet stratigraphically below summit of formation (H. R. Johnson; Ralph Arnold; W. H. Kerr); northwest end of Elkhorn Plain, 1 mile south of White's (Ralph Arnold).

Horizon.—Jacalitos formation, lower part of upper Miocene.

Genus PAPHIA Bolten.

PAPHIA JACALITOSENSIS n. sp.

Plate XVI, figure 3.

Description.—Shell attaining an altitude of over 50 millimeters, subcircular in outline, compressed, concentrically and finely radiately sculptured. Beaks small, turned sharply forward, situated about one-third the length from anterior to posterior extremity; both

anterior and posterior margins and base regularly rounded. Lunule small, impressed. Surface sculptured by numerous equidistant slightly elevated concentric laminæ and numerous fine, close-set radiating raised lines. Hinge and interior not visible.

Dimensions.—Longitude 55 mm.; altitude 57 mm.; diameter of both valves together, 24 mm.

Notes.—This species is readily distinguishable by its moderate size, circular outline, compressed form, and rather inconspicuous radiating sculpture. It is named for the Jacalitos formation, of which it is believed to be characteristic.

Type.—Catalogue No. 165587, U.S.N.M.

Locality.—United States Geological Survey locality 4765, on Ramirez place at forks of Jacalitos Creek a short distance northeast of Reef Ridge, on west side of center of SW. ¼ sec. 6, T. 22 S., R. 15 E. (Ralph Arnold).

Horizon.—Jacalitos formation, lower part of upper Miocene.

Genus DOSINIA Scopoli.

DOSINIA JACALITOSANA n. sp.

Plate XVI, figure 5.

Description.—Shell attaining a length of nearly 100 millimeters, subovate, equivalve, rather inflated, beaks anterior, surface concentrically sculptured. Beak about one-sixth the length from anterior end, tumid, turned prominently forward; posterior dorsal margin regularly rounded; posterior extremity more sharply curved; anterior dorsal margin short, excavated in front for a deep broad lunule; anterior extremity short, narrow and regularly rounded; base moderately curved. Surface sculptured by numerous, regular, low rounded concentric ridges. Hinge unknown.

Dimensions.—Longitude 95 mm.; latitude 83 mm.; diameter of single valve 23 mm.

Notes.—The hinge of this species is not exposed, but from the characteristic, glazed, concentrically sculptured surface it seems almost certain that it is a *Dosinia*. It is characterized by its great size, elongate outline, anterior beak and glazed, concentrically ridged surface.

D. jacalitosana is much larger, very much more elongated, and has, on the whole, finer concentric sculpture than *D. mathewsonii* Gabb from the lower Miocene; it is very much larger and more elongate and has more numerous concentric lines than *D. conradi* Gabb (*D. alta* of Conrad); it differs from *D. montana* Conrad, from the Salinas Valley, by its larger size, much more elongated outline and more gibbous disk; it differs from *D. ponderosa* Gray by its much more elongated

outline, more anterior beak, deeper and broader lunule, and usually more inflated disk. "*D. longula* Conrad," which is from the "bed of Salinas River" is probably a *Callista; D. subobliqua* Conrad, of which the type was not examined but of which there is a figure in the Pacific Railroad Reports (vol. 7, pl. 6, fig. 5), is probably a *Chione*, possibly *C. temblorensis*.

The species is named for the Jacalitos formation, of which it is believed to be characteristic.

Type.—Catalogue No. 165575, U.S.N.M.

Locality.—United States Geological Survey locality 4763, 200 yards north of Jacalitos Creek on the Stone Canyon and Coalinga road, on the flanks of Waltham Valley, 14 miles southwest of Coalinga (Ralph Arnold and Frank Stokes, jr.).

Horizon.—Jacalitos formation, lower part of upper Miocene.

Genus THRACIA (Leach) Blainville.

THRACIA JACALITOSANA n. sp.

Plate XVI, figure 4.

Description.—Shell averaging about 50 millimeters in length, oblong, only slightly inflated, subequivalve, inequilateral. Beak small, subcentral; posterior extremity slightly shorter than anterior; obliquely truncated, dorsal posterior margin rather short, concave, joins posterior line of truncation in angle slightly greater than 90°; a distinct ridge joins the beak and lower posterior angle; base regularly rounded; anterior extremity angulated above where the low sloping dorsal margin meets the rounded anterior periphery; the extreme anterior end is slightly below the horizontal medial line of shell. Sculpture consists of incremental lines and, near the base, of very faint small concentric undulations. Hinge and interior unknown.

Dimensions.—Of somewhat imperfect type, longitude 51 mm.; latitude 44 mm.; diameter of single valve, 8 mm.

Notes.—This peculiar shell recalls both *Thracia* and *Panomya*, the external characters of both apparently being united in it. A careful examination, however, leaves little doubt as to which group it properly belongs, and it is placed provisionally with *Thracia*. It differs from *T. trapezoides* Conrad by its much broader outline, shorter and broader posterior extremity, and shorter and more concave dorsal posterior margin; the posterior flexure or angle is not as well developed in *T. jacalitosana* as in *T. trapezoides*. It is named for the Jacalitos formation, of which it is believed to be characteristic.

Type.—An imperfect left valve, catalogue No. 165579, U.S.N.M.

Locality.—United States Geological Survey locality 4763, on Stone Canyon and Coalinga road 200 yards north of Jacalitos Creek

crossing, 14 miles southwest of Coalinga (Ralph Arnold and Frank Stokes, jr.).

Horizon.—Jacalitos formation, lower portion of upper Miocene.

GASTEROPODA.

Genus MARGARITA Leach.

MARGARITA JOHNSONI n. sp.

Plate XV, figure 6.

Description.—Shell attaining an altitude of 6 millimeters, globular-conical, umbilicated, spirally sculptured, apex subacute. Whorls four, slightly convex, ornamented by several (five on penultimate whorl of type) prominent, regular, equidistant, rounded threadlike spiral ridges and numerous fine sharp regular equidistant incremental lines which slope obliquely downward to the right. Suture impressed, rather inconspicuous. Body whorl faintly angular, ornamented on base by five or six spiral ridges only very slightly less prominent than those on sides of whorls. Aperture rounded; lips simple; umbilicus perforate.

Dimensions.—Altitude 6 mm.; latitude 6.2 mm.; altitude of body whorl 5 mm.

Notes.—*M. johnsoni* is allied to *M. pupilla* Gould (Recent range Alaska to Puget Sound), but may be distinguished by its smaller size, less convex whorls, less conspicuous suture, and much coarser but fewer spiral lines on base. The species is easily distinguishable from *Leptothyra* by its higher spire, perforate umbilicus, and more prominent oblique incremental sculpture. Believed to be characteristic of the Jacalitos formation. It is named in honor of Mr. Harry Roland Johnson, of the U. S. Geological Survey.

Type.—Catalogue No. 165663, U.S.N.M.

Locality.—United States Geological Survey locality 4765, on Jasper Creek just above its confluence with Jacalitos Creek, on west side of center of SW. ¼ sec. 6, T. 22 S., R. 15 E. About 2,000 feet stratigraphically below summit of formation. One of typical Jacalitos localities (Ralph Arnold).

Horizon.—Jacalitos formation, lower part of upper Miocene.

Genus THAIS Link.

THAIS KETTLEMANENSIS n. sp.

Plate XV, figure 4; Plate XXI, figures 1 and 1a.

Description.—Shell about 85 millimeters in length, broadly fusiform in outline, spire moderately elevated, surface sharply spirally sculptured. Whorls five, ventricose, faintly angulated in the middle and

carrying about nine low rounded nodes which become obsolete a short distance above and below the angle; body whorl somewhat more tabulated above than the others. The sculpture consists of three systems of prominent, squarish revolving ridges; on the body whorl there are two ridges of the major system above the angle, one line on it and seven equidistant lines below it; between each pair of these major ridges is a slightly less prominent ridge, and between each of these secondary ridges and each major ridge is still a smaller one; a prominent wavy sulcated sutural ridge adorns the top of the whorl; imbricating lamellæ of growth are prominent over much of the surface, especially on the sutural riblet. Suture distinct, wavy. Aperture oval, narrowed anteriorly; canal open, slightly recurved; outer lip advanced anteriorly; inner lip smooth, reflected anteriorly; umbilicus wide, rough with lines of growth.

Dimensions.—Type, from which a part of the columella is broken: Altitude, 82 mm.; latitude, 58 mm.; altitude of body whorl, 65 mm.; altitude of aperture, including canal, 45 mm.; latitude of aperture, 25 mm.

Notes.—This magnificent species, is quite different from any other fossil found in the Coalinga district, and may be readily recognized by its large size, broadly fusiform outline, low nodes, and sharp spiral ridges. *T. kettlemanensis* ranges throughout the Jacalitos formation, the type coming from beds at the extreme top of the Jacalitos or the base of the Etchegoin. At the type locality it was associated with no other species.

Several specimens, believed to be the young of this species, were found at localities 4763 and 4765. They show the characteristic spiral sculpture and sutural riblet exhibited by the type, and in addition indicate that the upper whorls are crossed by prominent rounded varices, about 15 to a whorl, and about 8 strong rounded revolving lines. These young specimens suggest *Chrysodomus* in general appearance, although the adult form bears only a remote resemblance to this genus. *Thais* was formerly known as *Purpura*.

Type.—Catalogue No. 165585, U.S.N.M.

Localities.—United States Geological Survey locality 4680, on plunging anticline in central part of Kettleman Hills, 2½ miles southwest of point where the Dudley-Lemoore road enters Tulare Plain (Ralph Arnold); locality 4763, 200 yards north of Jacalitos Creek on the Stone Canyon–Coalinga road, 14 miles southwest of Coalinga (Ralph Arnold and Frank Stokes, jr.); locality 4765, on Jasper Creek just above confluence with Jacalitos Creek northeast of Reef Ridge, on west side of center of SW. ¼ sec. 6, T. 22 S., R. 15 E. (Ralph Arnold).

Horizon.—Jacalitos formation to basal Etchegoin, upper middle Miocene to upper Miocene.

ETCHEGOIN (UPPERMOST MIOCENE) SPECIES.

PELECYPODA.

Genus CRYPTOMYA Conrad.

CRYPTOMYA QUADRATA n. sp.

Plate XXI, figures 2 and 2a.

Description.—Shell averaging about 35 millimeters in length, subquadrate in outline, width about four-fifths the length, inequivalve, compressed, moderately thin. Beaks subcentral, small, very slightly overlapping. Left valve with anterior extremity evenly rounded, dorsal margin nearly straight, sloping only slightly; posterior extremity rectangularly truncated, the line of truncation joining dorsal and ventral margins in rounded right angles; beak and posterior extremity joined by a low broad sulcation. Right valve with shorter and more steeply sloping dorsal margin, and somewhat more convex surface than left; sulcation not as prominently developed as in left. Surface of both valves prominently sculptured with irregular incremental lines and lamellæ. Hinge and interior not observable, but believed to be similar to *C. californica* Conrad.

Dimensions.—Longitude 35 mm.; latitude 28 mm.; diameter, both valves, 12.5 mm.

Notes.—This species is characterized by its large size, subquadrate outline, and posterior sulcation. It differs from *C. ovalis* Conrad by its greater size, more rectangularly truncate posterior extremity and less sloping dorsal margins; it differs from the recent *C. californica* Conrad in the same way. *C. ovalis* has the anterior extremity evenly rounded rather than subangular ventrally as in *C. californica*, otherwise the two are similar.

Type.—Catalogue No. 165525, U.S.N.M.

Locality.—United States Geological Survey locality 4665, on south side of White Creek, about 6 miles above junction with Los Gatos Creek, Coalinga district (Ralph Arnold; Robert Anderson; E. P. Davis).

Horizon.—Etchegoin formation, upper Miocene.

Genus MACTRA Linnæus.

MACTRA COALINGENSIS n. sp.

Plate XXV, figure 4.

Description.—Shell averaging about 52 millimeters in width, equivalve, trigonal in outline, rounded behind, slightly attenuated in front; beaks not prominent, situated slightly anterior to middle of

shell; anterior superior margin only slightly excavated in front of beaks, nearly straight to anterior extremity, which is quite abruptly truncated; posterior inferior margin slightly curved, and merging imperceptibly into the regularly convex posterior extremity; basal margin moderately curved. Hinge and cartilage areas concealed in type, but believed to be similar to *M. falcata* Gould.

Dimensions.—Longitude 65 mm.; latitude 52 mm.; anterior extremity 30 mm.

Notes.—This species is closely related to *M. falcata* Gould from the Recent fauna of the west coast, but may be distinguished by its relatively broader outline and abruptly truncated anterior extremity. It also bears some resemblance to *Spisula albaria* Conrad but is less ventricose, relatively narrower and more attenuated, but more abruptly truncated in front. Named for the Coalinga district, in which the type locality is situated.

Type.—Catalogue No. 165513, U.S.N.M., from locality 4806.

Localities.—United States Geological Survey locality 4665, on south side of White Creek about 6 miles northwest of junction with Los Gatos Creek; locality 4762, three-fourths mile east of Elmer Frame's place in Waltham Creek Valley, 13 miles southwest of Coalinga; locality 4806, *Glycymeris* bed on the north side of Alcalde Canyon, 2 miles northeast of Alcalde; center of SW. ¼ sec. 7, T. 21 S., R. 15 E.; all in the Coalinga district (Ralph Arnold and Robert Anderson).

Horizon.—Etchegoin formation, upper Miocene.

Genus TRANSENNELLA Dall.

TRANSENNELLA CALIFORNICA n. sp.

Plate XXVI, figures 7 and 7a.

Description.—Shell averaging between 5 and 6 millimeters in length, trigonal, moderately convex, equivalve, concentrically sculptured. Beaks prominent, somewhat anterior to the middle, turned forward; anterior extremity rounded, the point of greatest curvature being the extreme end; posterior extremity longer than the anterior and more sharply curved at extreme end which lies below the middle of the shell; surface sculptured by numerous regularly spaced incised concentric lines. Lunule relatively large, bounded by a deeply impressed line. Hinge of right valve consists of three cardinals, the middle one the most prominent, bowed and situated immediately under the beak, the anterior one very short, the posterior one straight and only slightly inferior to the middle one; anterior sulcus short, deep, with a prominent tooth or process on each side; a faint groove extends posteriorly from the beak for one-third the length of shell. Internal muscle and pallial impressions not visible in type.

Dimensions.—Longitude 5.5 mm.; latitude 4.2 mm.; diameter of single valve, 1.2 mm.

Notes.—*T. californica* is closely allied to *T. tantilla* Gould (formerly known as *Psephis* id.), the two having practically the same surface sculpture and general outline. *T. californica,* however, has a perceptibly shorter and less acute posterior extremity, a more prominent beak, and a more deeply sulcated and more anteriorly located forward cardinal tooth. The species is so far represented by but one specimen, which, fortunately, is a beautifully preserved right valve. It is named for the State of California.

Type.—Catalogue No. 165553, U.S.N.M.

Locality.—United States Geological Survey locality 4715, south end of Kettleman Hills, sec. 10, T. 25 S., R. 19 E. (O. D. Barton; H. R. Johnson and Ralph Arnold).

Horizon.—Upper Etchegoin formation, upper Miocene.

Genus MYTILUS (Linnæus) Bolten.

Subgenus MYTILOCONCHA Conrad.

MYTILUS (MYTILOCONCHA) COALINGENSIS n. sp.

Plate XIX, figure 5; Plate XXII, figure 6.

Description.—Shell attaining an enormous size, over 200 millimeters in length, elongate-ovate in outline, falcate toward beaks, gibbous, equivalve; surface comparatively smooth; shell moderately thick; beaks prominent, terminal, acute, curved sharply forward; posterior margin gently and regularly curved except for a faint suggestion of an angle a little above middle; base only very slightly curved; anterior margin gently and regularly concave; surface convex, the angle or region of greatest convexity being somewhat anterior to the middle of the shell, thus causing the anterior slope of the surface to be much steeper than the posterior; surface sculptured by numerous fine lines of growth, radiating striæ, and more or less conspicuous concentric irregularities. Apical region thickened, extended; cardinal area exceedingly long, its width being two-thirds of its length, and carrying two ridges on the left valve and one on the right, each ridge representing teeth in the younger stages of growth; hinge area concentrically and radially sculptured; a deep triangular, longitudinally sulcated pit occupies the space immediately back of the ridged hinge area; a well-defined groove on the interior of the shell corresponds to the angle on the surface.

Dimensions.—Longitude of fragment (type), 110 mm.; maximum latitude 52 mm.; maximum diameter 35 mm.

Notes.—This magnificent species is easily recognized by its elongate falcate and longitudinally grooved and ridged apical region,

where this is visible. It is closely allied to the type of the subgenus, *M.* (*M.*) *incurvus* Conrad, which occurs[a] in the Oligocene of Florida and in the Miocene from New Jersey to South Carolina, but may be distinguished from the latter by its greater size, broader outline, and prominent muscle pit just anterior to the beaks. The occurrence of these two closely allied and unique forms is one more piece of evidence indicating closer relations between the Atlantic and Pacific coast of North America during the upper Miocene than has as yet been definitely recognized. *M.* (*M.*) *coalingensis* is broader and more falcate toward the beaks than *Mytilus mathewsonii* Gabb from the lower Miocene; is relatively narrower and more falcate than *M. mathewsonii* var. *expansus* Arnold, from the lower Miocene; and lacks the corrugations of *M. californicus* Conrad, of the recent fauna. It is common in the basal Etchegoin and may usually be taken as a good horizon marker. No perfect specimen of the species is known, the shells always being broken approximately in the middle or near the beaks. It is named for the Coalinga district.

Type.—Fragment showing upper portion of a right valve, catalogue No. 165551,U.S.N.M., from locality 4556.

Localities.—Jacalitos formation: Locality 4652, on point of ridge three-fourths mile south-southwest of Alcalde, one-fourth mile south of bend in road, Coalinga district, Fresno County, SE. ¼ sec. 23, T. 21 S., R. 14 E. (Ralph Arnold and Robert Anderson). Upper middle Miocene.

Etchegoin formation: Locality 4656, lowest Etchegoin bed, SW. ¼ sec. 34, T. 19 S., R. 15 E.; locality 4658, on Anticline Ridge, about 3½ miles northwest of Kenny B. M.; locality 4660, *Glycymeris* bed just northeast of West Coalinga Oil Company's well, 2½ miles west of Coalinga; locality 4664, north side of White Creek, about 5 miles northwest of junction with Los Gatos Creek; locality 4671, on Anticline Ridge, about 2 miles north of Kenny B. M., 7 miles northeast of Coalinga; locality 4672, northeast nose of 1,200-foot ridge, four-fifths mile north-northwest of prominent hill on south side Alcalde Canyon, center of SE. ¼ sec. 13, T. 21 S., R. 14 E.; locality 4674, *Glycymeris* bed, halfway between Commercial Petroleum and West Coalinga wells; locality 4688, middle of S. ½ sec. 2, T. 20 S., R. 15 E.; locality 4693, south-central part Kettleman Hills, about 9¾ miles northwest of Light's place, SW. ¼ NE. ¼ sec. 3, T. 23 S., R. 18 E.; locality 4715, sec. 10, T. 25 S., R. 19 E., at south end Kettleman Hills; locality 4749, station "f," on ridge on south side of Garza Creek about 1 mile from Kettleman Plain, in NE. ¼ sec. 1, T. 23 S., R. 16 E.; locality 4750, station "g," about one-half mile northeast of locality 4749, SW. ¼ sec. 36, T. 22 S., R.

[a] Dall, W. H., Trans. Wagner Free Inst. Sci., vol. 3, pt. 4, pp. 789–790.

16 E.; locality 4758, bed C, near top of section at Henry Spring, 4 miles south of Coalinga, SW. ¼ sec. 18, T. 21 S., R. 15 E.; locality 4806, *Glycymeris* bed, on north side of Alcalde Canyon, 2 miles northeast of Alcalde, center of SW. ¼ sec. 7, T. 21 S., R. 15 E. (Ralph Arnold and Robert Anderson). Several localities in eastern Monterey County (Homer Hamlin and Ralph Arnold). Upper Miocene.

Horizon.—Upper half of the Miocene, Jacalitos, and Etchegoin formations, usually in the basal Etchegoin.

Genus PLACUNANOMIA[a] Broderip.

PLACUNANOMIA CALIFORNICA n. sp.

Plate XXIV, figures 2, 2a, and 3.

Description.—Shell averaging about 65 millimeters in length, subcircular in outline, inequivale, compressed. Right valve irregular, somewhat convex, the surface sculptured by numerous small, thread-like, rugose, radiating ridges and several laminæ of growth; byssal foramen, though closed, leaves an oblique semicovered pit near the beak; two strong elevated rough crests—the auricular crura—diverge from the beak at a very acute angle; immediately behind the auricular crura is the broadly V-shaped scar of the byssal muscle, on each side of which is a deeply impressed groove, and in the middle of which is an oblique V-shaped pit which was once connected with the external pit forming the byssal foramen; adductor scar subcircular to irregular and equal in diameter to over one-third the length of shell. Left valve flat to slightly concave; surface sculpture similar to but less prominent than that of right valve; a broad V-shaped socket, into which the crura of the right valve fits, occupies the area below the beaks; adductor scar same as in right valve.

Dimensions.—Altitude 66 mm.; latitude 60 mm.; diameter of both valves together, 17 mm.

Notes.—This rare shell, of which the type, paratype, and a fragment are the only specimens so far known, is characterized by the elevated auricular crura of the right valve and V-shaped socket of the left. Its external sculpture is quite similar to certain specimens of *Pododesmus* (*Monia*) *macroschisma* Deshayes, found Recent and fossil on the Pacific coast. The only other member of the genus *Placunanomia* on the Pacific coast is the Recent *P. cumingi* Reeve, of the Recent Gulf of California province, which is characterized by one or two very strong plications. *P. californica* is thinner and more nearly circular in outline than *P. plicata* Tuomey and Holmes, of the upper Miocene of the Carolinas; it also has radial sculpture, which

[a] See Dall, W. H., Trans. Wagner Free Inst. Sci., vol. 3, pt. 4, pp. 770–771, for description of this genus.

is lacking in the latter. It is named in honor of the State of California.

Type.—Right valve, catalogue No. 165546, U.S.N.M.

Paratype.—Left valve, same number.

Locality.—United States Geological Survey locality 4715, south end of Kettleman Hills, sec. 10, T. 25 S., R. 19 E., Coalinga district. (O. D. Barton; Ralph Arnold.)

Horizon.—Upper portion, Etchegoin formation, upper Miocene.

Genus PECTEN Müller.

Subgenus PLAGIOCTENIUM Dall.

PECTEN (PLAGIOCTENIUM) DESERTI Conrad.

Plate XXVI, figures 3 and 4.

1855. *Pecten deserti* Conrad, Descr. Fos. and Shells, House Doc. 129, July, 1855, p. 15 (*fide* Dall).

1856. *Pecten deserti* Conrad, Pacific R. R. Repts., vol. 5, 1856, p. 325, pl. 5. fig. 41.

1888. *Pecten deserti* Conrad, Cooper, Seventh Ann. Rept. California State Mineralogist, for 1887, p. 257.

1894. *Pecten (Plagioctenium) deserti* Conrad, Dall, Trans. Wagner Free Inst. Sci., vol. 3, pt. 4, 1898, p. 703.

1906. *Pecten (Plagioctenium) deserti* Conrad, Arnold, Prof. Paper U. S. Geol. Survey No. 47, 1906, p. 85, pl. 26, figs. 1, 2, 2a, 3, 4, and 4a.

Notes.—Some of the specimens of this species from the Kettleman Hills (locality 4715) are indistinguishable from individuals from the type locality on Carrizo Creek, San Diego County. The Kettleman Hill specimens vary in size considerably, the largest one in hand attaining an altitude of over 50 millimeters. A prominent characteristic which is developed in some of the Carrizo Creek shells, but is more common in the Kettleman Hills individuals, is the occurrence of one to three radiating lines or riblets in the bottom of each interspace or on the lower portions of the ribs in the later stages of growth. There is also a noticeable tendency for the disks to become contracted or show lines of interrupted growth from a diameter of about 25 millimeters upward.

Figured specimens.—Catalogue No. 165518, U.S.N.M., from locality 4715.

Localities.—In the Etchegoin formation, upper Miocene, Coalinga district, at United States Geological Survey locality 4712, east of Zapato Creek, three-fourths mile south-southwest of A. Kreyenhagen's house, SW. ¼ SE. ¼ sec. 8, T. 22 S., R. 16 E. (Fresno County); locality 4715, south end of Kettleman Hills, sec. 10, T. 25 S., R. 19 E. (Kings County). In the Carrizo Creek beds, upper Miocene, San Diego

County, at east end of Carrizo Mountain, and at Ulsa oil well, north of the Mexican boundary (Conrad; H. W. Fairbanks; S. Bowers; W. C. Mendenhall).

Horizon.—Upper Miocene.

Subgenus CHLAMYS Bolten.

PECTEN (CHLAMYS) WATTSI Arnold var. ETCHEGOINI F. M. Anderson.

1905. *Pecten etchegoini* Anderson, Proc. California Acad. Sci., 3d ser., Geology, vol. 2, p. 198, pl. 18, figs. 92–93, Dec. 4, 1905.

1906. *Pecten (Chlamys) wattsi* var. *morani* Arnold, Prof. Paper U. S. Geol. Survey No. 47, 1906, pp. 121–122, pl. 10, figs. 3, 4, 5, and 6.

This variety is characterized by a lack of the concentric constrictions common in the typical form. As Anderson's name antedates the writer's variety *morani*, it will have to replace the latter. (See Pl. XXVII, figs. 1 and 2, for typical *P. wattsi* Arnold.)

Localities.—United States Geological Survey locality 4712, east side Zapata Creek, three-fourths mile south-southwest of A. Kreyenhagen's house, Coalinga district, Fresno County, SW. ¼ SE. ¼ sec. 8, T. 22 S., R. 16 E. (F. M. Anderson; Ralph Arnold and Robert Anderson). T. H. Moran's place, SW. ¼ sec. 14, T. 20 S., R. 12 E., Priest Valley, Monterey County (Homer Hamlin and Ralph Arnold).

Genus OSTREA Linnæus.

OSTREA VESPERTINA Conrad.

Plate XXIV, figures 4 and 5.

1853. *Ostrea vespertina* Conrad, Jour. Philadelphia Acad. Nat. Sci., 2d ser., vol. 2, p. 300, Jan., 1853.

1856. *Ostrea vespertina* Conrad, Pacific R. R. Repts., vol. 5, p. 325–326, pl. 5, figs. 36, 37, 38.

1869. *Ostrea veatchii* Gabb, Pal. California, vol. 2, pp. 34, 106, pl. 11, fig. 59.

1869. *Ostrea vespertina* Gabb, Pal. California, vol. 2, p. 107.

1888. *Ostrea veatchii* Gabb, Cooper, Seventh Ann. Rept., California State Mineralogist, p. 256.

1888. *Ostrea vespertina* Conrad, Cooper, ibid., p. 256.

1895. *Ostrea haitensis* Dall (not Sowerby, 1850), Trans. Wagner Free Inst. Sci., vol. 3, pt. 4, p. 685 (California references only).

1907. *Ostrea veatchii* Gabb, Arnold, Proc. U. S. Nat. Mus., vol. 32, June 15, 1907, p. 544, pl. 49, fig. 1.

1907. *Ostrea veatchii* Gabb, Arnold, Bull. U. S. Geol. Survey No. 309, Oct. 23, 1907, p. 250, pl. 39, fig. 1, .

1907. *Ostrea veatchii* Gabb, Arnold, Smithsonian Misc. Coll., vol. 50, pt. 4, Dec. 13, 1907, p. 445, pl. 56, fig. 10.

1908. *Ostrea veatchii* Gabb, Arnold, Bull. U. S. Geol. Survey No. 322, Jan. 4, 1908, p. 148, pl. 23, fig. 10.

Description.—This species attains a length of about 70 to 80 millimeters, and is characterized by its oblong to subfalcate outline, sharply plaited surface of both valves, and more or less prominent beaks.

Dimensions.—Longitude 50 mm.; latitude 38 mm.; diameter of single valve, 17 mm.

Notes.—The writer can not agree with Dall[a] in assigning *O. vespertina* Conrad and *O. veatchii* Gabb to the synonymy of *O. haitensis* Sowerby, although it is evident to the most casual observer that *O. vespertina* and *O. veatchii* are the same species. The association of each of these last two with faunas having several other species in common adds weight to the argument that the beds on Carrizo Creek from which *O. vespertina* were originally described, and the beds along the Pacific coast of California and Lower California, where *O. veatchii* are abundant, are not far separated geologically.

An examination of the material in the United States National Museum discloses the following facts as interpreted by the writer: *O. vespertina* is smaller, relatively much narrower, and usually more falcate in outline and carries plaits more regular in size and generally fewer in number than *O. haitensis*. The former occurs in the upper Miocene and lower Pliocene on the Pacific coast, while the latter is found in the Oligocene of the West Indies and Florida.

O. vespertina is, however, very closely allied to *O. sculpturata* Conrad, which occurs[b] in the Miocene from Virginia to Florida and in the Pliocene of South Carolina and Florida. *O. vespertina* is distinguished from *O. atwoodi* Gabb, from the lower Etchegoin, by its fewer but more prominent plications and by the sculptured condition of both valves instead of one, as in the latter.

Specimens figured.—Catalogue No. 165536, U.S.N.M., from locality 4715.

Localities.—Carrizo Creek, San Diego County, at localities 2673, 3921, and 3922 (W. C. Mendenhall; Stephen Bowers); near Camulos, Ventura County (W. L. Watts); Coalinga district, Fresno, Kings, and Kern counties; locality 4708, in *Arca* bed, 4 miles southeast of the northwest end of Kettleman Hills, east side of sec. 32, T. 21 S., R. 17 E.; locality 4711, in layer 50 feet above *Arca* bed at same locality as 4758; locality 4712, east of Zapato Creek, three-fourths mile south-southwest of A. Kreyenhagen's house, SW. ¼ SE. ¼ sec. 8, T. 22 S., R. 16 E.; locality 4715, south end of Kettleman Hills, sec. 10, T. 25 S., R. 19 E.; locality 4722, in upper *Mya* bed, three-fourths mile southeast of A. Kreyenhagen's, northwest corner of sec. 16, T. 22 S., R. 16 E.; locality 4728, just below *Anodonta* bed, on northeast border of Kettleman Hills, nearly 6 miles east-southeast of northwest end of hills, in north part of sec. 35, T. 21 S., R. 17 E.;

[a] Dall, W. H., op. cit., p. 685.

[b] Dall, W. H., op. cit., p. 686.

locality 4758, near top of section at Henry Spring, 4 miles south of Coalinga, SW. ¼ sec. 18, T. 21 S., R. 15 E.; locality 4778, oyster bed, just below *Mya* bed, three-fourths mile southeast of A. Kreyenhagen's house, west side of sec. 9, T. 22 S., R. 16 E. (Ralph Arnold and Robert Anderson). Upper Miocene.

Cerros Island, and near Loreto, Lower California (Dr. J. A. Veatch); Pacific Beach, Russ School, San Diego well, San Diego County (Henry Hemphill; W. H. Dall; Homer Hamlin; Delos and Ralph Arnold, and others); Third street tunnel, Los Angeles oil wells, Brown Canyon, Los Angeles County (Homer Hamlin; W. L. Watts); locality 4473, Waldorf asphalt mine, 3 miles south-southeast of Guadalupe; and locality 4474, railroad cut 1 mile north of Schumann, Santa Barbara County (Ralph Arnold and Robert Anderson). Lower Pliocene.

Horizon.—Upper portion of Etchegoin formation, upper Miocene; lower portion of Fernando formation, which extends from the upper Miocene to the Pleistocene; San Diego formation, lower Pliocene.

OSTREA VESPERTINA Conrad var. SEQUENS n. var.

Plate XXIX, figures 5 and 6.

Description.—Shell averaging about 42 millimeters in length, subcircular in outline, irregular, plaited, usually with three major plaits, each of these sometimes sulcate or divided into minor plaits; foliaceous lines of growth not as prominent as in many species of *Ostrea;* beak prominent, curved toward right when viewed from exterior. Right valve nearly flat or only slightly folded, the plaits practically obsolete; incremental laminæ as in left valve; hinge not strong, subdentate laterally in left valve; muscle scars prominent.

Dimensions.—Longitude 45 mm.; latitude 43 mm.; diameter of both valves together, about 15 mm.

Notes.—This species is smaller, thinner, more circular in outline, and decidedly less plaited than the typical *O. vespertina.* The right valve of *O. vespertina* var. *sequens* is less ornate than the same valve in *O. vespertina.* *O. vespertina* var. *sequens* is found in the beds at the extreme top of the Etchegoin formation and lived during the period of unstable conditions, when the great inland sea of Etchegoin time was giving place to the great fresh-water Tulare lake which followed. The waters during this period of change were doubtless transformed from salt through brackish to fresh, and the poor development of this oyster, which, though living in great numbers, never attained the size of its predecessor, *O. vespertina,* was doubtless due to this changing environment. There is evidence also to show that the water was colder as well as less saline in the period during which *O. vespertina* var. *sequens* lived; and this, also, may account for some

of the differences between the typical and varietal form. *O. vespertina* lived in decidedly marine conditions, and is found in beds immediately underlying those in which the variety occurs. The fact that the variety is found in beds younger than those in which the typical form abounds led to the adoption of the varietal name, *sequens*. The shells of this variety are gathered in large quantities and used for chicken feed by the residents of this region.

Type.—Left valve, catalogue No. 165545, U.S.N.M., from locality 4728.

Localities.—United States Geological Survey locality 4702, south-central part of Kettleman Hills, 5⅓ miles N. 20° W. of Light's place, NW. ¼ NW. ¼ sec. 25, T. 23 S., R. 18 E.; locality 4716, near north end of Kettleman Hills, 1⅞ miles north-northwest of 1,244-foot hill, in bed below flinty white shale, east of center of SW. ¼ sec. 20, T. 21 S., R. 17 E.; locality 4718, main ridge of Kettleman Hills, central part, 8 miles northwest of Light's place, east side of sec. 11, T. 23 S., R. 18 E.; locality 4723, south group of Kettleman Hills, in *Mya* bed, one-half mile east-southeast of Light's place; south side of SE. ¼ sec. 17, T. 24 S., R. 19 E.; locality 4725, east side of Kettleman Hills, immediately west of where Dudley-Lemoore road enters plain west of Tulare Lake, SW. corner of sec. 8, T. 23 S., R. 19 E.; locality 4728, just below *Anodonta* bed on northeast border of Kettleman Hills, nearly 6 miles east-southeast of northwest end, in north part of sec. 35, T. 21 S., R. 17 E. (Ralph Arnold and Robert Anderson).

Horizon.—Extreme top of the Etchegoin formation, upper Miocene, just below Tulare bed (*Anodonta* fresh-water bed).

Genus GLYCYMERIS Da Costa.

GLYCYMERIS COALINGENSIS n. sp.

Plate XIX, figure 3.

1905. *Pectunculus septentrionalis* Anderson (not Middendorf), Proc. California Acad. Sci., 3d ser., Geology, vol. 2, p. 197, pl. 17, figs. 86, 87, not text.

Description.—Adult shell averaging about 40 millimeters in altitude, suborbicular in outline, equivalve, moderately convex, beaks central, surface radiately ribbed. Beaks small, projecting only slightly beyond dorsal margin; anterior dorsal margin sloping slightly more steeply than posterior. Surface sculptured by 34 well-defined, squarish, radiating ribs, separated by canal-like interspaces, each about as wide as a rib; the ribs and interspaces become narrower and finally obsolete near the anterior and posterior margins, and also flatten out and become less regular and less well defined in the later stages of growth; the incremental lines are imbricating, sharp and wavy, and, where the surface is slightly worn, loop downward in more or less

regular festoons in the interspaces, this being one of the unique characteristics of the species. Ligamental area divaricately and sharply striate. Hinge with a semicircular row of transverse teeth, which in the adult shell are partially obliterated by encroachment of the ligamental area; the anterior portion of the hinge usually carries 1 or 2 more teeth than the posterior.

Dimensions.—Altitude 42 mm.; latitude 42 mm.; diameter of both valves together, 22.5 mm.

Notes.—The separation of the different forms of this genus is usually attended with much difficulty and uncertainty, owing to the worn condition of the surface in most specimens, especially in those available for study. A comparison of *G. coalingensis* with some of the recent and fossil species in the collections of the National Museum discloses the following differences: *G. coalingensis* is relatively smaller, higher, and more convex and has relatively higher but narrower ribs than *G. gabbi* Dall from the Empire formation at Coos Bay; it is more convex and has less prominent beaks, but more and narrower ribs than *G. conradi* Dall from the Empire beds, Coos Bay; it closely resembles *G. grewingki* Dall from the Coos Bay Empire beds, but has much wider interspaces and relatively narrower and taller ribs than the latter and lacks the fine superficial radial striæ; it is smaller, more symmetrical, and has entirely different sculpture from *G. branneri* Arnold from the Vaqueros, lower Miocene, of the Coast Ranges; it differs from the recent *G. septentrionalis* Middendorf by its larger size, more symmetrical outline, and wider interspaces, and also in lacking the superficial radial striæ of this last-mentioned species and also of the Recent *G. intermedia* Broderip and the Pleistocene *G. barbarensis* Conrad; it is also less convex and more symmetrical and has wider interspaces than either of the latter. A recent shell in a box labeled *G. septentrionalis* Middendorf var. *subobsoletus* Carpenter (U.S.N.M. catalogue No. 15475), from Neah Bay, Washington, has the widely separated ribs of *G. coalingensis*, but is narrower than the latter and has its anterior dorsal margin sloping more steeply. The species is named in honor of the Coalinga district, in which it is found abundantly at several localities.

Type.—Catalogue No. 165526, U.S.N.M., from locality 4806.

Localities.—United States Geological Survey locality 4656, lowest Etchegoin bed, in SW. ¼ sec. 34, T. 19 S., R. 15 E.; locality 4661, *Glycymeris* bed, in NW. ¼ sec. 29, T. 19 S., R. 15 E.; locality 4664, north side of White Creek about 5 miles northwest of junction with Los Gatos Creek; locality 4672, northeast nose of 1,200-foot ridge, four-fifths mile north-northwest of prominent hill on south side of Alcalde Canyon, 3½ miles south-southwest of Coalinga, center

of SE. ¼ sec. 13, T. 21 S., R. 14 E.; locality 4750, station "g" on ridge on south side of Garza Creek, SW. ¼ sec. 36, T. 22 S., R. 16 E.; locality 4756, bed "A," near Henry Spring, 4 miles south of Coalinga, SW. ¼ sec. 18, T. 21 S., R. 15 E.; locality 4758, bed "C," 500 feet stratigraphically above bed "A," same locality as 4756; locality 4762, three-fourths mile east of Elmer Frame's house, in Waltham Valley, 13 miles southwest of Coalinga; locality 4806, *Glycymeris* bed on north side Alcalde Canyon, 2 miles northeast of Alcalde, center of SW. ¼ sec. 7, T. 21 S., R. 15 E.; all in the Coalinga district (Ralph Arnold, F. M. Anderson, and Robert Anderson).

Horizon.—Etchegoin formation, upper Miocene, usually in the basal portions.

GLYCYMERIS SEPTENTRIONALIS Middendorf.

Plate XX, figures 3 and 3a.

1849. *Pectunculus septentrionalis* Middendorf, Beitr. Mal. Ross, vol. 3, p. 67, pl. 21, figs. 1 to 3.
1856. *Pectunculus septentrionalis* Middendorf, Carpenter, Brit. Assn. Rept., 1856, p. 219.
1903. *Glycymeris septentrionalis* Middendorf, Arnold, Mem. California Acad. Sci., vol. 3, 1903, p. 101, pl. 18, fig. 10.
1905. *Pectunculus septentrionalis* Middendorf, Anderson, Proc. California Acad. Sci., 3d ser., Geology, vol. 2, p. 197. (Not pl. 17, figs. 86, 87=*G. coalingensis* Arnold, n. sp.)

This species, which is found living in the Strait of Juan de Fuca and northward, is characterized by its subangular outline, close-set ribs, and minute superficial radial striæ. It is smaller than *G. coalingensis* and less symmetrical in outline. *G. grewingki* Dall from the Empire formation at Coos Bay is very closely related to *G. septentrionalis*, the only points of difference being the slightly larger size, slightly less angular anterior extremity, and the 5 or 6 more ribs of the former.

Figured specimen.—Catalogue No. 165527, U.S.N.M., from locality 4806.

Localities.—In the Etchegoin: Coalinga district at United States Geological Survey locality 4657, bed just above bed "A," near south side of SW. ¼ sec. 34, T. 19 S., R. 15 E.; locality 4659, Anticline Ridge, 4 miles northwest of Kenny bench mark and 6 miles northeast of Coalinga; locality 4660, *Glycymeris* bed, about 2½ miles west of Coalinga; locality 4662, basal Etchegoin beds at north edge of White Creek basin, one-half mile west of White Creek and three-fourths mile southwest of Michigan Oil Company's well, center of NW. ¼ sec. 16, T. 19 S., R. 13 E.; locality 4673, at elevation of 1,600 feet on ridge on west side of prominent hill 1 mile southeast of Alcalde, center of NE. ¼ sec. 24, T. 21 S., R. 14 E.; locality 4684, south-central

part of Kettleman Hills, about 11 miles northwest of Light's place, center of SW. ¼ sec. 35, T. 22 S., R. 18 E.; locality 4806, *Glycymeris* bed on north side of Alcalde Canyon, 2 miles northeast of Alcalde, center of SW. ¼ sec. 7, T. 21 S., R. 15 E. (F. M. Anderson, Ralph Arnold, and Robert Anderson.)

In the upper San Pedro formation: Pleistocene, at San Pedro, Cal. (Delos and Ralph Arnold); Recent from Strait of Fuca north to Ukamok Island and coast of Alaska (Carpenter, J. G. Swan, and others).

Horizon.—Etchegoin formation, upper Miocene; San Pedro formation, Pleistocene; Recent.

GASTEROPODA.

Genus CALLIOSTOMA Swainson.

CALLIOSTOMA COALINGENSIS n. sp.

Plate XXVII, figure 7.

Description.—Shell averaging about 20 millimeters in altitude, trochiform, conical, not umbilicated; apex subacute. Whorls five or six, moderately convex, enlarging rapidly anteriorly, the body whorl being nearly twice as wide as the penultimate whorl; a narrow revolving band at the top of the whorl gives it a faint tabulate appearance; body whorl flat to slightly concave above, moderately sharply angulated below. The sculpture of the penultimate whorl usually consists of about five sharp revolving ridges or lines, the upper and middle ones the more prominent; the ribs above the middle of the whorl, especially the uppermost one, are often more or less nodose; the interspaces are concave, smooth, and each usually carries a fine intercalary; fine incremental lines are visible on well preserved portions of the surface; sculpture of other whorls similar to that of penultimate except number of spiral ridges variable. The suture is quite sharply impressed and distinct; aperture subquadrangular; lip simple; columella concealed in type.

Dimensions.—Altitude 21 mm.; latitude 20 mm.; altitude of body whorl, 15 mm.; altitude of aperture, 10 mm.

Notes.—This species is closely allied to the Recent *Calliostoma costata* Martyn (range, Puget Sound to Catalina Island), from which it differs by its relatively lower spire, more convex and angulated whorls, narrower, more numerous, more markedly unequal, and often sligthly nodose revolving ribs. It is named after the Coalinga district.

Type.—Catalogue No. 165499, U.S.N.M., from United States Geological Survey locality 4758.

Localities.—United States Geological Survey locality 4710, second ravine branching north from Zapato Creek, below A. Kreyenhagen's place, west-central part of NE. ¼ sec. 5, T. 22 S., R. 16 E.; locality 4758, bed "C," immediately east of Henry Spring, 4 miles south of Coalinga, SW. ¼ sec. 18, T. 21 S., R. 15 E. (Ralph Arnold and Robert Anderson).

Horizon.—*Pecten coalingaensis* horizon near top of Etchegoin formation, upper Miocene.

CALLIOSTOMA KERRI n. sp.

Plate XXVII, figure 6.

Description.—Shell averaging about 18 millimeters in altitude, trochiform, conical, not umbilicated, spiral sculpture nodose; apex subacute. Whorls five, with straight sloping sides, enlarging rapidly anteriorly, the body whorl being nearly twice as wide as the penultimate whorl; the angle of the body whorl is quite sharp and the base nearly flat. The sculpture consists of more or less nodose revolving ridges; on the penultimate whorl of the type are four major ridges, and intercalaries between each pair of these except the bottom pair; there are also the same number of major ridges on the body whorl but the intercalaries are more nearly equal to them, and an intercalary also appears between the lower pair; the upper two ridges are usually more nodose than the lower. The suture is moderately impressed and very distinct, giving the top of the whorl a semitabulate appearance and the base an excavated aspect; the base of the body whorl is ornamented by about nine concentric ridges, the outer three or four and the inner two are the most prominent and somewhat rougher than the remainder, which are squarish and partly smooth; occasional intercalaries and numerous microscopic revolving striæ occur between the ribs on the base; fine incremental lines are visible over most of the surface of the shell. Aperture subquadrangular; lips simple, thin; columella simple and may possibly be toothed in front.

Dimensions.—Altitude, 18.5 mm.; latitude, 19 mm.; altitude of body whorl, 13 mm.; altitude of aperture, 8 mm.

Notes.—This species is closely allied to the recent *C. variegatum* Carpenter (range, Strait of Fuca to Point Conception) from which it may be distinguished by its relatively broader outline, more nearly flat base, less prominently nodose revolving sculpture, and smaller and smoother concentric ribs on the base; also by the greater inequality between the outer and inner basal ribs on the one hand and the intermediate ones on the other. It is named in honor of Judge W. H. Kerr, Coalinga, Cal., who has assisted the writer during his investigations in this district.

Type.—Catalogue No. 165500, U.S.N.M., from locality 4758.

Localities.—United States Geological Survey locality 4693, south-central part of Kettleman Hills, about 9¾ miles northwest of Light's place, SW. ¼ NE. ¼ sec. 3, T. 23 S., R. 18 E.; locality 4712, east of Zapato Creek and three-fourths mile south-southwest of A. Kreyenhagen's home, SW. ¼ SE. ¼ sec. 8, T. 22 S., R. 16 E.; locality 4758, immediately east of Henry Spring, 4 miles south of Coalinga, in bed "A," SW. ¼ sec. 18, T. 21 S., R. 15 E., all in the Coalinga district (Ralph Arnold and Robert Anderson).

Horizon.—Upper portion of Etchegoin formation, upper Micoene.

Genus TURRITELLA Lamarck.

TURRITELLA VANVLECKI n. sp.

Plate XXII, figure 3.

Description.—Adult shell at least 75 millimeters in length, elongated, with acute apex. Whorls 10 or more, regularly and moderately convex, the convexity becoming accentuated near each margin where it bows over into the suture, thus giving the whorls a narrow tabulate appearance above and below. Sculpture consists of five equidistant rounded revolving ribs, the middle one of which is slightly more prominent than the others, and a single rounded riblet in each interspace; oblique lines of growth are noticeable in the later whorls, but are invisible in the earlier stages of growth. Suture deeply impressed. Aperture between rounded and subquadrate in outline; lip simple; columella short and not flattened.

Dimensions.—Type, which is broken: Longitude 57 mm.; latitude 21 mm.; longitude of body whorl, 22 mm.; longitude of aperture, 10 mm.

Notes.—This species, of which the type is poorly preserved, is characterized and may be distinguished by its deeply impressed suture, regularly and moderately convex whorls, and regular spiral sculpture. It reminds one more of certain varieties of *Turritella uvasana* Conrad, from the Eocene, than any other of the west coast Tertiary species, although it may readily be separated from the latter by its intercalated riblets. It is named in honor of Robert Van Vleck Anderson, Menlo Park, Cal., the writer's collaborator in the work in the Coalinga district.

Type.—Catalogue No. 165496, U.S.N.M.

Locality.—United States Geological Survey locality 4658, Anticline Ridge, northeast of Coalinga and 3½ miles northwest of Kenny bench mark, in NE. ¼ sec. 3, T. 20 S., R. 15 E. (Ralph Arnold and Robert Anderson); 3 miles north of Bradley, Monterey County (Robert Anderson).

Horizon.—Near the base of the Etchegoin formation, upper Miocene.

Genus LITTORINA Ferussac.

LITTORINA MARIANA n. sp.

Plate XXIX, figure 1.

Description.—Shell averaging about 15 millimeters in altitude, turbinated, thick, pointed. Whorls four, moderately convex, enlarging rapidly anteriorly, the whole body being almost twice as wide as the penultimate; a faint spiral groove adorns each whorl immediately in front of the suture and gives the shell a slightly tabulate appearance. The sculpture consists of very faint incremental lines and about seven or eight narrow impressed lines, separated by much broader smooth bands, these latter sometimes carrying faint spiral sculpture. Suture appressed and distinct. Aperture rounded; outer lip acute, and having a slightly flaring appearance when viewed from within; columella rather flattened and imperforate.

Dimensions.—Altitude 14.5 mm.; latitude 11.5 mm.; altitude of body whorl, 10.2 mm.; altitude of aperture, 8.5 mm.

Notes.—This species is characterized by its large size as compared with many members of the genus, by its spiral sculpture, and by its extreme variability in height. It is very closely allied to *L. grandis* Middendorf, but may be distinguished from the latter by its somewhat slenderer form and coarser sculpture. Its affinity to this northern species is evidence in favor of subboreal conditions in the Coalinga region during the late Miocene. *L. mariana* is also closely related to *L. petricola* Dall, from Fossil Rock, Coos Bay, Oregon, but may be distinguished from the latter by its smaller size, thinner shell, slenderer outline, and less prominent spiral sculpture. *L. mariana* is usually associated with *Mya japonica* Jay, *Macoma inquinata* Deshayes, and *Ostrea vespertina* Conrad var. *sequens* n. var. Named in honor of Mrs. Maria M. Kreyenhagen, Coalinga, Cal., who has materially assisted the writer in making collections from this region.

Type.—Catalogue No. 165481, U.S.N.M., from U. S. G. S. locality 4718.

Localities.—United States Geological Survey locality 4701, southeast-central part of Kettleman Hills, on Dudley-Lemoore road, 3⅝ miles northeast of Light's place, sec. 17, T. 23 S., R. 19 E.; locality 4715, south end of Kettleman Hills, in sec. 10, T. 25 S., R. 19 E.; locality 4718, main ridge of Kettleman Hills, central part, on summit of 1,020-foot hill, 8 miles northwest of Light's place, east side of sec. 11, T. 23 S., R. 18 E.; locality 4720, south side of 555-foot hill, 1 mile due north of Light's place, in center of SW. ¼ sec. 8, T. 24 S., R. 19 E.; locality 4722, south side of Zapato Creek, ¾ mile southeast of A. Kreyenhagen's place, northwest corner of sec. 16, T. 22 S., R.

16 E.; locality 4723, south group of Kettleman Hills, on point one-half mile east-southeast of Light's place, south side of SE. ¼ sec. 17, T. 24 S., R. 19 E.; locality 4724, main ridge, south group of Kettleman Hills, seven-eighths mile southeast of Light's place, NW. ¼ SE. ¼ sec. 20, T. 24 S., R. 19 E.; locality 4730, central part of Kettleman Hills, on summit of 1,030-foot hill on main ridge, 9¾ miles northwest of Light's place, center of sec. 3, T. 23 S., R. 18 E.; all in Coalinga district (Ralph Arnold and Robert Anderson, 1907).

Horizon.—Upper *Mya* horizon at top of Etchegoin formation, top of upper Miocene.

LITTORINA MARIANA var. ALTA n. var.

Plate XXIX, figure 2.

Description.—This variety differs from the typical *mariana* in having a much higher spire, less convex whorls, and usually less prominently spirally sculptured body whorl.

Dimensions.—Altitude 17 mm.; latitude 10.4 mm.; altitude of body whorl, 12 mm.; altitude of aperture 9 mm.

Type.—Catalogue No. 165487, U.S.N.M., from United States Geological Survey locality 4730, in central part of Kettleman Hills, 9¾ miles northwest of Light's place, center of sec. 3, T. 23 S., R. 18 E, Coalinga district.

Localities.—Associated with *Littorina mariana* n. sp. at the localities mentioned under that species. (See preceding page.)

Genus TROPHON Montfort.

Subgenus FORRERIA Jousseaume, 1880.

TROPHON (FORRERIA) COALINGENSE n. sp.

Plate XXII, figure 4.

Description.—Adult shell attaining over 75 millimeters in length, oblong, oval to fusiform, spire tall, apex subacute. Whorls, five or more, sharply angulate a little anterior to middle, tabulate above, very slightly convex below. Sculpture consists of numerous (15 on penultimate whorl of type) straight varices and one sharp spiral ridge near base of whorl; the varices become more numerous, more irregular in size and less regularly spaced on the body whorl; the varices become faintly spinose on the angle, this characteristic being more pronounced in the later stages of growth, especially on the body whorls of adults; at the base of the body whorl is a very pronounced stricture or canal, in which the lines of growth protrude as much as 5 millimeters toward the front; the body whorl usually carries three

or four prominent sharp spiral ridges above this stricture. Aperture ovate; outer lip simple; canal turned toward left; columella sulcate at base.

Dimensions.—Of imperfect type, longitude 65 mm.; latitude 45 mm.

Notes.—This fine species, which appears to be the descendant of *T.* (*Forreria*) *ponderosum* Gabb, resembles *T. stuarti* Smith in certain external characteristics. It differs from the former in its smaller size, slenderer outline, more numerous and less spinose varices and the prominent spiral ridge near base of whorl; it differs from *T. stuarti* in being larger in size, broader in outline, and in having more numerous but generally less elevated varices.

Named for the Coalinga district, in which it is believed to be characteristic of the Etchegoin formation.

Type.—Catalogue No. 165540, U.S.N.M., from locality 4857.

Localities.—United States Geological Survey locality 4749, on ridge on south side of Garza Creek, at station "f," in NE. ¼ sec. 1, T. 23 S., R. 16 E.; locality 4857, extreme southeastern end of Kettleman Hills, in secs. 11 and 12, T. 25 S., R. 15 E. (Ralph Arnold and Robert Anderson).

Horizon.—Etchegoin formation, upper Miocene.

Genus NASSA Lamarck.

NASSA CALIFORNIANA Conrad var. COALINGENSIS n. var.

Plate XXVII, figure 9.

Description.—Shell averaging from 30 to 35 millimeters in length and having the general characteristics of outline and cancellate sculpture of the typical *N. californiana*, but being slenderer, constricted below the sutural riblet in the later stages of growth, having more prominently tabulate whorls, and having practically no axial sculpture on the major part of the body whorl.

Dimensions.—Longitude 32 mm.; latitude 16 mm.; longitude of body whorl 21.5 mm.; longitude of aperture, including canal, 16 mm.

Notes.—This elongated, peculiarly constricted variety is found replacing the typical form in certain of the Etchegoin faunas of the Coalinga district. A similar variety is known from other localities outside the Coalinga region.

Type.—Catalogue No. 165511, U.S.N.M., from locality 4758.

Localities.—United States Geological Survey locality 4657, near south side of the SW. ¼ sec. 34, T. 19 S., R. 15 E.; locality 4659, in *Glycymeris* bed, on Anticline Ridge, northeast of Coalinga and 4 miles northwest of Kenny bench mark, SW. ¼ sec. 34, T. 19 S., R. 15 E.; locality 4670, Kettleman Hills, at southernmost end, 5¼ miles southeast of Light's place, in center of sec. 10, T. 25 S., R. 19 E.; locality 4673, on ridge west of 1,900-foot hill, 1 mile southeast of Alcalde, center

of NE. ¼ sec. 24, T. 21 S., R. 14 E.; locality 4712, east of Zapato Creek, one-half mile south-southwest of A. Kreyenhagen's house, SW. ¼ SE. ¼ sec. 8, T. 22 S., R. 16 E.; locality 4758, bed "C," near top of section at Henry Spring, 4 miles south of Coalinga, SW. ¼ sec. 18, T. 21 S., R. 15 E.; all in the Coalinga district (Ralph Arnold and Robert Anderson).

Horizon.—Ranges through Etchegoin formation, upper Miocene.

Genus THAIS Link.

THAIS ETCHEGOINENSIS n. sp.

Plate XVIII, figure 2.

Description.—Shell averaging about 40 millimeters in length, oblong-oval in shape, last whorl large, spire short, apex subacute, shell thick. Whorls five, very moderately convex, slightly compressed a little above middle, giving whorls a faint carinate appearance. Sculpture consists of well-defined incremental lines sloping downward obliquely toward the right; very faint spiral sculpture is visible on the lower half of the body whorl, becoming quite distinct at the base of the canal. Suture distinct, appressed. Aperture oval, broadest anteriorly; outer lip slightly flaring, subdentate internally; inner lip smooth; columella flattened, showing an umbilical groove between lip and twisted carina of columella. Canal short, curved backward from aperture.

Dimensions.—Décolleté type: Longitude 38 mm.; latitude 28 mm.; longitude of body whorl 32 mm.; longitude of aperture, including canal, 24 mm.

Notes.—This solid little shell is closely allied to the variable *T. crispatus* Chemnitz (commonly known as *Purpura crispata*), but is much smoother than any of the specimens of the latter species found in the large series in the United States National Museum. It is also more solid and has a relatively shorter canal than most of the specimens of *T. crispatus* examined. It is distinguishable from *T. trancosana* Arnold, from the Pliocene of the Santa Cruz Mountains, by its more convex whorls, less pronounced spiral sculpture, and longer aperture and canal. It is named in honor of the Etchegoin formation, of which it is believed to be characteristic.

Type.—Catalogue No. 165533, U.S.N.M., from locality 4697.

Localities.—United States Geological Survey locality 4695, south group of Kettleman Hills, about 3½ miles S. 65° E. of Light's place, NE. ¼ SE. ¼ sec. 27, T. 24 S., R. 19 E.; locality 4697, near south end of Kettleman Hills, about 4 miles S. 20° E. of Light's place, on west side of sec. 3, T. 25 S., R. 19 E.; locality 4712, east of Zapato Creek, three-fourths mile south-southwest of A. Kreyenhagen's house, SW. ¼ SE. ¼ sec. 8, T. 22 S., R. 16 E. (Ralph Arnold and Robert Anderson).

Horizon.—Upper portion of Etchegoin formation, upper Miocene.

Genus PLEUROTOMA Lamarck.

PLEUROTOMA COALINGENSIS n. sp.

Plate XXII, figure 2.

Description.—Shell averaging about 20 millimeters in length, terriculated, fusiform, prominently spirally and axially sculptured; apex acute. The whorls are eight or nine in number, prominently angulated just above the middle, concave and comparatively smooth posteriorly and overlapping sinuously upon the antecedent whorl; lower part of whorl convex and strongly sculptured; body whorl sharply angulated near posterior margin, regularly and moderately convex below angle. The axial sculpture consists of very prominent, rounded ribs (10 on penultimate whorl of type), which slope slightly obliquely from just above the angle downward to the left as far as the suture; sharp incremental lines are more or less prominent on the body whorl, and also posterior to the angle on the other whorls. The spiral sculpture on each whorl consists of two prominent rounded ridges, separated by an interspace of equal width to the ridges; below these and sometimes above also, is a less prominent ridge, the lower one sometimes overlapped by the following whorl; the body whorl and columella combined carry about 16 subequal, equidistant prominent revolving ribs, those on the base of the columella being the smaller. Aperture narrow, elliptical; posterior sinus very marked; anterior sinus short and curved backward; outer lip thin, prominently convex forward, retreating rapidly below; columellar lip smooth, slightly curved.

Dimensions.—Longitude, 20 mm.; latitude, 8 mm.; longitude of body whorl 13.5 mm.; longitude of aperture, 10 mm.

Notes.—This beautiful and highly ornate species is quite unlike any previously described from the Pacific coast. It is characterized by its regularly spindle-shaped outline, prominent peripheral angle, strong axial and spiral ridging, and sharp, beautifully bowing outer lip and deep posterior sinus. Named for the Coalinga district, in which the type locality occurs.

Type.—Catalogue No. 165509, U.S.N.M.

Locality.—United States Geological Survey locality 4806, *Glycymeris* bed, on north side of Alcalde Canyon, 2 miles northeast of Alcalde, center of SW. ¼ sec. 7, T. 21 S., R. 15 E. (Ralph Arnold).

Horizon.—Basal portion of the Etchegoin formation, upper Miocene.

TULARE (FRESH-WATER PLIOCENE) SPECIES.

PELECYPODA.

Genus ANODONTA Cuvier.

ANODONTA KETTLEMANENSIS n. sp.

Plate XXX, figure 10.

1894. *Anodonta decurtata* Cooper (not Conrad, Am. Jour. Conch., vol. 6, 1871, p. 200, pl. 11, fig. 8), Proc. California Acad. Sci., 2d ser., vol. 4, May 26, 1894, p. 168, pl. 14, figs. 5–8.

1905. *Anodonta decurtata* Cooper (not Conrad), Anderson, F. M., Proc. California Acad. Sci., 3d ser., vol. 2, December 4, 1905, p. 182.

Description.—Shell subtrapezoidal in outline, relatively short, averaging about 60 millimeters in longitude by 36 millimeters in latitude, gibbous, moderately thin. Beaks anterior, turned slightly forward, inconspicuous. Anterior extremity about one-half as long as posterior, rounded except for extreme end which is only slightly curved for one-fourth width of shell, and meets dorsal margin with a faint suggestion of an angle; surface of anterior extremity noticeably flattened; posterior extremity angulated about five-eighths the distance from umbo to end and also sharply angular at base; an approximately straight line joins the two angles; dorsal margin slightly convex. Surface of umbones, up to latitude of about 5 millimeters, is ornamented by seven or eight prominent rounded, rather irregular and wavy concentric ridges, which are discontinuous about halfway from anterior to posterior extremity, the disconnected ends of what appears to be the same rib being irregularly en échelon with each other; rest of disk ornamented by numerous fine incremental lamellæ. Hinge narrow, frail, without teeth; muscular scars shallow.

Dimensions.—Longitude, 59 mm.; latitude 36 mm.; diameter of both valves together, 25 mm.

Notes.—It is very evident from a comparison of the Kettleman Hills species with the original description and figure of Conrad's *A. decurtata* that the former is an entirely different form, and the likeness of outline only superficial. *A. kettlemanensis* is slightly narrower, more attenuated anteriorly, less sharply angular above posteriorly, and has the beaks considerably farther in advance than *A. decurtata*. As Conrad's species is based on a cast, and his figure is rather poor, it is impossible to make comparisons regarding the surface ornamentation of the two.

A. kettlemanensis differs from *A. oregonensis* Lea by its more gibbous form, more nearly rectangularly truncated posterior extremity, and finer crenulations on the umbo; it differs from *A. nuttalliana* Lea and

A. californiensis Lea by its more gibbous form and more nearly rectangularly truncated posterior extremity; it differs from *A. wahlametensis* Lea by its more gibbous form and more nearly rectangularly truncated posterior extremity, less sharply angulated dorsal posterior margin, and straight instead of concave posterior end. It is closer to *A. wahlametensis* var. *exilior* Lea, found Recent in the Pacific drainage of Mexico, than to any other living species. It is named for the Kettleman Hills, in which at certain horizons the species occurs abundantly.

Type.—Catalogue No. 165522, U.S.N.M., from locality 4731.

Localities.—United States Geological Survey locality 4721, east border of Kettleman Hills, 3⅛ miles S. 60° W. of road house at northwest corner of Tulare Lake, NE. ¼ sec. 15, T. 22 S., R. 18 E.; locality 4731, northeast border of Kettleman Hills, near northwest end, on top of 905-foot hill, NW. ¼ NE. ¼ sec. 35, T. 21 S., R. 17 E.; locality 4732, about 2 miles from the northwest end of Kettleman Hills, on south side of main ridge, SW. ¼ NE. ¼ sec. 30, T. 21 S., R. 17 E.; locality 4735, central part of Kettleman Hills, on southwest side, 1 mile southwest of 1,376-foot hill and one-third mile northwest of old oil derrick, in center of south line of SW. ¼ sec. 19, T. 22 S., R. 18 E.; locality 4737, just above *Mya* bed on east side of south-central part of Kettleman Hills just east of Dudley-Lemoore road NE. ¼ SW. ¼ sec. 17, T. 23 S., R. 19 E.; all in Coalinga district (Ralph Arnold and Robert Anderson).

Horizon.—Basal Tulare, fresh-water Pliocene.

Genus GONIDEA Conrad.

GONIDEA COALINGENSIS n. sp.

Plate XXX, figure 11.

Description.—This species belongs to the same group as *Gonidea angulata* Lea, found Recent in the streams of the Pacific States, and is characterized by its practically obsolete angle, only moderately angulated posterior dorsal margin (which is fairly regularly convex), and its slightly concave ventral margin, which, in connection with the convex posterior dorsal margin, often gives the shell a faintly falcate appearance. It differs from *G. angulata* Lea by its obsolete angle, less ventricose and narrower shell; the beaks of *G. coalingensis* are also more finely undulated than in *G. angulata*. It approaches nearest to *G. angulata* Lea var. *haroldi* Dall, but is distinguishable from the latter by its smaller size, less ventricose and much narrower shell, and less angulated posterior dorsal mar-

gin. It differs from *G. coalingensis* var. *cooperi*, n. var., by its narrower and more nearly rectangularly truncated posterior extremity, rounded rather than angulated posterior dorsal margin, and shallower excavation in front of beaks.

Dimensions.—Longitude 73 mm.; maximum latitude 33 mm.; beak to anterior extremity, 14 mm.; diameter of both valves together, 16 mm.

Notes.—This species seems to be more common than the variety *cooperi* in the localities visited by the writer. It is a beautiful shell, and at certain places in the Kettleman Hills may be gathered in large quantities and in a perfect though somewhat fragile state of preservation. Named for the Coalinga district, in which the type locality is situated.

Type.—Catalogue No. 165521, U.S.N.M., perfect pair of valves from locality 4739.

Localities.—United States Geological Survey locality No. 4721, east border of Kettleman Hills, 3⅓ miles S. 60° W. of road house at northwest corner of Tulare Lake, bed just below *Anodonta* layer, NE. ¼ sec. 15, T. 22 S., R. 18 E.; locality 4731, east border of Kettleman Hills, near northwest end, on top of 905-foot hill, just above oyster bed; NW. ¼ NE. ¼, sec. 35, T. 21 S., R. 17 E.; locality 4739, 1 mile northwest of Anderson well, 25 miles south of Coalinga, SE. ¼ sec. 10, T. 23 S., R. 17 E.; all in Coalinga district. (Ralph Arnold; Robert Anderson; H. R. Johnson.)

Horizon.—Extreme base of Tulare formation, fresh-water Pliocene.

GONIDEA COALINGENSIS var. COOPERI n. var.

1894. *Margaritana subangulata* Cooper (= *Gonidea* id.), Proc. California Acad. Sci., 2d ser., vol. 4, May 26, 1894, p. 166, pl. 14, figs. 1 to 4.

1891. Not *Anodonta angulata* var. *subangulata* Hemphill (= *Gonidea* id.), in A collector's notes on variations in shells with some new varieties; Zoe, vol. 1, No. 11, January, 1891, p. 325, pl. 10, figs. 1 and 2.

Description.—This variety differs from the typical *Gonidea coalingensis* n. sp. by its broader and more protracted posterior extremity, more angulated posterior dorsal margin and deeper excavation in front of beaks. It approaches a little more closely to the Recent *G. angulata* Lea var. *haroldi* Dall. It is named in honor of the late Dr. J. G. Cooper, of California.

Locality and horizon.—This species occurs at the same horizon and is associated with the typical form in some of the localities mentioned for *G. coalingensis*.

Genus SPHÆRIUM Scopoli.

SPHÆRIUM COOPERI n. sp.

Plate XXX, figures 2 and 2a.

1894. *Sphærium dentatum?* Haldeman, Cooper, Proc. California Acad. Sci., 2d ser., vol. 4, May 26, 1894, p. 167.

1905. *Sphærium dentatum* Haldeman, Anderson, F. M., Proc. California Acad. Sci., 3d ser., Geology, vol. 2, December 4, 1905, p. 182.

Description.—Shell averaging about 10 millimeters in length, oval, inflated, especially toward umbones; beaks central or very slightly in the rear of the middle; anterior extremity slightly more attenuate than posterior, which has the faintest suggestion of an angle slightly above middle; base evenly and moderately rounded; surface of type somewhat worn, but showing only fine concentric lines from umbo to periphery. Cardinal teeth very small and too much worn in type to disclose characteristics.

Dimensions.—Longitude 9.5 mm.; altitude 7.5 mm.; diameter of single valve, 2.4 mm.

Notes.—This species is more oval and ventricose than *S. kettlemanensis* n. sp., has a longer anterior extremity and is relatively broader than *S. striatum* Lamarck (Recent) and more trigonal in outline and more inflated near the umbones than *S. dentatum* Haldeman (Recent). In some respects *S. cooperi* appears to be more closely related to specimens in the National Museum collection labeled "*Sphærium magnum* Sterki, Pleistocene, Arroyo Pecos Las Vegas, New Mexico." It is named in honor of the late Dr. J. G. Cooper.

Type.—Catalogue No. 165528, U.S.N.M., a somewhat worn right valve from locality 4732.

Localities.—United States Geological Survey locality 4731, northeast border of Kettleman Hills, near northwest end on top of 905-foot hill, just above oyster bed, NW. ¼ NE. ¼ sec. 35, T. 21 S., R. 17 E.; locality 4732, about 2 miles from northwest end of Kettleman Hills, on south side of main ridge, SW. ¼ NE. ¼ sec. 30, T. 21 S., R. 17 E.; both localities in Coalinga district. (Ralph Arnold; Robert Anderson; H. R. Johnson.)

Horizon.—Base of Tulare, fresh-water Pliocene.

SPHÆRIUM KETTLEMANENSIS n. sp.

Plate XXX, figures 1 and 1a.

Description.—Shell averaging about 8 millimeters in length, thin, between oval and trigonal in shape, equivalve, slightly inflated; beaks well defined, but neither high nor prominent, situated in advance of

middle; anterior extremity shorter than posterior and more regularly convex; posterior extremity quite sharply rounded below middle; base moderately rounded; the surface of the shell in the younger stages up to an altitude of 1½ to 2 millimeters is ornamented by several prominent, sometimes sulcated, concentric ridges; in the later stages the concentric ridges become finer and closer set. Cardinal teeth small; one posterior bifurcated tooth and one small simple anterior one in right valve; left valve carries a moderately long simple posterior tooth, a middle bifurcated one, and an anterior rudimentary; lateral teeth compressed, lamelliform, the anterior shortest. Muscular and pallial impressions concealed in type.

Dimensions.—Longitude 8 mm.; altitude 6.5 mm.; diameter of single valve 1.8 mm.

Notes.—This species is different from any of those known and may be recognized by its subtrigonal outline, compressed form, and prominent concentric ribbing on umbones. It is probably nearer to *S. striatum* Lamarck than to any other described form, but may be distinguished from the latter by its more advanced umbones, more trigonal outline and more compressed form. *S. kettlemanensis* is found abundantly in the fresh-water Pliocene Etchegoin formation, of the Kettleman Hills, after which it is named.

Type.—Catalogue No. 165519, U.S.N.M., left valve, from locality 4731.

Localities.—United States Geological Survey locality 4731, northeast border of Kettleman Hills, near northwest end, on top of 905-foot hill, just above oyster bed, NW. ¼ NE. ¼ sec. 35, T. 21 S., R. 17 E.; locality 4732, about 2 miles from northwest end of Kettleman Hills, on south side of main ridge, SW. ¼ NE. ¼ sec. 30, T. 21 S., R. 17 E.; both in Coalinga district (Ralph Arnold; Robert Anderson; H. R. Johnson).

Horizon.—Base of the Tulare formation, fresh-water Pliocene.

GASTEROPODA.

Genus PLANORBIS Guettard.

PLANORBIS VANVLECKI n. sp.

Plate XXX, figures 4 and 4a.

1894. *Valvata virens* Cooper (not Tryon), Proc. California Acad. Sci., 2d ser., vol. 4, May 26, 1894, p. 167.

1905. *Valvata virens* Cooper (not Tryon), F. M. Anderson, Proc. California Acad. Sci., 3d ser., Geology, vol. 2, December 4, 1905, p. 182.

Description.—Shell averaging about 4.5 millimeters in maximum diameter, the whorls visible both from above and below. Whorls

four, prominently angulated above and with a faint suggestion of a sutural ridge along the inner margin; base of whorl flat and triangulate, with a faint spiral ridge between the angles in some of the specimens; incremental sculpture sharply marked both above and below. Aperture rounded above, subangulate below, retreating obliquely from top to bottom at an angle of about 45° with the plane of the base; lip simple; umbilicus deep and relatively narrow.

Dimensions.—Maximum diameter 4.5 mm.; altitude 1.4 mm.

Notes.—This beautiful little species is characterized by its angular whorls and suggestions of spiral ridging above near the suture, and below, between the angles. It resembles certain members of the genus *Valvata* but has a more oblique aperture and depressed spire than any examined by the writer. Its nearest affinity is probably *P. opercularis* Gould. It is named in honor of Robert Van Vleck Anderson, United States Geological Survey, the writer's collaborator in the investigations in the Coalinga district.

Type.—Catalogue No. 165506, U.S.N.M., from locality 4731.

Localities.—United States Geological Survey locality 4715, south end of Kettleman Hills, sec. 10, T. 25 S., R. 19 E. (in a mixture (?) of Etchegoin marine and Tulare fresh-water fossils) (Ralph Arnold and O. D. Barton); locality 4731, northeast border of Kettleman Hills, near northwest end on top of 905-foot hill above uppermost Etchegoin bed, NW. ¼ NE. ¼ sec. 35, T. 21 S., R. 17 E.; locality 4732, about 2 miles from northwest end of Kettleman Hills, on south side of main ridge, 1½ miles northwest of 1,245-foot hill, SW. ¼ NE. ¼ sec. 30, T. 21 S., R. 17 E.; all in Coalinga district (Ralph Arnold and Robert Anderson).

Horizon.—Base of Tulare, fresh-water Pliocene.

Genus CARINIFEX Binney.

CARINIFEX MARSHALLI n. sp.

Plate XXX, figures 3, 3a and 3b.

1894. *Carinifex newberryi* Cooper (not Lea), Proc. California Acad. Sci., 2d ser., vol. 4, May 26, 1894, p. 167.

1905. *Carinifex newberryi* Cooper (not Lea), Anderson, F. M., Proc. California Acad. Sci., 3d ser., Geology, vol. 2, December 4, 1905, p. 182.

Description.—Shell attaining a diameter of 5 millimeters or more, dextral, nearly planorbiform, the spire being depressed or only slightly raised. Whorls 3½ or more; the last whorl very large, broad above, rapidly attenuated below; all whorls convex, even the nuclear; from about 1½ whorls onward a rounded sutural carina is developed on the inner edge of the whorl; from this carina the surface of the whorl slopes downward at a low angle, and is often shallowly sulcated

between the carina and the periphery of the whorl; no outer angle is developed on the whorls, the upper surface bowing over regularly to the under surface. The sculpture consists of numerous fine, somewhat unequal incremental lines; no spiral sculpture is visible, although the somewhat worn condition of the specimens examined may account for its absence. The suture is V-shaped, profound and distinct. Umbilicus funnel-shaped; aperture slightly oblique to plane of spiral axis, subtriangular, broad above, narrowed below; lip simple, thin..

Dimensions.—Maximum diameter 3.5 mm.; altitude 2 mm.

Notes.—This small species, the largest specimen of which is little over 5 mm. in diameter, is closely allied to *C. newberryi* Lea, at present found living in the lakes of the Pacific and adjacent States. A careful comparison of *C. marshalli* with the series of *C. newberryi* in the United States National Museum discloses the fact that the former is smaller and lacks the flat-topped whorls in the younger stages of growth and the prominent peripheral angle of the latter, and usually has the carina on the inner edge of the whorl much more prominent. Other minor differences are the more involute spire, the less prominently downward projecting aperture, and the deeper V-shaped, more-pronounced suture of *C. marshalli.* The species is named in honor of William Blanchard Marshall, of the United States National Museum, whose assistance in many instances is here gratefully acknowledged.

Type.—Catalogue No. 165507, U.S.N.M.

Locality.—United States Geological Survey locality 4732, about 2 miles from northwest end of Kettleman Hills, on south side of main ridge, SW. ¼ NE. ¼ sec. 30, T. 21 S., R. 17 E. (Ralph Arnold; Robert Anderson; H. R. Johnson).

Horizon.—Base of Tulare formation, fresh-water Pliocene.

Genus PHYSA Draparnaud.

PHYSA WATTSI n. sp.

Plate XXX, figure 6.

1894. *Physa costata* Cooper (not Newcomb), Proc. California Acad. Sci., 2d ser., vol. 4, May, 1894, p. 167.

1905. *Physa costata* Cooper (not Newcomb), Anderson, F. M., Proc. California Acad. Sci., 3d ser., Geology, vol. 2, December 4, 1905, p. 182.

Description.—Shell averaging about 6 millimeters in longitude, sinistrally spiral, moderately thin, spire moderately elevated and acute. Whorls about 3½, subangular, the point of greatest convexity occurring just posterior to middle, giving the whorls a tabulate

appearance; surface sculptured by numerous more or less irregular and unevenly spaced rounded varices each ornamented by fine longitudinal corrugations and lines; the interspaces are somewhat narrower than the varices and are similarly sculptured; the varices become obsolete toward the base of the body whorl. Suture appressed and very distinct. Aperture rounded in front, angular behind; outer lip simple; columellar lip nearly straight, flaring slightly.

Dimensions.—Longitude 6 mm.; latitude 3.5 mm.; longitude of body whorl, 4.8 mm.; longitude of aperture 3.8 mm.

Notes.—This beautiful little shell is closely allied to and is probably the precursor of *P. costata* Newcomb, but is smaller, less fragile, less bubble-shaped, and has the spire more exserted than the latter. It is named in honor of W. L. Watts, Los Angeles, Cal., who, during the course of field work in the oil districts of the State, gathered material that has added greatly to the knowledge of west coast paleontology.

Type.—Catalogue No. 165503, U.S.N.M.

Locality.—United States Geological Survey locality 4732, on south side of main ridge about 2 miles from the northwest end of the Kettleman Hills, in SW. ¼ NE. ¼ sec. 30, T. 21 S., R. 17 E. (W. L. Watts; Ralph Arnold; H. R. Johnson; Robert Anderson.)

Horizon.—Basal Tulare formation, fresh-water Pliocene.

Genus AMNICOLA Gould and Haldeman.

AMNICOLA ANDERSONI n. sp.

Plate XXX, figure 9.

1894. *Amnicola turbiniformis* Cooper (not Tryon), Proc. California Acad. Sci., 2d ser., vol. 4, May, 1894, p. 167.

1905. *Amnicola turbiniformis* Cooper (not Tryon), Anderson, F. M., Proc. California Acad. Sci., 3d ser., Geology, vol. 2, December, 1905, p. 182.

Description.—Shell averaging about 4 millimeters in length, elongate, turbinate-globose, thin; spire tall for member of this genus. Whorls six, subcircular in cross section, giving the surface of the whorl a strongly but regularly convex contour with just the slightest suggestion of an angle about one-third the distance from posterior to anterior margin; faint lines of growth are visible over certain areas of the surface in the type; suture very deeply impressed. Aperture between subcircular and subovate; lip thin, simple; umbilicus perforate.

Dimensions.—Longitude 4 mm.; latitude 2.4 mm.; longitude of body whorl 2.5 mm.; longitude of aperture 1.3 mm.

Notes.—This beautiful little shell is characterized by its tall many-whorled spire and regularly convex whorls. It appears to be most closely related to *A. longinqua* Gould, found Recent and in Pleisto-

cene lake deposits in California, but differs from the latter in having one more whorl, in having more convex whorls and deeper sutures and in having the posterior end of the aperture rounded rather than subangular. *A. andersoni* is very much taller than *A. turbiniformis* Tryon, with which it was confused by Cooper. It occurs abundantly in the fresh-water deposits (Tulare formation) of the Kettleman Hills. It is named in honor of Mr. Frank M. Anderson, Berkeley, Cal., whose pioneer work on the east side of the Coast Ranges has added so much to our knowledge of their geology.

Type.—Catalogue No. 165505, U.S.N.M.

Locality.—United States Geological Survey locality 4732, on south side of main ridge about 2 miles from the northwest end of the Kettleman Hills, SW. ¼ NE. ¼ sec. 30, T. 21 S., R. 17 E. (W. L. Watts; Ralph Arnold; H. R. Johnson; Robert Anderson.)

Horizon.—Basal Tulare formation, fresh-water Pliocene.

Genus GONIOBASIS Lea.

√ GONIOBASIS KETTLEMANENSIS n. sp.

Plate XXX, figure 7.

1894. *Goniobasis occata* Cooper (not Hinds), Proc. California Acad. Sci., 2d ser., vol. 4, May 26, 1894, p. 167.

1905. *Goniobasis occata* Cooper (not Hinds), Anderson, F. M., Proc. California Acad. Sci., 3d ser., Geology, vol. 2, December 4, 1905, p. 182.

Description.—Shell averaging about 22 millimeters in length, spire long, apex blunt. Whorls seven or eight, the nuclear one without sculpture or worn smooth in those specimens examined; the second, third, and fourth whorls flat or angulated, the next moderately and evenly convex. The sculpture consists of six or more rounded thread-like revolving ridges, those in the upper part of the whorl usually being the most prominent; intercalaries of varying degrees of importance often occur in the interspaces; incremental lines and also lines of interrupted or unequal growth are also usually visible. Suture moderately deeply impressed. Aperture ovate, slightly angulate in front; lip thin and simple, concave above, bowing convexly outward below, slightly thickened toward columella, which is thick, and bowed; umbilicus imperforate to subperforate.

Dimensions.—Longitude 22.5 mm.; latitude 8.5 mm.; longitude of body whorl 12 mm.; longitude of aperture 7 mm.

Notes.—This species is distinct from any of the other west-coast species. Its almost exact counterpart may be found in a certain variety of *G. virginica* Say, inhabiting water which sometimes becomes brackish, thus illustrating parallel development under similar conditions of increasing salinity of habitat, although the two forms are

found in widely separated localities and geologic horizons. *G. kettlemanensis* is characterized by strong spiral and almost total lack of axial sculpture. At one locality (4715) it is found in the upper Etchegoin associated with a marine or mixed marine and brackish water fauna, while at another (4735) it is found only with fresh-water shells in the Tulare formation. It is named for the Kettleman Hills, the type locality.

Type.—Catalogue No. 165501, U.S.N.M., from locality 4715.

Localities.—Tulare formation, Pliocene: United States Geological Survey locality 4715, south end of Kettleman Hills, sec. 10, T. 25 S., R. 19 E. (R. Arnold and O. D. Barton); locality 4735, central part of Kettleman Hills, on southwest side, 1 mile southwest of 1,376-foot hill and one-third mile northwest of oil derrick, in center of south line of SW. ¼ sec. 19, T. 22 S., R. 18 E. (Robert Anderson).

Etchegoin formation, upper Miocene: Locality 4696, northeast side of south group of Kettleman Hills, about $1\frac{1}{16}$ miles due southeast of Light's place, SW. ¼ NW. ¼ sec. 21, T. 24 S., R. 19 E.; locality 4715 (see same locality, Tulare); all in Coalinga district (Ralph Arnold and Robert Anderson).

Horizon.—Top of the Etchegoin (upper Miocene) and base of the Tulare (fresh-water Pliocene). It is quite possible that at locality 4715 the *G. kettlemanensis* may be from a horizon just above that of its marine associates. It is mixed with the marine shells on the surface of the low hill at this place.

PISCES.

Fish spines and Bulbous growths.

Plate XXV, figures 6, 6a, 6b, 7, 7a, and 8.

Among the fossils found in the upper Etchegoin and lower Tulare are some peculiar shaped objects of bony material. By far the commonest form is one somewhat resembling in outline one valve of certain arcas (see Pl. XXV, figs. 6, 6a, 6b) but having an irregular base in which is a pit. The surface of the bone is reddish brown, rather rough, and usually showing fibery structure. Some of these bones have been recognized with the aid of J. W. Gidley, of the U. S. National Museum; David Starr Jordan, of Stanford University, and J. C. Merriam, of the University of California, as being the bulbous growths from the anterior portion of the back or the anterior end of the ventral fin of some kind of fish. Not even the order to which these belong is determinable, and they may be either marine or fresh-water fishes. They occur in both marine and fresh-water deposits. Another form (Pl. XXV, fig. 8) is nearly bilaterally symmetrical, with a groove down the middle and extended processes at either end; it is

rounded at the back. Still another form (Pl. XXV, figs. 7, 7a) has been identified as a fish spine; it has a deep longitudinal V-shaped groove in the base, a sharp ridge, and a few irregular longitudinal lines on the two sides.

Figured specimens.—Catalogue Nos. 165493, 165494, and 165495, U.S.N.M.

Localities.—Etchegoin: United States Geological Survey locality 4695, on east side of Kettleman Hills south of Avenal Gap, NE. ¼ SE. ¼ sec. 27, T. 24 S., R. 19 E.; locality 4696, northeast side of south group of Kettleman Hills, 1 mile southeast of Light's place, SW. ¼ NW. ¼ sec. 21, T. 24 S., R. 19 E.; locality 4697, near south end of Kettleman Hills, on summit 4 miles S. 20° E. of Light's place in Avenal Gap, on west side of sec. 3, T. 25 S., R. 19 E.; locality 4698, 1 mile north of White Creek and 3½ miles northwest of junction with Los Gatos Creek, in center of sec. 23, T. 19 S., R. 13 E.; locality 4715, south end of Kettleman Hills, sec. 10, T. 25 S., R. 19 E.; locality 4741, east side of Kettleman Hills at point 3½ miles west of entrance of Dudley-Lemoore road into hills, northeast corner of sec. 12, T. 23 S., R. 18 E. (Ralph Arnold and Robert Anderson).

Tulare: Locality 4731, northeast border of Kettleman Hills, near northwest end on top of hill just east of old road and cabin, NW. ¼ NE. ¼ sec. 35, T. 21 S., R. 17 E.; locality 4738, about 20 miles southeast of Coalinga, near Etchegoin–Tulare contact; SE. ¼ NW. ¼ sec. 14, T. 23 S., R. 17 E.; 1 mile northwest of El Cerrito well, 25 miles south of Coalinga, near north end of Kettleman Hills, 1⅞ miles north-northwest of 1,244-foot hill (Ralph Arnold and Robert Anderson).

Horizon.—Upper portion of Etchegoin (upper Miocene) and base of Tulare (fresh-water Pliocene).

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PLATE I.

PLATE I.

CHICO (UPPER CRETACEOUS) FOSSILS.

VOLUTODERMA GABBI White.

Page.

Figure 1. Natural size. Catalogue No. 20112, U.S.N.M.; copied from Bull. U. S. Geol. Survey No. 51, pl. 3, fig. 1. Found at locality 3 in the Coalinga district; also occurs as far north as Puget Sound region..... 11

PERISSOLAX BREVIROSTRIS Gabb.

Figure 2. Natural size. Copied from Whiteaves, Geol. Surv. Canada, Mes. Foss., vol. 1, pt. 5, pl. 43, fig. 3, 1903. Found at locality 4 in the Coalinga district; a not uncommon species in the Chico of the Pacific coast..... 11

TELLINA? OOIDES Gabb.

Figure 3. Exterior of imperfect left valve, showing a little of the original shell material, altitude 43 mm., natural size. Catalogue No. 31075, U.S.N.M. Found at locality 3 in the Coalinga district, and at other Chico localities on the west coast..... 11

MACTRA ASHBURNERI Gabb.

Figure 4. Exterior of small right valve, longitude 28 mm., × 2. Catalogue No. 31074, U.S.N.M. Found at locality 3 in the Coalinga district; also common at most Chico localities..... 11

MEEKIA SELLA Gabb.

Figure 5. Exterior of cast of right valve, altitude 18 mm., × 2. Catalogue No. 31073, U.S.N.M. Locality 3 in Coalinga district; also common at other Chico localities on the Pacific coast..... 11

AVICULA LINGUÆFORMIS Evans and Shumard.

Figure 6. Exterior of cast of small left valve, altitude 14 mm., × 2. Catalogue No. 31076, U.S.N.M. Locality 11..... 11

BACULITES CHICOENSIS Trask.

Figure 7. Natural size. Copied from Gabb, Pal. California, vol. 1, pl. 17, figs. 27, 27a, 1864..... 11

7a. Cross section. Ibid., figure 27a.

7b. Septum. Ibid., plate 14, figure 28b.

CHICO FOSSILS

PLATE II.

PLATE II.

TEJON (EOCENE) PELECYPODA.

VENERICARDIA PLANICOSTA Lamarck.

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Figure 1. Left valve; longitude 84 mm. Eocene; Little Falls, Wash. Catalogue No. 164973, U.S.N.M. This is the most widespread and characteristic Eocene species in the world..... 13

CORBULA PARILIS Gabb.

Figure 2. Exterior of right valve restored, longitude 6 mm., × 2. Catalogue No. 165621, U.S.N.M. Locality 4801..... 13

SEPTIFER DICHOTOMUS Gabb.

Figure 3. Exterior of right valve restored, longitude 22 mm., × 2. Catalogue No. 165623, U.S.N.M. Locality 4801..... 13

OSTREA IDRIAENSIS Gabb.

Figure 4. Exterior of right valve, longitude 27 mm.; natural size. Catalogue No. 165674, U.S.N.M. Locality 4801..... 13

OSTREA IDRIAENSIS Gabb.

Figure 5. Exterior of left valve, longitude 35.5 mm.; natural size. Catalogue No. 165674, U.S.N.M. Locality 4801. A common species in certain California Eocene localities..... 13

SPONDYLUS CARLOSENSIS F. M. Anderson.

Figure 6. Exterior of imperfect specimen, altitude 20 mm.; natural size. Catalogue No. 165628, U.S.N.M. Locality 4617. So far unknown outside the Coalinga district..... 13

Figure 7. Natural size. Copied from Proc. California Acad. Sci., 3d ser., Geology, vol. 2, no. 2, pl. 13, fig. 1.

LEDA GABBI Conrad.

Figure 8. Exterior of cast of left valve, longitude 13 mm., × 2. Catalogue No. 165662, U.S.N.M. Locality 5014. A common species in the Tejon..... 13

TELLINA HORNII Gabb.

Figure 9. Exterior of left valve of slightly imperfect specimen, longitude 42 mm.; natural size. Catalogue No. 165656, U.S.N.M. Locality 4617. A species found at many Tejon localities..... 13

CRASSATELLITES GRANDIS Gabb.

Figure 10. Exterior of imperfect right valve, altitude 50 mm.; natural size. Catalogue No. 165638, U.S.N.M. Locality 4613. A common Tejon species..... 13

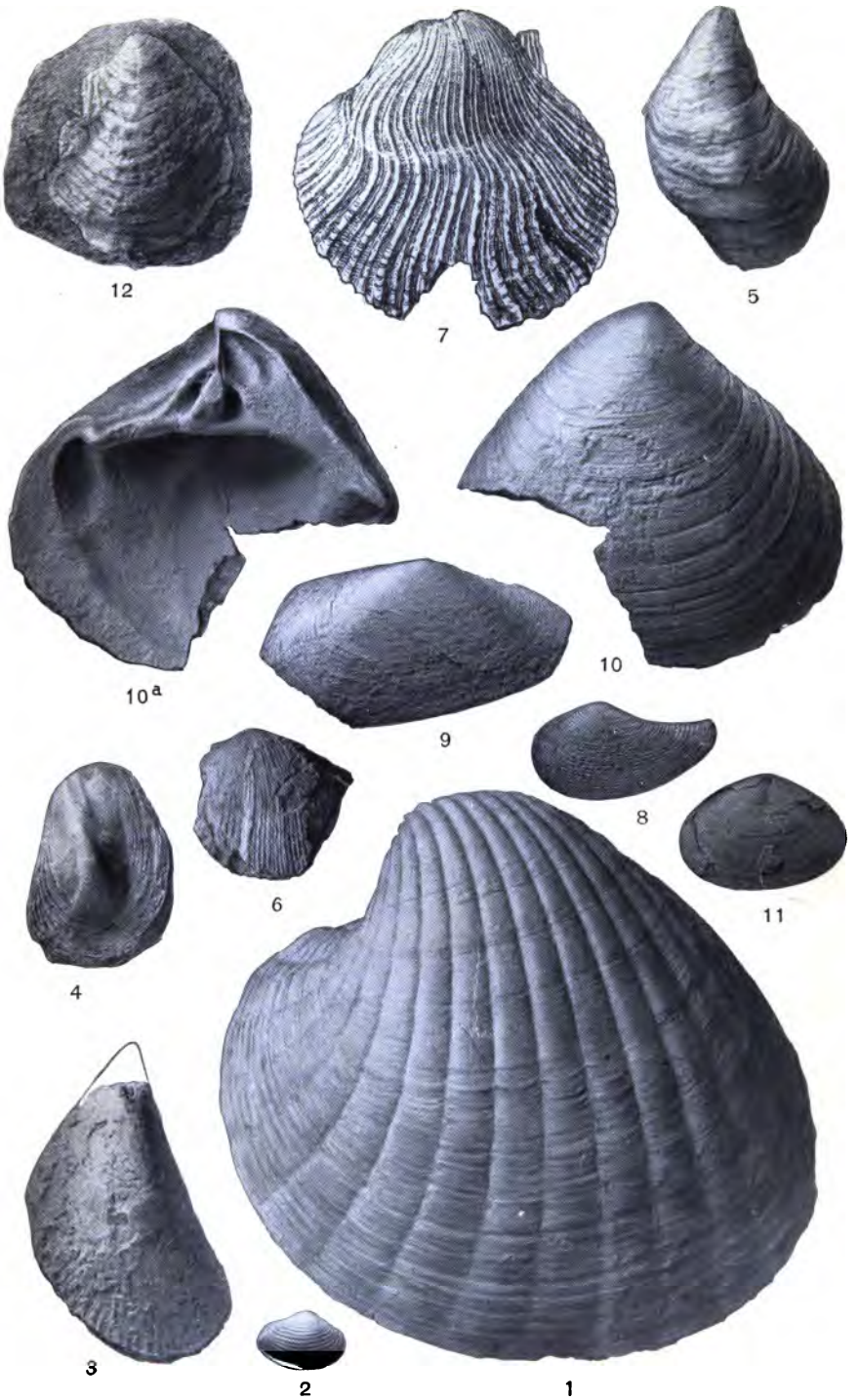
10a. Interior of same specimen.

TELLINA JOAQUINENSIS n. sp.

Figure 11. Exterior of left valve, longitude 22 mm.; natural size. Type, catalogue No. 165619, U.S.N.M. Locality 4801..... 49

OSTREA AVICULIFORMIS F. M. Anderson.

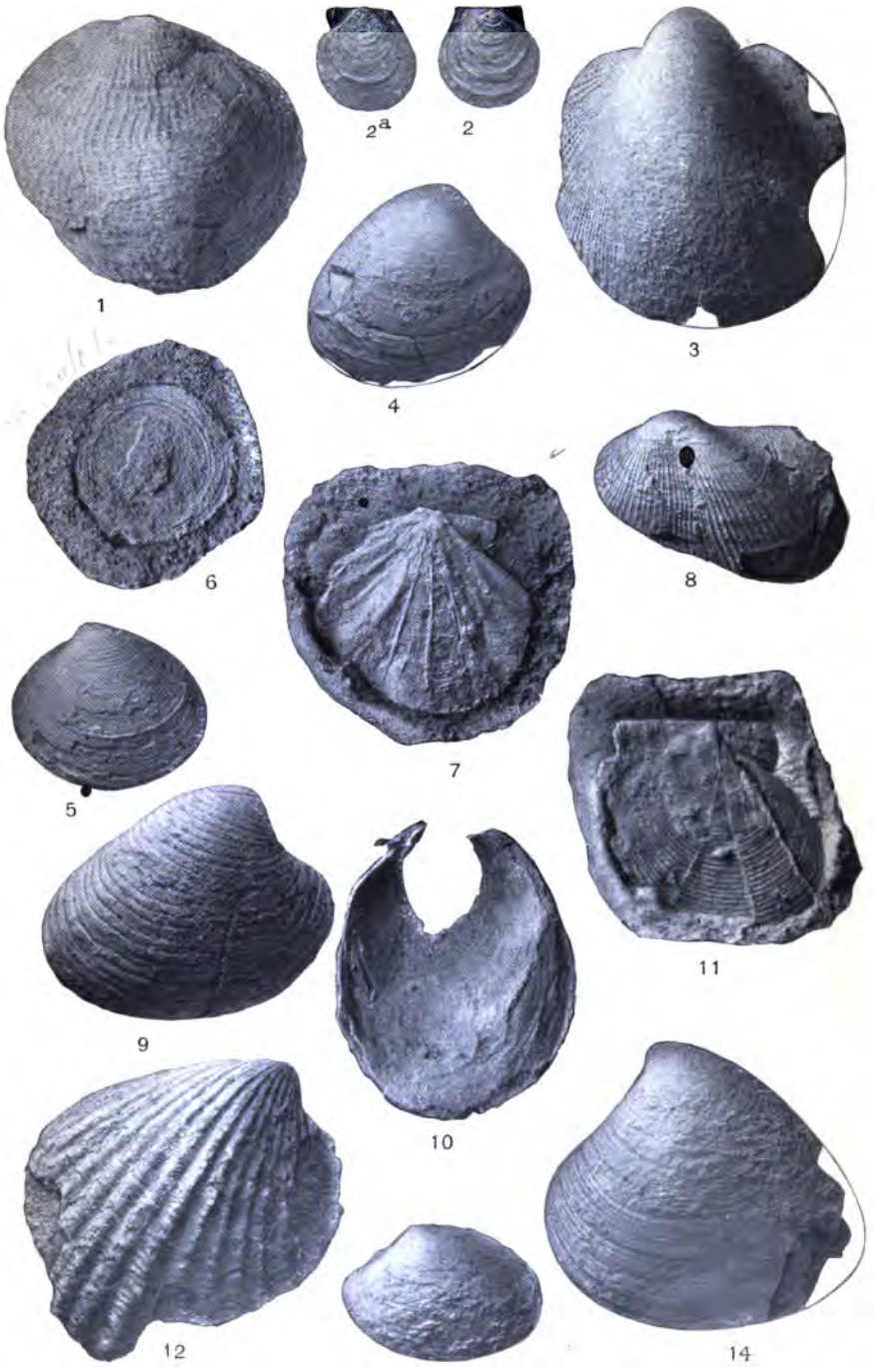
Figure 12. Exterior of left valve, longitude 16 mm., × 2. Catalogue No. 165627, U.S.N.M. Locality 4801..... 50



TEJON PELECYPODA.

PLATE III.

PLATE III.



TEJON PELECYPODA.

PLATE IV.

PLATE IV.

TEJON (EOCENE) GASTEROPODA AND ECHINODERMATA.

CASSIDULUS CALIFORNICUS F. M. Anderson.

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Figure 1. Top view of imperfect specimen, longitude 21 mm., × 2. Catalogue No. 165664, U.S.N.M. Locality 4622. So far known only from this locality 13

1a. Bottom of same specimen.

POTAMIDES CARBONICOLA Cooper.

Figure 2. Back of imperfect specimen, longitude 19 mm., × 2. Catalogue No. 165651, U.S.N.M. Locality 4801. So far known only from the type locality 14

3. Back of another specimen, longitude 16 mm., × 2. Catalogue No. 165651, U.S.N.M. Same locality as 2 14

TRITONIUM CALIFORNICUM Gabb.

Figure 4. Front of young and imperfect specimen, longitude 8 mm., × 4. Catalogue No. 165644, U.S.N.M. Locality 4619. A rather rare species; grows to much larger size than the figured specimen 14

SERPULORBIS sp. *a*.

Figure 5. Top, maximum diameter of specimen 15 mm., × 2. Catalogue No. 165659, U.S.N.M. Locality 4617. A common form at some localities of the Tejon 14

RIMELLA CANALIFERA Gabb.

Figure 6. Front of imperfect specimen, longitude 15 mm., × 2. Catalogue No. 165646, U.S.N.M. Locality 4618. This species has an expanded lip which is produced upward along the body and penultimate whorls. A common and characteristic Eocene form 14

AMAUROPSIS OVIFORMIS? Gabb.

Figure 7. Front of imperfect specimen, altitude 29 mm., natural size. Catalogue No. 165654, U.S.N.M. Locality 4617 13

GALERUS EXCENTRICUS Gabb.

Figure 8. Side view, altitude 12 mm., natural size. Catalogue No. 165643, U.S.N.M. Locality 4801. A very common and characteristic Eocene species 14

LUNATIA HORNII Gabb.

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Figure 9. Front view, altitude 13.3 mm., natural size. Catalogue No. 165620, U.S.N.M. Locality 4801. Often grows much larger than the specimen figured 14

TRITONIDEA KREYENHAGENI n. sp.

Figure 10. Front of décolleté and slightly imperfect specimen, longitude 16 mm., × 2. Type, catalogue No. 165657, U.S.N.M. Locality 4801 51

TURRITELLA UVASANA Conrad.

Figure 11. Side of a décolleté specimen; longitude 31 mm., × 2. Catalogue No. 165653, U.S.N.M. Locality 4617. A common and characteristic Eocene species, showing considerable variation as regards sculpture 14

NERITA TRIANGULATA Gabb.

Figure 12. Back and part of top, maximum diameter 12 mm., natural size. Catalogue No. 165700, U.S.N.M. Locality 4801. A characteristic Eocene species 14

12a. Top of same specimen.

LUNATIA sp. *a*.

Figure 13. Front of imperfect specimen, altitude 27 mm., natural size. Catalogue No. 165652, U.S.N.M. Locality 4801 14

TURRITELLA PACHECOENSIS Stanton.

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DENTALIUM COOPERI Gabb.

Figure 15. Side, longitude 9 mm., × 2. Catalogue No. 165622, U.S.N.M. Locality 4619. A common and long-lived species 13

PLEUROTOMA DOMENGINEI n. sp.

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LOXOTREMA TURRITA Gabb.

Figure 17. Back of imperfect specimen, longitude 20 mm., natural size. Catalogue No. 165649, U.S.N.M. Locality 4801. A peculiar and characteristic Tejon species 14

SPIROGLYPHUS? TEJONENSIS n. sp.

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CYLICHNA COSTATA Gabb.

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Figure 19. Front view of imperfect specimen, longitude 13 mm., × 2. Catalogue No. 165655, U.S.N.M. Locality 4617. A common Eocene form very much like some later species..... 13

PLEUROTOMA GUIBERSONI n. sp.

Figure 20. Rear view of imperfect specimen, longitude 13.5 mm., × 3. Type, catalogue No. 165648, U.S.N.M. Locality 4619..... 54

AMAUROPSIS ALVEATA Conrad.

Figure 21. Front view of specimen with slightly broken lip, altitude 43 mm., natural size. Catalogue No. 165650, U.S.N.M. Locality 4619. An exceedingly widespread and characteristic species in the Eocene..... 13

CANCELLARIA IRELANIANA Cooper.

Figure 22. Front view of imperfect specimen, longitude 39 mm., natural size. Catalogue No. 165645, U.S.N.M. Locality 4619..... 52

PLEUROTOMA FRESNOENSIS n. sp.

Figure 23. Front view of specimen from which the canal is missing, longitude 21 mm., × 2. Type, catalogue No. 165631, U.S.N.M. Locality 4619..... 53

TEJON GASTEROPODA AND ECHINODERMATA.

PLATE V.

PLATE V.

VAQUEROS (LOWER MIOCENE) FOSSILS: LOWER HORIZON.

OSTREA TITAN Conrad.

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Figure 1. Exterior of left valve, longitude 90 mm., natural size. Catalogue No. 165565, U.S.N.M. Lower Vaqueros formation; locality 4773. This rather diminutive variety is found abundantly below the reef bed on Laval grade, 9 miles north of Coalinga.... 17

DOSINIA MATHEWSONII Gabb.

Figure 2. Exterior of right valve, altitude 56 mm., natural size. Catalogue No. 165596, U.S.N.M. Vaqueros formation; locality 4803. This species is believed to be characteristic of the lower and middle Miocene..... 18

MYTILUS MATHEWSONII Gabb var. EXPANSUS Arnold.

Figure 3. Exterior of nearly perfect right valve, longitude 157 mm., natural size. Catalogue No. 165661, U.S.N.M. Vaqueros formation; locality 4803. This species is believed to be characteristic of the Vaqueros; the typical form is usually found in the upper half of the Miocene..... 18

SEPTIFER COALINGENSIS n. sp.

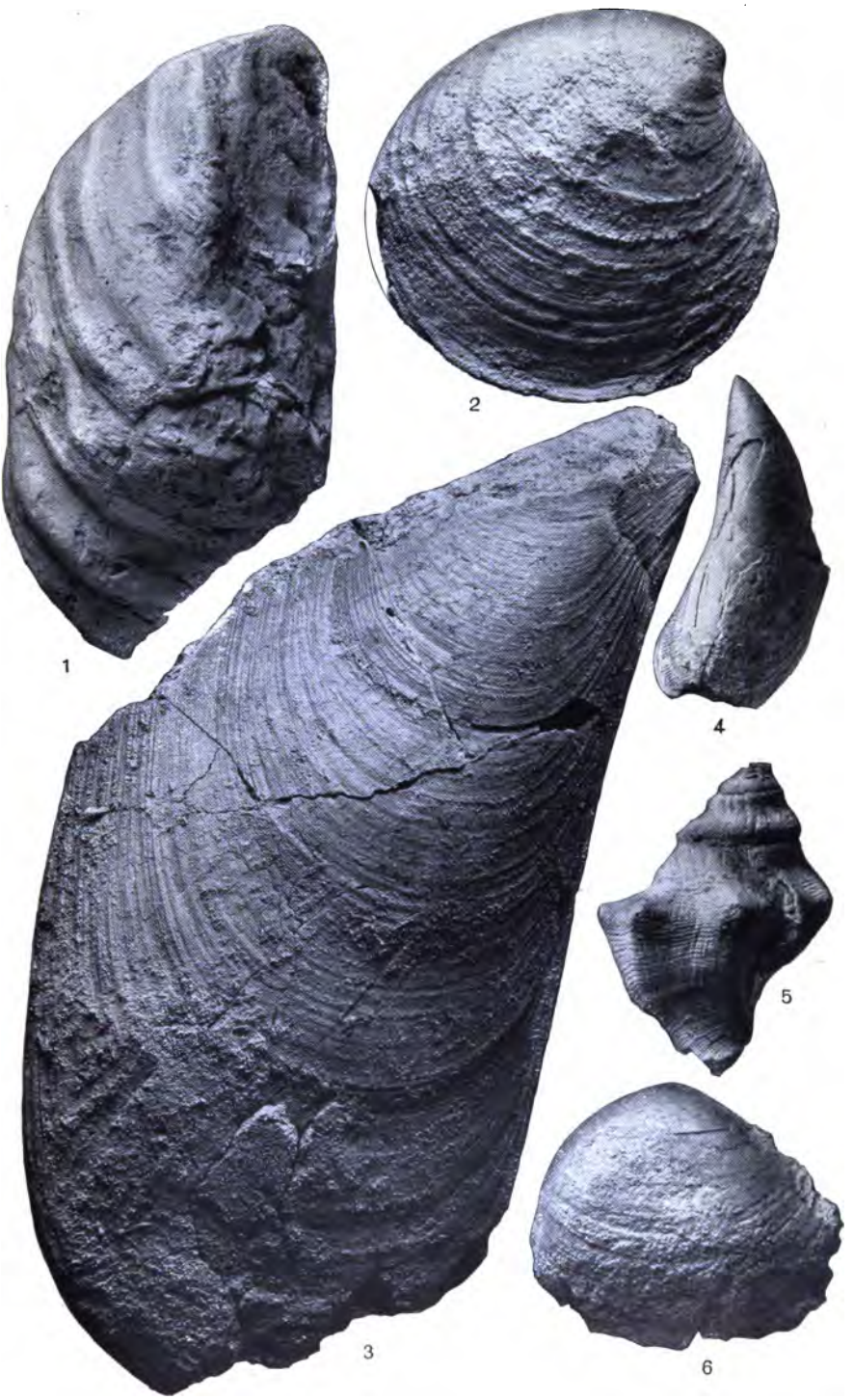
Figure 4. Exterior of left valve, longitude 45 mm., natural size. Type, catalogue No. 165580, U.S.N.M. Supposed Vaqueros formation; locality 4634..... 58

TROPHON (FORRERIA) GABBIANUM F. M. Anderson.

Figure 5. Back of imperfect specimen, altitude 44 mm., natural size. Catalogue No. 165572, U.S.N.M. Vaqueros formation; locality 4860. (See Pl. VI, fig. 5)..... 60

MULINIA DENSATA Conrad var. MINOR n. var.

Figure 6. Exterior of slightly imperfect right valve. Type, catalogue No. 165601, U.S.N.M. Vaqueros formation; locality 4777..... 54



VAQUEROS FOSSILS.

PLATE VI.

PLATE VI.

VAQUEROS (LOWER MIOCENE) FOSSILS: LOWER HORIZON.

METIS aff. ALTA Conrad.

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Figure 1. Exterior of right valve, longitude 32 mm., × 2. Catalogue No. 165567, U.S.N.M.; Vaqueros formation; locality 4627. This lower Miocene *Metis* may be different from the Recent *M. alta*, but the state of preservation of the fossils precludes a definite determination..... 17

Figure 2. Left valve of same specimen.

CONUS HAYESI n. sp.

Figure 3. Back of slightly imperfect specimen, longitude 60 mm., natural size. Type, catalogue No. 165566, U.S.N.M.; Vaqueros formation; locality 4861..... 62

SCUTELLA MERRIAMI F. M. Anderson.

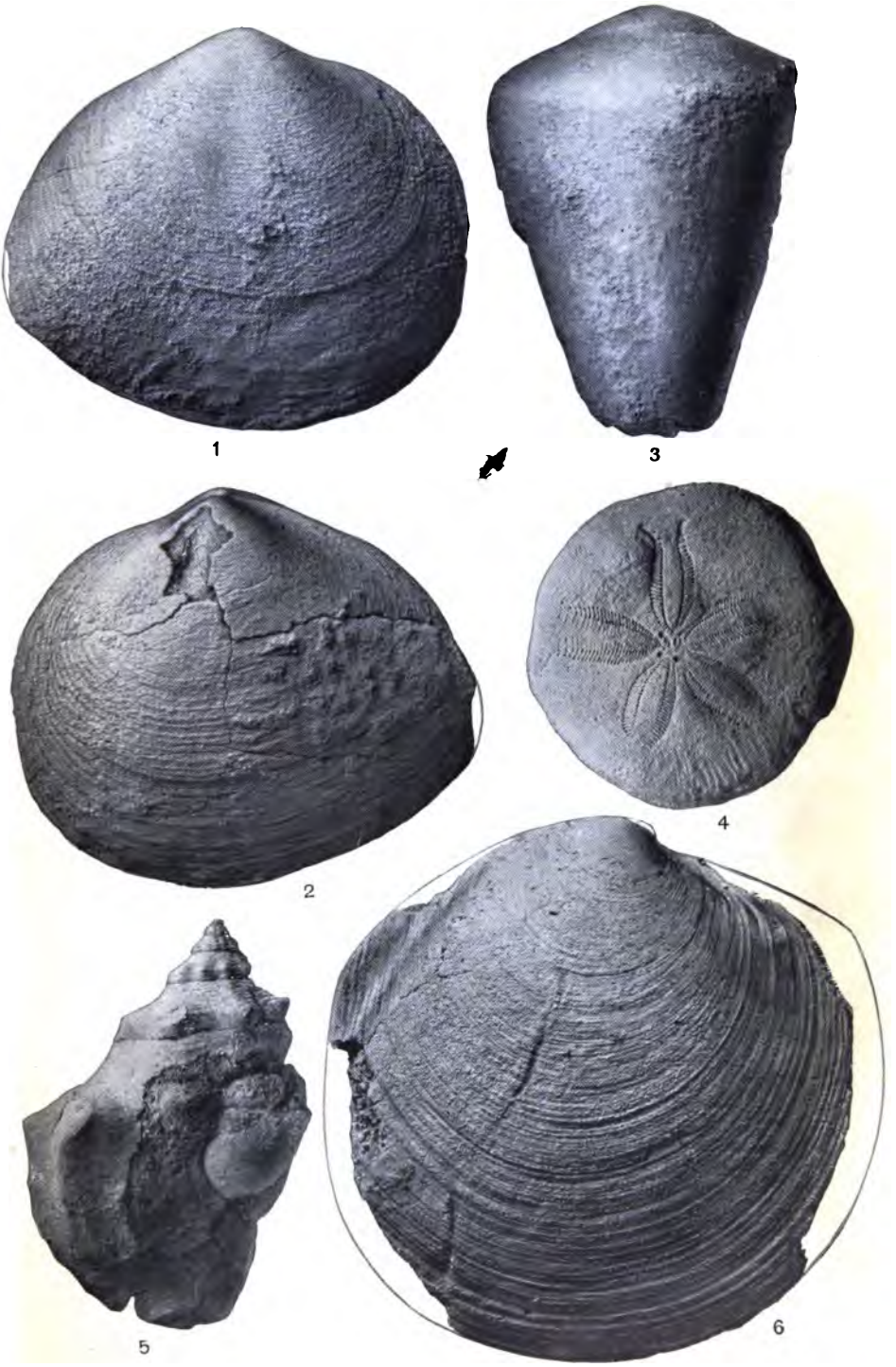
Figure 4. Top, maximum diameter 21 mm., natural size. Catalogue No. 165584, U.S.N.M. Vaqueros formation; locality 4775. This little echinoid from which the "button bed" in the Vaqueros derives its name, is found at many localities in the Coalinga district, and is believed to be characteristic of the Vaqueros or lower Miocene..... 18

TROPHON (FORRERIA) GABBIANUM F. M. Anderson var. CANCELLARIOIDES n. var.

Figure 5. Back of imperfect specimen, longitude 56 mm., natural size. Type, catalogue No. 165605, U.S.N.M. Vaqueros formation; locality 4861. (See Pl. V, fig. 5.)..... 60

PHACOIDES (MILTHA) SANCTÆCRUCIS n. sp.

Figure 6. Exterior of nearly perfect right valve, longitude 75 mm., natural size. Type, catalogue No. 165569, U.S.N.M. Vaqueros formation; locality 4861..... 57



VAQUEROS FOSSILS.

PLATE VII.

PLATE VII.

VAQUEROS (LOWER MIOCENE) FOSSILS: LOWER AND UPPER HORIZONS.

ARCA OSMONTI Dall.

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Figure 1. Exterior of left valve, longitude 49 mm., natural size. Catalogue No. 165563, U.S.N.M. Vaqueros formation; locality 4859. This species is believed to be characteristic of the lower Miocene. The specimen figured is from the type locality. Found also in Santa Monica Mountains, near Los Angeles..... 18

1a. Umbones of same specimen.

2. Exterior of left valve of a broader specimen, longitude 39 mm., natural size. Catalogue No. 165563, U.S.N.M..... 18

TROPHON (FORRERIA) BARTONI n. sp.

Figure 3. Imperfect specimen, altitude 33 mm., natural size. Type, catalogue No. 165571, U.S.N.M. Vaqueros formation; locality 4861..... 59

PECTEN ANDERSONI Arnold.

Figure 4. Exterior of right valve, longitude 37 mm., natural size. Catalogue No. 165583, U.S.N.M. Vaqueros formation; locality 4803. This species is believed to be characteristic of the Miocene. It is found abundantly in certain layers of the "reef beds," where it makes up the entire rock for small thicknesses..... 17

ZIRPHÆA DENTATA Gabb.

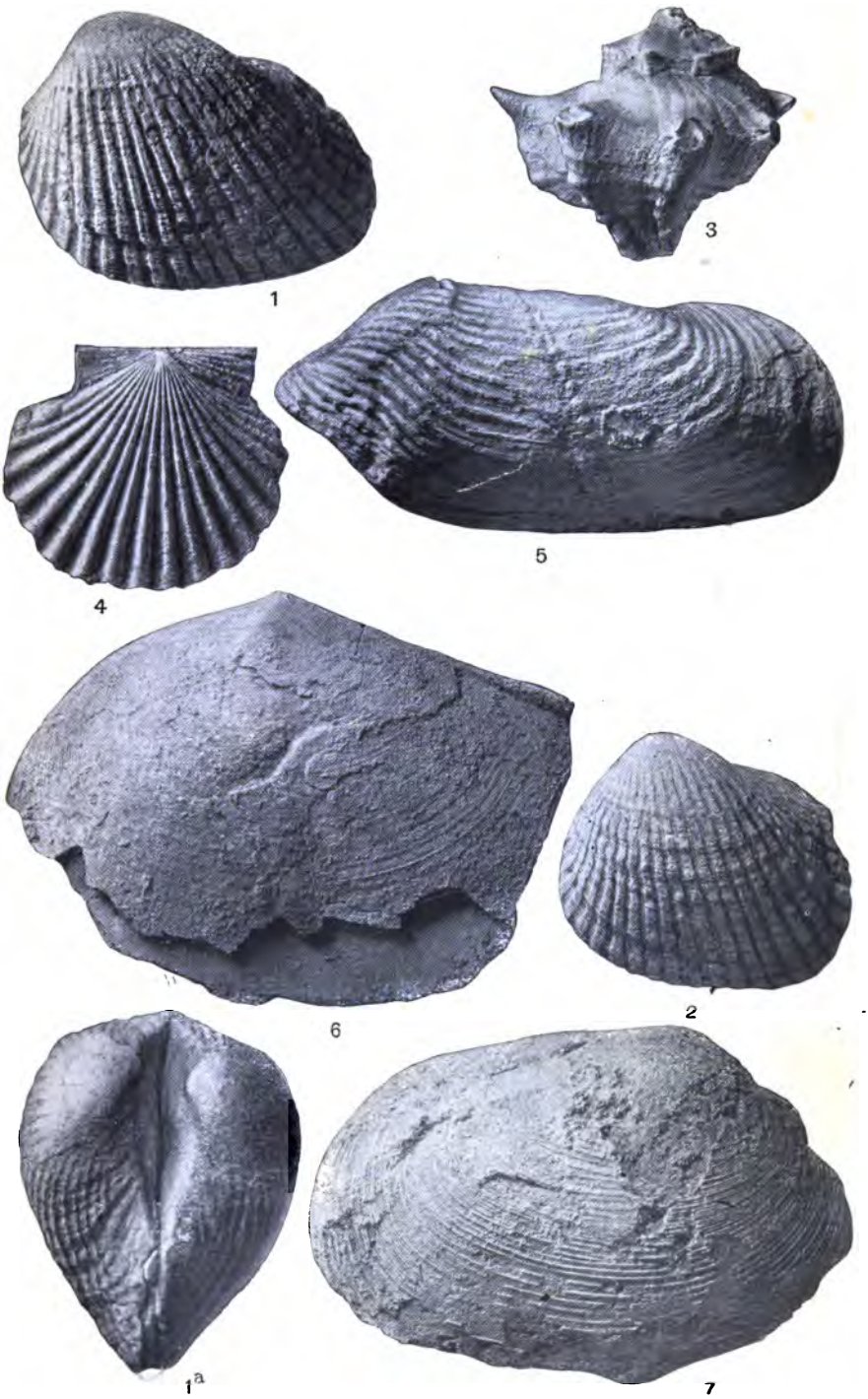
Figure 5. Exterior of left valve, longitude 73 mm., natural size. Catalogue No. 165573, U.S.N.M. Vaqueros formation; locality 4803. This species is believed to be characteristic of the Miocene.... 17

MACOMA PIERCEI n. sp.

Figure 6. Exterior of left valve of imperfect specimen, longitude 75 mm., natural size. Type, catalogue No. 165595, U.S.N.M. Upper Vaqueros formation; locality 4631..... 55

SAXIDOMUS VAQUEROSENSIS n. sp.

Figure 7. Exterior of left valve, longitude 69 mm., natural size. Type, catalogue No. 165570, U.S.N.M. Upper Vaqueros formation; locality 4631..... 56



VAQUEROS FOSSILS.

PLATE VIII.

PLATE VIII.

VAQUEROS (LOWER MIOCENE) FOSSILS: UPPER HORIZON.

TURRITELLA OCOYANA Conrad.

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Figure 1. Back of imperfect specimen, longitude 50 mm., natural size. Catalogue No. 165593, U.S.N.M. Vaqueros formation; locality 4631. This is one of the most characteristic fossils of the Vaqueros, especially in the San Joaquin Valley and in southern California..... 17

2. Back of two whorls of an exceedingly large specimen, altitude 42 mm., natural size. Catalogue No. 165574, U.S.N.M. Upper Vaqueros formation; locality 4631..... 17

VENUS PERTENUIS Gabb.

Figure 3. Exterior of right valve, longitude 88 mm., natural size. Catalogue No. 165597, U.S.N.M. Upper Vaqueros formation; locality 4631. This species is believed to be characteristic of the Miocene.... 17

PHACOIDES ACUTILINEATUS Conrad.

Figure 4. Exterior of left valve, altitude 35.5 mm., natural size. Catalogue No. 165564, U.S.N.M. Upper Vaqueros formation; locality 4803. This species ranges from the lower Miocene to the lower Pliocene fauna. Formerly called *Lucina acutilineata*..... 17

AGASOMA SANTACRUZANA Arnold.

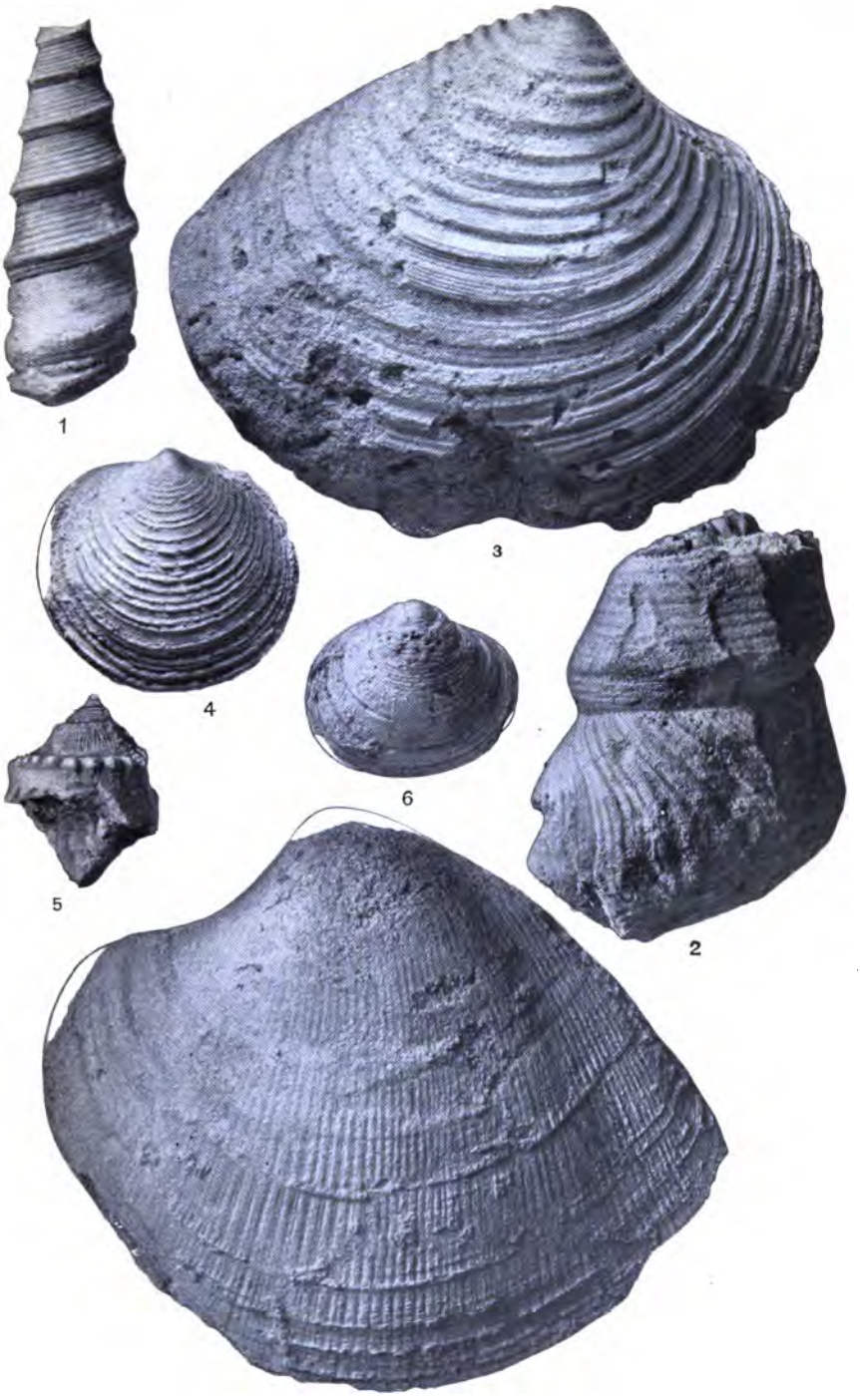
Figure 5. Front of imperfect specimen, consisting of spire and part of body whorl, latitude 19 mm., natural size. Catalogue No. 165609, U.S.N.M. Vaqueros formation; locality 4631. This species is believed to be characteristic of the Vaqueros..... 17

CORBICULA DUMBLEI F. M. Anderson.

Figure 6. Exterior of right valve, longitude 28 mm., natural size. Catalogue No. 165581, U.S.N.M. Vaqueros formation; locality 4628. This species is found abundantly in the Vaqueros oil sand where it outcrops in Anticline Canyon southwest of Coalinga..... 17

CHIONE TEMBLORENSIS F. M. Anderson.

Figure 7. Exterior of imperfect and decorticated left valve, longitude 92 mm., natural size. Catalogue No. 165612, U.S.N.M. Upper Vaqueros formation; locality 4631. This species, which is characterized by its central beaks and narrow form, is believed to be characteristic of the Vaqueros formation..... 17



VAQUEROS FOSSILS.

PLATE IX.

PLATE IX.

VAQUEROS (LOWER MIOCENE) FOSSILS: UPPER HORIZON.

DOSINIA PONDEROSA Gray.

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Figure 1. Exterior of left valve, altitude 78 mm., natural size. Catalogue No. 165660, U.S.N.M. Upper Vaqueros formation; locality 4631. This species ranges from the lower Miocene to the Recent fauna..... 17

CARDIUM (TRACHYCARDIUM) VAQUEROSENSIS Arnold.

Figure 2. Exterior of imperfect right valve, altitude 98 mm., natural size. Catalogue No. 165598, U.S.N.M. Upper Vaqueros formation; locality 4631..... 57

CONUS OWENIANUS F. M. Anderson.

Figure 3. Front, altitude 16 mm., natural size. Catalogue No. 165606, U.S.N.M. Upper Vaqueros formation; locality 4631. This species, which is characterized by spiral striations, is believed to be characteristic of the Vaqueros..... 17

OCINEBRA TOPANGENSIS Arnold.

Figure 4. Back, longitude 25 mm., natural size. Catalogue No. 165608, U.S.N.M. Upper Vaqueros formation; locality 4631. This species, which is also found in the Santa Monica Mountains, is believed to be characteristic of the Vaqueros formation..... 17

CANCELLARIA ANDERSONI n. sp.

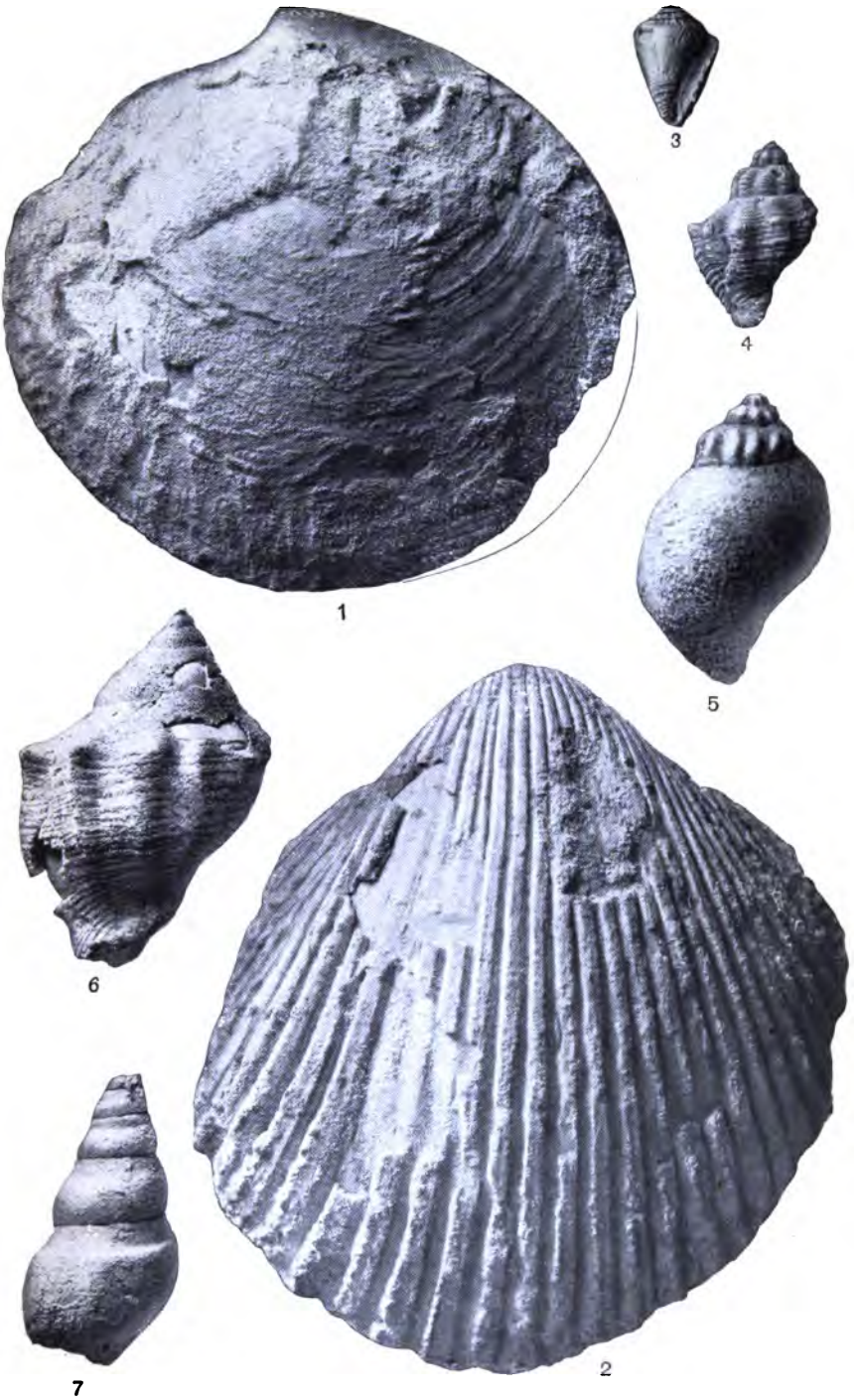
Figure 5. Back, longitude 21 mm., × 2. Type, catalogue No. 165607, U.S.N.M. Upper Vaqueros formation; locality 4631..... 60

CANCELLARIA VETUSTA Gabb.

Figure 6. Back, longitude 51 mm., natural size. Catalogue No. 165600, U.S.N.M. Upper Vaqueros formation; locality 4631. This species is believed to be characteristic of the Vaqueros..... 17

PLEUROTOMA (BATHYTOMA) PIERCEI n. sp.

Figure 7. Back of imperfect specimen, altitude 39.5 mm., natural size. Type, catalogue No. 165578 U.S.N.M. Upper Vaqueros formation; locality 4631..... 61



VAQUEROS FOSSILS.

PLATE X.

PLATE X.

PLATE X.

PLATE X.

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PLATE X.

SANTA MARGARITA (UPPER MIDDLE MIOCENE) FOSSILS.

TAMIOSOMA GREGARIA Conrad.

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Figure 1. Side, group of individuals, maximum altitude 187 mm., one-half natural size. Catalogue No. 165618, U.S.N.M. Santa Margarita (?) formation; locality 4766. This unique form, which is closely related to the barnacles, is believed to be characteristic of the upper Miocene and is usually found abundantly in the fossiliferous portions of the Santa Margarita (?) formation..... 21

HINNITES GIGANTEUS Gray.

Figure 2. Exterior of right valve, longitude 52 mm., natural size. Catalogue No. 165586, U.S.N.M. Santa Margarita (?) formation; locality 4651. This species ranges from the middle Miocene to the Recent fauna. The specimen figured is an immature, fair-sized individual..... 21

PECTEN ESTRELLANUS Conrad.

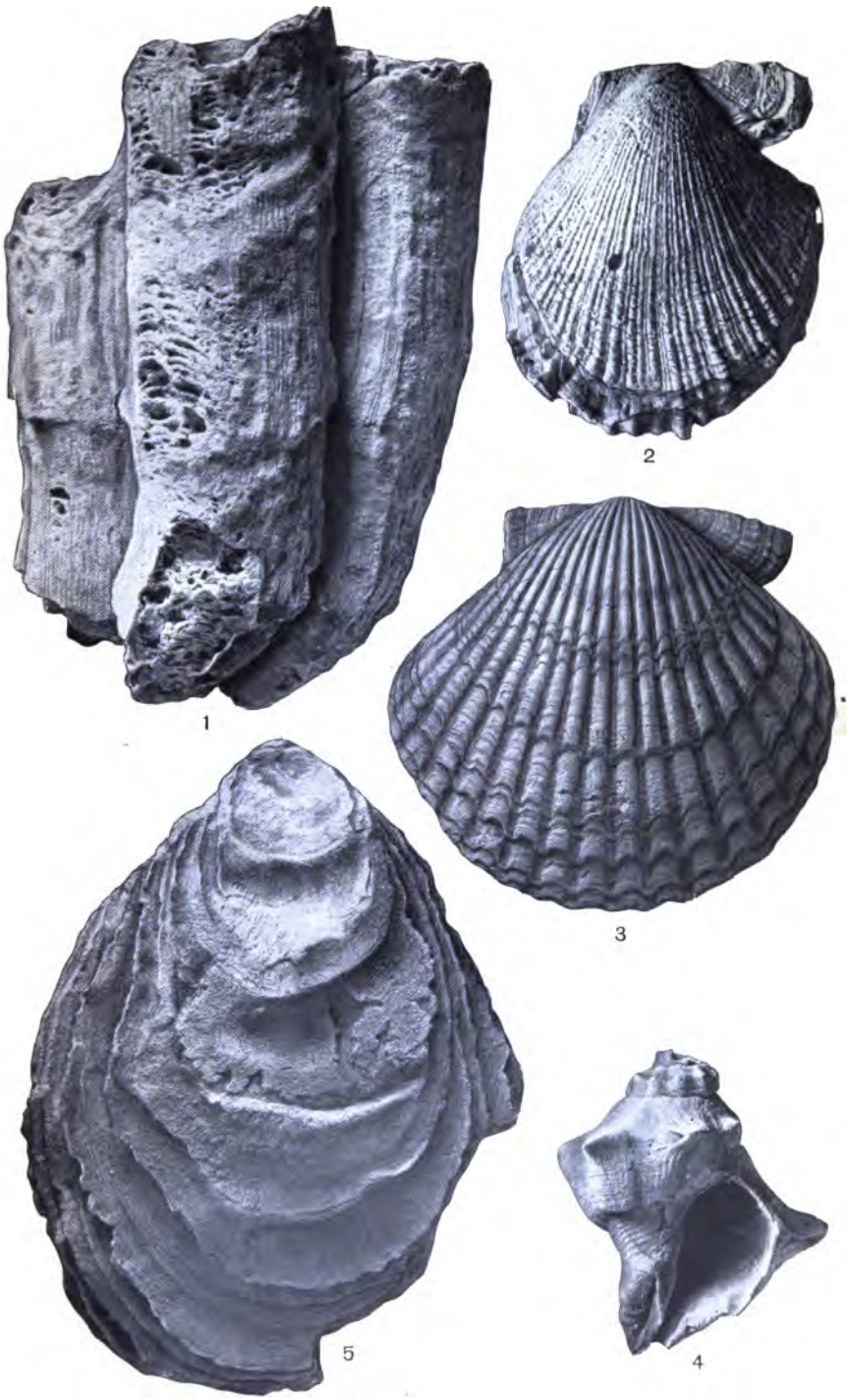
Figure 3. Exterior of right valve, altitude 111 mm., one-half natural size. Catalogue No. 165616, U.S.N.M. Santa Margarita (?) formation; locality 4766. This species is exceedingly common in the Santa Margarita (?) and Jacalitos formations, but may extend into the Vaqueros 21

TROPHON (FORRERIA) CARISAENSIS F. M. Anderson.

Figure 4. Front, longitude 41 mm., natural size. Type, catalogue No. 165591, U.S.N.M. Santa Margarita (?) formation; locality 4766. This species is characterized by its moderate size, and the spines which are located in the middle of the whorl. It is believed to be characteristic of the Santa Margarita formation..... 21

OSTREA TITAN Conrad.

Figure 5. Exterior of right valve; longitude 174 mm., one-half natural size. Catalogue No. 165617, U.S.N.M. Santa Margarita (?) formation; locality 4766..... 21



SANTA MARGARITA FOSSILS.

PLATE XI.

PLATE XI.

SANTA MARGARITA (UPPER MIDDLE MIOCENE) AND JACALITOS (UPPER MIOCENE) FOSSILS.

ASTRODAPSIS WHITNEYI Rémond.

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Figure 1. Top of back of imperfect specimen, maximum diameter 76 mm., natural size. Catalogue No. 165594, U.S.N.M. Santa Margarita (?) formation; locality 4766. This species is believed to be characteristic of the Santa Margarita (?) formation in the Coalinga district..... 63

OSTREA TITAN Conrad.

Figure 2. Exterior of left valve, altitude 290 mm., one-half natural size. Catalogue No. 165617, U.S.N.M. Santa Margarita (?) formation; locality 4766. This magnificent *Ostrea* is found abundantly throughout the Miocene, especially in the upper half of the middle Miocene; it sometimes attains a length of 20 inches and a weight of over 20 pounds..... 21

PLIOHIPPUS sp. *a*.

Figure 3. Side, longitude 49 mm., natural size. Catalogue No. 165665, U.S.N.M. Jacalitos formation, NW ¼ sec. 22, T. 19 S., R. 15 E. The extinct horse, of which this tooth is all that was found, is believed to be characteristic of the upper Miocene..... 26

3a. Crown of same specimen.

THAIS CRISPATUS Chemnitz.

Figure 4. Front of décolleté and otherwise slightly imperfect specimen, longitude 44 mm., natural size. Catalogue No. 165532 U.S.N.M. Upper Jacalitos formation; locality 4763. This species ranges from the upper Miocene to the Recent fauna, and is an exceedingly variable species, some specimens being almost smooth, others strongly sculptured. The genus *Thais* has heretofore been commonly known as *Purpura*..... 26

SANTA MARGARITA AND JACALITOS FOSSILS.

PLATE XII.

PLATE XII.

SANTA MARGARITA (UPPER MIDDLE MIOCENE) AND JACALITOS (UPPER MIOCENE) FOSSILS.

PECTEN CRASSICARDO Conrad.

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Figure 1. Exterior of right valve, altitude 165 mm., one-half natural size. Catalogue No. 165615, U.S.N.M. Santa Margarita (?) formation; locality No. 4766. This species is characterized by its large size, fine radial striations and lack of prominent intercalary rib. Ranges throughout the Miocene. Is usually more abundant in the middle and upper portions..... 21

MACOMA VANVLECKI n. sp.

Figure 2. Exterior of right valve, longitude 54 mm., natural size. Type, catalogue No. 165576, U.S.N.M. Jacalitos formation; locality 4763 (See Pl. XVI, fig. 1)..... 65

SCHIZODESMA ABSCISSA Gabb.

Figure 3. Exterior of right valve, longitude 100 mm., natural size. Catalogue No. 165604, U.S.N.M. Jacalitos formation; locality 4765. This species is believed to be characteristic of the upper Miocene.... 26

SANTA MARGARITA AND JACALITOS FOSSILS.

PLATE XIII.

PLATE XIII.

JACALITOS (UPPER MIOCENE) ECHINODERMATA.

~~ECHINARACHNIUS~~ GIBBSII (Rémond.)

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Figure 1. Top, longitude 81 mm., natural size. Catalogue No. 165611, U.S.N.M. Jacalitos formation; locality 4747. This large variety is believed to be characteristic of the lower part of the Jacalitos..... 25

2. Bottom of another specimen, longitude 87 mm., natural size. Same locality.

JACALITOS ECHINODERMATA.

PLATE XIV.

PLATE XIV.

JACALITOS (UPPER MIOCENE) FOSSILS.

MONIA MACROSCHISMA Deshayes.

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Figure 1. Exterior of left valve, longitude 66 mm., natural size. Catalogue No. 165602, U.S.N.M. Jacalitos formation; locality 4767. This species ranges from upper Miocene to the Recent fauna. Erroneously called *Placunanomia macroschisma*..... 25

TELLINA ARAGONIA Dall.

Figure 2. Exterior of right valve, longitude 48 mm., natural size. Catalogue No. 165577, U.S.N.M. Jacalitos formation; locality 4765. This species which was originally described from the Empire formation at Coos Bay, Oregon, is believed to be characteristic of the upper Miocene..... 26

TROPHON (FORRERIA) PONDEROSUM Gabb.

Figure 3. Back of young specimen, longitude 43 mm., natural size. Catalogue. No. 165590, U.S.N.M. Etchegoin formation; locality 4642. This species is common in the Jacalitos formation and rare in the Etchegoin..... 25

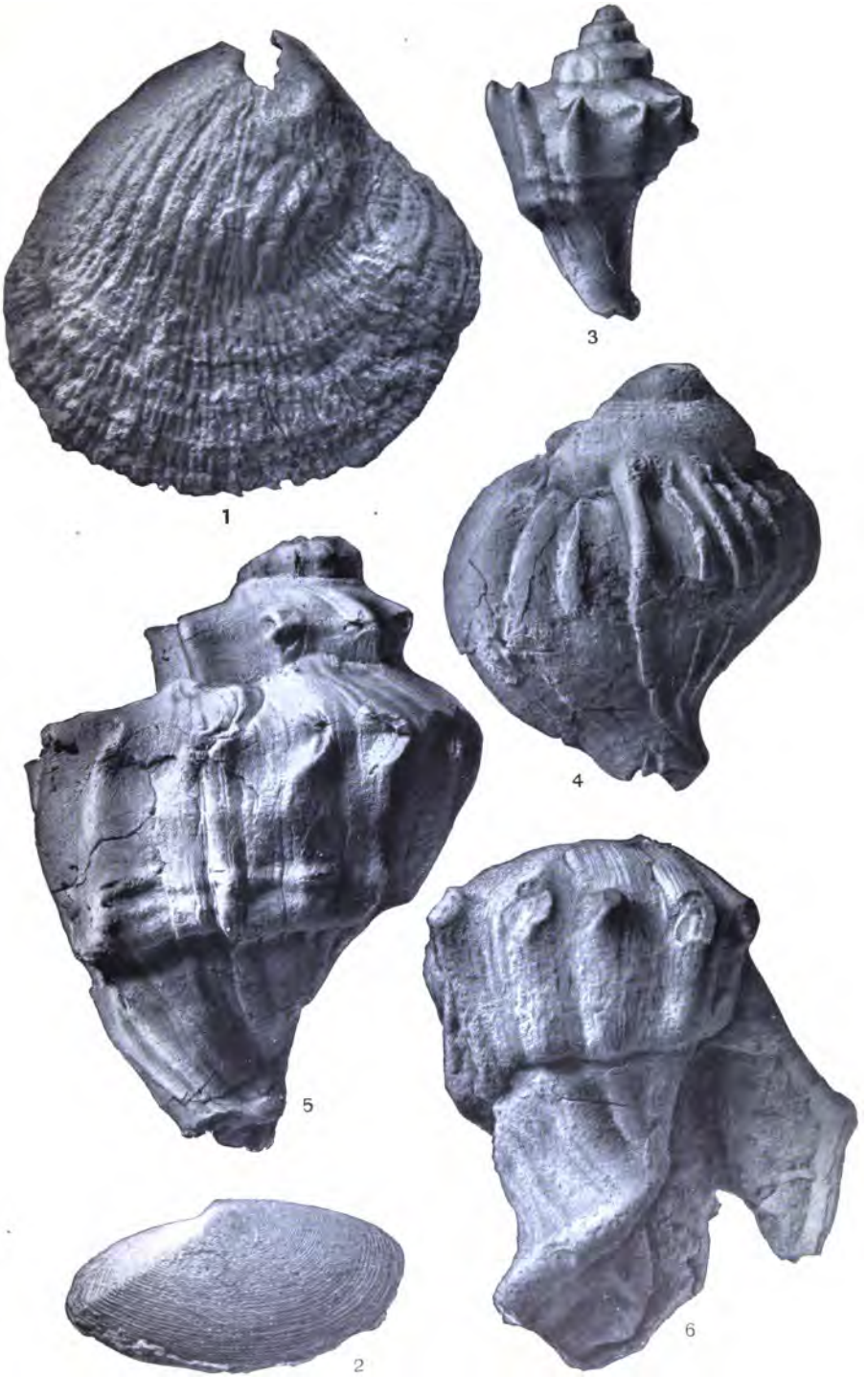
CHRYSODOMUS IMPERIALIS Dall.

Figure 4. Back of nearly perfect specimen, longitude 57 mm., natural size. Catalogue No. 165582, U.S.N.M. Upper Jacalitos formation; locality 4767. This species, which is characterized by its broad outline and peculiar reflexed varices, is believed to be characteristic of the upper Miocene. It is found in Oregon, in Santa Cruz County, and at one or two localities in the Coalinga district. 26

TROPHON (FORRERIA) PONDEROSUM Gabb.

Figure 5. Side of imperfect specimen; altitude 86 mm., natural size. Catalogue No. 165562, U.S.N.M. Jacalitos formation; locality 4847.

6. Front of imperfect specimen, altitude 72 mm., natural size. Catalogue No. 165555, U.S.N.M. Jacalitos formation; locality 4765. 25



JACALITOS FOSSILS.

PLATE XV.

PLATE XV.

JACALITOS (UPPER MIOCENE) FOSSILS.

PANOPEA ESTRELLANA Conrad.

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Figure 1. Exterior of imperfect right valve, longitude 80 mm., natural size. Catalogue No. 165568, U.S.N.M. Jacalitos formation; locality 4765 64

CHIONE SECURIS Shumard.

Figure 2. Exterior of slightly imperfect left valve, longitude 87 mm., natural size. Catalogue No. 165599, U.S.N.M. Jacalitos formation; locality 4763. This species, which is more inequilateral than *Chione temblorensis* F. M. Anderson, is believed to be characteristic of the upper Miocene 25

MACOMA sp. *a*.

Figure 3. Exterior of left valve, altitude 29 mm., natural size. Catalogue No. 165588, U.S.N.M. Jacalitos formation; locality 4763 64

THAIS KETTLEMANENSIS n. sp.

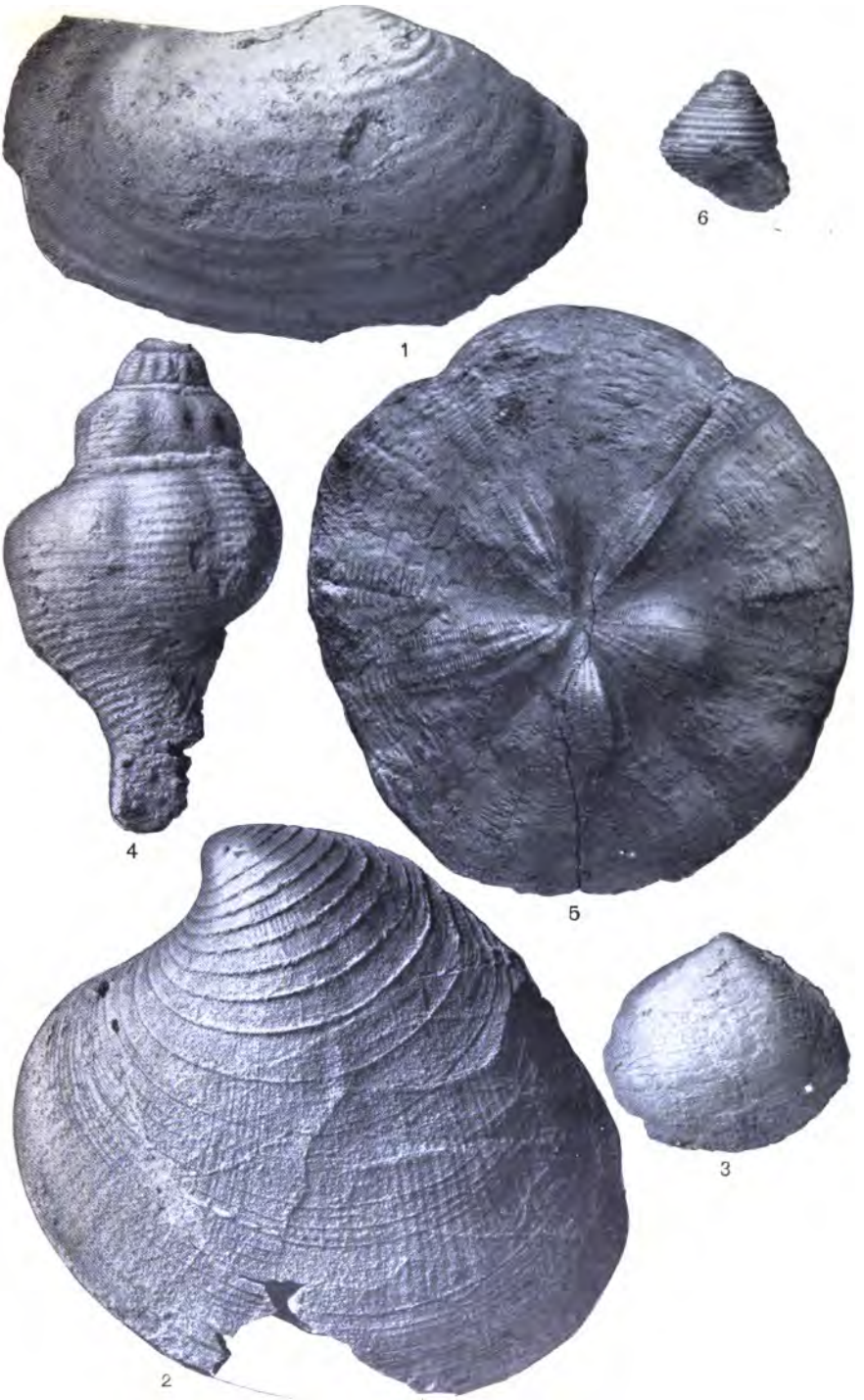
Figure 4. Back of a décolleté and otherwise imperfect specimen, longitude 53 mm., natural size. Paratype, catalogue No. 165614, U.S.N.M. Jacalitos formation; locality 4763. This genus was formerly known as *Purpura* 69

ASTRODAPSIS JACALITOSENSIS n. sp.

Figure 5. Top, longitude 79 mm., natural size. Type, catalogue No. 165610, U.S.N.M. Jacalitos formation; locality 4745 63

MARGARITA JOHNSONI n. sp.

Figure 6. Front, altitude 6 mm., × 3. Type, catalogue No. 165663, U.S.N.M. Jacalitos formation; locality 4765 69



JACALITOS FOSSILS.

PLATE XVI.

PLATE XVI.

JACALITOS (UPPER MIOCENE) PELECYPODA.

MACOMA VANVLECKI n. sp.

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Figure 1. Exterior of left valve, longitude 54 mm. Type, catalogue No. 165576, U.S.N.M. Jacalitos formation; locality 4763. (See Pl. XII, fig. 2)..... 65

MACOMA JACALITOSANA n. sp.

Figure 2. Exterior of right valve, longitude 70 mm., natural size. Type, catalogue No. 165613, U.S.N.M. Jacalitos formation; locality 4765. 65

PAPHIA JACALITOSENSIS n. sp.

Figure 3. Exterior of right valve, altitude 57 mm., natural size. Type, catalogue No. 165587, U.S.N.M. Jacalitos formation; locality 4765.. 66

THRACIA JACALITOSANA n. sp.

Figure 4. Exterior of cast of left valve, longitude 51 mm., natural size. Type, catalogue No. 165579, U.S.N.M. Jacalitos formation; locality 4763..... 68

DOSINIA JACALITOSANA n. sp.

Figure 5. Exterior of right valve, longitude 95 mm., natural size. Type, catalogue No. 165575, U.S.N.M. Jacalitos formation; locality 4763.. 67

JACALITOS PELECYPODA.

PLATE XVII.

PLATE XVII.

ETCHEGOIN (UPPER MIOCENE) FOSSILS: LOWER HORIZON.

OSTREA ATWOODI Gabb.

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Figure 1. Exterior of left valve, longitude 59 mm., natural size. Catalogue No. 165531, U.S.N.M. Lower Etchegoin formation; locality 4678. This species is believed to be characteristic of the upper Jacalitos and lower Etchegoin formations, or middle portion of upper Miocene..... 31

2. Exterior of right valve, longitude 48 mm. Same locality.

MULINIA DENSATA Conrad.

Figure 3. Exterior of right valve, longitude 65 mm., natural size. Catalogue No. 165559, U.S.N.M. Lower Etchegoin formation; locality 4682. This species ranges throughout the Miocene, but is more commonly found in the upper Miocene. It is sometimes known as *Pseudocardium gabbi*..... 54

4. Interior of left valve, longitude 75 mm., natural size. Catalogue No. 165559 U.S.N.M. Lower Etchegoin formation; locality 4679.... 54

DIPLODONTA PARILIS Conrad.

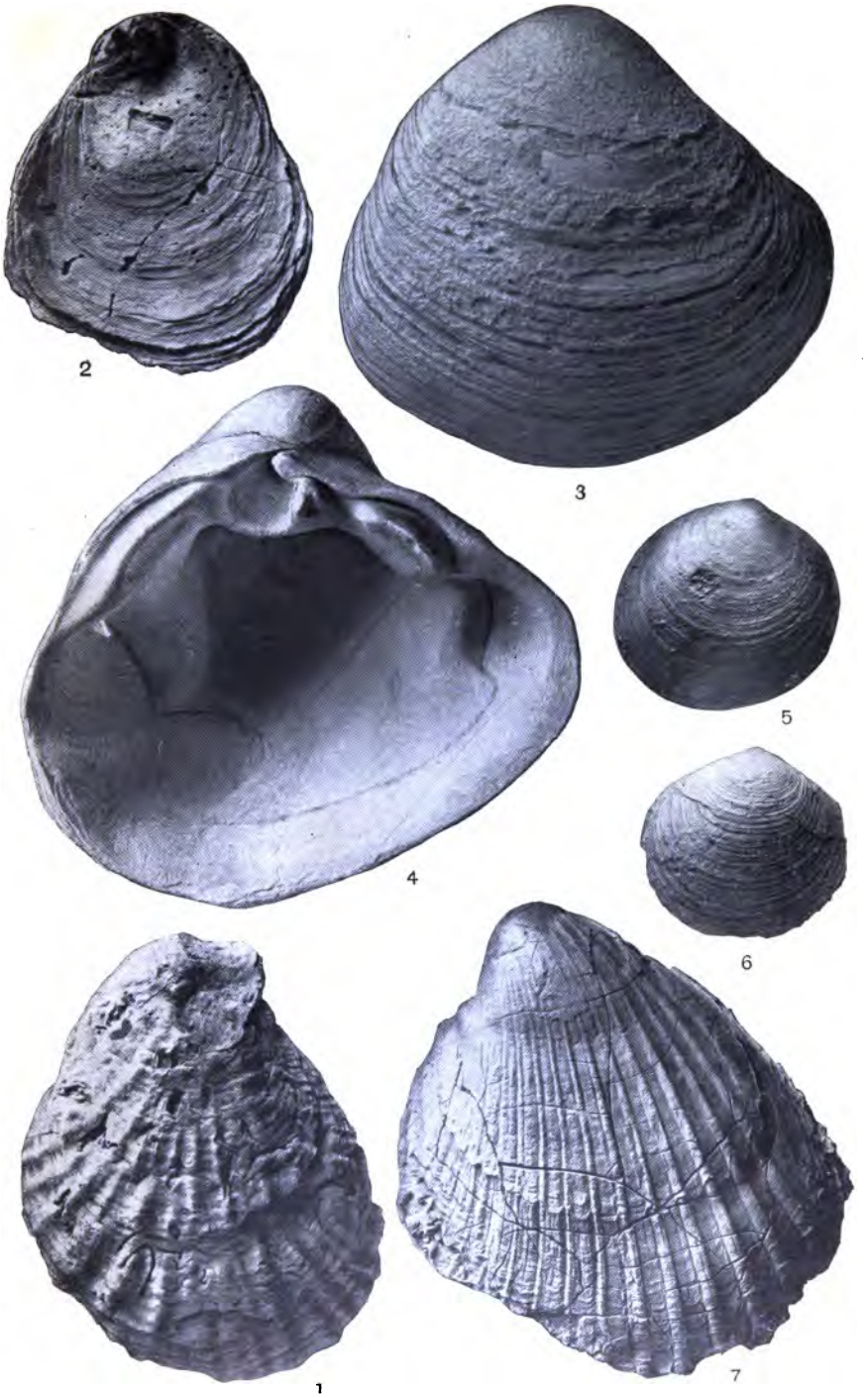
Figure 5. Exterior of right valve, longitude 31 mm., natural size. Catalogue No. 165484, U.S.N.M. Lower Etchegoin formation; locality 4806. This species is believed to be characteristic of the upper Miocene; it is known also from Oregon..... 30

DIPLODONTA HARFORDI F. M. Anderson.

Figure 6. Exterior of right valve, longitude 28 mm., natural size. Catalogue No. 165485, U.S.N.M. Lower Etchegoin formation; locality 4806. This species is believed to be characteristic of the upper Miocene and has so far been recognized only in the Coalinga district..... 30

CARDIUM MEEKIANUM Gabb.

Figure 7. Exterior of decorticated left valve, altitude 70 mm., natural size. Catalogue No. 165542, U.S.N.M. Lower Etchegoin formation; locality 4806. The external surface of this fossil is almost always gone. It is an abundant species in one or two of the layers of the lower Etchegoin, but has a range elsewhere from the upper Miocene to the lower Pliocene..... 30



ETCHEGOIN FOSSILS.

PLATE XVIII.

PLATE XVIII.

ETCHEGOIN (UPPER MIOCENE) FOSSILS: LOWER HORIZON.

ARCA TRILINEATA Conrad.

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Figure 1. Exterior of left valve, longitude 61 mm., natural size. Catalogue No. 165534, U.S.N.M. Lower Etchegoin formation; locality 4665. This species, which is variable both in outline and number and sculpture of ribs, ranges from the upper Miocene to the Pliocene. It is abundant in the upper Miocene marine faunas in the Coalinga district..... 30

1a. Umbones of same specimen.

THAIS ETCHEGOINENSIS n. sp.

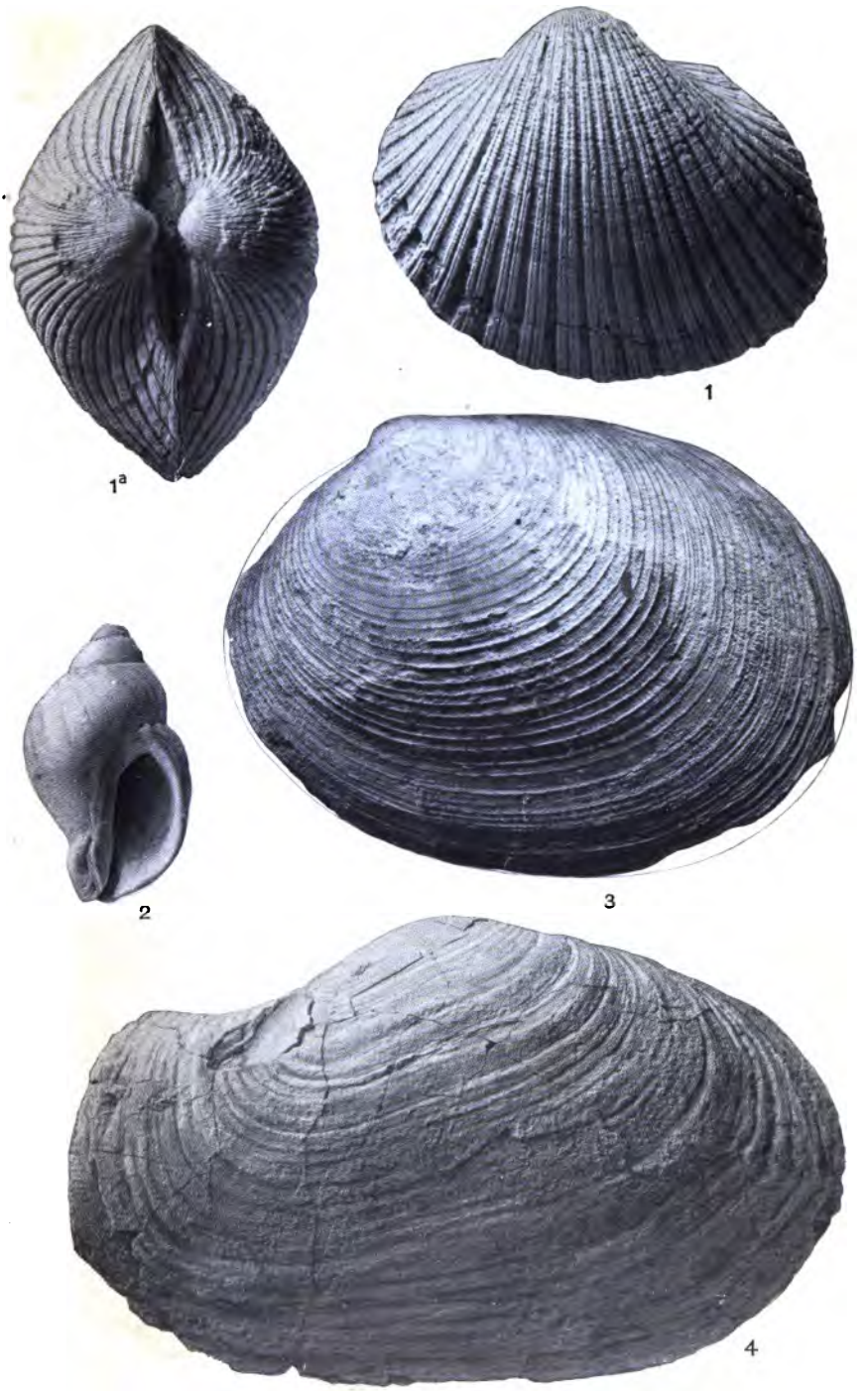
Figure 2. Front of slightly décolleté specimen, longitude 38 mm., natural size. Type, catalogue No. 165533, U.S.N.M. Lower Etchegoin formation; locality No. 4697. The genus *Thais* was formerly known as *Purpura*..... 89

PAPHIA TENERRIMA Carpenter.

Figure 3. Exterior of left valve, longitude 83 mm., natural size. Catalogue No. 165544, U.S.N.M. Middle Etchegoin formation; locality 4664. This species is quite abundant in the middle Etchegoin beds on White Creek and Anticline Ridge. It ranges from the upper Miocene to the Recent fauna..... 31

PANOPEA GENEROSA Gould.

Figure 4. Exterior of right valve, longitude 104 mm., natural size. Catalogue No. 165556, U.S.N.M. Upper Etchegoin formation; locality 4658. This species ranges from the lower Miocene to the Recent fauna..... 31



ETCHEGOIN FOSSILS.

PLATE XIX.

PLATE XIX.

ETCHEGOIN (UPPER MIOCENE) FOSSILS: LOWER HORIZON.

~~ECHINARACHNIU~~S GIBBSII Rémond var. ASHLEYI Arnold.

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Figure 1. Top, longitude 60 mm., natural size. Catalogue No. 165548, U.S.N.M. Lower Etchegoin formation; locality 4767. An abundant form at this locality, also in the Santa Maria district.

ECHINARACHNIUS GIBBSII Rémond.

Figure 2. Top, longitude 54 mm. Catalogue No. 165547, U.S.N.M. Locality 4661. A relatively narrower specimen than that shown in Plate XX, figure 7..... 30

GLYCYMERIS COALINGENSIS n. sp.

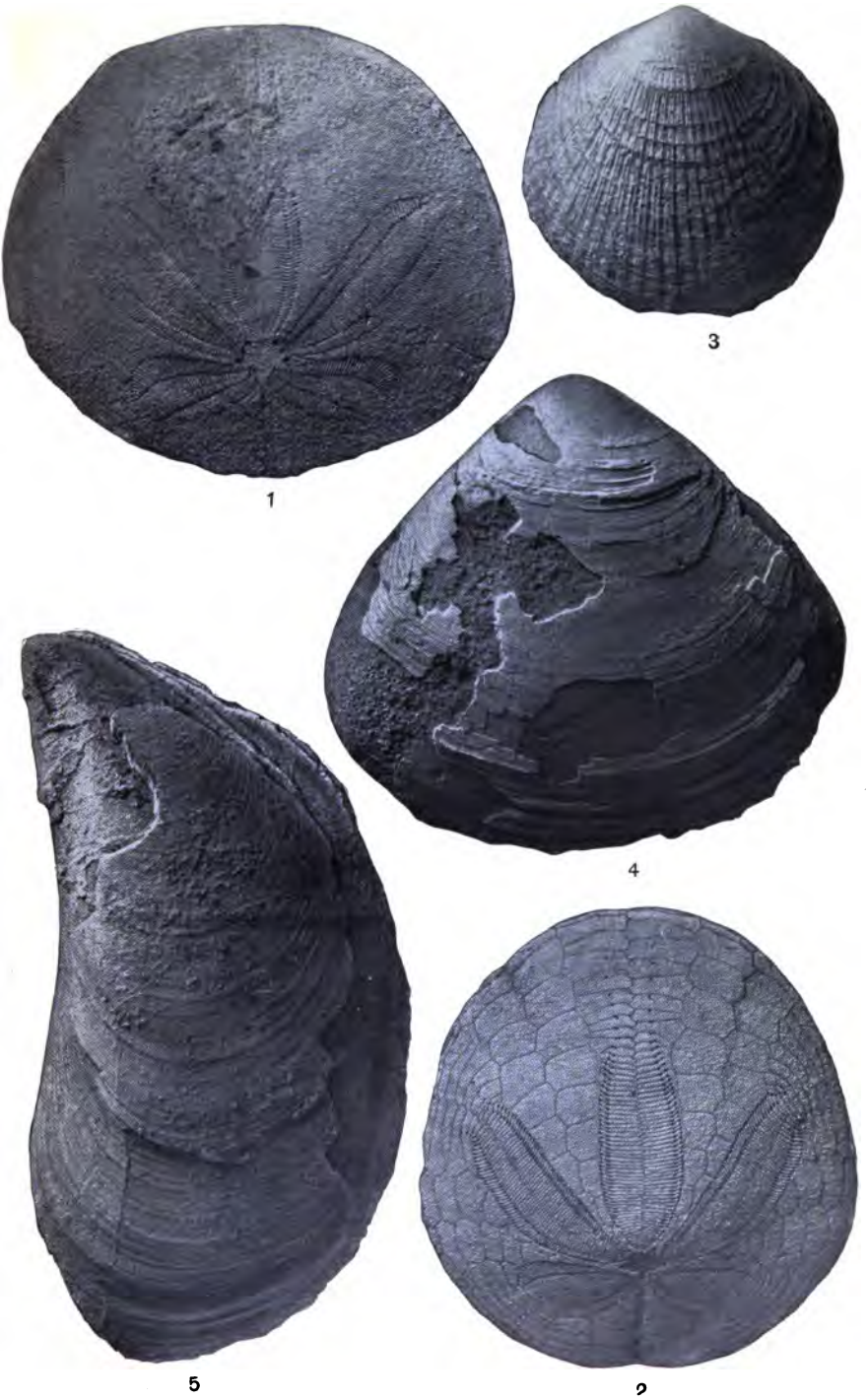
Figure 3. Exterior of decorticated right valve, longitude 42 mm., natural size. Type, catalogue No. 165526, U.S.N.M. Lower Etchegoin formation; locality 4806. This genus was formerly known as *Pectunculus*..... 80

MACTRA ALBARIA Conrad.

Figure 4. Exterior of an imperfect right valve from which a portion of the anterior extremity has been eroded; altitude 63 mm., natural size. Catalogue No. 165552, U.S.N.M. Lower Etchegoin formation; locality 4665. This species, which is believed to be characteristic of the upper Miocene, is found abundantly in Oregon, but only a few specimens were obtained in the Coalinga district..... 30

MYTILUS (MYTILOCONCHA) COALINGENSIS n. sp.

Figure 5. Exterior of imperfect left valve, altitude 100 mm., natural size. Paratype, catalogue No. 165557, U.S.N.M. Lower Etchegoin formation; locality 4668..... 73



ETCHEGOIN FOSSILS.

PLATE XX.

PLATE XX.

ETCHEGOIN (UPPER MIOCENE) FOSSILS: LOWER HORIZON.

MACOMA SECTA Conrad.

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Figure 1. Exterior of left valve, longitude 75 mm., natural size. Catalogue No. 165592, U.S.N.M. Etchegoin formation; locality 4806. This species ranges from the upper Miocene to the Recent fauna. 30

NEVERITA RECLUZIANA Petit.

Figure 2. Front view of decorticated and slightly imperfect specimen, altitude 36 mm., natural size. Catalogue No. 165486, U.S.N.M. Upper Etchegoin formation; locality 4710. This species ranges from the upper Miocene to the Recent fauna..... 31

GLYCYMERIS SEPTENTRIONALIS Middendorf.

Figure 3. Exterior of left valve, longitude 24 mm. Catalogue No. 165527, U.S.N.M. Lower part of the Etchegoin formation; locality 4806. This genus was formerly known as *Pectunculus*..... 82

3a. Interior view of same specimen.

MODIOLUS RECTUS Conrad.

Figure 4. Exterior of right valve from which the outer surface of the shell has been removed, longitude 86 mm., natural size. Catalogue No. 165535, U.S.N.M. Lower Etchegoin formation; locality 4698. This species ranges from the upper Miocene to the Recent and is characterized by its angular posterior outline..... 30

NEVERITA RECLUZIANA Petit var. ALTA Dall.

Figure 5. Front of slightly imperfect specimen, altitude 28 mm., natural size. Catalogue No. 165489, U.S.N.M. Upper Etchegoin formation; locality 4709. This variety ranges from the upper Miocene to the Recent fauna..... 32

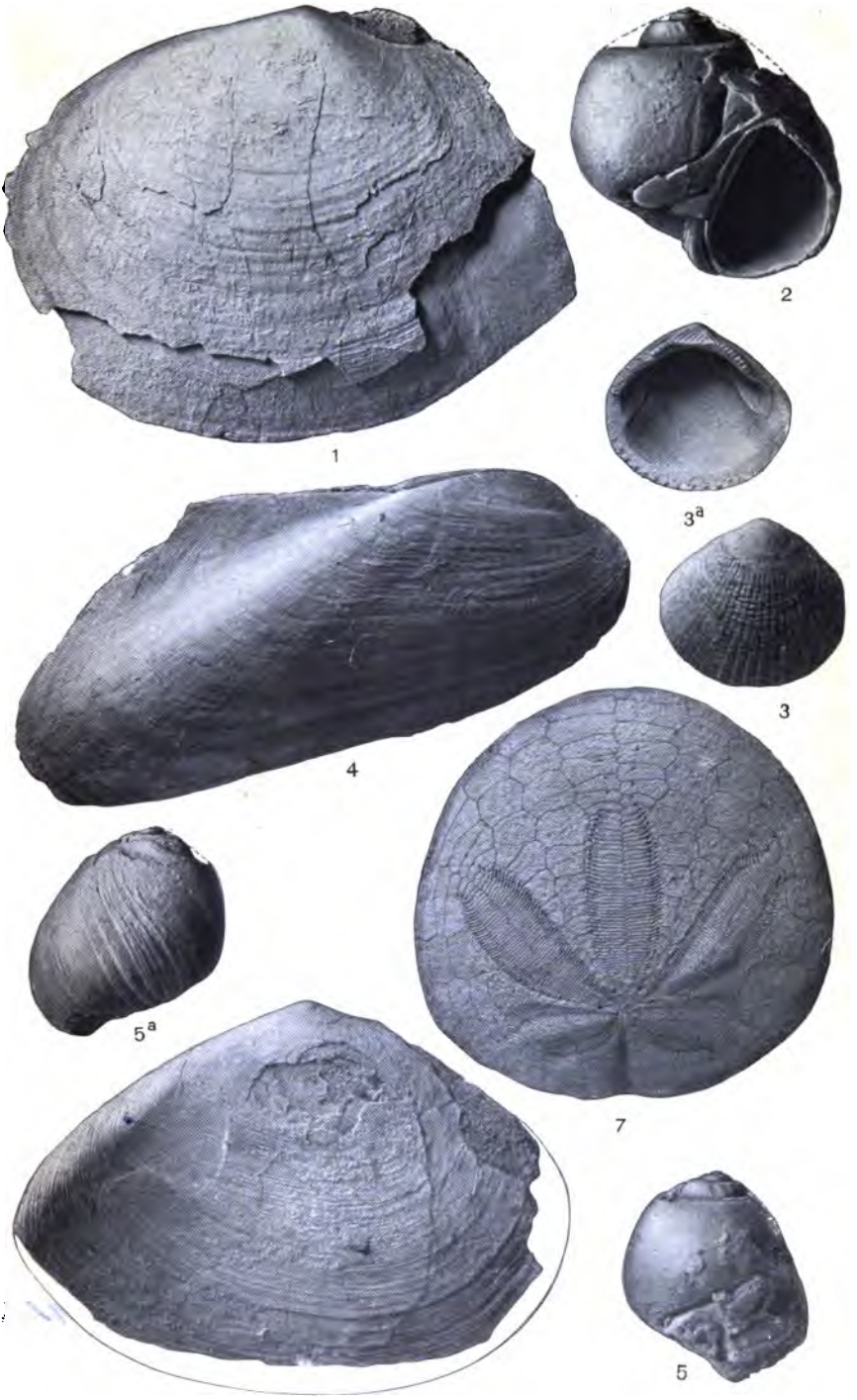
5a. Back of same specimen.

MACOMA NASUTA Conrad.

Figure 6. Exterior of slightly imperfect right valve, longitude 70 mm., natural size. Catalogue No. 165514, U.S.N.M. Lower part of the Etchegoin formation; locality 4756. This species ranges from the lower Miocene to the Recent fauna..... 30

ECHINARACHNIUS GIBBSII Rémond.

Figure 7. Top, longitude 61 mm., natural size. Catalogue No. 165547, U.S.N.M. Lower Etchegoin formation; locality 4661. This figure illustrates a typical undistorted specimen. The specimens found in this district are usually more or less distorted. The species ranges through the Jacalitos and Etchegoin formations. (See Pl. XIX, fig. 2)..... 30



ETCHEGOIN FOSSILS.

PLATE XXI.

PLATE XXI.

JACALITOS (EARLY UPPER MIOCENE) AND ETCHEGOIN (~~UPPER MIOCENE~~) FOSSILS: LOWER HORIZON.

THAIS KETTLEMANENSIS n. sp.

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Figure 1. Front of decorticated and slightly imperfect specimen; altitude 82 mm., natural size. Type, catalogue No. 165585, U.S.N.M. Lower Etchegoin and Jacalitos formation; locality 4680 69

1a. Back of same specimen.

CRYPTOMYA QUADRATA n. sp.

Figure 2. Exterior of right valve, longitude 35 mm., natural size. Type, catalogue No. 165525, U.S.N.M. Lower Etchegoin formation; locality 4665 71

2a. Exterior of left valve of same specimen.

MULINIA DENSATA Conrad.

Figure 3. Front of both valves, altitude 50 mm., natural size. Catalogue No. 165554, U.S.N.M. Lower Etchegoin formation; locality 4754. This species is usually confined to the upper Miocene, although it is known to extend down into the Vaqueros. It is sometimes listed as *Pseudocardium gabbi* Rémond 54

SAXIDOMUS NUTTALLI Conrad.

Figure 4. Exterior of right valve 105 mm., two-thirds natural size. Catalogue No. 165529, U.S.N.M. Upper part of Jacalitos formation; locality 4656. This species ranges from the upper Miocene to the Recent fauna 31

JACALITOS AND ETCHEGOIN FOSSILS.

PLATE XXII.

PLATE XXII.

ETCHEGOIN (UPPER MIOCENE) FOSSILS: LOWER HORIZON.

LUNATIA LEWISII Gould.

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Figure 1. Front of slightly imperfect internal cast which, however, shows the general outline of the shell. Altitude 90 mm., natural size. Catalogue No. 165541, U.S.N.M. Upper Etchegoin formation; locality 4665. This species ranges from the upper Miocene to the Recent fauna..... 31

PLEUROTOMA COALINGENSIS n. sp.

Figure 2. Front, longitude 20 mm., × 2. Type, catalogue No. 165509, U.S.N.M. Upper Etchegoin formation; locality 4806..... 90

TURRITELLA VANVLECKI n. sp.

Figure 3. Back of décolleté and otherwise somewhat imperfect specimen; longitude 57 mm., natural size. Type, catalogue No. 165496, U.S.N.M. Middle Etchegoin formation; locality 4658..... 85

TROPHON (FORRERIA) COALINGENSE n. sp.

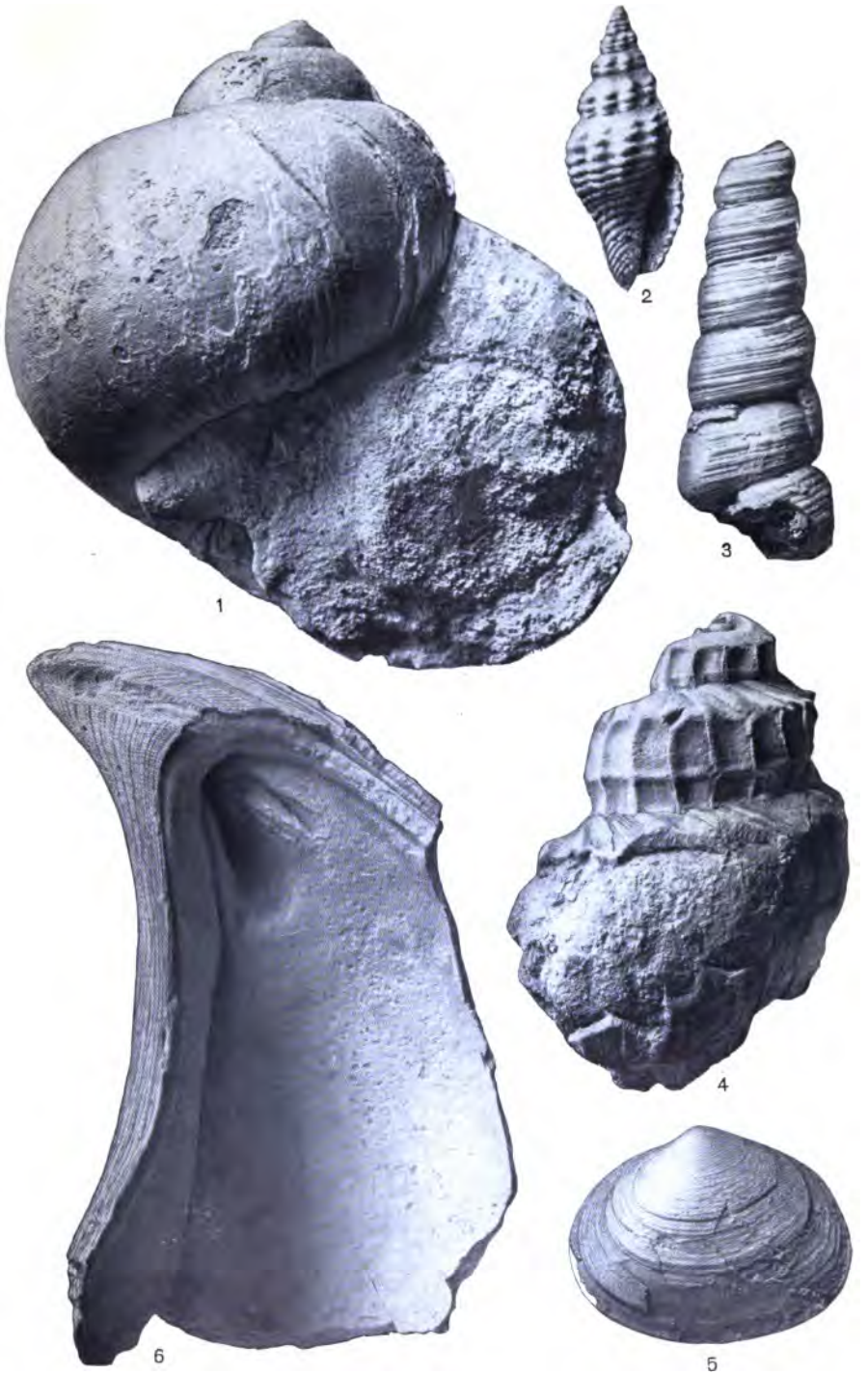
Figure 4. Back of imperfect specimen, longitude 65 mm., natural size. Type, catalogue No. 165540, U.S.N.M. Upper Etchegoin formation; locality 4857..... 87

CRYPTOMYA OVALIS Conrad.

Figure 5. Exterior of left valve, longitude 37 mm., natural size. Catalogue No. 165589, U.S.N.M. Etchegoin formation; locality 4845. This specimen appears to be intermediate between the typical *Cryptomya ovalis* Conrad and *Cryptomya quadrata* n. sp..... 30

MYTILUS (MYTILOCONCHA) COALINGENSIS n. sp.

Figure 6. Exterior of umbonal region of a moderate-sized right valve, longitude 105 mm., natural size. Type, catalogue No. 165551, U.S.N.M. Lower Etchegoin formation; locality 4656..... 73



ETCHEGOIN FOSSILS.

PLATE XXIII.

PLATE XXIII.

ETCHEGOIN (~~UPPER MIOCENE~~) FOSSILS.

PECTEN (PATINOPECTEN) OWENI Arnold.

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Figure 1. Exterior of right valve, anterior ear slightly broken, altitude 85 mm., slightly reduced. Type; Coll. Univ. California. Foxin's ranch, Santa Barbara County. A characteristic species in the upper Miocene..... 31

CREPIDULA PRINCEPS Conrad.

Figure 2. View of interior; longitude 106 mm., slightly reduced. Catalogue No. 165315, U.S.N.M. Packard's Hill, Santa Barbara. Found throughout the Miocene and Pliocene in California..... 31

ASTRANGIA COALINGENSIS Vaughan.

Figure 3. View of top of group of specimens, maximum altitude 20 mm., × 3. Type, catalogue No. 165666, U.S.N.M. Upper Etchegoin formation; locality 4710. This species is believed to be characteristic of the upper Miocene..... 34

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ETCHEGOIN FOSSILS.

PLATE XXIV.

PLATE XXIV.

ETCHEGOIN (~~UPPER MIOCENE~~) FOSSILS: UPPER HORIZON.

SIGARETUS SCOPULOSUS Conrad.

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Figure 1. Top, maximum diameter 36 mm., natural size. Catalogue No. 165524, U.S.N.M. Upper Etchegoin formation; locality 4662. This species ranges from the Oligocene to the lower Pliocene... 32

PLACUNANOMIA CALIFORNICA n. sp.

Figure 2. Exterior of right valve, altitude 66 mm., natural size. Type, catalogue No. 165546, U.S.N.M. Upper Etchegoin formation; locality 4715..... 75

2a. Interior of same specimen.

3. Interior of left valve, paratype, altitude 67 mm., natural size.

OSTREA VESPERTINA Conrad.

Figure 4. Exterior of left valve, longitude 57 mm., natural size. Catalogue No. 165536, U.S.N.M. Upper Etchegoin formation; locality 4715.. 77

5. Right valve, longitude 67 mm. Same locality.

ETCHEGOIN FOSSILS.

PLATE XXV.

PLATE XXV.

ETCHEGOIN (~~UPPER MIOCENE~~) FOSSILS: UPPER HORIZON, AND TULARE (PLIOCENE) FOSSILS.

ASTYRIS RICHTHOFENI Gabb.

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Figure 1. Front of a rather poorly preserved specimen, altitude 11 mm., × 2. Catalogue No. 165510, U.S.N.M. Upper Etchegoin formation; locality 4806. This species ranges from the upper Miocene to the Pliocene 30

TROPHON (BOREOTROPHON) STUARTI Smith.

Figure 2. Back of body whorl and portion of penultimate whorl, longitude 25 mm., natural size. Catalogue No. 165492, U.S.N.M. Upper Etchegoin formation; locality 4712. This species ranges from the upper Miocene to the Recent and is a boreal type 32

SEMELE RUBROPICTA Dall.

Figure 3. Slightly imperfect right valve, longitude 31 mm., natural size. Catalogue No. 165517, U.S.N.M. Upper Etchegoin formation; locality 4758. This species ranges from the upper Miocene to the Recent fauna 31

MACTRA COALINGENSIS n. sp.

Figure 4. Exterior of imperfect left valve, altitude 52 mm., natural size. Type, catalogue No. 165513, U.S.N.M. Upper Etchegoin formation; locality 4806 71

MACOMA NASUTA Conrad.

Figure 5. Imperfect left valve, longitude 69 mm., natural size. Catalogue No. 165515, U.S.N.M. Upper Etchegoin formation; locality 4758.. 30

BULBOUS GROWTH ON FISH SKELETON.

Figure 6. Top, longitude 52 mm., natural size. Catalogue No. 165495, U.S.N.M. Tulare formation; locality 4740 100

6a. Bottom of same specimen.

6b. Side of same specimen.

FISH SPINE.

Figure 7. Side, longitude 49 mm., natural size. Catalogue No. 165493, U.S.N.M. Upper Etchegoin formation; locality 4740 100

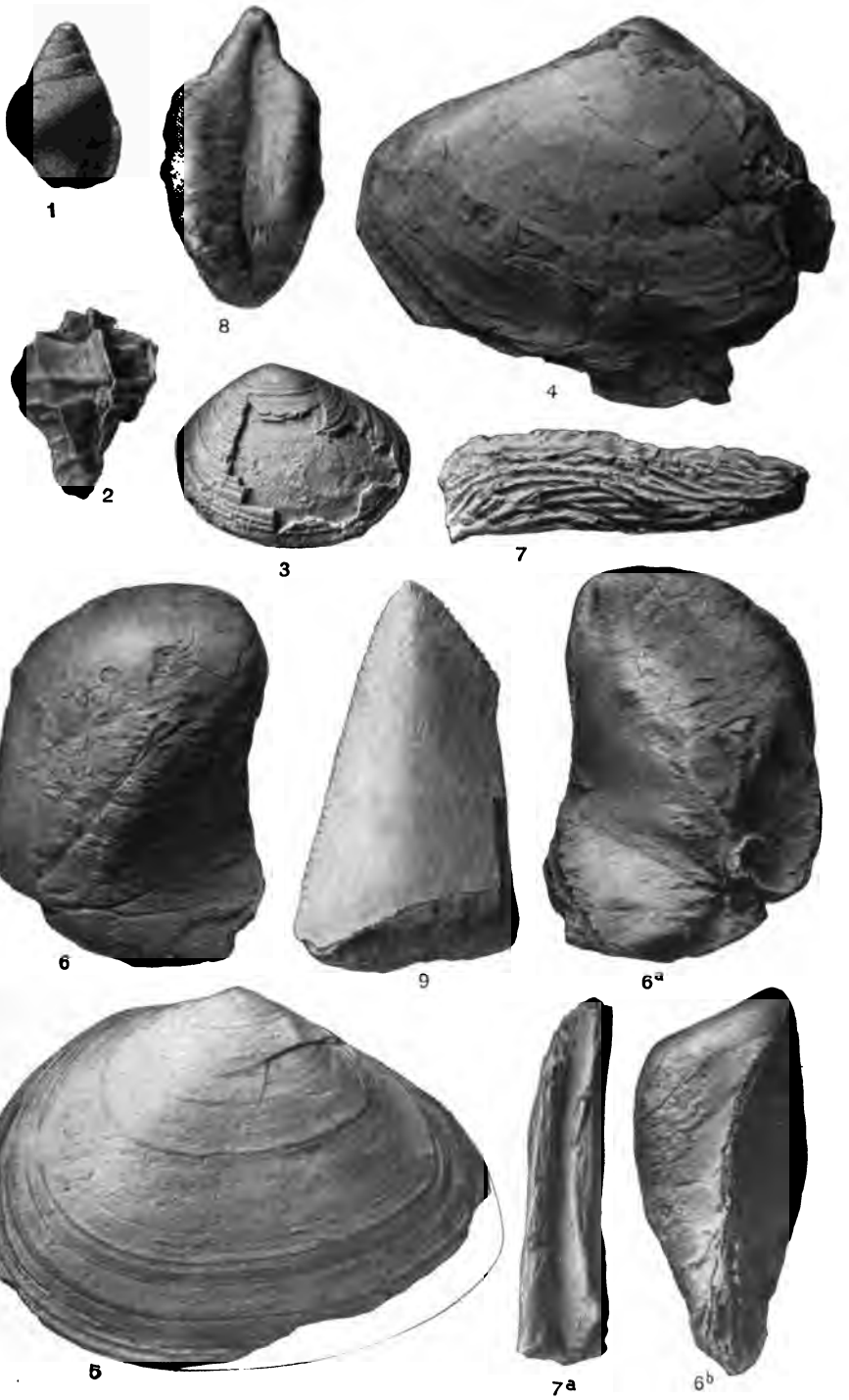
7a. Base of same specimen.

BULBOUS GROWTH ON FISH SKELETON.

Figure 8. Grooved base, longitude 40 mm., natural size. Catalogue No. 165494, U.S.N.M. Tulare formation; locality 4731 100

CARCHARODON ARNOLDI Jordan.

Figure 9. Back, longitude 50 mm., natural size. Catalogue No. 165488, U.S.N.M. Upper Etchegoin formation; locality 4709. This extinct species of shark is believed to be characteristic of the upper Miocene and lower Pliocene 36



ETCHEGOIN AND TULARE FOSSILS.

PLATE XXVI.

PLATE XXVI.

ETCHEGOIN (~~UPPER MIOCENE~~) FOSSILS: UPPER HORIZON.

PECTEN COALINGAENSIS Arnold.

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Figure 1. Exterior of right valve, longitude 58 mm., natural size. Catalogue No. 165530, U.S.N.M. Upper part of Etchegoin formation; locality 4710. This species is believed to be characteristic of the upper part of the Etchegoin formation at the top of the Miocene..... 31

2. Left valve, longitude 55 mm., natural size. Same locality.

PECTEN (PLAGIOCTENIUM) DESERTI Conrad.

Figure 3. Exterior of right valve, altitude 43 mm., natural size. Catalogue No. 165518, U.S.N.M. Upper Etchegoin formation; locality 4715... 76

4. Exterior of left valve, longitude 37 mm., natural size. Same locality.

CHAMA PELLUCIDA Sowerby.

Figure 5. Exterior of left valve, altitude 42 mm., natural size. Catalogue No. 165482, U.S.N.M. Upper Etchegoin formation; locality 4710. This species ranges from the upper Miocene to Recent, but is found in the Coalinga district only in the upper Etchegoin... 30

6. Exterior of right valve; altitude 24 mm., natural size. Catalogue No. 165482, U.S.N.M. Locality same as last.

TRANSENNELLA CALIFORNICA n. sp.

Figure 7. Exterior of right valve; longitude 5.5 mm., × 5. Type, catalogue No. 165553, U.S.N.M. Upper Etchegoin formation; locality 4715. 72

7a. Interior of same specimen.

PAPHIA STALEYI? Gabb.

Figure 8. Right valve of young specimen; longitude 8.5 mm., × 3. Catalogue No. 165516, U.S.N.M. Upper Etchegoin formation; locality 4715. This species is believed to be characteristic of the upper Miocene and Pliocene. It was formerly called *Tapes staleyi*.. 31

CHRYSODOMUS PORTOLAENSIS Arnold.

Figure 9. Front, longitude 64 mm., natural size. Type, catalogue No. 165473, U.S.N.M. Etchegoin formation; locality 4665. This species is believed to be characteristic of the upper Miocene, and is found abundantly in the lower Purisima formation near Portola in San Mateo County and in several other localities south of there..... 31

CANCELLARIA TRITONIDEA Gabb.

Figure 10. Front, longitude 78 mm., natural size. Catalogue No. 165561, U.S.N.M. Upper San Pedro formation, San Pedro, California. This species is believed to range from the upper Miocene to the Pleistocene. The specimen figured is from the type locality.... 31

ETCHEGOIN FOSSILS.

PLATE XXVII.

PLATE XXVII.

ETCHEGOIN (UPPER MIOCENE) FOSSILS: UPPER HORIZON.

PECTEN (CHLAMYS) WATTSI Arnold.

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Figure 1. Exterior of right valve, altitude 61 mm., natural size. Catalogue No. 165550, U.S.N.M. Upper Etchegoin formation; locality 4712. This specimen is also from the type locality. The species ranges from the upper Miocene to the lower Pliocene and is found in the Coalinga district only in the upper Etchegoin.... 77

2. Exterior of left valve, altitude 76 mm., natural size. Same locality.

PECTEN NUTTERI Arnold.

Figure 3. Exterior of right valve, altitude, 67 mm., natural size. Catalogue No. 165549, U.S.N.M. Upper Etchegoin formation; locality 4712. This specimen is from the type locality of the species, where it is moderately abundant. It is believed to be characteristic of the upper Miocene and possibly lower Pliocene..... 31

4. Exterior of left valve, altitude 63 mm. Same locality.

TEREBRATALIA SMITHI Arnold.

Figure 5. Exterior of dorsal valve showing beak of ventral valve, altitude of former 22 mm., natural size. Catalogue No. 165512, U.S.N.M. Upper Etchegoin formation; locality 4758. This brachiopod is very abundant in the *Pecten coalingaensis* horizon..... 30

5a. Ventral valve of same specimen. Longitude 27.5 mm., natural size.

CALLIOSTOMA KERRI n. sp.

Figure 6. Front of slightly distorted specimen, altitude 18.5 mm., natural size. Type, catalogue No. 165500, U.S.N.M. Upper Etchegoin formation; locality 4758..... 84

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Figure 7. Front view of slightly distorted specimen, altitude 21 mm., natural size. Type, catalogue No. 165499, U.S.N.M. Upper Etchegoin formation; locality 4758..... 83

NASSA CALIFORNIANA Conrad.

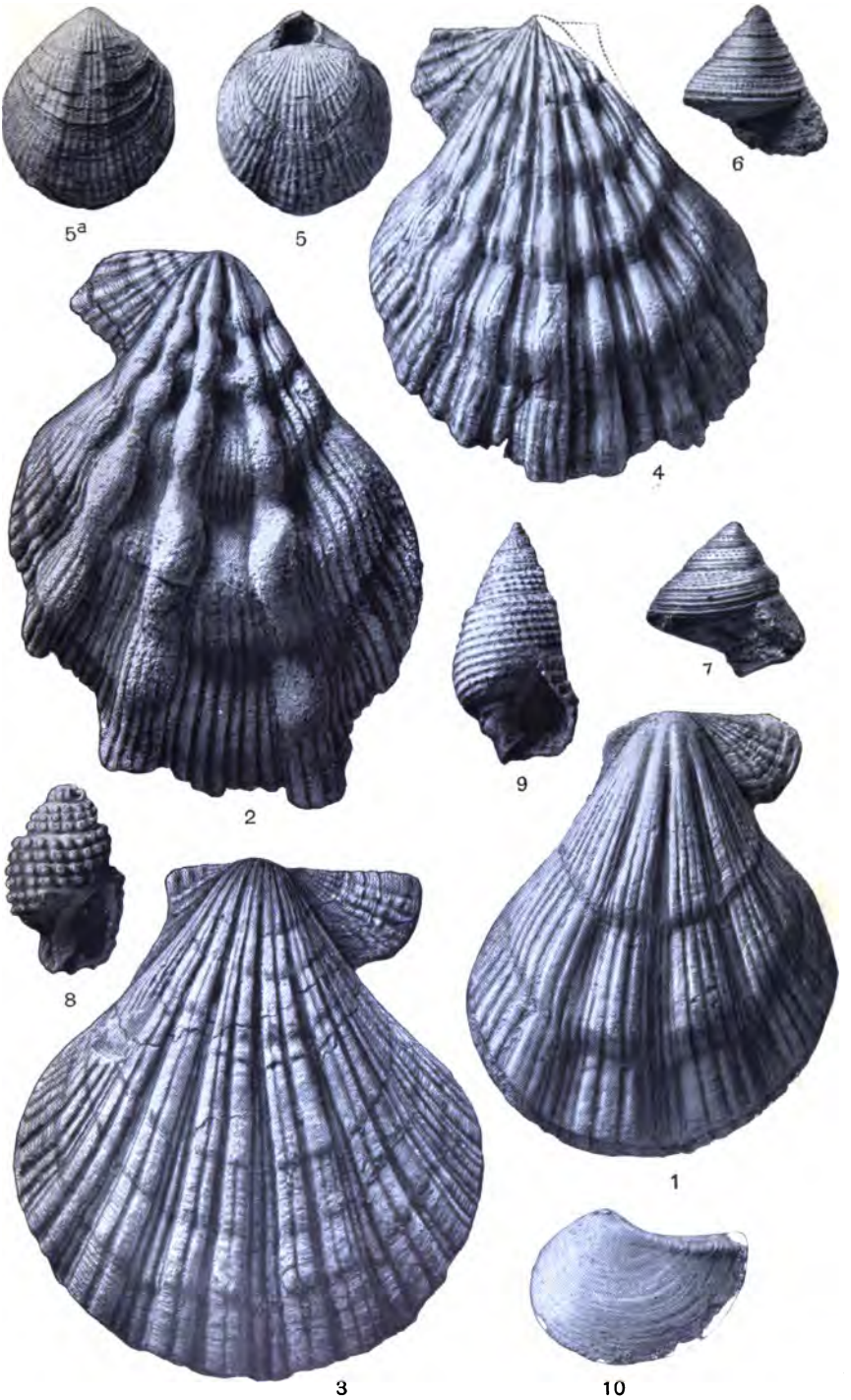
Figure 8. Front of a slightly imperfect young and unusually nodose specimen, altitude 13.5 mm., × 2. Catalogue No. 165508, U.S.N.M. Upper Etchegoin formation; locality 4806. This species ranges from the upper Miocene to the Pleistocene and may possibly have living representatives. This nodose form is apparently characteristic of the upper Miocene..... 31

NASSA CALIFORNIANA Conrad var. COALINGENSIS n. var.

Figure 9. Front, altitude 32 mm., natural size. Type, catalogue No. 165511, U.S.N.M. Upper Etchegoin formation; locality 4758..... 88

CLIDIOPHORA PUNCTATA Conrad.

Figure 10. Exterior of left valve, longitude 28 mm., natural size. Catalogue No. 165497, U.S.N.M. Upper Etchegoin formation; locality 4806. This species, in which the right valve is somewhat flatter than the left, ranges from the upper Miocene to Recent fauna.. 30



ETCHEGOIN FOSSILS.

PLATE XXVIII.

PLATE XXVIII.

ETCHEGOIN (UPPER MIOCENE) ECHINODERMATA: UPPER HORIZON.

SCUTELLA PERRINI Weaver.

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Figure 1. Top, longitude 46 mm., natural size. Catalogue No. 165560, U.S.N.M. Upper Etchegoin formation; locality 4712. This species is believed to be characteristic of the uppermost Miocene and possibly lower Pliocene..... 30

2. Bottom, longitude 45 mm., natural size. Catalogue No. 165560, U.S.N.M. Same locality.

ASTRODAPSIS? sp. *a*.

Figure 3. Top; longitude 28 mm., × 2. Catalogue No. 165701, U.S.N.M. Upper Etchegoin formation; locality 4712. A common form in this horizon..... 30

3a. Bottom of same specimen.

~~ECHINARACHNIUS~~ GIBBSII Rémond.

Figure 4. Top of young specimen, longitude 33 mm., × 2. Catalogue No. 165537, U.S.N.M. Upper Etchegoin formation; locality 4710. This is the most abundant sand dollar in the district and is found throughout both the Jacalitos and Etchegoin formations..... 30

4a. Bottom of same specimen.

~~ASTRODAPSIS~~ sp. indet.

Figure 5. Top of young specimen, longitude 10.5 mm., × 2. Catalogue No. 165538, U.S.N.M. Upper Etchegoin formation; locality 4708. Found in the upper Etchegoin formation..... 30

5a. Bottom of same specimen.

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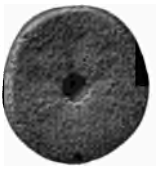

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3a

ETCHEGOIN ECHINODERMATA.

PLATE XXIX.

PLATE XXIX.

ETCHEGOIN (UPPER MIOCENE) FOSSILS: UPPERMOST FOSSIL BED.

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MACOMA INQUINATA Deshayes.

Figure 3. Exterior of left valve, longitude 46 mm., natural size. Catalogue No. 165483, U.S.N.M. Upper Etchegoin formation; locality 4736. This species ranges from the upper Miocene to the Recent fauna..... 30

SOLEN SICARIUS Gould.

Figure 4. Exterior of imperfect left valve; longitude 45 mm., natural size. Catalogue No. 165491, U.S.N.M. Upper Etchegoin formation; locality 4728. This species ranges from the Miocene to the Recent fauna, and is particularly abundant in the Coalinga district in the upper *Mya* zone..... 31

OSTREA VESPERTINA Conrad var. SEQUENS n. var.

Figure 5. Exterior of left valve, longitude 42 mm., natural size. Type, catalogue No. 165545, U.S.N.M. Uppermost Etchegoin formation; locality 4728..... 79

6. Exterior of right valve, longitude 41 mm. Same locality.

MYA JAPONICA Jay.

Figure 7. Interior of left valve, longitude 56 mm., natural size. Catalogue No. 165479, U.S.N.M. (Perry's voyage). Upper Etchegoin formation; locality 4736. This species is intermediate between *M. truncata* Linn. and *M. arenaria* Linn., and extends from the upper Miocene to the Recent fauna; it is a cold-water form..... 30

8. Exterior of left valve, longitude 66 mm., natural size. Catalogue No. 165480, U.S.N.M. Upper Etchegoin formation; locality 4736..... 30

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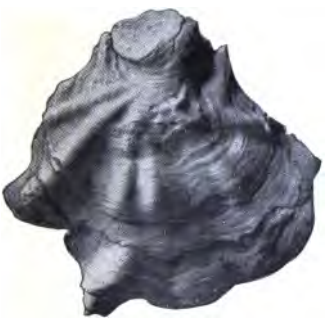

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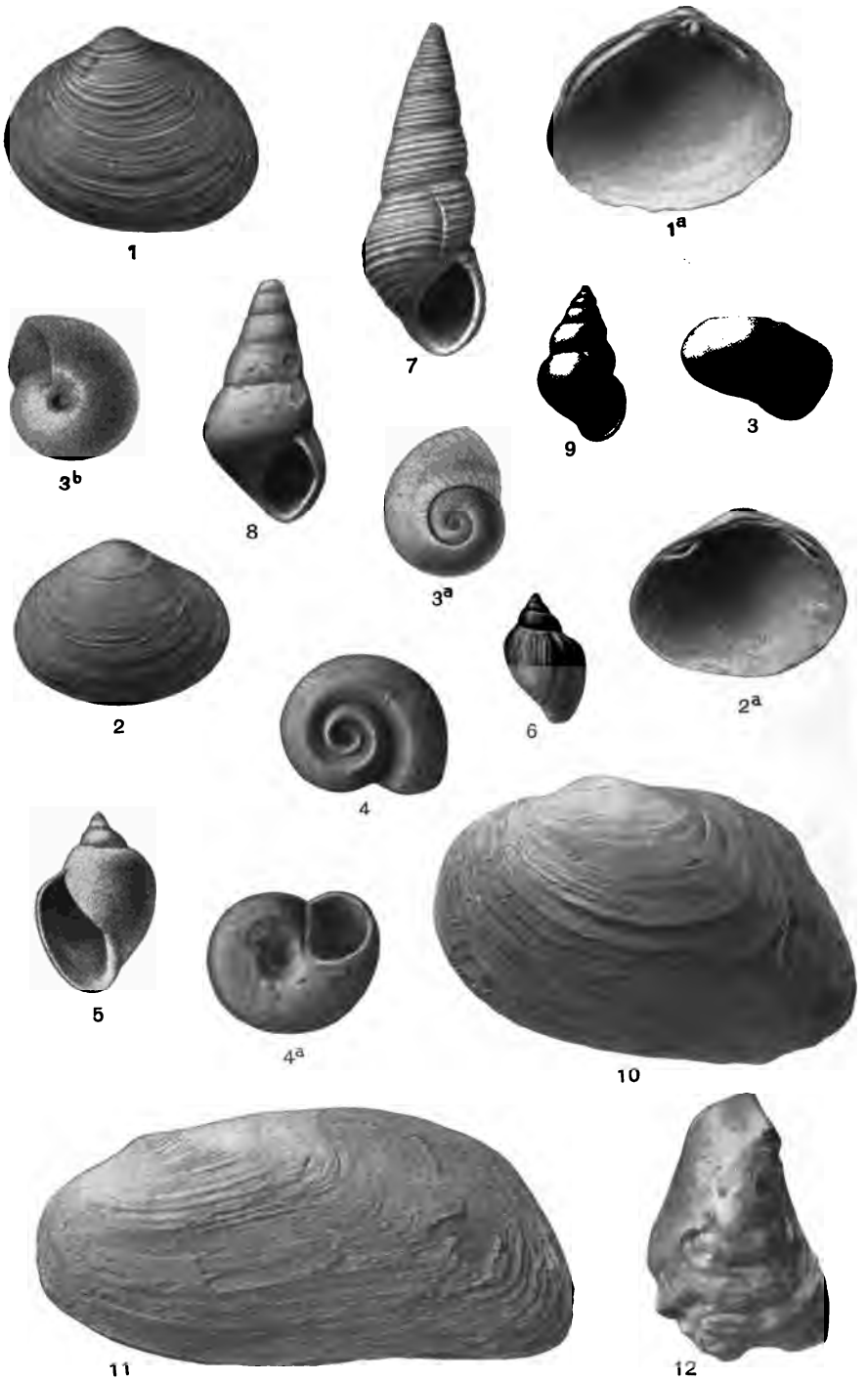
ETCHEGOIN FOSSILS.

PLATE XXX.



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