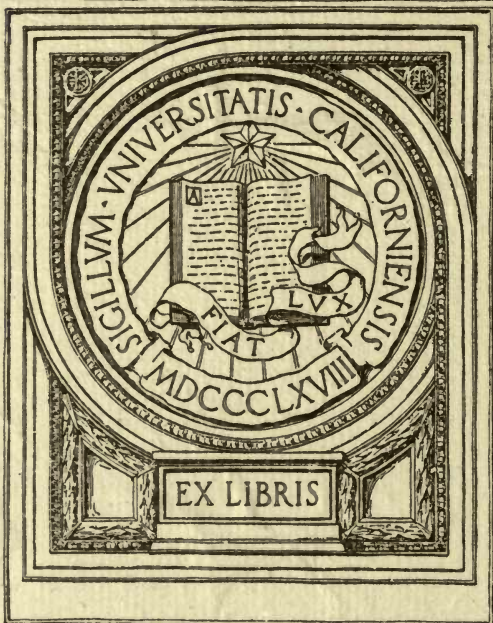


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GEOLOGY

Vol. 8, No. 6, pp. 61-180, pls. 6-18

Issued May 13, 1914

FAUNA OF THE MARTINEZ EOCENE OF  
CALIFORNIA

BY

ROY ERNEST DICKERSON

1677-

A thesis submitted in partial satisfaction of the requirements for the degree of doctor of philosophy in the University of California.

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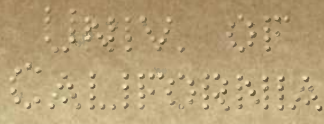
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## INTRODUCTION

The discovery of several new areas of Martinez rocks and the securing of large additions to the fauna in them have led to further investigation of the stratigraphy and fauna of the lower Eocene of the Pacific Coast. That the Martinez is separated from the Chico (Cretaceous) below and from the Tejon (upper Eocene) above by well-marked unconformities are the principal conclusions from stratigraphic studies. Faunal studies prove that the Martinez fauna of approximately two hundred species is quite distinct from the Chico and the Tejon faunas. The great increase in the fauna makes correlation with the lowermost Eocene of the Gulf and Atlantic states more certain. The proposed correlation made in this paper fixes a portion of the Martinez as the equivalent of the lowermost Eocene of the Gulf States, the Midway, and the rest as the representative of an earlier Eocene time than has been recognized elsewhere in the United States.

## REVIEW OF THE LITERATURE

W. M. Gabb<sup>1</sup> first used the term Martinez Group to describe strata which he thought were transitional between the Chico-Cretaceous and his Cretaceous "B," the Tejon of the present nomenclature. Dr. T. W. Stanton<sup>2</sup> next investigated this group. He proved that a portion of the Martinez Group of Gabb was Chico and placed the upper portion as a distinct faunal zone of the Tejon, designating it as lower Tejon.

Dr. Stanton's admirable review was followed by a short, decisive paper by Merriam<sup>3</sup> who worked at the type locality. Merriam described the conditions at the type locality as follows:

In the following discussion the name Martinez is applied to that portion of Gabb's Martinez Group which remains, after the removal of the Chico-Cretaceous element. The writer's statements are based on observations, extending over a period of several years, made in the typical region for the group, viz., that adjacent to the town of Martinez.

In the hills to the southwest of Martinez, strata of unquestionable Chico age, containing a characteristic fauna, occur over a considerable area. In a

<sup>1</sup> Gabb, W. M., Rept. Geol. Surv. of California, Palaeontology, vol. 2, p. 13 of preface, 1869.

<sup>2</sup> Stanton, T. W., The Faunal Relations of the Eocene and Upper Cretaceous on the Pacific Coast, 17th Ann. Rept. U. S. Geol. Surv., pp. 1011-1060, 1895-6.

<sup>3</sup> Merriam, J. C., The Geological Relations of the Martinez Group of California at the Typical Locality, Jour. of Geology, vol. 5, pp. 767-775, 1897.

fine outcrop of compact bluish sandstone occurring on the west side of Alhambra Valley, and near the top of the Chico, the writer found an abundance of fossils, characteristic of this group. . . . From this point to the east and west the structure of the strata is anticlinal, showing an apparently conformable series up as far as the Miocene on each side.

From the standpoint of stratigraphy, one would hardly be disposed to find fault with Gabb's conception of the Martinez, since in this, the typical locality, the Chico, Martinez, and Tejon appear everywhere to be conformable, while numerous complications of the stratigraphy have still farther increased the difficulty of separating these three groups on stratigraphic grounds.

Lithologically there are some differences between the Martinez and the adjoining formations, the most important of which are the slightly different aspect of its sandstones and the frequent presence in them of considerable quantities of glauconite. The sandstones are often grayish, differing from the yellowish or bluish rocks of the Chico and the massive white to dull red Tejon sandstones. In many places the Martinez contains large quantities of glauconite disseminated evenly through the sandstone in rounded grains of considerable size. Glauconite does not seem to occur at all in the Chico but may possibly be found toward the base of the true Tejon. The truly glauconitic rocks belong principally to the Martinez.

While the group shows little which would serve to separate it stratigraphically or lithologically from the over and underlying formations, its fauna, on which Gabb based his classification, contains numerous elements throwing light on its geologic relations. Between the Chico-Cretaceous and the Miocene there are two distant faunas present, viz., the Martinez (in part) and Tejon of Gabb, or the Lower and Upper Tejon of Mr. Stanton. As other criteria failed to separate satisfactorily the Chico, Martinez, and Tejon, extensive fossil collections were made by the writer at all possible points.

Merriam then discussed collections made in a section across the strike in the typical Chico, Martinez and Tejon, suggested the existence of two faunal zones in the Martinez, and described the palaeontology of the Martinez:

The faunas, though overlapping, are in the main quite distinct, and no great difficulty has been experienced by the writer in separating the groups on this basis. While some intermingling of species exists, it is not greater than we should expect to find in adjoining groups or periods. It should also be observed that the beds with a Tejon-like Martinez fauna and those containing an assemblage of characteristic Tejon forms are comparatively close together. The change from one fauna to the other may possibly have taken place in a short time by migration, but we can not assert positively as yet that the apparent conformity of the beds is a real one; sedimentation may have been interrupted between the times of deposition of the two groups. It is, at any rate, quite clear that the two sets of strata, or two faunas, while belonging perhaps to the same series, represent different periods in the geological history of California, periods quite as distinct, so far as faunal evidence is concerned, as the Miocene and Pliocene, or the Pliocene and Quaternary. The upper division of this series has already, on the grounds of its characteristic fauna, been named the Tejon. To a mixed group of rocks, to which the fauna here called the Martinez gave individuality, the name Martinez group was applied

by Gabb. It seems desirable, after having cut out the Chico portion of Gabb's Martinez which was probably not the one on which he based the group, to apply the name used by him to the distinct fauna or group which remains. As to the nomenclature of the supposedly conformable series, including the Martinez and Tejon, it seems best to apply to it for the present the term Martinez-Tejon series, though future convenience may demand a special series name. To apply the name Tejon to the whole series would be to modify considerably the meaning of this term as used originally, and would have besides the fault of taking the name from a smaller division to apply it to a larger, leaving the first to be virtually renamed.

He then closed with a definition of the Martinez Group as follows:

The Martinez group, comprising in the typical locality between one and two thousand feet of sandstones, shales, and glauconitic sands, forms the lower part of a presumably conformable series, the upper portion of which is formed by the Tejon. It contains a known fauna of over sixty species, of which the greater portion is peculiar to itself. A number of its species range up into the Tejon and a very few long-lived forms are known to occur also in the Chico. Since the Martinez and Chico are faunally only distantly related, it is probable that an unconformity exists between them. Though satisfactory correlation of California formations with the subdivisions of the standard geological scale can be accomplished only when the local scale is fully worked out, we may, for the present at least, accept Mr. Stanton's correlation of the Martinez with a portion of the Eocene.

In a general correlation paper, Dall<sup>4</sup> places both the Martinez and the Tejon as correlative of the Midway stage of the southeastern United States and the Cernaysian of Europe.

Lawson<sup>5</sup> in describing a section in the neighborhood of the type locality of the Martinez substitutes the name "Karquinez series" for that of Merriam's Martinez-Tejon series, and estimates their combined thickness as 4300 feet.

In a paper entitled "Contribution to the Palaeontology of the Martinez Group," Weaver<sup>6</sup> carefully described the distribution of the Martinez, its stratigraphic relations, recognized two faunal zones, correlated it with the Midway of the Gulf States and the Aquia stage of Maryland and Virginia, and described several new species. In summary he said:

. . . . the Martinez represents a distinct division of time in the geological history of California. It contains a fauna distinct from both the Chico and

<sup>4</sup> Dall, W. H., A Table of the North American Tertiary Horizons correlated with one another and with those of western Europe, 18th Ann. Rept. U. S. Geol. Surv., part 2, pp. 327-348, 1898.

<sup>5</sup> Lawson, A. C., A Geological Section of the Middle Coast Ranges of California, Science, n.s., vol. 15, p. 416, 1902.

<sup>6</sup> Weaver, C. E., Contribution to the Palaeontology of the Martinez Group, Univ. Calif. Publ. Bull. Dept. Geol., vol. 4, pp. 101-123, 1905.

the Tejon. On the average it is composed of about two thousand feet of thick-bedded sandstones and conglomerates. Its geographical extent as at present known is confined to southern Lake County and a belt extending north and south across Carquinez Strait. Its position in the geological scale seems to correspond most closely to a portion or all of the lower quarter of the Eocene.

Arnold<sup>7</sup> gave a list of fossils compiled from the papers of Stanton, Merriam, and Weaver, added a few new species obtained "from a locality of doubtful Martinez age," and described *Pecten proavus* from this locality in Santa Cruz County. He mentioned Rock Creek, Los Angeles County as a Martinez locality. In a later paper<sup>8</sup> he described the Santa Cruz locality, gave a list of fossils obtained from it and described *Cidaris merriami*, *Semele gayi*, *Tritonium newsomi*, *Hipponyx carpenteri*, *Patella mateoensis*, and *Fissurella perrini*. He described the Martinez(?) of the Santa Cruz Quadrangle as follows:

The diabase dike exposed north of the headwaters of Pescadero Creek has brought up considerable inclusions of impure limestone which, from the fossils found in them, appear to be of Eocene age. Obviously the stratigraphic relations of this great limestone inclusion are unknown, but the fossils indicate its Eocene age and that it probably belongs in the lower part of the formation. The following fauna occurs in this limestone:

LIST OF LOWER EOCENE FOSSILS FROM THE SANTA CRUZ QUADRANGLE

ECHINOIDEA

*Cidaris merriami*, new species

BRACHIOPODA

*Terebratalia*, new species, m.

*Terebratulina tejonensis* Stanton

*Terebratalia*, new species, p.

PELECYPODA

*Pecten proavus* Arnold

*Semele gayi* Arnold

GASTROPODA

*Chlorostoma*, new species, c.

*Patella*, new species, b.

*Cylindrites brevis*(?) Gabb

*Patella mateoensis* Arnold

*Fissurella perrini* Arnold

*Thylacodes*, new species, w.

*Hipponyx carpenteri* Arnold

*Tritonium newsomi* Arnold

*Odostomia*, new species, b.

<sup>7</sup> Arnold, Ralph, The Tertiary and Quaternary Pectens of California, Professional Paper no. 47, U. S. Geological Survey, pp. 11-12, 1906.

<sup>8</sup> Arnold, Ralph, Descriptions of New Cretaceous and Tertiary Fossils from the Santa Cruz Mountains, California, Proceedings of the United States National Museum, vol. 34, no. 1617, pp. 347, 359-363, August, 1908.

A short description of these same beds is also given in the Santa Cruz folio:<sup>9</sup>

The diabase exposed north of the headwaters of Pescadero Creek has brought up some considerable inclusions of impure limestone which, from the fossils found in them, appear to be of Eocene age. The limestone is light brown in color, usually rather soft except where silicification has begun, and appears to be made up of broken marine shells, a little argillaceous material, and small fragments of what may be tuff. The thickness of the limestone is nowhere more than 100 or 200 feet.

On Langley and Mindego Hills, two and a half miles northeast and southeast, respectively, of the village of La Honda, are two other small areas of calcareous sandstone, supposed to be of the same age as that exposed north of the headwaters of Pescadero Creek.

Fossils—The fauna of the limestone in the Pescadero Creek exposure above referred to is different from that of any of the other known formations of California. Some of its species as *Patella mateoensis* Arnold, *Fissurella perrini* Arnold, *Tritonium newsomi* Arnold, and *Pecten proavus* Arnold, are closely allied to Chico (Cretaceous) forms, while *Ostrea cf. idriaensis* Gabb is found only in the Tejon (middle Eocene), and *Terebratulina tejonensis* Stanton only in the Martinez (lower Eocene). In view of the affinities of the above species and also of the several new ones, it appears probable that the fauna represents either a new horizon of the lower Eocene or a local development of the Martinez (lower Eocene) fauna.

These beds do not appear to be of Martinez age to the writer.

Dickerson<sup>10</sup> in a short paper described unconformities between the Martinez and Chico and between the Tejon and Martinez, and gave partial lists of fossils collected from a section across the strike from the Chico, Martinez and Tejon. These lists show a very marked difference between the faunas of the Chico, Martinez and Tejon.

In a recent number of the *Journal of Geology*, Dumble<sup>11</sup> described an unconformity between the Cretaceous and beds which he supposed to be of Martinez age. Later work by Taff, Gester, Parsons, and Dickerson has shown that the so-called Martinez is Tejon.

<sup>9</sup> Branner J. C., Newsom, J. R., Arnold, R., Santa Cruz Folio, No. 165, U. S. Geological Survey, p. 3, April, 1908.

<sup>10</sup> Dickerson, Roy E., The Stratigraphy and Faunal Relations of the Martinez Formation to the Chico and Tejon North of Mount Diablo, Univ. Calif. Publ. Bull. Dept. Geol., vol. 4, pp. 173-177, 1911.

<sup>11</sup> Dumble, E. T., Notes on Tertiary Deposits near Coalinga Oil Field and their Stratigraphic Relations with Upper Cretaceous, Jour. Geol., vol. 20, pp. 28-37, 1912.



## AREAL DISTRIBUTION OF THE MARTINEZ IN CALIFORNIA

## PRINCIPAL LOCALITIES

The most northerly occurrence of Martinez thus far reported is near the town of Lower Lake, in Lake County. Martinez strata occur in the Napa Quadrangle four miles northwest of Suisun, where Gabb<sup>12</sup> found fine specimens of *Turritella pachecoensis* and *Meretrix(?) fragilis*, and near Benicia. Across the Carquinez Strait from Benicia is the type locality of the Martinez near the town of that name. In 1909, R. W. Paek and G. E. Gester recognized a small area of Martinez on Carquinez Strait at Selby Station. North of Mount Diablo another area occurs, and a very small but interesting locality was found southwest of Mount Diablo by the 1911 University of California Summer Session class in palaeontology. Beds of Martinez age make up a portion of the strata at San Pedro Point, in San Mateo County. Dumble<sup>13</sup> reported Martinez north of Coalinga, but later work has shown that these beds are a phase of the Tejon.

A typical collection of Martinez fossils was made by the 1910 Stanford University class in geology forty miles northwest of Los Angeles in the Calabassas Quadrangle. Arnold<sup>14</sup> reported Martinez at Rock Creek, Los Angeles County. The Martinez was recognized by the 1913 University of California Summer Session class in palaeontology in the Santa Ana Mountains. No positive evidence of Martinez south of this last point is known, but Stanton<sup>15</sup> reports *Glycimeris veatchii* var. *major* from Point Loma near San Diego. None of the collections from this locality which the writer has examined have contained any typical Martinez forms; all appear to be Tejon or Chico.

## DISTRIBUTION OF THE MARTINEZ COMPARED WITH THAT OF THE TEJON

Some interesting relations between the Martinez and the Tejon are brought out when their distribution is studied. (See fig. 1.) In certain localities the Martinez and Tejon occur together, but in other

<sup>12</sup> Gabb., W. M., Rept. Geol. Surv. of California, Palaeontology, vol. 2, p. 135, 1869.

<sup>13</sup> Dumble, E. T., Notes on Tertiary Deposits near Coalinga Oil Field and their Stratigraphic Relations with Upper Cretaceous, Jour. Geol., vol. 20, pp. 28-37, 1912.

<sup>14</sup> Arnold, R., Tertiary and Quaternary Pectens of California, Professional Paper no. 47, U. S. Geological Survey, p. 11, 1906.

<sup>15</sup> Stanton, T. W., The Faunal Relations of the Eocene and Upper Cretaceous on the Pacific Coast, 17th Ann. Rept. U. S. Geol. Surv., p. 1040, 1895-6.

places the one occurs without the other. They are associated at Lower Lake in Lake County, but no Martinez occurs at the Marysville Buttes in Colusa County where uppermost Tejon is found. The Tejon of Merced Falls rests directly upon rocks of Jurassic age. Both are found at Benicia, Martinez, and north of Mount Diablo, but on the south side of Mount Diablo, the Tejon for the most part rests directly upon the Chico. At San Pedro Point, San Mateo County, Martinez without Tejon is found. At the type locality of the Tejon on the Cañada de las Uvas the upper Eocene rests upon the basement complex of the Tehachapi Mountains, and no Martinez appears to be present at the southern end of the San Joaquin Valley. However, Martinez does occur on the seaward side of the ranges along the coast thirty miles south of this same latitude in the Calabazas Quadrangle. The Tejon at San Diego overlies the Chico. Fairbanks<sup>16</sup> mapped no Eocene in the San Luis Quadrangle. South of this quadrangle great thicknesses of Eocene strata were reported by Eldridge and Arnold<sup>17</sup> in the Santa Clara Valley. These beds were called the Topatopa formation. No attempt was made to differentiate the upper and lower portions of the "formation."

At least three marked epirogenic movements occurred during Eocene time: (1) a subsidence of the coast during which the Martinez sediments were deposited, (2) an uplift during which large portions of Martinez sediments were removed, (3) a subsidence during which the Tejon sediments were deposited. That the sea during the first subsidence did not extend so far inland as during the second appears to be true, and deposition by a transgressing sea might account for the occurrence of Tejon at Merced Falls and the Marysville Buttes unassociated with Martinez if it were not for a widespread unconformity between these two groups. Tejon sediments 2600 feet thick south of Mount Diablo rest unconformably upon Chico, whereas at least 700 feet of Martinez is found between the groups north of the mountain. Unconformity between the two groups and a more widely spread sea during Tejon time account for the difference in distribution of the Martinez and Tejon in California.

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<sup>16</sup> Fairbanks, H. W., San Luis Folio, no. 101, U. S. Geological Survey, p. 3, 1904.

<sup>17</sup> Eldridge, G. H., and Arnold, R., The Santa Clara Valley, Puente Hills and Los Angeles Oil District, Southern California, Bull. no. 309, U. S. Geological Survey, pp. 5-7, 1907.



Fig. 1. Map of California showing probable extent of the Tejon and Martinez Seas. The solid line in general is the more easterly marks the maximum inland extension of the Tejon Sea. The dashed line indicates the probable easterly limit of the Martinez Sea.

- 1, Tejon of Round Valley, Mendocino County; 2, Tejon near Oroville; 3, Tejon of Marysville Buttes; 4, Mouth of Merced River Cañon; 5, Tejon of the Tehachapi Mountains; 6, Martinez of Rock Creek; 7, Tejon of the locality of Martinez; 8, Tejon and Martinez at Clear Lake; 9, Martinez north of Suisun; 10, Martinez and Tejon at Benic; 11, Martinez and Tejon north of Mount Diablo; 12, Martinez and Tejon north of Mount Diablo; 13, Martinez and Tejon south of Mount Diablo; 14, Martinez of San Pedro Point, San Mateo County; 15, Tejon at New Idria; 16, Tejon at Coalinga District; 17, Martinez of the Santa Clara Valley; 18, Martinez of Colchagua, Oyardlands; 19, Tejon and Martinez of the Santa Ana Valley; 20, Martinez of the Santa Ana Valley.



DESCRIPTIONS OF THE TYPICAL MARTINEZ SECTIONS  
IN CALIFORNIA

## LOWER AND MIDDLE ZONES OF MARTINEZ NORTH OF MOUNT DIABLO

The stratigraphy and the faunal relations of the Martinez to the Chico and Tejon have already been fully discussed in a former paper.<sup>18</sup> The zonal relations of the Martinez in this area have not been described. In the Martinez area four miles north of Mount Diablo we have a lower section which has yielded the most abundant fauna of any Martinez locality, over eighty species having been found in the lowermost beds alone. Abundantly fossiliferous, distinctly bedded outcrops extending for the entire length of the east-west four-mile strip have enabled the writer to be sure of the stratigraphic position of the various fossil localities. A north-south cross-section examined a mile south of Stewartville is, in descending order, as follows:

- (5) Gray-green shales, 250-300 feet.
- (4) Gray-green, glauconitic sandstone, 50 feet.
- (3) Fine-grained, hard, gray sandstone, 200 feet.
- (2) Shales and argillaceous sandstones, 100 feet.
- (1) Brown, conglomeratic, lower sandstone, 50-100 feet.

Total, 650-750 feet.

(See figure 2.)

A similar section was examined at the head of Oil Creek, two miles west of this line. The principal fossil localities are limited to the lower bed and the gray-green glauconitic sandstone four hundred feet above the base. The accompanying map shows these localities (see fig. 3). The lower bed yielded a fauna in which one of the most abundant forms was *Meretrix dalli*, n. sp.

## FAUNA OF THE MERETRIX DALLI ZONE

Large collections from the lowermost beds have been made by J. R. Powers, B. L. Clark, William Kew and the writer in the past three years. Below is a complete list of the fauna obtained from these beds:

<sup>18</sup> Dickerson, Roy E., Univ. Calif. Publ. Bull. Dept. Geol., vol. 6, pp. 173-177, 1911.

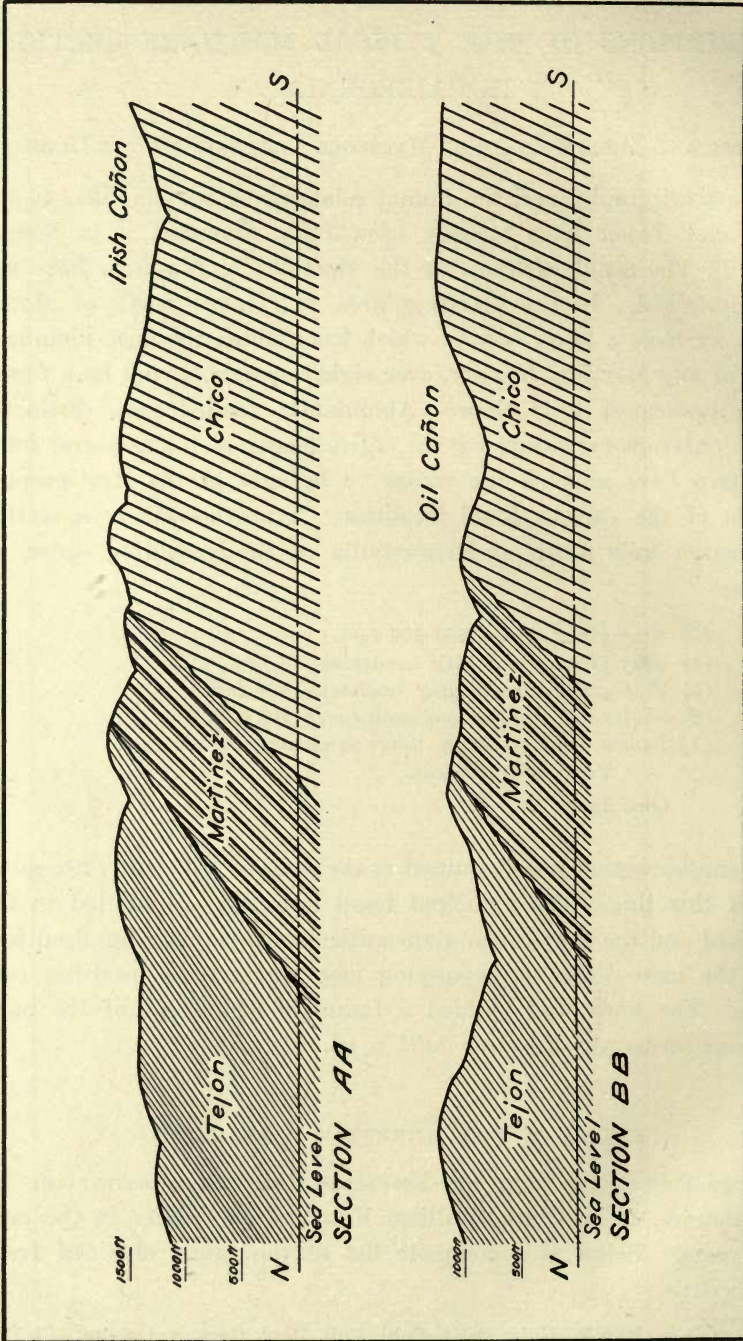


Fig. 2. North-south sections showing relations of Chico, Martinez and Tejon in the region north of Mount Diablo. See figure 3 for location of sections.

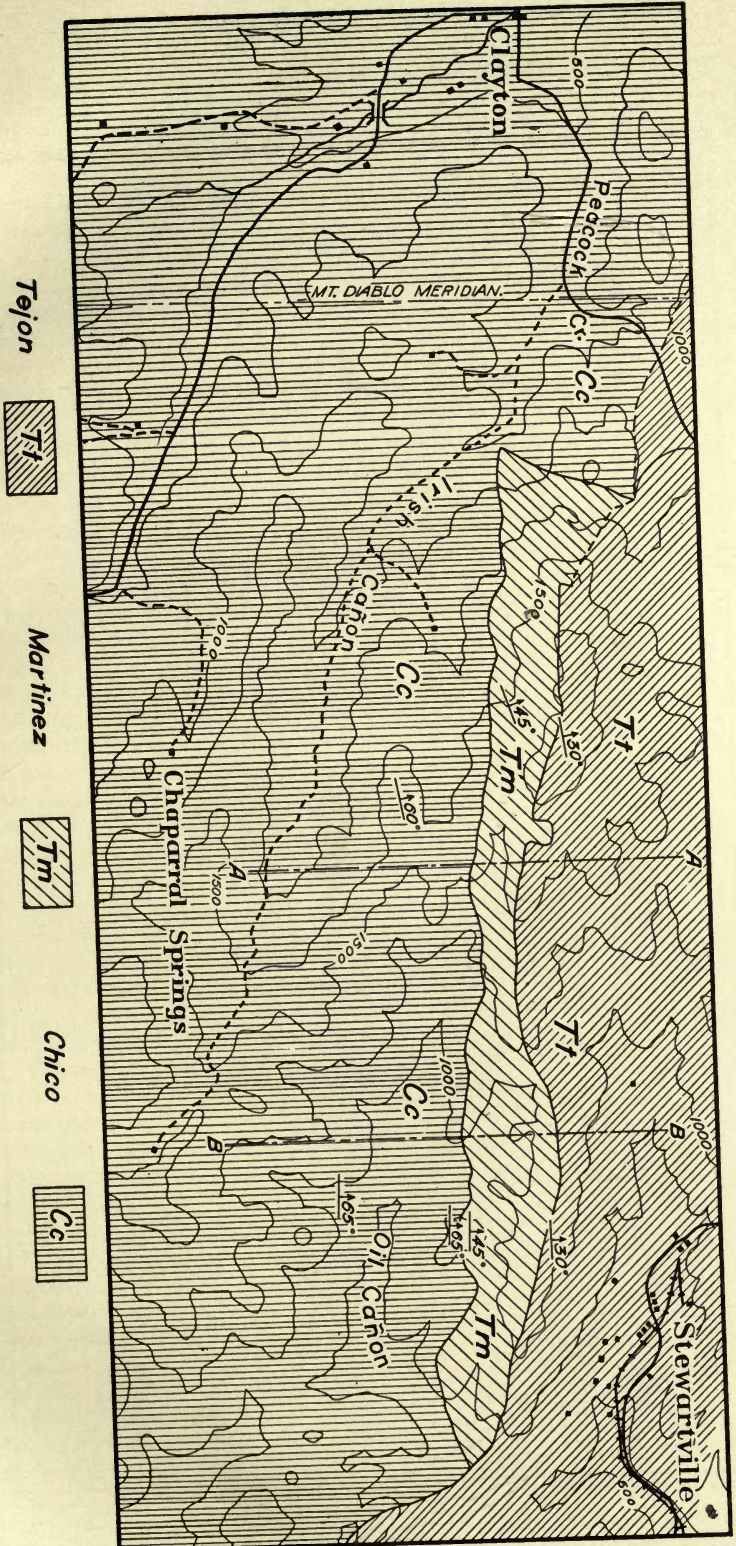


Fig. 3. Map showing Martinez area north of Mount Diablo. Scale, 1/2 inch = 1 mile.





## FAUNA OF THE MERETRIX DALLI ZONE IN THE MARTINEZ NORTH OF MOUNT DIABLO

	Loc. 1745	Loc. 1556	Loc. 1743	Loc. 1557
<i>Flabellum remondianum</i> Gabb .....	---	x	x	x
<i>Cidaris</i> , sp., <i>a</i> .....	---	x	---	---
<i>Cidaris</i> , sp., <i>d</i> .....	---	x	---	---
<i>Schizaster lecontei</i> Merriam .....	---	---	x	---
<i>Terebratula</i> (?), sp. ....	---	x	---	---
<i>Terebratulina tejonensis</i> Stanton .....	---	---	x	---
<i>Cardium cooperi</i> Gabb .....	---	---	x	x
<i>Cardium</i> , sp. ....	---	x	---	---
<i>Cardita veneriformis</i> Gabb .....	---	x	---	---
<i>Cucullaea mathewsonii</i> Gabb .....	---	x	x	x
<i>Corbula</i> , sp. ....	---	x	---	x
<i>Crassatellites uniooides</i> (Stanton) .....	---	---	x	---
<i>Cuspidaria dolabraeformis</i> (Gabb) .....	---	x	---	---
<i>Glycimeris veatchii</i> , var. <i>major</i> (Stanton) .....	---	x	x	---
<i>Lima</i> cf. <i>multiradiata</i> Gabb .....	---	x	---	---
<i>Leda gabbi</i> Conrad .....	---	x	x	x
<i>Leda packardi</i> , n. sp. ....	x	---	x	---
<i>Leda milleri</i> , n. sp. ....	---	x	---	---
<i>Modiolus bakeri</i> , n. sp. ....	---	x	---	---
<i>Modiolus ornatus</i> (Gabb) .....	---	x	---	---
<i>Mytilus</i> cf. <i>ascia</i> Gabb .....	---	x	---	---
<i>Meretrix stantoni</i> , n. sp. ....	---	x	---	x
<i>Meretrix dalli</i> , n. sp. ....	---	---	x	---
<i>Nucula</i> ( <i>Acila</i> ), sp. ....	---	x	---	x
<i>Ostrea</i> , sp. ....	---	x	---	---
<i>Paphia</i> (?) <i>clarki</i> , n. sp. ....	---	x	x	x
<i>Phacoides turneri</i> (Stanton) .....	x	---	---	x
<i>Pecten</i> , sp., <i>a</i> .....	---	x	---	---
<i>Pholadomya nasuta</i> Gabb .....	---	x	x	---
<i>Solen</i> , sp. ....	---	---	x	---
<i>Solen stantoni</i> Weaver .....	---	---	x	---
<i>Spisula</i> (?) <i>weaveri</i> , n. sp., Packard .....	---	x	---	---
<i>Tapes</i> , sp., <i>a</i> .....	---	---	---	x
<i>Tapes</i> (?) <i>quadrata</i> Gabb .....	---	x	---	---
<i>Tellina undulifera</i> Gabb .....	---	x	x	---
<i>Tellina</i> cf. <i>aequalis</i> Gabb .....	---	x	---	---
<i>Tellina</i> , sp., <i>a</i> .....	---	---	---	x
<i>Teredo</i> , sp. ....	---	x	x	x
<i>Zirphaea</i> (?), sp. ....	---	x	---	x
<i>Dentalium</i> , sp. ....	---	x	---	---
<i>Dentalium cooperi</i> Gabb .....	---	x	x	---
<i>Amauropsis martinezensis</i> , n. sp. ....	x	---	---	---
<i>Anchura</i> , sp. ....	x	---	---	---
<i>Ampullina striata</i> Gabb .....	---	x	---	x
<i>Brachysphingus liratus</i> Gabb .....	---	---	---	x
<i>Cylichna costata</i> Gabb .....	---	x	x	x
<i>Fusus</i> cf. <i>martinez</i> Gabb .....	x	---	---	---
<i>Fusus</i> (?), sp. ....	---	x	---	---

FAUNA OF THE MERETRIX DALLI ZONE IN THE MARTINEZ NORTH OF MOUNT DIABLO  
(Continued)

	Loc. 1745	Loc. 1556	Loc. 1743	Loc. 1557
Fusus, sp. ....	....	X	....	....
Galerus excentricus Gabb .....	....	....	....	X
Heteroterma striata Stanton .....	....	X	....	....
Lunatia hornii Gabb .....	....	X	....	....
Natica, sp., a .....	....	X	....	....
Natica (Gyrodes) lineata, n. sp. ....	....	X	X	....
Neptunea mucronata Gabb .....	....	X	X	....
Perissolax tricarnatus Weaver .....	....	X	....	....
Ringinella pinguis Gabb .....	....	....	X	....
Surcula merriami, n. sp. ....	....	....	X	....
Tritonium martinezensis, n. sp. ....	....	X	X	X
Turritella infragranulata Gabb .....	....	X	X	X
Turritella pachecoensis Stanton .....	....	X	....	....
Urosyca caudata Gabb .....	....	X	....	X
Xenophora zitteli Weaver .....	....	X	....	....
Fish tooth .....	....	....	X	....
Leaf .....	....	....	X	....

Of the forms in the above list the following as far as known are characteristic of this lower zone: *Cidaris*, sp., *Terebratulina tejonensis* Stanton, *Cardita veneriformis* Gabb, *Corbula*, sp., *Leda milleri*, n. sp., *Meretrix stantoni*, n. sp., *Meretrix dalli*, n. sp., *Spisula(?) weaveri* Packard, *Zirphaea(?)*, sp. and *Tritonium martinezensis*, n. sp. *Schizaster lecontei* Merriam is very rare in these beds, only one specimen being found. The striking thing, however, is the absence of such forms as *Trochocyathus zitteli* (Merriam), *Modiolus merriami* Weaver, *Crassatellites grandis* Gabb, *Anchura gabbi*, n. sp., *Ficopsis*, sp., *Neptunea cretacea* Gabb, and *Surcula fairbanksi*, n. sp.

The large number of pelecypods in comparison to the gastropods is very noteworthy. The coarse character of the sediments indicates that they were deposited in shallow water and in part even within the littoral zone, as the presence of *Zirphaea(?)*, sp., proves. How much this depth factor was influential in giving distinctiveness to this fauna will be discussed after the middle or *Trochocyathus zitteli* zone has been considered.

FAUNA OF THE TROCHOCYATHUS ZITTELI ZONE

Three to four hundred feet above the base of the Martinez, another very distinct zone is found in hard, gray-green, glauconitic sandstone. This zone is characterized by *Trochocyathus zitteli* (Merriam). Its fauna is tabulated below.



## FAUNA OF THE TROCHOCYATHUS ZITTELI ZONE NORTH OF MOUNT DIABLO—(Continued)

	Loc. 1540	Loc. 1580	Loc. 1746	Loc. 1747	Loc. 1656	Loc. 1695	Loc. 1586	Loc. 1592	Loc. 1558
Surcula, sp. ....	×	---	---	---	---	---	---	---	---
Siphonalia(?) lineata Stanton .....	×	---	---	---	---	---	---	---	---
Turritella pachecoensis Stanton .....	×	×	×	---	---	---	---	---	---
Turritella clarki, n. sp. ....	×	---	---	---	---	---	---	---	---
Tritonium, sp., a .....	---	---	---	---	---	---	---	×	---
Turris, sp. ....	---	×	---	---	---	×	---	---	---
Turris louderbacki, n. sp. ....	×	---	---	---	---	---	---	---	---
Urosyca caudata Gabb .....	×	×	×	---	---	×	---	---	---
Xenophora zitteli Weaver .....	×	---	×	×	---	---	---	---	---

*Trochocyathus zitteli* (Merriam), *Lima haseltinei*, n. sp., *Crassatellites stewartvillensis*, n. sp., *Anchura gabbi*, n. sp., *Ficopsis*, sp., *Nephtunea cretacea* Gabb, *Surcula fairbanksi*, n. sp., and *Turritella clarki*, n. sp., are some of the forms which have not been found in the *Meretrix dalli* zone or in the *Solen stantoni* zone at the type locality. The principal difference between this fauna and that of the lower beds is in the ratio of the gastropods to the pelecypods, viz., 3:2 in the *Trochocyathus zitteli* zone, 3:4 in the *Meretrix dalli* beds. This difference is still greater when all the gastropods and pelecypods are enumerated. At least two factors figure in the cause of these differences—bathymetric conditions and difference in age of the two zones. The bathymetric conditions of the lower beds have already been described. The genus *Trochocyathus*, according to the "Challenger" Report<sup>19</sup> ranges from a depth of 100 to 750 fathoms. Glauconite is abundantly formed at a depth of a hundred fathoms or more in the ocean of the present. A study of the gastropods brings us to the same conclusion, viz., that the *Trochocyathus zitteli* beds were deposited in at least one hundred fathoms of water. The age difference between the faunas of the two zones is obvious, the one being stratigraphically above the other. Just how much control these two factors exert is an exceedingly difficult matter to determine. The absence of *Trochocyathus* in the lower beds may be explained upon a basis of depth relations, but why certain forms such as *Cardita veneriformis* Gabb, *Leda milleri*, n. sp., *Meretrix dalli*, n. sp. *Tritonium martinezensis*, n. sp., and *Cidaris*, sp., a, should not appear in the *Trochocyathus zitteli* zone cannot be explained upon the same basis, for apparently some of these forms disappeared before the upper

<sup>19</sup> Moseley, Challenger Report, Zoology, vol. 2, part 7, pp. 132-133, 1881

beds were deposited. At Benicia an entire section of Martinez appears to be present, and in the middle of the section forms elsewhere associated with *Trochocyathus zitteli* are found in beds which were not deposited in deep water, as is shown by the absence of *Trochocyathus zitteli* and *Schizaster lecontei*. As none of the above-mentioned forms occur here, difference in age appears to be the principal cause of the faunal differences.

#### MARTINEZ AND TEJON SOUTH OF MOUNT DIABLO

During the field work of the last two University summer classes in palaeontology we did not succeed in recognizing the Martinez group south of Mount Diablo until the collections were correctly determined. The base of the Tejon was found to be in unconformable contact with the underlying beds in three different places six or more miles apart. In one locality (University of California Locality 1308), the Tejon rests unconformably on a gray limestone of Martinez age, in another locality upon a dark gray sandstone of Chico age.

In a locality on Little Pine Creek an angular unconformity was observed between the overlying Tejon, strike N 20° W, dip 7° S, and the underlying Chico strata, strike N 20° W, dip 7° N. On the divide between Pine and Curry cañons an angular unconformity between the Chico and the Tejon was recognized, and mollusc borings were noted. This unconformable contact was traced for over four miles east of this divide.

The underlying Chico yielded only fragments of *Inoceramus*, but the basal beds of the Tejon are very fossiliferous in many places. At a locality on the ridge between Little Pine Creek and Pine Cañon (SE ¼ of NE ¼ Sec. 4, T. 1 S, R. 1 W, M. D. B. & M.) both the Tejon and underlying limestone are fossiliferous. The following partial list shows the fauna which was found in the beds of the Tejon a hundred and fifty to two hundred feet above the base.

<i>Solen parallelus</i> Gabb	<i>Pecten</i> , sp.
<i>Venericardia planicosta</i> Lamarek	<i>Psammobia hornii</i> (Gabb)
<i>Meretrix hornii</i> Gabb	<i>Fusus mathewsonii</i> Gabb
<i>Glycimeris</i> , sp.	<i>Spiroglyphus</i> (?), sp.
<i>Leda gabbi</i> Conrad	<i>Cylichna costata</i> Gabb
<i>Cardium breweri</i> Gabb	<i>Rimella canalifera</i> Gabb
<i>Tapes conradiana</i> Gabb	<i>Amauropsis alveata</i> Gabb
<i>Tellina</i> (?), sp.	<i>Fusus</i> (?), sp.
<i>Acila</i> , sp.	<i>Surcula</i> , sp.

The unconformity was further marked by unmistakable mollusc borings at this point. The limestone contains a few species of undoubted Eocene age. The following forms have been recognized:

Dosinia lawsoni, n. sp.	Teredo, sp.
Phacoides diaboli, n. sp.	Fusus mathewsonii Gabb
Paphia(?) clarki, n. sp.	Surcula claytonensis (Gabb)
Venus(?) martinezensis, n. sp.	Aturia mathewsonii Gabb

Of these forms *Aturia mathewsonii* has been reported from both the Tejon and the Martinez. The genus *Aturia* is wholly restricted to the Eocene, Oligocene, and Miocene. *Fusus mathewsonii* was originally described from the Tejon. It also occurs in the basal beds of the Martinez north of Mount Diablo. *Paphia(?) clarki*, n. sp., occurs in the Martinez north of Mount Diablo. *Surcula claytonensis* was first described from the upper portion of the Tejon, north of Mount Diablo in strata above the Clark, or upper vein of coal. *Phacoides diaboli*, n. sp., found here appears to be the same species as the *Phacoides*, n. sp., found in the Eocene beds of San Pedro Point. The stratigraphic evidence, together with a fauna of undoubted Eocene age, indicate that these underlying beds are Martinez. The relationship of these Martinez beds to the Chico has not been worked out. One locality south of Mount Diablo where Chico fossils were found is Curry Cañon. Mr. Reginald Stoner determined the following from this locality:

Trigonia evansana	Baculites, sp.
Cucullaea truncata	Cinulia obliqua
Cardium annulatum	Anchura californica
Venus varians	Glycimeris veatchii
Dentalium stramineum	Ammonites, n. sp.
Cyprinella tenuis	Schloenbachia chicoensis
Dentalium cooperi	

At the locality on the ridge between Pine Cañon and Little Pine Cañon, the thickness of Martinez exposed cannot be more than two hundred to three hundred feet, as the Franciscan schists and associated serpentine are found only one-eighth of a mile away, and Cretaceous strata probably occur between the two.

It is seen from this description that the Martinez exhibits some lithologic differences on the north and south sides of the mountain. On the north side of the mountain, the beds—about seven hundred feet thick—in descending order consist of:

- (5) Gray-green shales, 250-300 feet.
- (4) Gray-green glauconitic sandstone, 50 feet.
- (3) Fine-grained, hard, gray sandstone, 200 feet.
- (2) Shales and argillaceous sandstones, 100 feet.
- (1) A brown, conglomeritic, basal sandstone, 50 to 100 feet in thickness.

On the south side of the mountain the limestone, ten feet in thickness, is interbedded with shales and fine gray micaceous sandstone. From this evidence we conclude that:

1. An unconformity exists between the Tejon and beds evidently of Martinez age southwest of Mount Diablo, as well as between the Tejon and Chico.

2. This unconformity is marked by mollusc borings recognized in localities six miles apart, and an angular unconformity is recognizable in several places between the Tejon and the underlying Chico.

Field relations show that the unconformity between the Tejon and Martinez represents a time interval so long that at least several hundred feet of thickness of Martinez were removed before the land was lowered to receive the sediments of the Tejon sea directly upon the Chico, the former basement of the Martinez.

#### TYPE LOCALITY OF THE MARTINEZ

##### STRATIGRAPHY

Dr. Weaver<sup>20</sup> described the stratigraphy at the type locality as follows:

In the vicinity of the Strait of Carquinez the Chico, Martinez, Tejon and Monterey have all participated in the folding of the strata, which has resulted in the formation of a synclinal trough, the axis of which has a northwest to southeast trend. The apex is situated about four miles to the north of Benicia. The maximum width of this syncline, extending from a short distance west of Pacheco on the east to Del Hambre Cañon on the west, is about four miles. In this cross-section the Chico, Martinez, Tejon and Monterey are found in succession toward the center of the syncline. The same holds true on the northern side of the straits, except that the Monterey is not represented. To the south and west of Martinez, on the western limb of the syncline, all of these beds dip at high angles to the northeast. West of the syncline the Martinez becomes thinner, and is represented by a narrow strip extending up nearly to the head of Del Hambre Cañon. At this locality the Martinez, together with the Chico, dips to the southwest.

<sup>20</sup> Weaver, C. E., Contribution to the Palaeontology of the Martinez Group, Univ. Calif. Publ. Bull. Dept. Geol., vol. 4, no. 5, p. 105, 1905.

On the eastern flank of the syncline, beds of Martinez age are represented immediately west of Bull's Head Point, and south of this point they appear east of the road leading from Pacheco to Martinez. These, together with the Chico and Tejon, dip steeply to the southwest. The strike of these beds carries them across the Strait of Carquinez, where they again outcrop just north of Army Point Station. At this point the formation was so thickly bedded that it was difficult to obtain accurate observations of the dip. Apparently, however, they dip at high angles to the southwest. In this locality the outcrops are separated from both Chico and Tejon by low marshes, so that no actual contact could be observed. However, no marked irregularity in the dip was seen. The strike of these beds was traced to a point about three miles northwest of Benicia. Farther than this no outcrops were seen which could definitely be called Martinez. To the west of Benicia thick-bedded sandstones closely resembling those at Army Point were observed dipping steeply to the northeast. Farther west the Chico again occurs, dipping at the same angle as the thick-bedded sandstones, but near the shore it is folded and again dips to the southwest. The strike and dip of these beds were carried across the straits are almost identical with those south and west of Martinez. The most reasonable conclusion would seem to be that there exists here a closely folded syncline.

The structure of the Martinez to the south and west of the town of Martinez is not as simple as Weaver's description implies. Basal beds of the Martinez with their associated fauna such as have been described above in the Martinez area north of Mount Diablo have not been recognized with certainty, but the *Trochocyathus zitteli* zone is very thick in the southeastern portion of the Martinez between Cañada del Hambre and Ignacio Valley, a distance of three miles. On the southwest of this area, the Martinez is in contact with the Monterey. Just what relation exists between the two is very difficult to discover. No Tejon appears to be present along this line, but near the town of Walnut Creek the continuation of the Monterey strata is in contact with the Tejon, so we are inclined to think that the Monterey has overlapped the Tejon and a part of the Martinez, and lies upon both unconformably. Outcrops are infrequent along the contact and are in general too poor to give any decisive evidence. The dips of the Martinez in this area are all to the northeast. The area, however, is twice as wide as the distance between the Chico and Tejon at Muir Station. The northward extension of this area consists of two strips of Martinez with a tongue of Chico between. The southern strip runs northward for three miles to Alhambra Springs. Here it is cut off by a thrust fault, which runs northward to Carquinez Strait, where Martinez again occurs at the Selby Smelter.



## RELATIONS TO THE MARTINEZ AT SELBY SMELTER

The Martinez at Selby Smelter is traceable southward to the southern edge of the Napa Quadrangle sheet near Christie Station on the Santa Fé railroad, a distance of six miles. Extensive overthrusting has occurred, so that in places the Chico has completely overridden the Martinez and even a part of the Monterey. The Martinez at Selby was probably once connected with the southernmost tongue of Martinez of the type locality, as their extensions are separated by a distance of only two miles. A conglomerate in the Martinez is found one quarter of a mile north of Vaca Cañon near the Chico. A small conglomerate area also occurs about one-half to three-quarters of a mile north of Vaca Cañon. Both dip at high angles to the north. Whether these conglomerates are basal it is impossible to determine positively from poor exposures and lack of fossils, but that such is the case is strongly suggested. The great area of Martinez southeast of Cañada del Hambre, the tongue of Chico coming in between the two extensions of the Martinez and a probable basal conglomerate indicate that we have a closely folded, overturned anticline in this portion of the type section which is locally broken by both strike and cross-faults. On account of these structural complications, very small exposures, if any, of the true base of the Martinez occur at the type section; but the major exposures are those of the upper and middle portions of the group. Although the localities at Selby and Benicia are structurally connected with the type locality, it is best to consider them separately.

## FAUNAL ZONES

We are chiefly indebted to Merriam and Weaver for the recognition of two distinct faunal zones at the type section, viz., the *Trochocyathus zitteli* and the *Solen stantoni* zones. Many students in the field classes in palaeontology have collected near Muir Station, and from all of these sources the writer has determined the faunas listed below. What the persistent efforts of collectors will accomplish is well illustrated by these lists when one knows how poor the collecting really is in this field.

## TROCHOCYATHUS ZITTELI ZONE OF THE TYPE LOCALITY

	Loc. 500-243	Loc. 333	Loc. 65	Loc. 544	Loc. 267	Loc. 1547
<i>Flabellum remondianum</i> Gabb .....	x	---	x	x	---	x
<i>Trochocyathus zitteli</i> (Merriam) .....	x	x	x	x	x	x
<i>Schizaster lecontei</i> Merriam .....	x	---	---	---	---	---
<i>Serpula</i> , sp. ....	x	---	---	---	---	---
<i>Avicula</i> (?), sp. ....	x	---	---	---	---	---
<i>Anatina</i> , sp. ....	x	---	---	---	---	---
<i>Cucullaea mathewsonii</i> Gabb .....	x	---	x	---	x	x
<i>Cuspidaria hannibali</i> , n. sp. ....	---	---	---	---	---	x
<i>Cardium cooperi</i> Gabb .....	x	---	x	---	---	x
<i>Crassatellites studleyi</i> , n.sp. ....	x	---	---	---	---	---
<i>Crassatellites claytonensis</i> , n. sp. ....	---	---	---	---	---	x
<i>Dosinia lawsoni</i> , n. sp. ....	x	---	---	---	---	---
<i>Leda gabbi</i> Conrad .....	x	---	---	---	x	x
<i>Lima multiradiata</i> Gabb .....	x	---	---	---	---	---
<i>Lima haseltinei</i> , n. sp. ....	x	---	---	---	---	---
<i>Modiolus bakeri</i> , n. sp. ....	x	---	---	---	---	---
<i>Modiolus merriami</i> (Weaver) .....	x	x	---	---	---	---
<i>Modiolus ornatus</i> (Gabb) .....	x	---	---	---	---	---
<i>Nucula</i> ( <i>Acila</i> ) cf. <i>truncata</i> Gabb .....	x	x	---	---	x	---
<i>Pinna barrowsi</i> , n. sp. ....	x	---	---	---	x	x
<i>Phacoides turneri</i> (Stanton) .....	---	---	x	---	---	---
<i>Phacoides muirensis</i> , n. sp. ....	x	---	---	---	---	---
<i>Pholadomya nasuta</i> Gabb .....	x	x	x	---	---	x
<i>Psammobia hornii</i> (Gabb) .....	x	---	---	---	---	---
<i>Solen</i> , sp. ....	x	---	---	---	---	---
<i>Tapes</i> (?) <i>quadrata</i> Gabb .....	x	---	---	---	---	---
<i>Tellina undulifera</i> Gabb .....	x	---	---	---	---	---
<i>Teredo</i> , sp. ....	---	x	---	---	---	---
<i>Dentalium cooperi</i> Gabb .....	x	---	---	---	---	x
<i>Actaeon lawsoni</i> Weaver .....	x	---	---	---	---	---
<i>Anchura englishi</i> , n. sp. ....	x	---	---	---	---	---
<i>Amauropsis martinezensis</i> , n. sp. ....	x	---	x	---	---	---
<i>Architectonica</i> , sp. ....	x	---	---	---	---	---
<i>Cylichna costata</i> Gabb .....	x	---	---	---	---	x
<i>Discohelix californicus</i> Weaver .....	x	---	---	---	---	x
<i>Fusus aequilateralis</i> Weaver .....	x	---	---	---	---	---
<i>Fusus</i> (?) sp., <i>a</i> .....	x	x	---	---	---	---
<i>Fusus flexuosus</i> Gabb .....	x	---	---	---	---	---
<i>Fusus mathewsonii</i> Gabb .....	x	---	x	---	---	---
<i>Fusus martinez</i> Gabb .....	x	---	x	---	---	---
<i>Fusus</i> (?) sp., <i>b</i> .....	x	---	---	---	---	---
<i>Fusus occidentalis</i> Gabb .....	x	---	---	---	---	---
<i>Fusus</i> cf. <i>aratus</i> Gabb .....	x	---	---	---	---	---
<i>Ficopsis</i> , sp. ....	---	x	---	---	---	---
<i>Lunatia hornii</i> Gabb .....	---	---	---	---	---	x
<i>Neptunea mucronata</i> Gabb .....	x	---	---	---	---	---
<i>Natica</i> ( <i>Gyrodes</i> ) <i>lineata</i> , n. sp. ....	x	---	---	---	---	---
<i>Nerita</i> (?) <i>biangulata</i> , n. sp. ....	x	---	---	---	---	---

## TROCHOCYATHUS ZITTELI ZONE OF THE TYPE LOCALITY—(Continued)

	Loc. 500-243	Loc. 333	Loc. 65	Loc. 544	Loc. 267	Loc. 1547
Naticina, sp. ....	x	....	....	....	....	....
Perissolax triearnatus Weaver .....	x	....	....	....	....	....
Ringinella pinguis Gabb .....	....	....	....	....	....	x
Siphonalia(?) lineata Stanton .....	x	....	....	....	....	....
Surcula (Sureulites) andersoni, n. sp. ....	x	....	....	....	....	....
Surcula merriami, n. sp. ....	x	....	....	....	....	x
Turbinella crassatesta Gabb .....	x	....	....	....	....	....
Turris louderbacki, n. sp. ....	x	....	....	....	....	....
Urosyca caudata Gabb .....	x	....	....	....	....	x
Urosyca robusta Weaver .....	x	....	....	....	....	....
Hercoglossa merriami, n. sp. ....	x	....	....	....	....	....
Nautilus stephensoni, n. sp. ....	x	....	....	....	....	....
Shark tooth .....	x	....	....	....	....	....

A comparison of this list with that of the *Trochocyathus zitteli* zone north of Mount Diablo, as might be expected, will bring out some differences. The following are common to the two localities:

Flabellum remondianum Gabb	Ficopsis, sp.
Trochocyathus zitteli (Merriam)	Fusus matthewsonii Gabb
Cardium cooperi Gabb	Neptunea mucronata Gabb
Cucullaea mathewsonii Gabb	Perissolax triearnatus Weaver
Crassatellites stewartvillensis, n. sp.	Siphonalia(?) lineata Swanton
Tapes(?) quadrata Gabb	Surcula merriami, n. sp.
Tellina undulifera Gabb	Turritella pacheoensis Stanton
Teredo, sp.	Urosyca caudata Gabb
Amauropsis martinezensis, n. sp.	Xenophora zitteli Weaver
Cylichna costata Gabb	

Practically all of these species are common forms and, if they occur at all, they are abundant. The lists appear quite different on their face, but this difference is due almost wholly to the occurrence of species of which but single specimens have been found. Thus, among the Fusidae listed from the type locality only two, *Fusus*(?), sp., *a*, and *Fusus martinez* Gabb, are reported from more than one locality, and of the rest only individual specimens have been found thus far. In many of the other cases the same thing is true. *Brachysphingus livatus* Gabb is not reported from the type locality, but it occurs at Selby, which is the same horizon without doubt. A few widespread abundant forms are of more real value than forms which occur occasionally. Thus, *Trochocyathus zitteli* (Merriam), *Amauropsis martinezensis*, n. sp., *Crassatellites stewartvillensis*, n. sp.,

*Neptunea mucronata* Gabb, *Xenophora zitteli* Weaver, do not range into uppermost Martinez and most of these forms occur frequently enough to be useful within certain limits to determine horizons. Since most of these occur in the basal beds north of Martinez such forms will serve to distinguish between the uppermost Martinez and the *Trochocyathus zitteli* zone. Thus far, *Trochocyathus zitteli* (Merriam) is the most useful fossil in the recognition of the middle zone of the Martinez. The middle zone of the type section resembles the middle zone of the area north of Mount Diablo in the ratio of gastropods to pelecypods, which is approximately 4:3.

The absence of certain species which occur in the basal beds north of Mount Diablo is another noteworthy point. Practically the list cited above in the comparison of the basal and middle zones north of Mount Diablo holds here as well. Such is the evidence for correlating the two *Trochocyathus zitteli* beds in these two areas. In the opinion of the writer they appear to be of approximately the same age.

The uppermost or *Solen stantoni* zone was first described by Weaver, although Merriam previously suggested a faunal difference between the upper and lower beds. Weaver lists the following from this zone:

## UPPER MARTINEZ

Foraminifera nummuloid	Perissolax blakei Gabb
Schizaster lecontei Merriam	Solen stantoni Weaver
Cancer, sp.	Tellina martinezensis Weaver
Arca biloba Weaver	Tellina hornii Gabb
Cardita hornii Gabb	Tellina undulifera Gabb
Cardium cooperi Gabb	Thracia karquinezensis Weaver
Cucullaea mathewsonii Gabb	Ampullina (conf.) striata Gabb
Leda gabbi Conrad	Brachysphingus liratus Gabb
Modiolus merriami (Weaver)	Bullinula subglobosa Weaver
Modiolus ornatus (Gabb)	Siphonalia (?), lineata Stanton
Dentalium cooperi Gabb	Architectonica tuberculata Weaver
Dentalium stramineum Gabb	Strepsidura pacheocoensis Stanton
Ficopsis angulatus Weaver	Tritonium impressum Weaver
Heteroterma gabbi Stanton	Tritonium pulchrum Weaver
Heteroterma trochoidea Gabb	Tritonium eocenium Weaver
Heteroterma, indet.	Turritella infragranulata Gabb
Megistostoma striata Gabb	Turritella pacheocoensis Stanton
Cassidaria tuberculata (Gabb)	Turritella conica Weaver
Natica, sp.	Turris, sp. indet.
Perissolax tricarnatus Weaver	Urosyca caudata Gabb

Of these forms *Tellina martinezensis*, *Bullinula subglobosa*, *Heteroterma trochoidea*, *Megistostoma striata*(?), *Architectonica tuberculata*,

*Strepsidura pachecoensis*, *Tritonium pulchrum*, and *Turritella conica* have not as yet been found in a lower horizon. *Ficopsis angulatus*, *Cassidaria tuberculatus*, *Tritonium impressum*, *Tritonium eocenicum*, also reported as not present in the lower beds, were really found in beds just above the Martinez, that is, in the basal Tejon. All of these forms come from University of California Locality 337, where they are associated with:

Nummuloid(?), sp.	Bela cf. clathrata Gabb
Orbitoides, sp.	Ficopsis remondii Gabb
Schizaster lecontei Merriam	Megistostoma striata Gabb
Cardium cooperi Gabb	Cassidaria tuberculata (Gabb)
Modiolus merriami (Weaver)	Rimella canalifera Gabb
Psammobia hornii (Gabb)	Spiroglyphus(?) tejonensis Arnold
Tellina martinezensis Weaver	Turris monolifera Cooper
Solen parallelus Gabb	Tritonium eocenicum Weaver
Venericardia planicosta Lamarck	

Of these forms *Rimella canalifera*, *Venericardia planicosta*, var. *hornii*, *Bela clathrata*, *Megistostoma striata*, *Cassidaria tuberculata*, *Turris monolifera* and *Spiroglyphus(?) tejonensis* are, as far as the writer knows, typical Tejon forms and they all occur in the basal beds of the Tejon south of Mount Diablo. The others, except the unplaced species described by Weaver, are all found in the Tejon. *Ficopsis angulatus* Weaver is not a valid species but a variety of *F. remondii* Gabb, and along with this we must regard the others as Tejon forms from its lower portion.

*Thracia karquinezensis* Weaver was found at University of California Locality 532, which is on the same horizon as 537. Its associates were *Perissolax*, n. sp., and *Solen stantoni* Weaver. Although *Solen stantoni* Weaver is not wholly restricted to the uppermost Martinez, it is a characteristic and abundant form of this horizon. One specimen has been found in the basal beds of the Martinez and it also occurs in the Tejon near the base in the Muir syncline.

Below is given a revised list of the fauna of the upper Martinez, or the *Solen stantoni* beds.

REVISED LIST OF SPECIES OF SOLEN STANTONI ZONE

	Loc. 213-501	Loc. 541	Loc. 1828	Listed by Weaver
Flabellum remondianum Gabb .....	....	....	....	×
Schizaster lecontei Merriam .....	....	....	....	×
Cucullaea mathewsonii Gabb .....	×	....	....	....
Cardium cooperi Gabb .....	×	....	....	....
Leda gabbi Conrad .....	×	....	....	....

## REVISED LIST OF SPECIES OF SOLEN STANTONI ZONE—(Continued)

	Loc. 213-501	Loc. 541	Loc. 1828	Listed by Weaver
Meretrix, sp. ....	---	---	X	---
Modiolus ornatus (Gabb) .....	X	---	---	---
Modiolus merriami (Weaver) .....	---	---	---	X
Nucula (Acila) truncata Gabb .....	---	---	---	X
Pholadomya nasuta Gabb .....	---	---	X	---
Psammobia(?) cylindrica, n. sp. ....	---	---	X	---
Psammobia hornii (Gabb) .....	---	X	---	---
Solen stantoni Weaver .....	X	---	X	---
Solen, sp. ....	X	---	---	---
Tellina martinezensis Weaver .....	---	---	---	✓
Tellina undulifera Gabb .....	X	---	---	---
Tellina aequalis Gabb .....	X	---	---	---
Teredo, sp. ....	---	---	X	---
Ampullina cf. striata Gabb .....	---	---	---	X
Architectonica tuberculata Weaver .....	---	X	---	---
Brachysphingus liratus Gabb .....	X	---	---	---
Bullinula subglobosa Weaver .....	X	---	---	---
Cylichna costata Gabb .....	---	---	X	---
Dentalium cooperi Gabb .....	X	---	---	---
Dentalium stramineum Gabb .....	---	---	---	X
Fusus occidentalis Gabb .....	X	---	---	---
Fusus mathewsonii Gabb .....	X	---	---	---
Fusus aequalateralis Gabb .....	X	---	---	---
Heteroterma gabbi Stanton .....	X	---	---	---
Heteroterma trochoidea Gabb .....	X	---	---	---
Heteroterma, indet. ....	---	---	---	X
Lunatia, sp. ....	X	---	---	---
Lunatia hornii Gabb .....	---	---	X	---
Megistostoma(?), sp. Gabb .....	---	X	---	---
Perissolax tricarnatus Weaver .....	---	---	---	X
Siphonalia(?) lineata Stanton .....	X	---	X	---
Strepsidura pachecoensis Stanton .....	X	X	---	---
Tritonium pulchrum Weaver .....	---	X	---	---
Turritella infragranulata Gabb .....	X	---	---	---
Turritella pachecoensis Stanton .....	---	---	X	---
Turritella conica Weaver .....	---	X	---	---
Turris, sp., indet. ....	---	---	---	X
Urosyca caudata Gabb .....	X	---	---	---

But one specimen each of *Architectonica tuberculata* Weaver, *Bullinula subglobosa* Weaver and *Megistostoma(?)*, sp. Gabb have been found in these upper beds. The number of guide fossils is really very small. *Solen stantoni* has not been found in the *Trochocyathus zitteli* zone, but it is reported from the basal beds north of Mount Diablo. *Strepsidura pachecoensis* Stanton and *Turritella conica* Weaver appear to be the only others which are restricted to this horizon. The absence

of several species which occur in the middle or *Trochocyathus zitteli* zone is the noteworthy feature of the *Solen stantoni* beds. Among these are *Trochocyathus zitteli* (Merriam), *Crassatellites unioides* Stanton, *Glycimeris veatchii* var. *major* (Stanton), *Leda alaeformis* (Gabb), *Meretrix stantoni*, n. sp., *Paphia* (?) *clarki*, n. sp., *Amauropsis martinezensis*, n. sp., *Discohelix californica* Weaver, *Neptunea cretacea* Gabb, and *Xenophora zitteli* Weaver.

#### MARTINEZ AT BENICIA

The Martinez at Benicia is a continuation of the eastern limb of the Muir syncline, a portion of the type section. The best exposures are found in the Arsenal Grounds. Basal beds of the Martinez are exposed in a rock quarry about one hundred yards west of the Arsenal Reservoir Hill. They are composed of about twenty feet of conglomerate, upon which is laid about fifty feet of fine-grained white foraminiferal shale with strike N 60° W, dip 55° W. Unfortunately minor faulting has so complicated the structure that the relation to the underlying Chico is not clear. The basal beds are non-fossiliferous, but the glauconitic sandstone beds one thousand feet above the base contain fossils.

The following species have been reported from this locality:

<i>Flabellum remondianum</i> Gabb	<i>Tapes</i> (?) <i>quadrata</i> Gabb
<i>Terebratulina tejonensis</i> Stanton	<i>Tellina</i> (?) <i>undulifera</i> Gabb
<i>Cucullaea mathewsonii</i> Gabb	<i>Tellina</i> (?) , sp. <i>a</i>
<i>Glycimeris veatchii</i> var. <i>major</i> (Stanton)	<i>Actaeon lawsoni</i> Weaver
<i>Leda gabbi</i> Conrad	<i>Ampullina</i> (conf.) <i>striata</i> Gabb
<i>Leda alaeformis</i> (Gabb)	<i>Brachysphingus liratus</i> Gabb
<i>Meretrix</i> cf. <i>dalli</i> , n. sp.	<i>Discohelix californica</i> Weaver
<i>Meretrix</i> , sp.	<i>Natica</i> , sp.
<i>Meretrix stantoni</i> , n. sp.	<i>Perissolax tricarnatus</i> Weaver
<i>Nucula truncata</i> Gabb	<i>Turbinella crassatesta</i> Gabb
<i>Phacoides diaboli</i> , n. sp.	<i>Turritella infragranulata</i> Gabb
<i>Pholadomya nasuta</i> Gabb	<i>Urosyca caudata</i> Gabb

*Cassidaria tuberculata* was in the old collections made by Dr. Weaver, but it may have been mixed in from a Tejon collection. Its sandstone matrix appears different from the Martinez sandstone.

All of the other forms occur in the *Trochocyathus zitteli* zone either at the type locality or in the area north of Mount Diablo. *Meretrix stantoni*, n. sp., *Meretrix dalli*, n. sp., *Tellina*, n. sp., *a*, *Discohelix californica*, *Turbinella crassatesta*, *Terebratulina tejonensis*, *Glycimeris*

*veatchii* var. *major*, *Leda alaeformis*, *Actaeon lawsoni* do not occur in the uppermost Martinez. Although the fauna is small, it appears sufficient to correlate it with the *Trochocyathus zitteli* zone of the type section. Dr. Stanton<sup>21</sup> reports the following fauna from beds "several hundred feet higher in the section":

Modiolus ornatus (Gabb)	Fusus flexuosus Gabb
Glycimeris sagittata (Gabb)?	Turritella infragranulata Gabb
Nucula truncata Gabb	Brachysphingus liratus Gabb
Meretrix, sp.	Cylichna costata Gabb
Tellina(?) undulifera Gabb	Actaeon, sp.
Tellina hoffmaniana Gabb	

This fauna comes from the upper beds. The Martinez exposed along the Carquinez Strait probably includes the three major zones. The lack of fossils makes it a poor section for the palaeontologist, but for the geologist is one of the best in the vicinity.

#### MARTINEZ AT SELBY SMELTER

This locality was discovered by Robert Pack and Clark Gester while students in the University of California. J. R. Powers made thorough collections in both the Chico and the Martinez near the Southern Pacific tunnel. The writer has identified most of the material collected at this locality (no. 1888).

#### LIST OF SPECIES

Flabellum remondianum Gabb	Amauropsis martinezensis, n. sp.
Trochocyathus zitteli (Merriam)	Brachysphingus liratus Gabb
Schizaster lecontei Merriam	Dentalium cooperi Gabb
Cucullaea mathewsonii Gabb	Fusus(?), n. sp.
Cardium cooperi Gabb	Fusus(?), sp.
Glycimeris, sp.	Heteroterma gabbi Stanton
Leda gabbi Conrad	Perissolax tricarnatus Weaver
Nucula (Acila) truncata Gabb(?)	Surcula near praeattenuata Gabb
Ostraea weaveri, n. sp.	Surcula (Surculites) inconspicua Gabb
Phacoides turneri (Stanton)	Surcula merriami, n. sp.
Solen, sp.	Turritella, sp.
Tellina kewi, n. sp.	Urosyca caudata Gabb
Tellina, sp.	Urosyca robusta Weaver
Serpula, sp.	

This fauna evidently belongs to the *Trochocyathus zitteli* zone. As in nearly all new Martinez localities, new or unplaced forms occur here, such as *Surcula* near *praeattenuata* Gabb, *Surcula*

<sup>21</sup> Stanton, T. W., The Faunal Relations of the Eocene and Upper Cretaceous on the Pacific Coast, 17th Ann. Rept. U. S. Geol. Surv., p. 1024, 1895-6.



(*Surculites*) *inconspicua* Gabb, *Ostrea weaveri*, n. sp., *Tellina kewi*, n. sp. This fauna was found in gray-green glauconitic sandstone typical of the *Trochocyathus zitteli* zone. Although Chico fossils have been found only a short distance away, no basal Martinez beds appear. Evidently they were covered by the overthrust of the Chico upon them. The Martinez sandstone containing fossils at Selby Smelter is one or two hundred feet thick. Above this lie four or five hundred feet of gray-green foraminiferal shale with a little interbedded sandstone. This shale is in turn overlain unconformably by the Monterey. Whether this shale at the contact is Tejon or Martinez is difficult to determine, as it has thus far yielded only poorly preserved foraminifers. Good exposures are not common in this vicinity and the structure is complicated. One-quarter of a mile south of Selby, and about two hundred feet from the Eocene-Monterey contact, the writer found *Urosyca caudata* and one or two other Martinez species in sandstone exposed in a road cut. This leaves but two hundred feet of strata which could be assigned to the Tejon at this place. Since no Tejon has been found along the Monterey contact for several miles to the south, it appears that the shales underlying the Monterey are probably Martinez.

#### MARTINEZ AT LOWER LAKE, LAKE COUNTY

##### TRANSITIONARY BEDS OF GABB

Gabb<sup>22</sup> referred to the Transitional Beds of Lower Lake as furnishing some of the most important evidence indicating the continuity between his "Cretaceous A" and "Cretaceous B." That author stated that he found at a "locality near Clear Lake . . . within a space of two feet . . . an admixture of upper and lower forms proving the existence of a transitional bed or group of beds."

Although geologists of the present day do not accept his view we shall see in the discussion which follows that Gabb appreciated the peculiarities of the fauna found here. His keen vision is particularly worthy of note when we remember that he had no libraries or collections containing comparative material to consult. A virgin field was his, with all the difficulties that usually confront the pioneer in science.

<sup>22</sup> Gabb., W. M., Proc. Cal. Acad. Nat. Sci., vol. 3, p. 302, 1866.

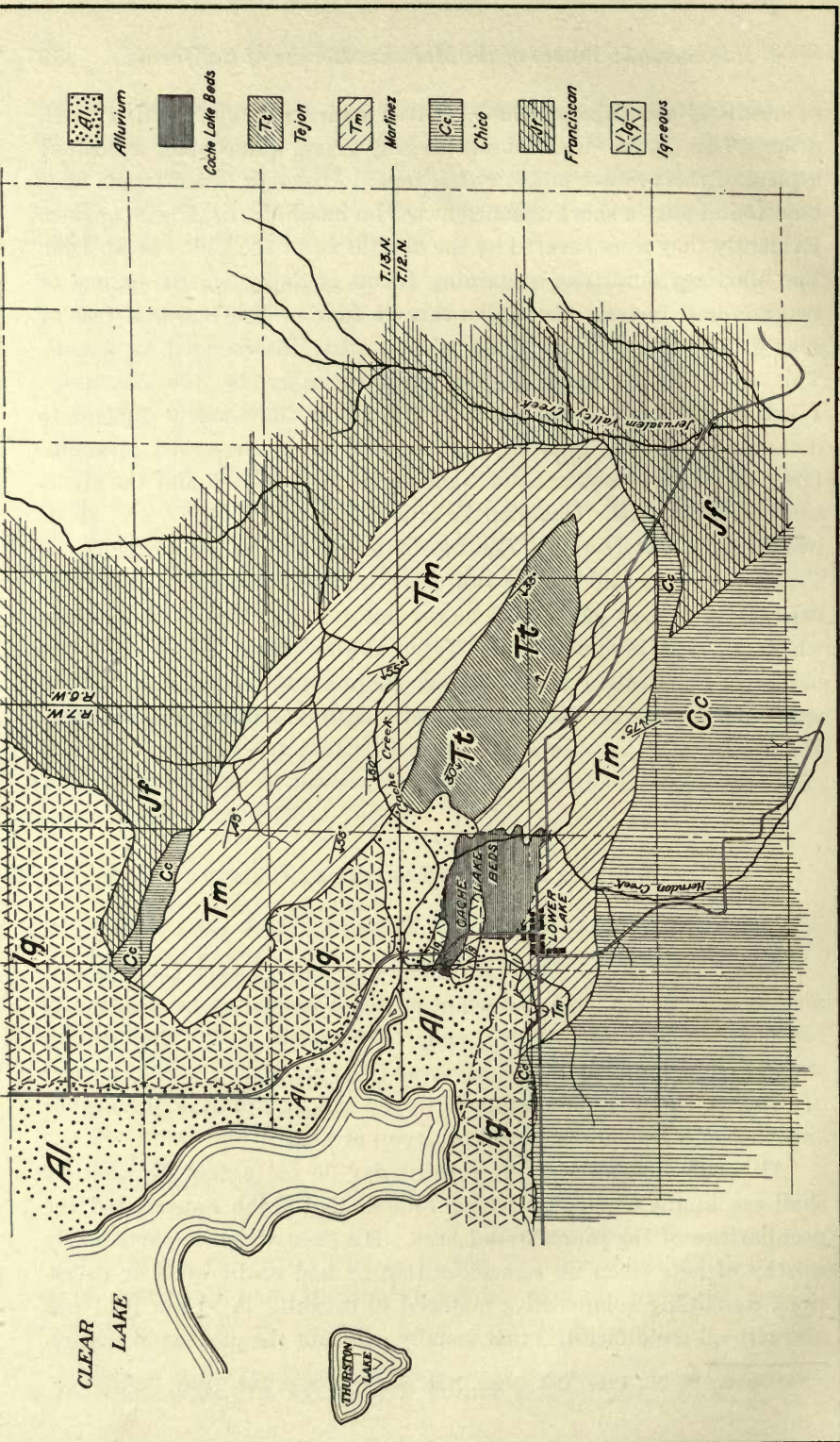


Fig. 4. A sketch map showing the areal distribution of the Martinez and the formations in contact with it near Lower Lake, Lake County, California. Scale,  $\frac{3}{4}$  inch = 1 mile.

## STANTON'S DISCUSSION OF THE FAUNA

Stanton<sup>23</sup> visited the Lower Lake locality in 1895. He described it as follows:

Another important locality is near the village of Lower Lake, in Lake County about 75 miles north of San Francisco, where Gabb reported the discovery of intermediate beds which showed a commingling of the Chico and Tejon faunas in a single thin stratum. Gabb's list of fossils from one mile southeast of Lower Lake is as follows:

<i>Avicula pellucida</i> Gabb	<i>Gyrodes expansa</i> Gabb
<i>Lima multiradiata</i> Gabb	<i>Lunatia shumardiana</i> Gabb
<i>Axinaea veatchi</i> Gabb	<i>Galerus excentricus</i> Gabb
<i>Cucullaea mathewsonii</i> Gabb	<i>Spirocrypta pileum</i> Gabb
<i>Crassatella grandis</i> Gabb	<i>Brachysphingus liratus</i> Gabb
<i>Tapes conradiana</i> Gabb	<i>Perissolax brevirostris</i> Gabb
<i>Corbula alaeformis</i> Gabb	<i>Fusus californicus</i> Gabb
<i>Turritella saffordi</i> Gabb	<i>Fasciolaria laeviuscula</i> Gabb
<i>Amauropsis alveata</i> (Conrad)	

Considerable collections were made by me [Stanton] from the original locality on Herndon Creek, and also from material taken from a well at an old brickyard one-fourth mile nearer town, but on the same horizon. The following species were obtained:

<i>Flabellum remondianum</i> Gabb? fragment	<i>Solen parallelus</i> Gabb
<i>Terebratulina tejonensis</i> Stanton	<i>Dentalium cooperi</i> Gabb
<i>Plicatula ostreaformis</i> Stanton	<i>Patella</i> , sp.
<i>Lima multiradiata</i> Gabb	<i>Turritella pachecoensis</i> Stanton = <i>T. saffordi</i> Gabb
<i>Perna</i> , sp.	<i>Turritella martinezensis</i> Gabb
<i>Modiola ornata</i> Gabb	<i>Turritella infragranulata</i> Gabb
<i>Cucullaea mathewsonii</i> Gabb	<i>Lunatia hornii</i> Gabb
<i>Pectunculus veatchi</i> , var. major Stanton	<i>Ampullina striata</i> Gabb
<i>Leda gabbi</i> Conrad	<i>Galerus excentricus</i> Gabb
<i>Leda alaeformis</i> Gabb = <i>Corbula</i> <i>alaeformis</i>	<i>Cerithiopsis alternata</i> Gabb
<i>Crassatella unioides</i> Stanton	<i>Brachysphingus liratus</i> Gabb
<i>Venericardia planicosta</i> Lamarck	<i>Urosyca caudata</i> Gabb
<i>Lucina turneri</i> Stanton	<i>Heteroterma gabbi</i> Stanton
<i>Meretrix</i> , sp.	<i>Heteroterma striata</i> Stanton
<i>Tellina hornii</i> Gabb?	<i>Siphonalia</i> (?) <i>lineata</i> Stanton
<i>Tellina aequalis</i> Gabb	<i>Cypraea bayerquei</i> Gabb
<i>Tellina hoffmaniana</i> Gabb	<i>Actaeon</i> , sp.
	<i>Cylichna costata</i> Gabb?

While this list contains several species that have not been found elsewhere, it also contains a large proportion of the most characteristic forms of the lower Tejon at Benicia (Army Point) and near Pacheco, so that there

<sup>23</sup> Stanton, T. W., The Faunal Relations of the Eocene and Upper Cretaceous on the Pacific Coast, 17th Ann. Rept. U. S. Geol. Surv., p. 1024, 1895-6.

can be no doubt that practically the same horizon is represented at all three places. Chico species, with the exception of forms that appear to be specifically identical with *Pectunculus veatchi* and *Tellina hoffmaniana*, are absent. One of the forms which I have referred to *Heteroterma* was probably identified by Gabb as *Perissolax brevirostris*, and his *Gyrodes expansa* was probably also an erroneous identification.

The palaeontological evidence, therefore warrants the reference of the "intermediate beds" to the lower part of the Tejon as it is developed in the Mount Diablo region, where some localities of the same zone must have been included in Gabb's Martinez Group.

Owing to the absence of other recognizable horizons, the stratigraphy of the Lower Lake region adds little to our knowledge of the position of the zone. The fossils enumerated above occur not more than 300 to 400 feet north of the southern edge of a belt about two miles wide, consisting largely of light-colored sandstones with some beds of clay and bands of conglomerate. The strike is nearly east and west, and the dip is very high, often vertical. South of this sandstone there are heavy beds of crumpled clay shales with thin sandstones and occasional calcareous lenses. These are doubtless of Cretaceous age, but in the absence of fossils their exact horizon could not be determined. Precisely similar beds occur on the north side of the sandstone belt at a locality on the north side of Cache Creek about two and a half miles northwest of Lower Lake, and some 400 feet within the sandstone belt a number of the Lower Tejon species were found, including

*Ostrea appressa* Gabb  
*Perna*, sp.  
*Leda alaeformis* (Gabb)  
*Meretrix*, sp.

*Tellina*, sp.  
*Dentalium cooperi* Gabb  
*Turritella pachecoensis* Stanton  
*Natica*, sp.  
*Ancillaria*, sp.

This locality is about two miles across the strike from the localities that yielded the larger collection from the same horizon. It is evident that we have here a closely folded syncline, the rocks between the two localities of Lower Tejon probably having a thickness of 3000 or 4000 feet. The few fossils that have been found in the intervening beds include an *Ostrea*, a *Natica*, and *Crassatella uvasana* Conrad, the latter being an upper Tejon species. Possibly there are later beds in the middle of the fold, but it is more probable that the entire thickness belongs to the Tejon.

#### STRATIGRAPHY AND STRUCTURE

Dr. Weaver later visited the Lower Lake section and made a collection of fossils from the locality on Herndon Creek. In August, 1912, Packard and Dickerson, while collecting fossils for the Department of Palaeontology of the University of California, made a stratigraphic study of the Eocene series and the beds in contact with them. The accompanying map (fig. 4) was made at that time. The Eocene in this region is folded in a plunging asymmetric syncline with an east-west axis which is located nearer to the steeply dipping south limb

of the fold. This syncline plunges toward the west. Both the Tejon and Martinez are found in this fold. The Martinez rests upon the Chico, Knoxville, and Franciscan and on the west it is overlapped by the later "Cache Lake" beds, andesitic lava flows, and alluvium.

The Franciscan in this region consists of a typical complex of diabase, radiolarian cherts, seamed quartzitic sandstone, fine-grained, dark gray schists, and bedded foraminiferal limestones. Serpentine is intruded as small dikes in the sedimentaries. This series appears to be in fault contact with the Chico on the south side of the syncline described above and the Martinez appears to rest upon it unconformably.

A small area of Knoxville appears in contact with Martinez on the extreme eastern limit of the Martinez area. It consists of a dark gray limestone and shale containing well-preserved specimens of *Aucella piochii* Gabb. The main Chico area borders the Martinez on the south. It consists of a laminated, dark gray sandstone weathered to yellow brown, dark gray shale with limestone strata or limy concretions and minor strata of micaceous, carbonaceous, brown sandstone interbedded with it. The only fossils found in it were *Chione varians* (Gabb) and a *Pecten*, n. sp., obtained at University of California Location 783, three-quarters of a mile west of Lower Lake. Structurally the Chico is folded in many minor plications and shows complex twisting and faulting. The lower Martinez can be readily distinguished from the underlying Chico by great differences in lithology and structure. The lower Martinez consists of medium-grained, hard sandstone containing grains of hornblende, quartz and biotite. It has a peculiar velvety luster which may be due to secondary silica. Structurally the Martinez is not faulted, nor has it been folded and contorted like the underlying Chico. In the bed of Herndon Creek near the contact with the Chico it has a strike of N 50° W, while that of the Chico is N 65° W. The basal Martinez appears to overlie the Chico, Knoxville and Franciscan indifferently and without doubt it is unconformable upon all of them. Differences in strike, in the amount of folding and crushing, in fauna and in areal distribution between the Martinez and the underlying Chico, Knoxville and Franciscan lead us to the above conclusion. The great thickness of the Martinez in this region is noteworthy. A measured section down Herndon Creek shows that the basal Martinez consists of 1200 feet of medium gray sandstone. This is overlain by 500 feet of fine, massive, tan-colored sandstone flecked with black grains. No exposures of Martinez are found for

one thousand feet, but Cache Lake beds of fine-grained argillaceous sandstone and gray sandstone with gray shale, strike N 30° E and dip 20° E, unconformably overlie the Martinez. An outcrop of Martinez one hundred feet thick which yielded *Pholadomya nasuta*, *Dentalium cooperi*, *Schizaster lecontei*, and *Modiolus ornatus* is next found. These beds are composed of fine-grained, massive sandstone dipping northward. Five hundred feet down the creek from this point similar beds about one hundred feet thick appear with a high dip to the north. Even in this partial section we have at least 3500 feet of Martinez strata present. That this is not complete is seen when we study the upper portion of the Martinez on the other limb of the syncline. At least three hundred to five hundred feet of gray-green shales lie above the last-mentioned fine-grained tan sandstone at this place. A minimum estimate is between thirty-eight hundred and four thousand feet for the total thickness of these beds.

A small area of the Cache Lake formation which was originally described by Becker<sup>24</sup> is found unconformably overlying the Martinez north and east of Lower Lake village. It is best observed in Herndon Creek, where its fine-grained, argillaceous sandstones and gray shales have a dip of 15°–20° E. Near the mouth of Herndon Creek are seen about two hundred feet of a coarse gray tuff which appears to be the uppermost portion of these fresh-water beds. The tuff beds are folded in an asymmetric syncline, the south limb of which dips 60° to the north. The total thickness of these beds appears to be from seven hundred to eight hundred feet. The Cache Lake beds, like the Martinez, are cut off on the west by andesitic lava flows which appear to overlie them. According to Stearns, who determined the fresh-water fossils found in these beds by Becker, they are of Pliocene age.

Rocks of Tejon age occupying an elliptical area two and one-half miles long on the eastern portion of the Lower Lake syncline rest upon the Martinez. Coarse gray to white, conglomeritic concretionary sandstone which gives rise to bluffs make up practically its entire thickness, 1100 to 1200 feet. It is lithologically distinct from the uppermost Martinez which consists of thin-bedded, fine-grained, green-gray sandstone with green shales. No sharp contacts between the Martinez and Tejon were found and hence their relations to one another are not entirely clear. The dips in the Tejon vary from 30° to 35°, while those of the Martinez are, on the whole much higher.

<sup>24</sup> Becker, G. F., Geology of the Quicksilver Deposits of the Pacific Slope, Monograph 13, U. S. Geological Survey, pp. 219–221, 1888.

This, taken together with a distinct faunal break and abrupt lithological change, leads us to believe that a considerable time-interval elapsed between the deposition of these two groups of the Eocene. Only two fossil localities were found in the Tejon. The following fauna was found at University of California Locality 785:

Crassatellites cf. uvasana (Gabb)	Drillia, n. sp.
Dosinia elevata Gabb	Fusus californicus Gabb
Spisula, n. sp.	Fusus, sp.
Meretrix ovalis Gabb	Lunatia hornii Gabb
Meretrix, sp.	Naticina obliqua Gabb
Meretrix hornii Gabb	Neverita globosa Gabb
Psammobia hornii (Gabb)	Surecula (sureulites) cf. sinuata Gabb
Solen parallelus Gabb	Tritonium whitneyi Gabb
Tapes cf. cretacea Gabb	Whitneya ficus Gabb
Tellina longa Gabb	Serpula, sp.
Bulla hornii Gabb	Shark (?) tooth
Cancellaria marysvillensis Dickerson	

Of the forms listed above, *Dosinia elevata* Gabb, *Meretrix ovalis* Gabb, *Solen parallelus* Gabb, *Tellina longa* Gabb, *Bulla hornii* Gabb, *Cancellaria marysvillensis* Dickerson, *Fusus californicus* Gabb, *Naticina obliqua* Gabb, *Neverita globosa* Gabb, *Tritonium whitneyi* Gabb, and *Whitneya ficus* Gabb are as far as known entirely typical of the Tejon.

#### FAUNA OF THE MARTINEZ AT LOWER LAKE

The preservation of the fossils in the Martinez near Lower Lake is better than at most localities and their abundance at a few localities make the collections from this place particularly valuable. Most of the fossils were found in strata approximately five hundred to a thousand feet above the base of this group. The following list of species collected from these beds appear to belong in the same faunal zone:

#### LIST OF SPECIES

	Loc. 784	Loc. 790	Listed by Stanton
Stylophora(?), sp. ....	....	×	....
Flabellum remondianum Gabb .....	....	....	×
Cidarid, sp. ....	....	×	....
Cidarid merriami Arnold .....	×	....	....
Membranipora(?), sp. ....	....	×	....
Rhynconella(?), sp. ....	×	....	....
Terebratulina tejonensis Stanton .....	×	×	×
Crassatellites unioides (Stanton) .....	....	×	×

## LIST OF SPECIES—(Continued)

	Loc. 784	Loc. 790	Listed by Stanton
<i>Crassatellites grandis</i> (?) (Gabb) .....	---	×	---
<i>Cucullaea mathewsonii</i> Gabb .....	×	×	×
<i>Glycimeris veatchii</i> , var. <i>major</i> (Stanton).....	×	×	×
<i>Leda gabbi</i> Conrad .....	×	×	×
<i>Leda alaeformis</i> (Gabb) .....	×	×	×
<i>Leda packardi</i> , n. sp. ....	×	×	---
<i>Lima multiradiata</i> Gabb .....	---	×	×
<i>Lucina</i> , sp. ....	×	---	---
<i>Lucina turneri</i> Stanton .....	×	×	×
<i>Martesia</i> (?), sp. ....	×	---	---
<i>Mactra</i> (?) <i>tenuissima</i> Gabb .....	×	×	---
<i>Macrocallista</i> (?), <i>packi</i> , n. sp. ....	×	---	---
<i>Meretrix stantoni</i> , n. sp. ....	×	×	×
<i>Meretrix dalli</i> , n. sp. ....	×	×	---
<i>Modiolus ornatus</i> Gabb) .....	×	×	×
<i>Ostraea buwaldana</i> , n. sp. ....	×	×	---
<i>Ostraea weaveri</i> , n. sp. ....	---	×	---
<i>Perna</i> , sp. ....	---	---	×
<i>Pecten</i> , sp. ....	---	×	---
<i>Paphia</i> (?) <i>elarki</i> , n. sp. ....	×	×	---
<i>Plicatula ostreaformis</i> Stanton .....	---	×	×
<i>Phacoides quadrata</i> , n. sp. ....	×	---	---
<i>Psammobia hornii</i> (Gabb) .....	×	×	×
<i>Solen parallelus</i> Gabb .....	---	---	×
<i>Solen</i> , sp. ....	×	×	---
<i>Tapes</i> cf. <i>quadrata</i> Gabb .....	×	---	---
<i>Tellina</i> (?) <i>undulifera</i> Gabb .....	---	×	---
<i>Tellina kawi</i> , n. sp. ....	×	×	---
<i>Tellina herndonensis</i> , n. sp. ....	×	---	---
<i>Tellina packardi</i> , n. sp. ....	×	×	---
<i>Tellina perrini</i> , n. sp. ....	×	---	---
<i>Tellina</i> cf. <i>parilis</i> Gabb .....	×	×	---
<i>Tellina</i> , sp., <i>a</i> .....	---	×	---
<i>Tellina aequalis</i> Gabb .....	---	---	×
<i>Tellina</i> , sp., <i>b</i> .....	---	---	---
<i>Venericardia planicosta</i> Lam. ....	---	---	×
<i>Venus</i> (?), sp. ....	---	×	---
<i>Yoldia gesteri</i> , n. sp. ....	×	×	---
<i>Ampullina striata</i> Gabb .....	---	---	×
<i>Acmaea martinezensis</i> , n. sp. ....	---	×	---
<i>Actaeon</i> , sp. ....	---	---	×
<i>Amauropsis</i> cf. <i>martinezensis</i> , n. sp. ....	×	---	---
<i>Brachysphingus liratus</i> Gabb .....	×	×	×
<i>Certhiopsis alternata</i> Gabb .....	---	×	×
<i>Cylichna costata</i> Gabb .....	---	×	×
<i>Cylichna</i> , sp. ....	---	×	---
<i>Cypraea bayerquei</i> Gabb .....	---	---	×
<i>Dentalium cooperi</i> Gabb .....	---	×	×



## LIST OF SPECIES—(Continued)

	Loc. 784	Loc. 790	Listed by Stanton
Dentalium stramineum Gabb .....	X	X	....
Dentalium, sp. ....	....	X	....
Fusus dumblei, n. sp. ....	....	X	....
Galerus excentricus Gabb .....	....	X	X
Heteroterma gabbi Stanton .....	....	....	X
Heteroterma, sp. ....	....	X	....
Heteroterma striata Stanton .....	X	....	X
Lunatia hornii Gabb .....	X	X	X
Lunatia cf. nuciformis Gabb .....	....	X	....
Lunatia, sp., a .....	....	X	....
Natica (Gyrodos) lineata, n. sp. ....	X	X	....
Neptunea, sp. ....	....	X	....
Natica, sp., e .....	....	X	....
Patella, sp. ....	....	....	X
Perissolax tricarnatus Gabb .....	....	X	....
Ringinella pinguis Gabb .....	X	X	....
Siphonalia(?) lineata Stanton .....	X	X	X
Seraphs(?) thompsoni, n. sp. ....	....	X	....
Tritonium buwaldi, n. sp. ....	....	X	....
Turritella pachecoensis Stanton .....	....	....	X
Turritella martinezensis(?) Gabb .....	....	....	X
Turritella infragranulata Gabb .....	....	....	X
Urosyca caudata Gabb .....	X	X	X
Urosyca robusta Weaver .....	X	....	....
Shark tooth .....	....	X	....

A comparison of the fauna listed above with that of our reference zones at Mount Diablo and the type locality brings out at once a striking resemblance between it and that of the basal beds north of Mount Diablo. Both are inshore deposits. This is shown both by the nature of the sediments which constitute them and the character of the included faunas. The ratio of gastropods to pelecypods is about 2:4½ in the above fauna. Not only is this true in the number of different species but a census shows that pelecypods flourished in the waters of the shallow Martinez sea of this time better than the gastropods. Out of this total fauna of sixty-four species, the following species have not been found in the *Meretrix dalli* zone north of Mount Diablo or in higher strata:

Stylophora(?), sp.	Tellina cf. parilis Gabb(?)
Rhynchonella, sp.	Venus(?), sp.
Ostrea buwaldana, n. sp.	Yoldia gesteri, n. sp.
Pecten, sp.	Martesia(?), sp.
Plicatula ostreaformis Stanton	Acmaea martinezensis, n. sp.
Phacoides quadrata, sp.	Seraphs(?) thompsoni, n. sp.
Tellina packardi, n. sp.	Tritonium buwaldi, n. sp.
Tellina perrini, n. sp.	

Of these most are new species, the types of which in several cases are the only ones thus far found. The ratio of Tejon forms in this fauna is about 15 to 80 while that of the *Meretrix dalli* beds is 14 to 80. Most of the Tejon forms which range downward belong to the same species in both cases. In other words, they are the persistent forms. It is thus apparent that this fauna is nearly the equivalent of the *Meretrix dalli* zone in the area north of Mount Diablo. Since it is found five hundred to a thousand feet above the base of the Martinez at Lower Lake, it is evident that we have strata at Lower Lake which are considerably lower than any other Eocene known in the state. The writer is inclined to believe that the fauna above listed is slightly lower than that of the *Meretrix dalli* zone of the Mount Diablo region. This impression is gathered in part from the aspect of the new forms mentioned above and the possible occurrence of two *Tellinas* which may occur in the Chico. The specimen listed as *Tellina* cf. *parilis* Gabb seems to be identical with Gabb's description and figure. The specimens of *Tellina herndonensis*, n. sp., agree with one of Gabb's figures of *T. hoffmaniana* in volume I of the *Palaeontology of California*, but he unfortunately confused this species. The figure in volume I does not agree with his figure for this species in volume II. *Rhynconella* (?), sp., also lends a Cretaceous aspect to the fauna. The absence of *Pholadomya nasuta* Gabb from the lower zone and its presence in strata a thousand feet above is noteworthy. Of all forms in the Martinez *Pholadomya nasuta* is one of the most widely ranging, both stratigraphically and geographically, and we should expect to find it in a Martinez fauna as well-preserved as this.

The upper and middle portions of the Martinez at Lower Lake are but sparingly fossiliferous. *Schizaster lecontei* Merriam, *Turritella pachecoensis* Stanton, *Ostrea weaveri*, n.sp., which were found at University of California Locality 782, are the only fossils which were found in the middle of the Martinez section exposed at Lower Lake.

The following species were obtained from the upper beds:

FAUNA OF THE UPPER MARTINEZ

	Loc. 788	Loc. 779	Loc. 782	Loc. 787	Loc. 780
<i>Schizaster lecontei</i> Merriam .....	x	....	....	....	....
<i>Cucullaea mathewsonii</i> Gabb .....	....	x	....	....	....
<i>Leda gabbi</i> Conrad .....	....	x	....	....	....
<i>Leda alaeformis</i> (Gabb) .....	....	....	....	x	....
<i>Leda packardi</i> , n. sp. ....	....	....	x	....	....
<i>Modiolus ornatus</i> (Gabb) .....	x	....	....	....	....

## FAUNA OF THE UPPER MARTINEZ—(Continued)

	Loc. 788	Loc. 779	Loc. 782	Loc. 787	Loc. 780
Meretrix(?), sp. ....	....	....	....	X	....
Ostrea weaveri, n. sp. ....	....	X	....	....	....
Ostrea, sp. ....	....	....	X	....	....
Phacoides, sp. ....	....	X	....	....	....
Psammobia cylindrica, n. sp. ....	....	....	....	....	X
Pholadomya nasuta Gabb ....	X	....	X	....	....
Paphia cf. clarki, n. sp. ....	....	....	....	X	....
Solen stantoni Weaver ....	....	....	....	X	....
Tellina, sp., indet. ....	....	....	....	....	....
Dentalium cooperi Gabb ....	X	X	....	....	....
Fusus cf. flexuosus Gabb ....	....	....	....	X	....
Natica, sp. ....	X	....	....	....	....
Turritella pachecoensis Stanton ....	X	X	....	....	....
Turritella infragranulata Gabb ....	X	X	....	....	....

All of these localities are over 3200 feet above the base and may therefore be regarded as representing the uppermost Martinez of this region. Although they contain but one form, *Solen stantoni*, characteristic of the upper horizon at the type locality of the Martinez the absence of many of the species characteristic of the middle and lower zones is noteworthy. While the evidence is meager, the strata 3200 feet or more above the base are tentatively correlated with the uppermost zone of the type section. Localities 787 and 780 are probably about two hundred feet below the base of the Tejon, so that their faunas represent the very youngest Martinez in the whole Lower Lake area.

## MARTINEZ OF SAN MATEO COUNTY

A collection of fossils from a formation in the vicinity of San Pedro Point was referred to the writer for determination and study by Professor A. C. Lawson and Professor J. C. Merriam. The collection was made by Messrs. G. D. Gerson, R. W. Pack, and E. Behr during the past four years.

Professor A. C. Lawson,<sup>25</sup> in "A Sketch of the San Francisco Peninsula," first described these beds as follows:

(1) A basal formation of conglomerates, coarse grits, sandstones, shales, and argillaceous limestones, exposed in the vicinity of San Pedro Point. . . . The base of the series is exposed in the vicinity of San Pedro Point. Here the basal detrital rocks mantle over the crest of the Montara granite ridge. A little to the north of the ridge, on the slope to San Pedro Valley, the strata are somewhat complexly folded. They have the appearance of having been

<sup>25</sup> Lawson, A. C., A Sketch of the San Francisco Peninsula, 15th Ann. Rept. U. S. Geol. Surv., pp. 416, 436, 1894.

crowded up against the granite and of having been sharply folded against it. The result has been to throw the strata into anticlines and synclines, some of which have reversed dips. The stratification in this basal formation is more distinct and even than anywhere else in the fragmental portions of the series. As we follow the contact of the series against the granite slopes of Montara Mountain from San Pedro Point southeastward, it becomes apparent that these basal beds have been dropped out of sight by a fault parallel to the axis of the ridge, so that higher and higher horizons of the series come against the granite. If the basal formations of San Pedro Point were all coarse-grained, it might be supposed that we had to deal simply with a case of transgression of sediment from northwest to southeast. But a portion of the basal formation is a fine, bluish-black clay-shale. While, therefore, it is possible that a portion of the contact of the granite against higher and higher portions of the series may be due to transgression, it seems more probable that the greater part of it is due to faulting. It is also possible that the rocks classed here as the basal detrital formation of San Pedro Point may be an older series separated from the Franciscan series by an unconformity. This suggestion has little to support it at present beyond the fact that the relations of these rocks to the San Francisco sandstone are not clear, and that the latter very commonly contains fragments of black shale similar to that of San Pedro Point. But whether transgression or unconformity, or both, occur, the fault is present.

Mr. G. D. Gerson again investigated these beds in the spring of 1907 and found the fossil locality from which the main collection came.

The section along the sea cliff from Devil's Slide to Tobin Station, a quarter of a mile north of San Pedro Point, gives the following sequence of beds:

- (4) Soft tan-colored sandstone and thin-bedded shale, 200-300 feet.
  - (3) Coarse sandstone and conglomerate, 200-300 feet.
  - (2) Thin-bedded, fine-grained, gray sandstone and black shale with black limestone, 300-400 feet.
  - (1) Basal conglomerate and sandstone resting on Montara granite at Devil's slide, 300-400 feet.
- Total, 1200-1400 feet.

The basal conglomerate (1) appears only at Devil's Slide and (4), the upper sandstone and shale, only in the center of the section. There are at least two or three folds with some faulting in the cliff section. The fossils occur in (3), the coarse sandstone and conglomerate, at the head of a small cañon south of Tobin Station, and east of San Pedro Point at an elevation of 350 feet. This coarse sandstone bears a peculiar relation to the underlying shales and sandstones. An unconformity is suggested, but the strata are faulted only a short distance away—one or two hundred feet south—and the relation of the two may be due to this movement. Large boulders of granite in coarse sandstone and conglomerate occur in an exposure along the road from San Pedro to Half Moon Bay. Possibly they are blocks

from a sea cliff buried in the sands of the beach of that time. This evidence seems to lend support to the interpretation of an unconformity rather than a fault as the best explanation of the relations of the second and third beds.

The fossils were found in the lower portion of (3), the coarse sandstone and conglomerate described above. The matrix, a coarse sandstone, does not preserve the details of the fossils well. The rock is exceedingly friable and, although shell impressions are abundant, it is difficult to discern even the generic characters.

Below is a list of the fauna from these beds:

Flabellum, sp.	Amauropsis(?), sp.
Paraeyathus(?), sp.	Alaria, sp.
Cidaris, sp.	Chlorostoma(?), sp.
Terebratulina cf. tejonensis Stanton	Cylichna costata Gabb
Cardium cf. cooperi Gabb	Dentalium, sp. striated
Cucullaea cf. mathewsonii Gabb	Dentalium cooperi Gabb
Dosinia cf. lawsoni, n. sp.	Discohelix, sp.
Glycimeris, sp.	Fissurella, sp.
Glycimeris cf. veatchii var. major Stanton	Galerus excentricus Gabb
Macrocallista (?) packi, n. sp.	Hipponyx, sp.
Meretrix stantoni, n. sp.	Natica, sp., a
Modiolus cf. bakeri, n. sp.	Natica(?) sp., b, spiral lined
Ostrea buwaldana, n. sp.	Patella, sp.
Phacoides diaboli, n. sp.	Ringinella cf. pinguis Gabb
Phacoides quadrata, n. sp.	Spirogylyphus(?), sp.
Semele(?), sp.	Tritonium martinezensis, n. sp.
Tapes(?) quadrata Gabb	Tritonium, sp., a
Teredo, sp.	Turritella, sp.
Venus(?), sp.	Turritella cf. pachecoensis Stanton
Venericardia, sp.	Urosyca cf. caudata Gabb
	Crustacean fragments

Nearly all the genera represented occur in the Martinez Group and one, *Urosyca*, appears to be restricted to it.

*Macrocallista(?) packi*, n. sp., *Meretrix stantoni*, n. sp., *Modiolus bakeri*, n. sp., *Phacoides quadrata*, n. sp., *Cidaris*, sp., *Tritonium martinezensis*, n. sp., *Urosyca caudata*, *Galerus excentricus*, *Cylichna costata*, and *Dentalium cooperi* occur in the basal Martinez north of Mount Diablo or in the Martinez of Lower Lake. Of these the first seven are characteristically Martinez, the last four range upward into the Tejon, and the last two downward into the Chico. Several of the others listed appear to be close to Martinez forms, but they are too poorly preserved to be specifically determined. Several of these species are new, but none of them represent characteristically Cretaceous

genera. The beds in which the fossils occur are of Eocene age and of the Martinez stage. They possibly represent a lower phase than has been recognized in the type locality of the Martinez or in the region north of Mount Diablo.

Fossils had previously been found in the same formation at Montara Mountain by Merriam and Ransome, and a brief note concerning their occurrence was given by Lawson<sup>26</sup> in "A Sketch of the Geology of the San Francisco Peninsula":

On the northeast slope of Montara Mountain, on the crest of Whiting Ridge, a number of imperfect fossils were found. . . . The matrix in which they occur is sandstone. These fossils were submitted to Mr. Stanton, who kindly prepared the following statement concerning them: "The fossils are nearly all casts of small Lamellibranchia, usually showing some of the features of the external surface and so few of their characteristics that most of them can not be determined even generically. Several specimens, however, that retain impressions of the hinge, belong to the Arcidae, and some of these seem referable to *Pectunculus*, a genus that ranges from Lower Cretaceous to the present time. One small imperfect cast has the form of *Opis*, and if we could be certain that it is that genus it would fix the age as Mesozoic, with the probabilities in favor of Lower Cretaceous or Jurassic. On the other hand there is a fragment showing the imprint of a small part of the surface of a shell that, in the ornamentation, is very much like some of the late Tertiary and recent species of *Venus*. These notes are sufficient to show that there are no characteristic forms recognizable in the collection that are decisive of its Mesozoic or Cenozoic Age. There is nothing among them that suggests the Palaeozoic. It is hoped that these beds may yield to future search some better preserved forms which will decide their age."

Professor Lawson informs me that these beds are directly connected with those of San Pedro Point, so that they too are to be regarded as Martinez Eocene.

#### EOCENE(?) OF THE SANTA CRUZ QUADRANGLE

The fauna from this locality which was listed above in the review of the literature was, at the time of its discovery, so unique that its stratigraphic position was questioned. *Terebratulina tejonensis* Stanton was the only previously described species listed in the entire fauna. The species which was identified as *Terebratulina tejonensis* by Arnold differs slightly from *T. tejonensis*. It is broader in outline and the ribs are more numerous. A cidarid spine is found in the basal Martinez which resembles *Cidarid merriami* Arnold, but it has only ten

<sup>26</sup> Lawson, A. C., *op. cit.*, p. 445, 1894.

ribs instead of thirteen or fourteen. There is really no good evidence to warrant placing this fauna in the Martinez. Until it has been recognized with certainty at some other locality, or a better fauna has been obtained at the original locality, its age will remain in doubt.

### SUMMARY OF MARTINEZ STRATIGRAPHY

The greatest thickness of strata of Martinez age yet recognized in California is exposed near the town of Lower Lake. These strata probably represent the greatest length of time as well. The seven hundred feet of strata beneath the first fossiliferous horizon, the *Meretrix dalli* zone, are older than any strata known elsewhere in the state, as the *Meretrix dalli* zone appears to represent a slightly earlier period of Martinez time than this same zone at the base of the Martinez in the area north of Mount Diablo. The Martinez at San Pedro Point, San Mateo County, may be the equivalent of the *Meretrix dalli* zone of the Lower Lake Martinez. The *Trochocyathus zitteli* and *Solen stantoni* zones are not easily recognized at Lower Lake, but they both appear to be present.

The 2400 feet of strata at Benicia is probably the equivalent of the upper 3300 feet of strata at Lower Lake. The Martinez of the type locality is probably equivalent to the upper 2600–3000 feet of the Lower Lake Martinez. The Martinez at Selby Smelter represents only the middle portion of the Martinez, the *Trochocyathus zitteli* zone. The Martinez north of Mount Diablo is equivalent to most of the *Meretrix dalli* zone of the Lower Lake strata and to the *Trochocyathus zitteli* zone of the type locality. The *Solen stantoni* zone appears to be lacking in this section and is probably represented in the unconformity between the overlying Tejon and the Martinez at this point. The accompanying diagram presents the relations between the strata of various localities graphically (see fig. 5). The sections given below refer to their respective columns in figure 5.

#### I. SECTION AT POINT SAN PEDRO, SAN MATEO COUNTY, CALIFORNIA

			Feet
Martinez	{	(5) Soft tan sandstone and shale .....	300
Eocene		(4) Coarse-grained sandstone and conglomerate .....	300
		(3) Fossiliferous beds .....	
Eocene(?)	{	(2) Fine-grained sandstone, limestone and black shale .....	400
		(1) Coarse sandstone and conglomerate .....	400
Total .....			1400

II. SECTION AT BENICIA, CALIFORNIA

		Feet		
Martinez Eocene	{	(7) Gray-green shales and thin bedded sandstones .....	} 1400	
		(6) Solen stantoni beds .....		
		(5) Gray-green shales and thin bedded sandstones .....	} 900	
		(4) Trochocyathus zitteli beds .....		
		(3) Brown sandstones .....		
		(2) White shale .....		50
		(1) Conglomerate and sandstone .....		20
Total .....		2370		

III. SECTION AT LOWER LAKE, LAKE COUNTY, CALIFORNIA

		Feet	
Martinez Eocene	{	(10) Gray shales and thin bedded sandstones .....	} 700
		(9) Solen stantoni beds .....	
		(8) Gray shales and thin bedded sandstones .....	} 1600
		(7) Massive, tan sandstone .....	
		(6) Trochocyathus zitteli beds .....	
		(5) Massive, tan sandstone .....	
		(4) Fine-grained, massive, tan sandstone .....	500
		(3) Medium-grained, gray, sandstone .....	500
		(2) Meretrix dalli beds .....	} 700
		(1) Medium-grained, gray sandstone .....	
Total .....		4000	

IV. SECTION NEAR MARTINEZ AT TYPE LOCALITY

		Feet	
Martinez Eocene	{	(7) Solen stantoni beds .....	} 1000
		(6) Gray sandstone .....	
		(5) Gray-green, glauconitic sandstone .....	} 300
		(4) Trochocyathus zitteli beds .....	
		(4) Hard gray sandstone .....	
		(3) Gray-green, glauconitic sandstone .....	
		(3) Trochocyathus zitteli beds .....	50
		(2) Gray sandstone with lenses of limestone .....	300
(1) Conglomerate .....	50		
Total .....		1700	

V. SECTION NEAR SELBY SMELTER, CARQUINEZ STRAITS

		Feet	
Martinez Eocene	{	(3) Gray-green, foraminiferal shale .....	500
		(2) Trochocyathus zitteli beds .....	} 200
		(1) Gray-green, glauconitic sandstone .....	
Total .....		700	



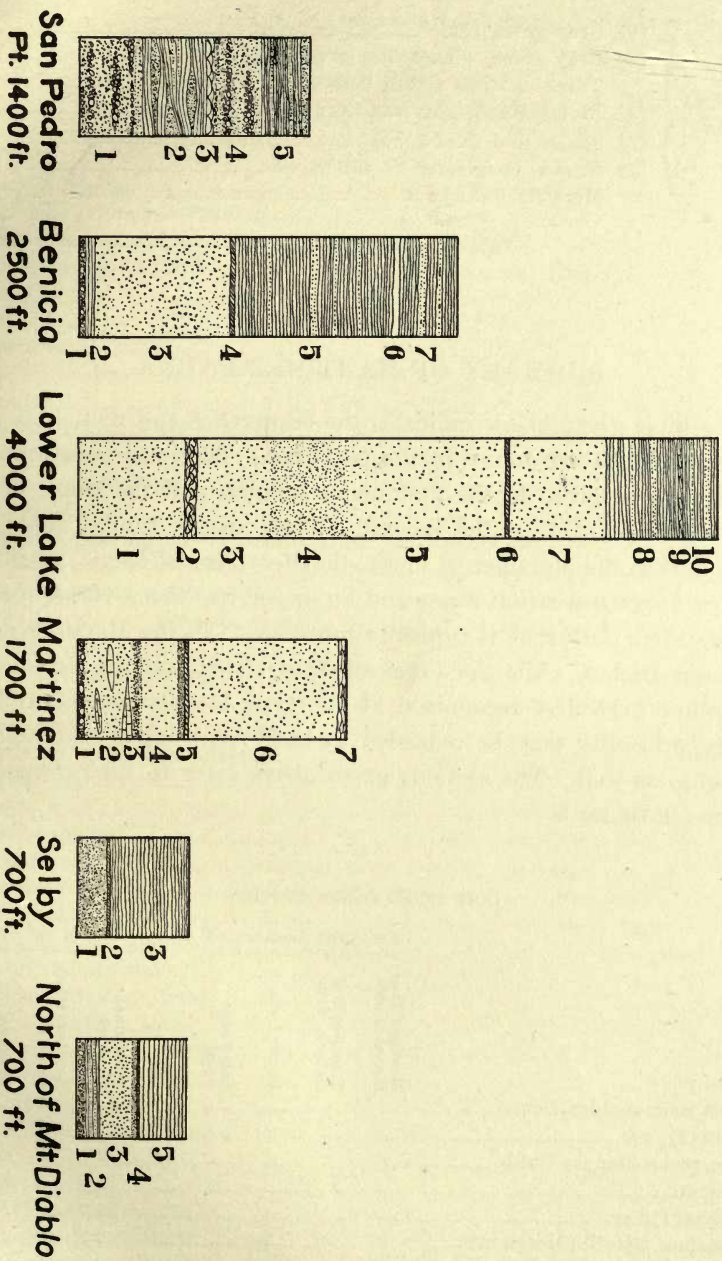


Fig. 5. Columnar sections of Martinez-Eocene strata.

Scale 1 cm. = 500 ft.

VI. SECTION NORTH OF MOUNT DIABLO

		Feet
}	(5) Gray-green shale .....	300
	(4) Gray-green, glauconitic sandstone .....	} 50
	<i>Trochocyathus zitteli</i> beds .....	
	(3) Fine-grained, gray sandstone .....	200
	(2) Shales and sandstones .....	100
	(1) Brown, conglomeritic sandstone .....	} 50
<i>Meretrix dalli</i> beds .....		
	Total .....	700

SUMMARY OF MARTINEZ FAUNA

The table given below indicates the occurrence and distribution of the forms which are found in the Martinez. The local occurrence of each species is given in the first major column and the range of the species is indicated in the second. Three major faunal zones are recognized in the Martinez: a lower, the *Meretrix dalli* zone; a middle, the *Trochocyathus zitteli* zone; and an upper, the *Solen stantoni* zone. The *Meretrix dalli* zone is typically represented in the Martinez north of Mount Diablo, while the *Trochocyathus zitteli* and the *Solen stantoni* zones were first recognized at the type locality near Martinez. The type locality may be regarded as the type locality of these last two zones as well. The sections given above refer to their respective columns in figure 5.

LIST OF MARTINEZ SPECIES

	MARTINEZ LOCALITIES					RANGE OF SPECIES				
	Martinez N. of Mount Diablo	Type locality, Benicia, Selby	Lower Lake	San Pedro Point	Tejon	Solen stantoni zone	<i>Trochocyathus zitteli</i> zone	<i>Meretrix dalli</i> zone	Chico	
<i>Anomalina ammonoides</i> Reuss .....	...	x	...	...	...	...	x	...	...	
<i>Stylophora</i> (?), sp. ....	...	...	x	...	...	...	...	x	...	
<i>Flabellum remondianum</i> Gabb .....	x	x	x	...	x?	x	x	x	...	
<i>Flabellum</i> , sp. ....	...	...	...	x	...	...	...	x	...	
<i>Paracyathus</i> (?), sp. ....	...	...	...	x	...	...	...	x	...	
<i>Trochocyathus zitteli</i> (Merriam) .....	x	x	...	...	...	...	x	...	...	
<i>Schizaster lecontei</i> Merriam .....	x	x	x	...	x	x	x	x	...	
<i>Cidaris</i> (?), sp., <i>c</i> .....	x	...	...	...	...	...	...	x	...	
<i>Cidaris</i> (?), sp., <i>a</i> .....	x	x	...	...	...	...	x	x	...	
<i>Cidaris</i> (?), sp., <i>d</i> .....	x	...	...	...	...	...	x	...	...	



## LIST OF MARTINEZ SPECIES—(Continued)

	MARTINEZ LOCALITIES				RANGE OF SPECIES				
	Martinez N. of Mount Diablo	Type locality, Benicia, Selby	Lower Lake	San Pedro Point	Tejon	Solen stantoni zone	Trochocyathus zitteli zone	Meretrix dalli zone	Chico
Martesia(?), sp. ....	...	...	×	...	...	...	...	×	...
Macrocallista(?) packi, n. sp. ....	...	...	×	×	...	...	...	×	...
Mytilus cf. ascia Gabb ....	×	...	...	...	...	...	...	...	...
Neaera dolabraeformis Gabb ....	×	×	...	...	×?	...	×	×	...
Neaera hannibali, n. sp. ....	...	×	...	...	...	...	×	...	...
Nucula (Acila) truncata Gabb ....	...	×	...	...	...	×	×	...	×
Nucula (Acila), sp. ....	×	×	...	...	...	...	...	...	...
Ostrea, sp. ....	×	...	...	×	...	...	...	...	...
Ostrea weaveri, n. sp. ....	...	×	×	...	...	×?	...	...	...
Ostrea buwaldana, n. sp. ....	...	...	×	×	...	...	...	×	...
Ostrea appressa Gabb ....	...	...	×	...	...	...	...	...	...
Paphia(?) clarki, n. sp. ....	×	...	×	...	...	...	...	×	...
Paphia, sp., a ....	×	...	...	...	...	...	...	...	...
Pecten, sp. ....	...	...	×	...	...	...	...	...	...
Pecten interradiatus Gabb ....	...	×	...	...	×	...	×	...	...
Pecten, sp. ....	×	...	...	...	...	...	...	...	...
Perna, sp. ....	...	...	×	...	...	...	...	...	...
Pholadomya nasuta Gabb ....	×	×	×	...	...	×	×	×	...
Pinna barrowsi, n. sp. ....	...	×	...	...	...	...	×	...	...
Phacoides muirensis, n. sp. ....	...	×	...	...	...	...	×	...	...
Phacoides quadrata, n. sp. ....	...	...	×	...	...	...	...	×	...
Phacoides diaboli, n. sp.* ....	...	...	...	...	...	...	...	...	...
Phacoides, sp. ....	...	...	...	×	...	...	...	...	...
Phacoides turneri (Stanton) ....	×	×	×	...	...	...	×	×	...
Phacoides, sp. ....	×	...	×	...	...	...	...	...	...
Plicatula ostreaformis Stanton ....	...	...	×	...	...	...	...	...	...
Psammobia(?) cylindrica, n. sp. ....	...	×	×	...	...	×	...	...	...
Psammobia hornii (Gabb) ....	...	×	×	...	×	×	×	×	...
Solen parallelus Gabb(?) ....	...	...	×	...	×	...	...	...	...
Solen, sp. ....	×	×	×	...	...	...	...	...	...
Solen stantoni Weaver ....	×	×	...	...	×	×	...	×	...
Spisula(?) weaveri, n. sp. Packard ....	×	...	...	...	...	...	...	×	...
Tapes(?) quadrata Gabb ....	×	×	...	×	×	...	×	×	...
Tapes cf. quadrata Gabb ....	...	...	×	...	...	...	...	...	...
Tellina(?) undulifera Gabb ....	×	×	×	...	...	×	×	×	...
Tellina kawi, n. sp. ....	...	×	×	...	...	...	×	×	...
Tellina packardi, n. sp. ....	...	...	×	...	...	...	...	×	...
Tellina herndonensis, n. sp. ....	...	...	×	...	...	...	...	×	...
Tellina cf. parilis Gabb ....	...	...	×	...	...	...	...	×	...
Tellina, sp., a ....	...	...	×	...	...	...	...	...	...
Tellina, sp., b ....	×	...	...	...	...	...	...	...	...
Tellina aequalis Gabb ....	×	×	×	...	×?	...	×	×	...
Tellina perrini, n. sp. ....	...	...	×	...	...	...	...	×	...
Teredo, sp. ....	×	×	...	×	...	...	×	×	...



## LIST OF MARTINEZ SPECIES—(Continued)

	MARTINEZ LOCALITIES				RANGE OF SPECIES				
	Martinez N. of Mount Diablo	Type locality, Benicia, Selby	Lower Lake	San Pedro Point	Tejon	Solen stan-toni zone	Trochocyathus zitteli zone	Meretrix dalli zone	Chico
<i>Fusus</i> (?), sp. ....	x	...	...	...	...	...	...	x	...
<i>Galerus excentricus</i> Gabb .....	x	...	x	x	x	...	x	x	...
<i>Heteroterma gabbi</i> Stanton .....	...	x	x	...	...	...	...	...	...
<i>Heteroterma trochoidea</i> Gabb .....	...	x	...	...	...	x	...	x	...
<i>Heteroterma striata</i> Stanton .....	x	...	x	...	...	x	...	x	...
<i>Heteroterma</i> , sp. indet. ....	...	x	x	...	...	...	x	x	...
<i>Hemifusus</i> (?) <i>waringi</i> , n. sp. ....	...	x	...	...	...	...	...	...	...
<i>Hipponyx</i> (?) , sp. ....	...	...	...	x	...	...	...	...	...
<i>Lunatia hornii</i> Gabb .....	x	...	x	...	x	...	x	x	...
<i>Lunatia cf. nuciformis</i> Gabb .....	...	...	x	...	x	...	...	x	...
<i>Lunatia</i> , sp. <i>a</i> .....	...	...	x	...	...	...	...	...	...
<i>Megistostoma striata</i> Gabb(?) .....	...	x?	...	...	x	x?	...	...	...
<i>Neptunea mucronata</i> Gabb .....	x	x	...	...	...	...	x	x	...
<i>Neptunea</i> ( <i>Tritonofusus</i> ) <i>cretacea</i> , Gabb .....	x	...	...	...	...	...	...	x	...
<i>Neptunea</i> , sp., <i>a</i> .....	...	...	x	...	...	...	...	...	...
<i>Natica</i> ( <i>Gyrodes</i> ) <i>lineata</i> , n. sp. ....	x	...	x	...	...	...	x	...	...
<i>Natica</i> , sp., <i>a</i> .....	...	...	...	x	...	...	...	x	...
<i>Natica</i> , sp., <i>b</i> .....	...	...	...	x	...	...	...	...	...
<i>Natica</i> , sp., <i>c</i> .....	...	...	...	x	...	...	...	...	...
<i>Natica</i> , sp., <i>e</i> .....	...	...	...	x	...	...	...	...	...
<i>Naticina</i> , sp. ....	...	x	...	...	...	...	x	...	...
<i>Nerita biangulata</i> , n. sp. ....	...	x	...	...	...	...	x	...	...
<i>Niso polito</i> Gabb .....	x	...	...	...	x	...	...	x	...
<i>Ovula martini</i> , n. sp. ....	x	x	...	...	...	...	x	x	...
<i>Olivella claytonensis</i> , n. sp. ....	x	...	...	...	...	...	...	x	...
<i>Perissolax tricarnatus</i> Weaver .....	x	x	x	...	x	x	x	x	...
<i>Patella</i> , sp. ....	...	...	x	...	...	...	...	...	...
<i>Patella</i> , sp. ....	...	...	...	x	...	...	...	...	...
<i>Ringinella pinguis</i> Gabb .....	x	x	x	...	...	...	x	x	...
<i>Surcula merriami</i> , n. sp. ....	x	...	...	...	...	...	...	x	...
<i>Surcula</i> ( <i>Surculites</i> ) <i>inconspicua</i> Gabb	...	x	...	...	...	...	x	...	...
<i>Surcula fairbanksi</i> , n. sp. ....	x	...	...	...	...	...	x	...	...
<i>Surcula</i> ( <i>Surculites</i> ) <i>andersoni</i> , n. sp.	...	x	...	...	...	...	x	...	...
<i>Surcula</i> , sp. ....	x	...	...	...	...	...	...	...	...
<i>Siphonalia</i> (?) <i>lineata</i> Stanton .....	x	x	x	...	...	x	x	x	...
<i>Strepsidura pachecoensis</i> Stanton .....	...	x	...	...	...	x	...	...	...
<i>Spiroglyphus</i> (?) , sp. ....	...	...	x	...	...	...	...	...	...
<i>Seraphs</i> (?) <i>thompsoni</i> , n. sp. ....	...	...	x	...	...	...	...	x	...
<i>Turbinella crassatata</i> Gabb .....	...	x	...	...	...	...	x	...	...
<i>Turritella martinezensis</i> Gabb .....	x	...	x	...	...	...	x	...	...
<i>Turritella cf. martinezensis</i> Gabb .....	...	...	x	...	...	...	...	...	...
<i>Turritella pachecoensis</i> Stanton .....	x	x	x	...	...	...	x	x	...
<i>Turritella cf. pachecoensis</i> Stanton .....	...	...	...	x	...	...	...	...	...

LIST OF MARTINEZ SPECIES—(Continued)

	MARTINEZ LOCALITIES					RANGE OF SPECIES				
	Martinez N. of Mount Diablo	Type locality, Benicia, Selby	Lower Lake	San Pedro Point	Tejon	Solen stan- toni zone	Trochocyathus zitteli zone	Meretrix dalli zone	Chico	
<i>Turritella infragranulata</i> Gabb	×	×	×	...	...	×	×	×	...	
<i>Turritella conica</i> Weaver	...	×	...	...	× <sup>?</sup>	× <sup>?</sup>	...	...	...	
<i>Turritella clarki</i> , n. sp.	×	...	...	...	...	...	×	...	...	
<i>Turris</i> , sp., <i>a</i>	×	...	...	...	...	...	...	...	...	
<i>Turris claytonensis</i> Gabb*	...	...	...	...	×	...	...	...	...	
<i>Turris</i> , sp. indet.	...	×	...	...	...	...	...	...	...	
<i>Tritonium martinezensis</i> , n. sp.	×	...	...	×	...	...	...	×	...	
<i>Tritonium</i> , sp., <i>a</i>	×	...	...	...	...	...	...	...	...	
<i>Tritonium buwaldi</i> , n. sp.	...	...	×	...	...	...	...	×	...	
<i>Tritonium</i> (?), sp.	...	×	...	...	...	...	×	...	...	
<i>Tritonium pulchrum</i> Weaver	...	×	...	...	...	×	...	...	...	
<i>Tritonium</i> , sp.	...	...	...	×	...	...	...	...	...	
<i>Urosyca caudata</i> Gabb	×	×	×	...	...	×	×	×	...	
<i>Urosyca robusta</i> Weaver	...	×	×	...	...	...	×	×	...	
<i>Xenophora zitteli</i> Weaver	×	×	...	...	...	...	×	×	...	
<i>Aturia mathewsonii</i> Gabb*	...	...	...	...	×	...	...	...	...	
<i>Hereoglossa merriami</i> , n. sp.	...	×	...	...	...	...	×	...	...	
<i>Nautilus stephensoni</i> , n. sp.	...	×	...	...	...	...	×	...	...	
Crustacean, indet.	...	...	...	...	...	...	...	...	...	
Crustacean remains	...	...	...	×	...	...	...	...	...	
Shark tooth	...	×	×	...	...	...	×	×	...	
Leaf	×	...	...	...	...	...	...	...	...	
Fossil wood	×	×	...	...	...	...	...	...	...	

\* South of Mount Diablo.

SUGGESTION OF FAUNA AS TO CLIMATE DURING MARTINEZ TIME

The collections from strata of Martinez age contain the genera *Cypraea*, *Ovula*, *Aturia*, *Turris*, and *Surcula*, which are represented mainly by tropical or subtropical species in the ocean of the present time. Several genera which are now represented by boreal or temperate species are found in this fauna as well. This evidence seems to indicate that the climate of Martinez time was decidedly milder than that of the Recent period in these latitudes. The mixture of subtropical and boreal forms indicates a warm temperate climate. Practically none of the genera mentioned above occur in the Chico, and an absence of other tropical or subtropical genera from the uppermost Cretaceous shows some change in climate between Chico and Martinez times. Tejon climate, however, was decidedly warmer

than that of the Martinez, judging from the much greater abundance of tropical forms represented in its fauna. For a discussion of the Tejon climate the reader is referred to a recent paper by the writer<sup>27</sup> on the Eocene of the Marysville Buttes.

#### RELATIONSHIP OF THE CHICO AND MARTINEZ FAUNAS

The check-list given above shows that the following Chico species range upward into the Martinez: *Nucula truncata* Gabb, *Cylichna costata* Gabb, *Dentalium cooperi* Gabb, *Dentalium stramineum* Gabb. All of these species appear practically identical with those of the Chico, but unfortunately they represent genera whose species are usually very persistent. *Tellina* cf. *parilis* Gabb which was found near Lower Lake is nearly identical, as far as external form is concerned, with *T. parilis* of the Chico. *Meretrix*(?) *dalli*, n. sp., is very similar to *M. fragilis* Gabb of the Chico. *Glycimeris veatchii* var. *major* (Stanton) is distinguishable from *G. veatchi* (Gabb) but it is evidently a descendant of the Chico form. *Amauropsis martinezensis*, n. sp., is allied to *A. oviformis* Gabb in the strata beneath. The Cretaceous genera *Ringinella* and *Anchura*, are represented by *R. pinguis* Gabb, *A. englishi* and *A. gabbi*, n. sp., respectively.

This evidence indicates a much closer relationship between the Eocene and the Cretaceous than is generally found.

#### FAUNAL RELATIONSHIP OF THE MARTINEZ TO THE TEJON

The relationship between the Tejon and the Martinez is shown by the list given above. About twenty-five to thirty species range through portions of both groups. About fifteen to twenty of these range from the base of the Martinez to at least as high as the middle Tejon of the Mount Diablo region, and some of these extend even to uppermost Eocene at the Marysville Buttes. The following are species common to both the Martinez and the Tejon:

Schizaster leontei Merriam	Leda gabbi Conrad
Cardium cooperi Gabb	Modiolus merriami (Weaver)
Crassatellites grandis (Gabb)	Modiolus ornatus (Gabb)
*Cuspidaria dolabraeformis (Gabb) (?)	Nucula (Acila) cf. truncata Gabb

\* Described by Gabb from his Cretaceous B (= Tejon).

<sup>27</sup> Dickerson, Roy E., Fauna of the Eocene at Marysville Buttes, California, Univ. Calif. Publ. Bull. Dept. Geol., vol. 7, p. 267, 1913.



† <i>Ostrea appressa</i> Gabb(?)	<i>Dentalium cooperi</i> Gabb
<i>Pecten interradiatus</i> Gabb	<i>Dentalium stramineum</i> Gabb
<i>Psammobia hornii</i> (Gabb)	<i>Fusus martinez</i> Gabb
† <i>Solen parallelus</i> Gabb	<i>Fusus mathewsonii</i> Gabb
<i>Tapes(?) quadrata</i> (Gabb)	<i>Galerus excentricus</i> Gabb
† <i>Venericardia planicosta</i> Lamarck(?)	<i>Lunatia hornii</i> Gabb
<i>Cylichna costata</i> Gabb	<i>Niso polito</i> Gabb
<i>Cerithiopsis alternata</i> Gabb	<i>Perissolax tricarnatus</i> Weaver
* <i>Cuspidaria dolbraformis</i> (Gabb) (?)	<i>Aturia mathewsonii</i> Gabb

\* Described by Gabb from his Cretaceous B (= Tejon).

† Reported by Stanton from Lower Lake.

*Perissolax tricarnatus* and *Schizaster lecontei* occur abundantly in the type section of the Tejon near Fort Tejon. *Modiolus merriami* was found in the Tejon on the south side of Pine Cañon, Mount Diablo Quadrangle, by the Summer Session class in palaeontology. *Flabellum remondianum* is questionably reported from the Tejon. The following species were indeterminate: *Avicula* cf. *pellucida* Gabb, *Megistostoma striata* Gabb(?).

The type specimen of *Turritella conica* Weaver appears very similar to a *Turritella* in the Tejon, but owing to the poor preservation of the type it is impossible to decide the point. *Cassidaria tuberculata* (Gabb) is questionably reported from the Martinez at Benicia.

The absence of the common Martinez species, such as *Trochocyathus zitteli* (Merriam), *Cardita veneriformis* Gabb, *Cucullaea mathewsonii* Gabb, *Crassatellites unioides* Stanton, *Glycimeris veatchii*, var. *major* (Stanton), *Lucina turneri* Stanton, *Leda alaeformis* (Gabb), *Meretrix stantoni*, n. sp., *Pholadomya nasuta* Gabb, *Tellina undulifera* Gabb, *Ampullina striata* Gabb, *Amauropsis martinezensis*, n. sp., *Discohelix californicus* Weaver, *Heteroterma gabbi* Stanton, *Heteroterma striata* Stanton, *Natica lineata*, n. sp., *Ringinella pinguis* Gabb, *Siphonalia(?) lineata* Stanton, *Turritella martinezensis* Gabb, *Turritella pachecoensis* Gabb, *Turritella infragranulata* Gabb, and *Urosyca caudata* Gabb from an Eocene fauna is quite sufficient to make its Martinez age questionable. These species are excellent guide fossils because nearly any fossiliferous Martinez locality will yield at least three or four of them. Their range in many cases is through the entire Martinez, but so far as known none occurs in the Tejon or the Chico. A study of the list of Martinez species shows the absence of a great many typically Tejon species. Among the absent ones are: *Cardium breweri* Gabb, *Cardita planicosta* var. *hornii* (Gabb), *Corbula parilis* Gabb,

*Dosinia elevata* Gabb, *Dosinia gyrata* Gabb, *Glycimeris sagittata* Gabb, *Meretrix hornii* Gabb, *Meretrix ovalis* Gabb, *Meretrix uvasana* Gabb, *Ostrea aviculaformis* Anderson, *Placunanomia inornata* Gabb, *Tapes conradiana* Gabb, *Tellina longa* Gabb, *Tellina remondii* Gabb, *Amuropsis alveata* Gabb, *Bulla hornii* Gabb, *Fusus californica* Gabb, *Rimella canalifera* Gabb, *Turritella merriami* Dickerson, *Turritella uvasana* Conrad, *Whitneya ficus* Gabb. Many of these forms have a wide range in the Tejon, but so far as known they are not found in the Martinez. There are many other Tejon forms which will serve as guides. The faunal break between the Martinez and the Tejon is very wide when we consider the large number of species which are confined to the one group or the other.

#### COMPARISON OF THE UPPER MARTINEZ AND THE LOWERMOST TEJON

During the last two Summer Sessions of the University the field classes in palaeontology made extensive collections in the Tejon, south of Mount Diablo. As was mentioned above in describing the small area of Martinez south of Mount Diablo, the Tejon for the most part is in unconformable contact with the Chico. Between Cave Point and Oyster Point a complete section of the Tejon was studied and it was found to be fossiliferous from top to bottom. The basal portion in contact with the Chico was most prolific and yielded a very large fauna, a portion of which is given in the list below. This basal fauna was obtained from beds not over twenty-five feet above the bottom of the section.

#### PARTIAL LIST OF SPECIES IN THE BASAL TEJON SOUTH OF MOUNT DIABLO

<i>Fungia</i> (?), n. sp.	<i>Glycimeris</i> cf. <i>sagittata</i> (Gabb)
<i>Turbinolia</i> (?), n. sp., <i>a</i> (long)	<i>Glycimeris</i> <i>cor</i> (Gabb)
<i>Turbinolia</i> (?), n. sp., <i>b</i> (short)	<i>Leda</i> <i>gabbi</i> Conrad
Coral (reef form), sp.	<i>Maetra</i> , sp.
<i>Cassidulus californicus</i> Anderson	<i>Spisula</i> , n. sp.
<i>Scutella</i> , n. sp.	<i>Meretrix hornii</i> Gabb
<i>Acila</i> , sp.	<i>Meretrix ovalis</i> Gabb
<i>Astarte mathewsonii</i> Gabb	<i>Meretrix uvasana</i> Gabb
<i>Avicula pellucida</i> Gabb	<i>Modiolus ornatus</i> (Gabb)
<i>Cardium cooperi</i> Gabb	<i>Ostrea aviculaformis</i> Anderson
<i>Cardium</i> , sp.	<i>Ostrea</i> , sp.
<i>Corbula parilis</i> Gabb	<i>Phacoides</i> , sp.
<i>Dosinia elevata</i> Gabb	<i>Placunanomia inornata</i> Gabb
<i>Dosinia gyrata</i> Gabb	<i>Psammobia hornii</i> (Gabb)

PARTIAL LIST OF SPECIES IN THE BASAL TEJON SOUTH OF MOUNT DIABLO—  
(Continued)

Pteria(?), sp.	Cassidaria tuberculata (Gabb)
Solen parallelus Gabb	Ficopsis remondii (Gabb)
Tapes conradiana Gabb	Fusus californica Gabb
Tapes, sp.	Fusus diaboli Gabb
Tapes(?) quadrata Gabb	Fusus martinez (Gabb)
Tellina cf. aequalis(?) Gabb	Fusus, sp.
Tellina longa Gabb	Galerus excentricus Gabb
Tellina remondii Gabb	Littorina compacta? Gabb
Tellina, n. sp.	Lunatia hornii Gabb
Venus(?), sp., a	Neptunea(?) supraplicata Gabb
Venus(?), sp., b	Neptunea(?), sp.
Venericardia planicosta Lamarek, var. hornii Gabb	Neverita secta Gabb
Yoldia(?), n. sp.	Olivella mathewsonii Gabb
Zirphaea(?), sp.	Perissolax blakei Gabb
	Pseudoliva volutaeformis Gabb
Dentalium cooperi Gabb	Rimella canalifera Gabb
Dentalium stramineum Gabb	Sureulites, sp.
Amauropsis alveata Gabb	Turris perkinsiana (Cooper)
Bulla hornii Gabb	Turris, sp., a
Cylichna costata Gabb	Turris, sp., b
	Turritella merriami Dickerson

The basal Tejon in contact with the upper Martinez of the type section is non-fossiliferous and on this account a direct comparison with the upper Martinez is not possible. The Tejon south of Mount Diablo is only ten miles away from the upper Martinez of the type section, so a comparison between the two is profitable.

The following species are common to the two:

Cardium cooperi Gabb	Dentalium cooperi Gabb
Leda gabbi (Conrad)	Dentalium stramineum Gabb
Modiolus ornatus (Gabb)	Lunatia hornii (Gabb)
Acila, sp.	Perissolax tricarnatus(?) Gabb
Psammobia hornii (Gabb)	

Such characteristic species as the following are not found in the basal Tejon:

Cucullaea mathewsonii Gabb	Fusus aequalateralis Weaver
Pholadomya nasuta Gabb	Heteroterma gabbi Stanton
Tellina kewi, n. sp.	Heteroterma trochoidea Gabb
Tellina undulifera Gabb	Siphonalia(?) lineata Stanton
Ampullina striata Gabb	Turritella pachecoensis Stanton
Brachysphingus liratus Gabb	Urosyca caudata Gabb
Bullinula subglobosa Weaver	

This faunal difference would be far better shown, no doubt, if better collecting places in the uppermost Martinez could be found.

In making our comparisons between faunas, the condition of deposition should be stated. The fauna of the uppermost Martinez flourished in moderately deep water while that of the basal Tejon is littoral. Luckily we do have a moderately deep-water fauna contained in the Tejon beds just overlying the basal beds. These beds south of Mount Diablo are about fifty to seventy-five feet thick and they have yielded *Schizaster lecontei*, *Pecten interradiatus* and several species of foraminifers. They are in turn succeeded by *Turritella uvasana* beds which yield a typical Tejon fauna of the inshore type. These last mentioned horizons are represented at the type section of the Martinez by fossiliferous beds. The *Turritella uvasana* beds near Muir Station contain a typical Tejon fauna, but the shales and glauconitic sands beneath have yielded a fauna which was so unusual for the Tejon that Dr. Weaver included it in the Martinez. This fauna is as follows:

	Loc. 215	Loc. 337	Loc. 532
Nummuloid(?), sp. ....	---	x	---
Orbitoides, sp. ....	---	x	---
Cardium cooperi Gabb .....	x	x	---
Cassidaria tuberculata (Gabb) .....	---	x	---
Modiolus merriami (Weaver) .....	---	x	---
Leda gabbi Conrad .....	x	---	---
Tellina hornii Gabb .....	---	x	---
Tellina cf. remondii Gabb .....	x	---	---
Tellina martinezensis Weaver .....	---	x	---
Thracia karquinezensis Weaver .....	---	x	x
Solen parallelus Gabb .....	---	x	---
Solen stantoni Weaver .....	x	---	x
Venericardia planicosta Lamarck. ....	---	x	---
Bela cf. clathrata Gabb .....	---	x	---
Ficopsis remondii Gabb .....	---	x	---
Megistostoma striata Gabb .....	---	x	---
Perissolax, n. sp .....	---	---	x
Rimella canalifera Gabb .....	---	x	---
Spiroglyphus(?) tejonensis Arnold .....	---	x	---
Turris monolifera Cooper .....	---	x	---
Turritella conica Weaver .....	---	x	---
Tritonium eocenium Weaver .....	---	x	---
Tritonium impressum Weaver .....	---	x	---

Of these forms *Solen parallelus*, *Venericardia planicosta*, *Bela clathrata*, *Ficopsis remondii*, *Cassidaria tuberculata*, *Rimella canalifera*, *Spiroglyphus(?) tejonensis*, *Turris monolifera* are typical of the Tejon. No typical Martinez species such as *Tellina undulifera*, *Cucullaea mathewsonii*, *Urosyca caudata* or *Brachysphingus liratus* have been found in these strata.

## TIME-INTERVAL BETWEEN DEPOSITION OF MARTINEZ AND TEJON

The time-interval which elapsed between the deposition of these gray-green Tejon shales and the uppermost Martinez strata must have been very great. During this time many characteristic Martinez species entirely disappeared. A portion of this time-interval is probably represented by unconformity between the lowermost Tejon strata and the Martinez, although there is no one place yet discovered at the type locality which proves this fact. A marked change in lithology, a considerable difference in dip throughout the field, and a very abrupt change in fauna suggest unconformity at the type locality.

CORRELATION OF MARTINEZ WITH EOCENE OF THE  
ATLANTIC AND GULF STATES

Dr. W. H. Dall<sup>29</sup> first attempted a correlation of the Pacific Coast Eocene with that of the eastern states. In this general correlation paper, the Martinez and Tejon were correlated with the lower portion of the Eocene. Weaver,<sup>30</sup> in his paper on the palaeontology of the Martinez Group, correlates the Martinez with the Midway of the Gulf States region. He says:

“For comparison with the Martinez fauna, the following important localities have been selected: the Gulf States, the Atlantic States, the London and Paris Basins, and the Sind district of western India.

“Compared with these the fauna of the Martinez Group seemed to be a distinct unit. Of the forty-nine genera listed only twenty-two could be found in the literature on the Eocene of the Gulf and Atlantic States. No species were found in common yet several were somewhat similar. This fauna has its closest affinities with that represented in the Midway of the Gulf States and the Aquia stage of Maryland and Virginia. The correspondence to the Aquia is however less marked than to the Midway. . . . The fauna of the Tejon Group bears a closer similarity to both the Aquia and Chickasawan than does the Martinez.”

Weaver also concludes from a comparison with the London Basin and Paris Basin faunas that the Martinez is more nearly related to the fauna of the Thanet Sands and the Bracheux Beds. He states: “the Martinez may represent some portion or all of the lower quarter of the Eocene.”

<sup>29</sup> Dall, W. H., 18th Ann. Rept. U. S. Geol. Surv., pt. 2, pp. 327-328, 1898.

<sup>30</sup> *Op. cit.*, pp. 111-113.

The writer agrees with Dr. Weaver's position in correlating the Martinez with the Midway of the Gulf States. The Tejon bears a much stronger resemblance to the Aquia and Chickasawan than does the Martinez. Harris<sup>31</sup> has given an excellent summary of the Midway stage.

#### GENERA COMMON TO MARTINEZ AND MIDWAY

There are several species figured by Harris which are very close to forms found in the Martinez. *Ostrea crenulimarginata* Gabb resembles *Ostrea buwaldana* very closely, if it is not identical with it. *Modiolus saffordi* (Gabb) resembles *Modiolus ornatus* (Gabb). *Cucullaea saffordi* Gabb resembles *Cucullaea mathewsonii* Gabb. The variety *Venericardia planicosta* called *Venericardia alticostata* Conrad resembles a species found in the uppermost Martinez, but none of the species of *Venericardia* figured by Harris vary from the type of *V. planicosta* as much as does *Cardita veneriformis* Gabb.

*Fulgur(?) dallianum* Harris looks like *Perissolax blakei*. *Gyrodes alabamensis* Whitf. resembles *Gyrodes lineata*, n. sp., of the Martinez. *Hercoglossa (Enclimatoceras) ulrichi* White bears a very close resemblance to *Hercoglossa merriami*, n. sp. Thus we see that even some specific resemblances can be found between the faunas of the lower Eocene of the east coast and the Martinez of the west.

The following genera are common to the Martinez and the Midway:

Ostrea	Tellina
Plicatula	Corbula
Pecten	Lucina
Avicula	Martesia
Perna	Pholadomya
Modiolus	Dentalium
Arca	Actaeon
Cucullaea	Cylichna
Glycimeris	Turris
Nucula	Pseudoliva
Leda	Surecula
Yoldia	Olivella
Venericardia	Fusus
Astarte	Triton (= Tritonium)
Crassatellites	Strepsidura
Protocardia	Neptunea
Meretrix	Cypraea

<sup>31</sup> Harris, G. D., The Midway Stage, Bull. no. 4, American Palaeontology, pp. 1-156, June, 1896.

Cerithium	Natica
Turritella	Gyrodes
Architectonica	Amaura (= Amauropsis)
Calyptraea	Fissurella
Xenophora	Enclimatoceras (= Hercoglossa)

*Pyrgula* is the equivalent of *Ficopsis*. *Fulgur(?) dallianum* Harris is rather close to *Perissolax blakei* Conrad. They are generically the same, at least.

#### GENERA PRESENT IN MIDWAY BUT ABSENT IN MARTINEZ

The following genera listed by Harris have not been found in the Martinez:

Lithodomus	Pyropsis
Chama	Leucozonia
Gastrochaena	Mazzalina
Verticordia	Levifusus
Cadulus	Levibucinum
Atys	Murex
Pleurotomella	Calyptrophorus
Drillia	Aporrhais
Caricella	Mesalia
Scaphella	Rissoina
Voluta	Keilostoma
Lyria	Scala
Mitra	Solariella
Exilia	Pleurotomaria

Of these missing genera the following are found in the Tejon, the upper Eocene of the west coast: *Cadulus* (represented by *Dentalium pusillum* Gabb), *Drillia*, *Caricella*, *Voluta*, *Mitra*, *Exilia* (represented by *Fusus dickersoni* Weaver) *Lyria*, n. sp.

#### PROPOSED CORRELATION

The absence of several of the genera mentioned from the Martinez such as *Drillia*, *Caricella*, *Voluta*, *Mitra*, *Exilia*, and *Pseudoliva* which are typical Eocene forms over the world suggests that the Martinez represents a stage in the Eocene of the United States which is at least in part decidedly lower than the Midway.

On account of the close relationship of the Martinez to the Chico-Cretaceous, the much greater thickness of the Eocene strata on this coast compared to that of the Gulf States, and the absence of certain genera typical of upper, middle and lower Eocene, the writer concludes that the Martinez is not only equivalent to a portion of the Midway, but represents a still earlier stage of the Eocene as well.

## SUMMARY

Conclusions based upon the work of all investigators are as follows:

1. The Martinez Group is a definite unit both stratigraphically and faunally.
2. An unconformity exists between the Martinez and the underlying Chico and between the Martinez and the overlying Tejon.
3. The Martinez was deposited in two distinct basins, one being in the vicinity of San Francisco Bay and the other in the neighborhood of Los Angeles.
4. These basins of deposition are only partially coextensive with the larger basin of the Tejon.
5. The faunal differences between Chico and Martinez and between the Martinez and the Tejon are very great.
6. Three major faunal zones have been recognized in the Martinez Group.
7. The Martinez is in part the correlative of the Midway of the Gulf States and in part represents a division of time earlier than the Midway.

## DESCRIPTIONS OF SPECIES

## ANTHOZOA

## FLABELLUM, sp.

A short, conical, slightly curved, and somewhat compressed form is found in the Martinez at San Pedro Point. It appears to have about twenty-four principal septa with one or two secondary septa in the interspaces. Costae appear to correspond to each of the principal septa. The principal septa appear bifid but this may be due to weathering. A small, short pedicel is found on some specimens.

*Dimensions.*—Greater transverse diameter of calice, 9 mm.; lesser, 8 mm.; height, 8.5 mm.

*Occurrence.*—Martinez at San Pedro Point, San Mateo County, California.

## PARACYATHUS(?), sp.

## Plate 6, figure 2

Short, conical, circular, with base truncated, attached at truncation. Costae correspond to all the principal septa which are numerous. About thirty-six of these were counted. One and sometimes two secondary septa are found between the primary ones. Costae appear to be granulated. Wall rather thick.



*Dimensions*.—Diameter of calice, 12 mm.; height, 9 mm.

*Occurrence*.—Martinez of San Pedro Point, San Mateo County, California.

#### ECHINOIDEA

##### CIDARIS, sp., *a*

Plate 6, figures 4*a*, 4*b*

Test unknown. Spines long, very slender, circular in cross-section. Certain incomplete specimens are 15 mm. long and only 1 mm. in diameter with only a slight taper. Surface of spine marked by microscopic, longitudinal, lines or ribs. The distal end is marked by a small ball which is decorated by about fourteen strong rounded ribs. This ball terminates in a rounded tip. The base is marked by a well-developed collar and a rounded socket in its end. The base does not appear to be ornamented.

The surface of the rock is covered with pieces of spines which have been weathered out. The description is based upon several fragments of spines.

*Occurrence*.—University of California Localities 245 and 1556, Martinez Group.

##### CIDARIS(?), sp., *c*

Plate 6, figures 6*a*, 6*b*

A cast of a hemispherical test with the mouth and apical system. central was found in beds of Martinez north of Mount Diablo.

*Dimensions*.—Height, 4 mm.; diameter, 6 mm.

*Occurrence*.—University of California Locality 1592, two and one-half miles east of Clayton.

#### SCHIZASTER LECONTEI Merriam

Plate 6, figure 7

*Schizaster lecontei*.—Merriam, J. C., Proceedings, California Academy of Sciences, Geology, vol. 1, pp. 164–165, 1899.

California Academy of Sciences, vol. 1.

“Small forms averaging a little less than 20 mm. in length. The largest specimen measured is about 23 mm. long. Test distinctly notched anteriorly by the groove of the anterior ambulacrum truncated posteriorly; upper surface much elevated, with a sharp ridge running from the apical system to the posterior end, summit situated far back. Apical system eccentric, posterior, anterior to the summit.

“Ambulacra broad, sunken; anterior petals reaching a little more than half way to the margin; posterior laterals very short, less than half the length of the anterior pair, sometimes almost circular in outline. Ambulacral pores elongated, apparently yoked.(?) Mouth opening well forward, broad two-lipped. Anus high up on the truncated posterior end.

“Numerous large spines much like those of *Schizaster* have been found at one locality in the Martinez, but if they belong to this genus at all they were probably derived from another and much larger species. Tubercles larger on the actinal surface. Peripetalous fasciole quite distinct on one specimen. Traces of what appears to be the lateral fasciole have been seen beneath the anus.

“Though crushed fragments of this species have been known to the writer for some years, the first recognizable specimens were discovered by the members of the class in palaeontology in April, 1907.

“Not rare in the Martinez in Contra Costa County. Specimens preserved only as impressions or casts, usually badly crushed.”

Mr. William Kew has redescribed this species as follows:

“Dimensions: Twenty forms averaged 21.3 mm. in length, the largest being 35 mm. and the smallest 14 mm. Of nine specimens measured the average height was 14 mm., the highest being 22 mm. and the lowest 11 mm. The ratio of height to length varies somewhat. As a rule the length is greater than the height. The average ratio of eight specimens is  $L:H = 1:0.5999$ . In one case the ratio is  $L:H = 1:1.1$ .

“Test deeply and distinctly notched anteriorly by the ambulacral groove, continuing around to the mouth of the actinal side with slight reduction in the size of the groove. Posteriorly the test is truncated at right angles to the bottom. Upper surface slopes steeply to the front and has a sharp ridge running from the apical center to the posterior end which forms the summit of the test. Apical system, eccentric, anterior to the summit. Shell of test very thin, and rarely preserved.

“Ambulacra broad and deeply sunken; anterior petal reaches almost to margin; anterior laterals a little over half way and posterior petals very short and almost circular in outline. Ambulacral pores elongated and consist of two series of three rows each, the middle row of the latter alternating with, and overlapping the outside ones. Extremities of the petals closed. Mouth opening situated about two-thirds the distance forward; broad, two-lipped. Anus high up and at base of the sharp ridge forming the summit.

“Apical shield shows madreporic body large and pentagonal in outline. Tubercles small, numerous on both upper and lower surface, regularly spaced.”

## BRYOZOA

### MEMBRANOPORA(?), sp.

Incrustations doubtfully referred to the genus *Membranopora* were found at University of California Locality 765 near Lower Lake, Lake County, California. The zoecia are hexagonal, regularly arranged in quincunx about 0.5 mm. long and 0.3 mm. wide. Surface slightly concave and bordered by an impressed line.

## BRACHIOPODA

### RHYNCHONELLA(?), sp.

Plate 7, figure 1

A small brachiopod was found at University of California Locality 784 near Lower Lake, which has been referred doubtfully to the genus

*Rhynchonella*. Its ventral valve is marked by concentric growth lines and by microscopic radiating lines. A very prominent median fold extends from the center of the shell to its edge. Cardinal slopes gentle, straight. The outer portion of the shell appears to have been removed.

*Dimensions*.—Length, 9 mm.; height, 8 mm.; convexity, 3 mm.

*Occurrence*.—Martinez near Lower Lake.

#### PELECYPODA

##### LEDA PACKARDI, n. sp.

Plate 7, figures 3a, 3b

Shell thin, marked by fine rounded concentric lines, short, convex; beaks central, small but prominent; anterior dorsal margin, slightly sloping; posterior, straight; anterior end rounded; posterior end bluntly pointed with apex of point at end of straight posterior dorsal margin; base rounded from anterior to middle of posterior ventral margin; from this point the slightly curving posterior margin slopes abruptly upward to the posterior extremity. This species differs from all the other California ledas in shape and in the central position of its beaks. The oddly blunted rostrum is another distinguishing feature.

*Dimensions*.—Length of medium-sized specimen, 10 mm.; height, 5 mm.; convexity, 3 mm.

*Occurrence*.—University of California Locality 784; *Meretrix dalli* zone north of Mount Diablo and the *Trochocyathus zitteli* zone of the Martinez type section, near Muir Station.

Named in honor of Mr. Earl Packard, who assisted the writer in collecting Martinez fossils in Lake County.

##### LEDA MILLERI, n. sp.

Plate 7, figure 4

Shell small, moderately convex; beak, prominent, located one-third of the distance from anterior end. Posterior dorsal edge straight with a very slight slope to a blunt pointed posterior end. Anterior dorsal edge straight with a slightly greater slope than posterior dorsal edge. Ventral margin gently convex. This margin curves sharply toward the two pointed extremities of the shell.

*Dimensions*.—Length, 9 mm.; height, 5 mm.; convexity, 2 mm.

*Occurrence*.—University of California Locality 1556.

Named in honor of Dr. L. H. Miller.

This form resembles *L. packardi*, n. sp., but it has a much less height, its beak is more anterior and its length is greater. It somewhat resembles *Malletia chehalisensis* Arnold in shape.

YOLDIA GESTERI, n. sp.

Plate 7, figure 5

Shell thin, very compressed; anterior end, the shorter, and equally rounded above and below; posterior end, slightly longer, pointed; posterior dorsal margin very slightly concave; escutcheon, long, narrow; base, rounded and most prominent beneath beak, from which point it curves regularly to the pointed, posterior end; beaks, inconspicuous; sculpture consists of fine, rounded concentric threads.

This species is not as convex as *Y. cooperi* Gabb of the Miocene, its posterior dorsal margin is not as concave as that of *Y. cooperi*, and the decoration is much finer.

*Dimensions*.—Length, 28 mm.; height, 12 mm.; convexity, 2 mm.

*Occurrence*.—Lake County at University of California localities 784 and 790.

Named in honor of Mr. Clark Gester, Geologist, Kern Trading and Oil Company.

The outline of the shell is restored by a dotted line.

YOLDIA(?) POWERSI, n. sp.

Plate 7, figure 6

Shell small, thin, elongated, slightly curved, shaped like a pruning knife. Beak, situated a fifth of the length from the anterior end, prominent. Anterior end, broadly rounded; posterior end, pointed sharply. Anterior dorsal margin, convex, short; posterior dorsal edge, concave, long. An impressed groove extends on the east from the beak to the posterior end parallel to and just below the posterior dorsal edge. This groove divides the sharply pointed posterior end. Surface marked by rounded concentric lines which do not show on the type.

*Dimensions*.—Length, 10 mm.; height, 25 mm.; convexity, 1 mm.

*Occurrence*.—Type specimen at University of California Locality 1556, lower zone, north of Mount Diablo. It is abundant at this locality and appears to be characteristic of this horizon. It is easily distinguished from *Y. gesteri*, n. sp., by its more prominent beaks,

by its concave dorsal posterior margin and by its short anterior margin. The knife-like form identifies it readily.

Named in honor of Mr. J. R. Powers, who made very careful collections in the Martinez at Selby Smelter.

PINNA BARROWSI, n. sp.

Plate 8, figure 3

*Description.*—The shape of the shell is elongate-cuneate. The cross-section of the shell is quadrate-oval. The valves meet on their dorsal margins at a sharp angle which increases from sixty degrees near the base to ninety degrees near the beak. The ventral portions of the valves are rounded. Each valve presents two slopes: a flat, dorsal and a slightly convex, ventral which meet along a radial line. This line divides the shell so that the flat dorsal slope is one-third and the rounded ventral, two-thirds of the total surface. The rounded ventral slope is marked in its central half by approximately eight compressed and slightly elevated radial ribs whose interspaces are twice their width, and by eight to ten concentric rounded ribs in its marginal portion as well as radial ribs, thus further dividing the convex slope into equal parts. These ribs do not show on figured specimen. The flat dorsal slope of the shell is ornamented by about ten compressed radial ribs which are separated by interspaces two times as wide. The nearly straight posterior end makes almost a right angle with the ventral margin.

*Dimensions.*—Total length, unknown. Length of specimen whose beak and lower margin are broken, 30 mm., width, 15 mm., approximate.

*Occurrence.*—Two and one-half miles south of Muir Station and one-half mile east of the road which crosses the Briones Hills going south from Muir Station, on north slope of a small tributary of a tributary of Arroyo del Hambre. Elevation, 550 feet. About 100 yards north of Monterey-Martinez contact, University of California Locality 1547, and at University of California Locality 243.

*Notes.*—*Pholadomya nasuta*, *Trochocyathus zitteli*, *Urosyca caudata*, *Siphonalia(?) lineata*, and many other Martinez species are associated with this form. *Pinna barrowsi* has two kinds of ornamentation while *P. brewerii* has but radial ribs. The gore or plait which divides both valves of *P. brewerii* is approximately central, while the

radial line which sets off the flat dorsal portion of *P. barrowsi* is not central nor is it deeply eroded.

This *Pinna* is also found in the lower Tejon, southwest of Mount Diablo, near Pine Creek, at University of California Locality 1489.

Named in honor of Mr. A. L. Barrows.

LIMA(?) CLAYTONENSIS, n. sp.

Plate 7, figures 9a, 9b

Shell inflated, with radial sculpture; rounded and almost symmetrical. Ratio of length to height about .65 to 1. Beak prominent, acute, and in some specimens compressed. Hinge line short and straight with about twelve small striations perpendicular to hinge line. These striations may be plications within the shell wall, revealed by the breaking away of the inner shell layer. Area, narrowly elliptical and central. Basal margin, rounded. Ribs—about thirteen in number—are acute-angled and beaded; the interspaces are the same in width as the ribs.

*Dimensions*.—Length, 2.5 mm.; height, 3.8 mm.

*Occurrence*.—Martinez Group, two miles due east of Clayton in beds near base, University of California Locality 1592. It also occurs at localities 1546 and 1557. (See table of localities.)

The various features described were recognized from a study of four different specimens. This little shell is quite characteristic of the basal beds or beds about 100 feet above the base at its type localities. It is one of the few species found in the Martinez shales.

Named for its occurrence near Clayton.

LIMA(?) HASELTINEI, n. sp.

Plate 8, figure 2; plate 9, figure 11

Shell large, slightly oblique, nearly equivalve, moderately convex; beak prominent, pointed, anterior, prosogyrate; hinge, edentulous, long, straight; ears not markedly set off from rest of shell, the posterior one being the larger; anterior end broadly rounded; posterior, slightly truncated; ventral margin, arcuate; decoration consists of numerous squarish radial ribs with very narrow interspaces.

*Dimensions*.—Height of large specimen, 130 mm.; length, 135 mm.; convexity, 27 mm.

*Occurrence.*—University of California localities 1540 and 1580, both being in the *Trochocyathus zitteli* zone of the area north of Mount Diablo. The Stanford University class in field geology, 1910, also found this form in the Martinez just north of the Calabasas Quadrangle. This is the largest lamellibranch thus far reported from either the Tejon or Martinez on this coast.

Named in honor of my friend, Mr. R. S. Haseltine.

OSTREA BUWALDANA, n. sp.

Plate 9, figure 4

Shell, medium, with thick shell substance, only slightly oblique, elliptical; upper valve flat; lower valve deep, convex and marked by rough, squamose growth lines and about six strong radiating ribs. Muscular scar is reniform, nearly central. Internal margins of some specimens distinctly pitted on both sides of beaks in casts of this species. Occasionally small tooth-like projections are seen on the shell itself on both sides of the beaks.

*Dimensions.*—Length, 35 mm.; height, 48 mm.; convexity of lower valve, 5 mm.

*Occurrence.*—University of California localities 790 near Lower Lake and 693 at San Pedro Point, San Mateo County, California.

It differs from *O. idriaensis* Gabb in that the lower valve is marked by radiating ribs. Its shape is more angular than that of *O. idriaensis*. The type is from University of California Locality 790.

Named in honor of Mr. J. P. Buwalda.

OSTRAEA WEAVERI, n. sp.

Plate 9, figure 3

Shell medium in size, subequivalve, irregularly oval, contorted near the beaks, unattached. Surface marked by regular squamose lines of growth. Beak twisted and terminating at the anterior dorsal margin. The upper half is subglobose while the lower half is flat or slightly concave. These two portions are very deeply set off and the species is readily determined by this characteristic. In the lower valve, the bulging of the upper portion is less prominent. The growth lines are remarkably even for this genus.

*Dimensions.*—Length, 23 mm.; height, 37 mm.; convexity, 11 mm.

*Occurrence.*—University of California localities 781 and 790 near Lower Lake and 1888 near Selby Station.

Named in honor of Professor Charles E. Weaver of the University of Washington.

PECTEN (CHALAMYS?), sp.

Plate 9, figure 6

Shell minute, subcircular, equilateral, slightly ventricose. Right valve with exterior surface ornamented by ten squarish ribs, the middle two being decidedly dichotomous; interspaces channeled and about half as wide as ribs; ears nearly equal, markings, obscure.

*Dimensions.*—Length, 3 mm.; height, 2.5 mm.; convexity, 1 mm.

*Occurrence.*—Only one specimen was found, at University of California Locality 790.

It can be distinguished from all other Eocene pectens on this coast by its small number of external ribs and by the shape of these ribs.

MODIOLUS BAKERI, n. sp.

Plate 9, figure 8

Shell, medium in size, thick; beak small but prominent, about a sixth of the length from the anterior end which is narrowly rounded; posterior end, broadly rounded; cardinal margin, straight; ventral margin, slightly rounded; umbonal ridge prominent, rounded, and extending to the posterior end below its center. A marked concavity in larger specimen figured extends from the beaks to the middle of the ventral margin. Surface marked by lines of growth.

*Dimensions.*—Smaller specimen: length, 17 mm.; height, 8 mm.; convexity, 4 mm.

*Occurrence.*—University of California localities 243, near Murr Station, and 1556, lower zone of Martinez north of Mount Diablo.

This species appears to grow more robust with increase in age. It resembles *Modiolus major* (Gabb), but its beak is not quite so nearly terminal. The marked concavity on the shell also aids in distinguishing it. It differs in shape and in lack of ornamentation from *M. ornatus* (Gabb).

Named in honor of Mr. Charles Lawrence Baker, Geologist, Southern Pacific Company.



## CUSPIDARIA HANNIBALI, n. sp.

Plate 9, figure 10

Shell small; beaks subcentral, of medium size, approximate, prominent and slightly curved anteriorly. Posterior end is about one-third the height of the shell and is produced. The posterior portion of the shell is marked off sharply from the anterior by four transverse rounded ribs which extend from the beak to the base. The interspaces are somewhat wider than the ribs. In two of these interspaces a riblet is found. These ribs do not extend to the posterior tip but end where the posterior portion suddenly narrows, thus dividing the shell into three distinct parts. The anterior portion is rounded and its base is regularly convex. The anterior portion is marked only by concentric lines of growth. A sharp ridge extends from the beak to the dorsal edge of the posterior end and a sharp groove is found between the hinge line and this ridge. Interior unknown.

*Dimensions.*—Length, 10 mm. (?); height, 5 mm; width of produced anterior portion near ribs, 2 mm.

*Occurrence.*—University of California Locality 1547, Martinez Group, *Trochocyathus zitteli* zone.

This specimen differs from *Neaera dolabraeformis* Gabb, which is reported from his "Cretaceous B," in the following ways: (1) Its beak is far less prominent. (2) Its ribs are confined to the central third of the shell, only, while the radial ribs of *N. dolabraeformis* cover all the shell but the produced posterior end. (3) *N. dolabraeformis* lacks the prominent ridge extending from the beak to the anterior end.

This specimen was found by Mr. Hannibal, who accompanied the writer to the locality. The species is associated with *Trochocyathus zitteli*, *Pholadomya nasuta*, *Urosyca caudata*, *Cucullaea mathewsonii*, *Glycimeris veatchii*, var. *major* and *Cardium cooperi*.

Named in honor of Mr. Harold Hannibal.

## CRASSATELLITES STUDLEYI, n. sp.

Plate 10, figure 1

Shell thick, high, suborbicular; beaks prominent, prosogyrate, moderately high, approximate, and situated back of mid-length. Posterior dorsal margin slightly convex, sloping to the broadly rounded posterior end. A well-marked, narrow escutcheon is set off by two acute ridges from the rest of the shell. Anterior dorsal margin nearly

straight, longer than posterior dorsal margin, sloping more steeply than the posterior dorsal margin to a narrowly rounded anterior end. A narrow lunule inset in this margin is slightly concave under the beaks. Ventral margin, rounded. A marked rounded umbonal slope, which extends to a point between the posterior end and the ventral margin, divides the shell into a posterior and an anterior part. The posterior portion is a nearly flat surface while the anterior is convex.

*Dimensions*.—Length, 25 mm.; height, 22 mm.; convexity, 7 mm.

*Occurrence*.—*Trochocyathus zitteli* zone north of Mount Diablo near University of California Locality 1540.

This species is distinguished from *C. grandis* by its greater convexity, by its marked umbonal slope and by lack of trigonal shape. It is distinguished from *C. stewartvillensis*, n. sp., by its more central position of beaks and by its umbonal slope.

Named in honor of Mr. C. K. Studley.

#### CRASSATELLITES STEWARTVILLENSIS, n. sp.

##### Plate 10, figure 3

Shell large, thick, trigonal; beaks rounded, prosogyrate, approximate, situated a third of the distance from the anterior end. Anterior end broadly rounded; posterior, rounded but narrower than anterior. Posterior dorsal margin, nearly straight sloping gently to the posterior end; anterior dorsal margin, short and steep; ventral margin, nearly straight. A prominent heart-shaped lunule is set off by a rounded ridge. The escutcheon is long and narrow and very definitely limited by two sharp angular ridges which extend along most of its length. Surface marked by growth lines only.

*Dimensions*.—Length of broken specimen, 28 mm.; height, 25 mm.

*Occurrence*.—Found at University of California Locality 1540, *Trochocyathus zitteli* zone, north of Mount Diablo.

This form differs from *C. grandis* Gabb in the less central position of the beak, in the slopes of the dorsal margins and in the less convex ventral margin. It differs from *C. unioides* Stanton in beak position and in its less elongate form.

Named for the old coal-mining village of Stewartville, near which it was found.

## CRASSATELLITES CLAYTONENSIS, n. sp.

Plate 10, figures 4a, 4b

Shell, elongate oval; beak, prominent and located one-fourth the distance from anterior end; posterior dorsal margin straight, with gentle slope to posterior; anterior dorsal margin short, concave; anterior end rounded; posterior end, truncated. A rounded umbonal slope extends to the junction of the posterior end and the arcuate ventral margin. Surface marked in umbonal region by prominent, rounded, concentric ribs. The specimens are imbedded in the matrix so that a complete hinge cannot be exposed, but the cardinal teeth appear to be those of *Crassatellites*.

*Dimensions*.—Length, 11 mm.; height, 8.5 mm.; convexity, 3 mm.

*Occurrence*.—University of California localities 1558, basal Martinez beds north of Mount Diablo, and 1547, *Trochocyathus zitteli* zone near Muir Station.

Named for the town of Clayton, near which one of the type specimens was found.

## CARDITA VENERIFORMIS Gabb

Geological Survey of California, Palaeontology, vol. 1, p. 215, 1864.

“Shell small, very convex, subquadrate; beaks rather large, strongly incurved; cardinal margin nearly straight; posterior end obliquely and convexly truncated; anterior end deeply excavated under the beaks, produced and narrowly rounded below; base broadly rounded; lunule broad, deeply impressed. Surface marked by about forty fine, acute, radiating, ribs, with sometimes an intercalated one arising in the middle of the shell, and becoming as large as the others before it reaches the base; these are most numerous anteriorly, where all of the ribs are smaller than on the middle; margin strongly crenulated.

“Locality: West of Martinez. Martinez Group.”

This species has the same acute ribs as the young of *V. planicosta*, and the same variations in form. Some specimens found in the basal Martinez north of Mount Diablo vary from an elongate quadrate form to a high form similar to the high variety of *V. planicosta*.

## PHACOIDES QUADRATA, n. sp.

Plate 10, figure 6

Shell thin, compressed, markedly quadrate, high; beaks rounded, prosogyrate; posterior dorsal margin straight, sloping moderately to the straight posterior end, which is nearly parallel to altitude line;

anterior dorsal margin very slightly convex; anterior end nearly straight; ventral margin rounded; sculpture consists of raised sharp incremental lines with interspaces about three times their width.

*Dimensions*.—Length, 10 mm.; height, 10 mm.; convexity, 1.5 mm.

*Occurrence*.—University of California Locality 784 near Lower Lake.

The quadrate shape of this species is quite sufficient to distinguish it from other members of the genus.

PHACOIDES MUIRENSIS, n. sp.

Plate 10, figures 11a, 11b

Shell small, suborbicular, convex; beaks nearly central; in some specimens slightly posterior to the center. Lunule narrow, small; escutcheon long, narrow; posterior dorsal margin nearly straight; anterior dorsal margin slightly excavated under the beaks; anterior and posterior extremities subtruncate; ventral margin broadly rounded. Surface is marked by strong concentric growth lines and by a very faint, narrow, posterior furrow which is absent in young specimens.

This species differs from *Phacoides turneri* (Stanton) in the truncation of the extremities, in the slightly posterior position of the beak and in the lesser prominence of the posterior furrow.

*Dimensions*.—Height, 14.5 mm.; length, 15.5 mm.; convexity, 3.5 mm.

*Occurrence*.—University of California Locality 243.

Named for its occurrence near Muir Station.

PHACOIDES DIABOLI, n. sp.

Plate 10, figure 7

Shell thin, equivalve, suborbicular, nearly equilateral; beaks prominent, prosogyrate, central; valves convex; lunule narrow and extending half the length of the straight horizontal anterior dorsal margin; escutcheon narrow, two-thirds the length of the straight sloping posterior dorsal margin and set off in each valve by a high, sharp ridge from rest of shell. A rounded ridge extends from the beaks to the middle of the posterior end; the portion of shell between the umbonal ridge and the ridge bordering the escutcheon is slightly concave; sculpture consists of sharp concentric lamellae with interspaces about three times their width.

*Dimensions*.—Length, 23 mm.; height, 18 mm.; convexity, 4 mm.

*Occurrence*.—Common at University of California Locality 340, Martinez Group southwest of Mount Diablo.

The sculpture resembles that of *P. acutilineatus* (Conrad) but its height is proportionally much less than that of *P. acutilineatus*. Its long lunule and escutcheon are also distinctive features.

Named for its occurrence near Mount Diablo.

DOSINIA(?) LAWSONI, n. sp.

Plate 10, figure 9

Shell, medium in size, subglobular, very convex, with full rounded beaks centrally placed; anterior dorsal margin excavated under beaks, where a small lunule is found; posterior dorsal margin nearly straight, with steep slope to the rounded posterior end; anterior end narrowly rounded; ventral margin arcuate; surface smooth or marked by fine incremental lines only.

*Dimensions*.—Length, 16 mm.; height, 14 mm.; convexity, 4.5 mm.

*Occurrence*.—University of California localities 243 and 340, Martinez limestone southwest of Mount Diablo.

The type is a small specimen used on account of its fair preservation. The species is far more convex than the other Eocene species of this genus. In this respect it resembles *D. inflata* Gabb of the Chico, but the shape and position of the beaks is entirely different.

Named in honor of Professor A. C. Lawson, University of California.

VENUS(?), sp.

Plate 10, figure 10

Shell thick subtriangular, convex; beaks very high, nearly central; posterior dorsal margin gently convex, sloping steeply to the rounded posterior; anterior margin very concave and abrupt; ventral margin rounded; lunule indistinct.

*Dimensions*.—Length, 26 mm.; height, 28 mm.; convexity, 7 mm.

*Occurrence*.—University of California localities 790, vicinity of Lower Lake, and 340, southwest of Mount Diablo.

The specimen is a cast, hence the generic reference is doubtful. It differs from *V. lenticularis* Gabb of the Chico in that the beak is considerably higher and the posterior dorsal margin is decidedly

convex and not straight. The anterior and posterior dorsal margins of *V. aequilateralis* Gabb are straight, while those of *Venus(?)*, sp., are concave and convex respectively.

MERETRIX STANTONI, n. sp.

Plate 11, figures 1a, 1b

*Meretrix*, sp.—Stanton, T. W., The Faunal Relations of the Eocene and Upper Cretaceous on the Pacific Coast, 17th Ann. Rept., U. S. Geological Survey, p. 1042, 1896.

Dr. Stanton in his paper on the Eocene and Upper Cretaceous of the Pacific Coast describes a *Meretrix*, but does not give it a specific name. Since this form is abundant in the basal beds north of Mount Diablo and the Martinez in Lake County at Lower Lake, and is distinctive, it is thought best to name it specifically. Dr. Stanton's description is as follows:

"One of the most abundant species at the locality one mile southeast of Lower Lake is a venerid apparently belonging to the genus *Meretrix* and closely resembling the original figure of *M. hornii* Gabb, but as Gabb discredited that figure when it was published and his later figure and the specimens preserved in the Academy of Natural Sciences, Philadelphia, are not at all like it, our fossils can not be identified with his species. Possibly this will prove to be a new species, but I shall not venture to name it until several of Gabb's venerid species represented by conventionalized figures are better known. Shell subtriangular, moderately convex; with thin test; beaks prominent, considerably in advance of the middle, lunule small, deeply impressed; dorsal margin slightly convex behind the beak, sloping rapidly to the narrowly rounded posterior end; anterior end broadly rounded; ventral margin forming a regular curve; surface marked by closely arranged, rather prominent ridges and furrows which vary considerably in size. The numerous specimens collected show considerable variation in relative length of the shells, but this feature does not seem sufficiently constant for specific separation. The dimensions of the largest specimens: Length, 43 mm., height, 31 mm.; convexity of single valve about 8 mm. The corresponding measurements of a smaller specimen of the short variety are 27, 23, and 6 mm., respectively."

*M. stantoni*, which is probably related to *M. hornii*, is more acute posteriorly and the anterior end is higher above. The concentric lines of *M. hornii* are less numerous and more prominent than those of *M. stantoni*. This shell appears to be distinct from the short species, *M. dalli*, described below. It is very abundant in the lower beds of the Martinez formation at University of California Locality 1556, Martinez Group, Mount Diablo Quadrangle, one and one-eighth miles south of Stewartville in the lower beds ten feet above the Martinez-

Chico contact. Elevation, 1050 feet. E. side of the NW  $\frac{1}{4}$  of Section 15, R. 1 E, T. 1 N, Mount Diablo Baseline and Meridian.

MERETRIX DALLI, n. sp.

Plate 11, figures 2a, 2b

Shell trigonal, convex with very thin test; beaks prominent, incurved and bent forward, situated slightly in advance of the center; posterior dorsal margin slightly convex and sloping steeply to the rounded posterior end; anterior dorsal margin concave under the beaks, rounded in advance; ventral margin gently convex; lunule small; escutcheon long and very narrow; sculpture consists of fine incremental lines only.

*Dimensions*.—Length, 22 mm.; height, 17 mm.; convexity, 6 mm.

*Occurrence*.—This species occurs abundantly in the Martinez near Lower Lake. The type specimen was found at University of California Locality 790. It is also found in the basal Martinez north of Mount Diablo.

*M. dalli*, n. sp., differs from *M. stantoni*, n. sp., in its much greater convexity, greater height and shorter length, and the concavity of the anterior dorsal margin is much greater. It differs from *M. hornii* Gabb in shape and sculpture. *M. gabbi* Arnold is higher and inequilaterally trigonal, while *M. dalli*, n. sp., is equilaterally trigonal. *M. ovalis* Gabb and *M. uvasana* Gabb have very different shapes than *M. dalli*, n. sp.

MERETRIX, sp.

Plate 11, figure 3

Shell very convex, trigonal, beaks anterior being one-third of total length from anterior end; posterior dorsal margin but slightly convex and sloping to a narrow posterior end; anterior dorsal margin, concave with a well-marked, large, heart-shaped lunule, anterior end broadly rounded; ventral margin, arcuate; sculpture, fine lines of growth only.

*Dimensions*.—Length, 12 mm.; height, 10 mm.; convexity, 3 mm.

*Occurrence*.—University of California Locality 1556, basal Martinez beds north of Mount Diablo, and University of California Locality 340 southwest of Mount Diablo.

This form, though shorter, resembles *Meretrix hornii* Gabb in shape, but lacks its marked ribbing. It differs from *M. stantoni*, n. sp., in its larger lunule and greater convexity.

## MACROCALLISTA(?) PACKI, n. sp.

Plate 11, figure 4

Shell elongate-oval in shape; beaks prominent, being situated one-third the distance from anterior end; posterior dorsal margin straight, sloping gently to a narrowly rounded posterior end; anterior dorsal margin excavated under the beaks, unusually long; anterior end broadly rounded; ventral margin slightly arcuate; shell substance, thin; surface smooth.

*Dimensions*.—Length, 27 mm.; height, 15 mm.; convexity, 4 mm.

*Occurrence*.—University of California Locality 790, vicinity of Lower Lake, 1580, Lower Martinez beds north of Mount Diablo, and in the Eocene of San Pedro Point, San Mateo County.

This species can readily be distinguished from all other *venerid* species on this coast by its elongate form and by its long anterior dorsal margin.

Named in honor of Mr. Robert Pack, Geologist, U. S. Geological Survey.

## PAPHIA(?) CLARKI, n. sp.

Plate 11, figure 6

Shell long, narrow, inequilateral; beaks small, placed a third of the distance from the anterior end; posterior dorsal margin slightly convex, sloping to a narrow rounded posterior extremity; anterior dorsal margin concave with a very small lunule upon it; sculpture, small, regularly rounded ribs.

*Dimensions*.—Length, 9.5 mm.; height, 6 mm.; convexity, 2 mm.

*Occurrence*.—University of California localities 790 and 784, vicinity of Lower Lake; basal Martinez and *Trochocyathus zitteli* beds north of Mount Diablo.

This form resembles *Tapes conradiana* Gabb closely, but is a shorter form with finer ribbing. The specimens found are all small ones.

Named in honor of Mr. B. L. Clark, Instructor in Palaeontology, University of California.

## TELLINA HERNDONENSIS, n. sp.

Plate 11, figure 9

Shell moderate in size, longer than high; beaks nearly central, prominent. Posterior dorsal margin, straight with slightly greater slope than the posterior dorsal margin. Posterior end narrowly



rounded; anterior broadly rounded; ventral margin nearly straight. A marked, rounded ridge nearly parallels the posterior dorsal margin.

*Dimensions*.—Length, 13.5 mm.; height, 10 mm.; convexity, 2 mm.

This species is very similar in form to *T. hoffmaniana* Gabb which was figured in volume 1, Palaeontology of California (see fig. 113a, pl. 22), but Gabb has undoubtedly confused two different species in this case, as figure 133 is very different. All the specimens from Pence's Ranch in the University of California Cretaceous collections correspond to figure 133, which we will regard as *T. hoffmaniana* Gabb, a Chico form.

*Occurrence*.—University of California Locality 784.

Named for its occurrence near Herndon Creek, Lake County, California.

#### TELLINA PACKARDI, n. sp.

Plate 11, figure 11

Shell large, nearly equilateral, compressed; anterior end evenly rounded; posterior end angulated in middle; beak central, small; sides making an angle of  $110^\circ$  at the umbo; anterior dorsal margin slightly convex with abrupt slope nearly equal to that of the straight posterior dorsal margin; ventral margin broadly rounded; surface marked by concentric lines of growth.

*Dimensions*.—Length, 36 mm.; height, 30 mm.; convexity, 4 mm.

*Occurrence*.—University of California localities 790 and 784, near Lower Lake.

This species differs from *T. parilis* Gabb, *T. aequalis* Gabb, and *T. lorenzoensis* Arnold in its smaller umbonal angle and in its proportionally greater height.

Named in honor of Mr. Earl Packard.

#### TELLINA PERRINI, n. sp.

Plate 11, figure 8

Shell long, very narrow; beaks small and located two-fifths of the shell-length from the anterior end; anterior dorsal slope straight, with gentle slope toward the rounded anterior end; the steeper posterior dorsal slope is slightly concave from beaks outward to half its length and then it becomes convex; posterior extremity very angular; basal margin narrowly arcuate; lunule and escutcheon, long and narrow.

A straight line which extends from the beaks to the sharp angular posterior extremity marks a prominent umbonal slope. The space between this slope and the posterior dorsal margin is decidedly concave. Surface of shell marked by concentric lines of growth.

*Dimensions.*—Length, 33 mm.; height, 11 mm.; convexity, 2 mm.

This species can be distinguished from all other West Coast Eocene forms of the genus, *Tellina*, by its great length and marked umbonal slope.

Named in honor of Professor James Perrin Smith of Stanford University.

TELLINA KEWI, n. sp.

Plate 12, figure 1

Shell medium, thin, broad, slightly convex, very inequilateral, but longer than high; beak small, incurved; posterior and anterior dorsal margins nearly straight, the posterior sloping the more abruptly; anterior end very broadly rounded; posterior end produced and pointed; ventral margin broadly rounded, more prominent beneath the beaks, and curving from this point abruptly upward to the pointed posterior end. Surface plain, or marked with simple growth lines. This species was probably described and refigured by Gabb<sup>32</sup> in the second volume of Palaeontology of California, as *Tellina hoffmaniana*. He says: "This rather variable species is extremely common in the Martinez group at Martinez, and has been found in the Chico group at Pence's Ranch, as well as in the Tejon group at Griswold's. I have now a single specimen from the latter group from Martinez associated with *Turritella uvasana*, and other characteristic species. The present figure illustrates a common, and one of the most marked forms of the Martinez group, Martinez, from the same bed with *Pugnellus hamulus*." The old State Geological Survey specimens now in the collection of the University of California show, upon careful examination, a decided difference between the Chico forms from Pence's Ranch and the ones from Martinez. Several forms which Gabb described from Division A near Martinez have since been proved to be Martinez or Tejon forms. The appearance of the Chico and Martinez sandstones are sometimes very much alike and, if he collected near the Chico-Martinez contact, it is quite likely that he did not distinguish the difference and so placed *T. hoffmaniana* with the Chico

<sup>32</sup> Gabb, Wm., Geological Survey of California, Palaeontology, vol. 2, p. 182.

form, *Pugnellus hamulus*. Comparing the true *Tellina hoffmaniana*, i.e., the Chico form obtained from Pence's Ranch, and described in the first volume issued by the State Survey, with *Tellina kewi*, n. sp., the following differences are noted: (1) The beaks of *T. kewi* are situated anteriorly, while those of *T. hoffmaniana* are central. (2) The length of *T. hoffmaniana* is proportionally greater than *T. kewi*. (3) The posterior end of *T. kewi* is pointed, while that of the other is sub-truncated. (4) The anterior end of *T. kewi* is far more broadly rounded. Dr. Stanton probably compared his specimens obtained from Lake County with Gabb's second figure, and hence identified it as *T. hoffmaniana*.

*Dimensions*.—Length, 18 mm.; height, 14 mm.; convexity, 1.5 mm.

*Occurrence*.—This *Tellina* is common at University of California localities 784 and 790, near Lower Lake, Lake County, California.

Named in honor of Mr. Wm. Kew, University of California, who has ably assisted the writer in collecting.

PSAMMOBIA(?) CYLINDRICA, n. sp.

Plate 12, figures 2a, 2b

Shell moderately long, thick, convex; beak located a fifth of distance from anterior end, prosogyrate, approximate; nymph narrow, cylindrical, elongate; posterior dorsal margin straight and nearly parallel with the nearly straight ventral margin; anterior dorsal margin slightly concave under beak, with moderate slope to a narrowly rounded anterior end; posterior end almost straight. A rounded umbonal slope extends from the beak to the angle which the posterior end makes with the ventral margin. Shell ornamented by concentric lines of growth.

*Dimensions*.—Length, 39 mm.; height, 18 mm.; convexity, 8 mm.

*Occurrence*.—University of California Locality 780, near Lower Lake village, in the uppermost Martinez. This locality is probably 200 feet below the base of the Tejon. It is also found at the very top of the Martinez, at the type locality.

SPISULA(?) WEAVERI, n. sp. Packard

Plate 12, figures 4a, 4b

Shell small, relatively thick, subtrigonal to oval, moderately ventricose, evenly rounded; umbones nearly central, prosogyrate, prominent, nearly adjacent; anterior dorsal margin concave for a distance

equal to about one-third the height of the shell; anterior extremity slightly attenuated, evenly rounded; base broadly rounded; posterior evenly rounded, curving gently in the dorsal region to the beak; surface roughened by coarse lines of growth; hinge and interior but imperfectly known.

*Dimensions.*—Length, 32 mm.; height, 26 mm.; diameter of one valve, 5 mm.

*Horizon.*—Lower Martinez, *Meretrix dalli* zone.

This form varies considerably from the type specimen to an elongated form, which is slightly more ventricose. Gradational types are found between these forms.

Type from University of California Locality 1556.

#### MARTESIA(?), sp.

Shell elongate with thin test; beaks anterior, incurved, approximate; posterior dorsal margin concave and undulating; anterior dorsal margin short, rounded; anterior end rounded; posterior end slightly flaring; ventral margin nearly straight. One beaded umbonal groove diverges from the beak. A posterior groove, which indicates the position of an internal rib, makes a very obtuse angle with the ventral margin. Tube unknown.

*Dimensions.*—Height, 13 mm.; length, unknown.

*Occurrence.*—Found at University of California Locality 784, near Lower Lake.

The posterior dorsal margin is concave, while that of *Turnus plenus* Gabb of the Chico is nearly straight. Its flaring posterior end serves to distinguish it from *T. plenus* Gabb and *Martesia clausa* Gabb.

Mr. Barrows, who is making a study of boring molluses, kindly helped me in determining this form.

#### GASTROPODA

##### ACMAEA MARTINEZENSIS, n. sp.

Plate 12, figure 8

Shell large, high, elliptical, smooth except for indistinct growth lines; apex rounded and situated two-fifths of length from anterior end; the slopes on the sides from the apex are much steeper than those to the ends.

*Dimensions*.—Major axis, 35 mm.; minor axis, 23 mm.; height, 11 mm.

*Occurrence*.—University of California Locality 790.

This species differs from *A. tejonensis* Gabb of the Tejon in having a rounded apex instead of a pointed curved one, and in shape of base.

Named for the Martinez group, in which it was found.

FISSURELLA(?) BEHRI, n. sp.

Plate 12, figure 9

Shell oval, conical, with form and decoration like an individual coral; apex acute, with round aperture (?), located two-fifths of length from anterior end; margin crenulated; surface of shell marked by fourteen acute, nearly straight, radiating ribs with concave interspaces twice their width.

*Dimensions*.—Major axis, 12 mm.; minor axis, 10 mm.; height, 7 mm.

*Occurrence*.—University of California Location 243, *Trochocyathus zitteli* zone, type locality of Martinez Group.

Named in honor of Mr. Ernest Behr.

NERITA(?) BIANCULATA, n. sp.

Plate 12, figure 12

Shell semiglobose, with low immersed spire, whorls three. The body whorl is marked by spiral lines and transverse nodose ribs. The other whorls are also nodose. Mouth subquadrate. The shell is marked by two angles—a right angle setting off the body whorl from the spire and an obtuse angle which divides the body whorl in halves, both of which are flattened. Inner lip callused with plications; outer lip characters unknown.

*Dimensions*.—Height, 10 mm.; width of body whorl, 6 mm.

*Occurrence*.—University of California localities 243 and 211.

This species is easily distinguished from *N. triangulata* Gabb by its having only two angulations and by the presence of transverse, nodose ribs.

NATICA (GYRODES) LINEATA, n. sp.

Plate 13, figure 3a, 3b

Shell of moderate size, solid, thick, moderately elevated, and marked by strong spiral lines. These spiral lines are crossed by growth lines occasionally; five rounded whorls which are distinctly channeled; body

whorl large; mouth ovate; outer lip simple; inner lip smooth; umbilicus open and appears to be bounded by a line.

*Dimensions*.—Height, 18 mm.; width of body whorl, 21 mm.

*Occurrence*.—This species is abundant in the basal beds of the Martinez, University of California Locality 1556, from which the type and co-type were obtained. It ranges from the basal beds to uppermost Martinez.

This species is readily distinguished by its prominent spiral lines from all other similar forms in the Eocene, except *Bullinula subglobosa* Weaver. It differs from *Bullinula subglobosa* Weaver by having a much wider aperture, by its distinct channeling between whorls, and by a less prominent spire.

AMAUOPSIS MARTINEZENSIS, n. sp.

Plate 13, figures 4a, 4b

Shell elongated with very high spire for this genus; whorls six; rounded on sides; suture deeply channeled and bordered by a narrow flat margin which slopes to the suture. Aperture half oval; outer lip simple; inner lip thinly incrustated forming a fold which at first sight seems to be an umbilicus. Surface marked by fine but well-marked revolving lines and lines of growth.

*Dimensions*.—Height, 33 mm.; width of body whorl, 28 mm.

*Occurrence*.—Martinez Group, University of California Locality 1540, one mile south of Stewartville.

This species appears to be the precursor of *Amauopsis alveata* (Conrad). It has a narrow channeling on upper portion of whorl while *A. alveata* has a wide slightly concave channeling. The spire of this species is decidedly higher than that of *A. alveata*. It differs from *A. oviformis* Gabb in its greater height and in its decoration.

TURITELLA CLARKI, n. sp.

Plate 13, figure 8

Shell short, conical with eleven whorls. When uneroded the whorls lines with flatly channeled interspaces equal in width to ribs. The are nearly flat. A faint angulation can be seen slightly below the center of certain whorls. This angle is marked by a spiral line which is somewhat stronger than the rest. The body whorl appears to have a double angulation, the spiral line below its impressed linear suture marking the upper angle. The decoration consists of flat-topped spiral

number of spiral lines on the different body whorls is variable. Eight were counted on the penultimate whorl, ten on the next and seven on the eighth. Faint lines of growth cross the spiral lines.

*Dimensions*.—Length, 32 mm.; width of body whorl, 12 mm.

*Occurrence*.—University of California Locality 1540, *Trochocyathus zitteli* zone north of Mount Diablo.

This species resembles *T. martinezensis* Gabb in its apical angle, but the number of spiral lines is much greater than that of *T. martinezensis*. Its great apical angle is quite sufficient to distinguish this form from all the other Eocene species of this genus.

Named in honor of Mr. Bruce L. Clark, Instructor in Palaeontology, University of California.

#### CERITHIUM, sp.

Plate 14, figure 2

Shell robust, conical, with a large apical angle; about twelve flat-sided whorls. These whorls are decorated by about twenty vertical ribs, crossed by about ten revolving ribs. Of the two sets, the vertical is the stronger. The body whorl has the short canal of this genus.

*Dimensions*.—Length of broken specimen, 30 mm.; width of body whorl about 12 mm.

*Occurrence*.—Abundant, but poorly preserved in the Martinez of San Pedro Point, San Mateo County, California, University of California Locality 692.

#### ALARIA, sp.

Plate 14, figure 3

Shell elongated; spire high; nine or ten whorls; upper whorls spinous, convex, widest a little below the middle; last whorl sharply and acutely angulated, sloping and gently concave above and below the angle; suture impressed. Surface ornamented by fine, thread-like, revolving lines, and by sinuous lines of growth. Canal long, narrow, straight. Outer lip unicarinate, slightly curved.

*Dimensions*.—Width of body whorl, 11 mm.; approximate height of spire, 12 mm.

*Occurrence*.—University of California Locality 692.

This species resembles *Anchura angulata* Gabb closely and it may be identical with it, as Gabb's description was based upon a single poorly preserved specimen found at Bull's Head Point. This form may later be found to belong to the genus *Spinigera*.

## ANCHURA ENGLISHI, n. sp.

Plate 14, figure 5

Shell fusiform with very low spire; six whorls; body whorl large with long, slender, slightly curved canal; lip long, straight. Body whorl shows a node about ninety degrees from expanded lip. The portion of the body whorl above the shoulder slopes gently upward to an impressed suture; decoration, unknown.

*Dimensions*.—Height, 20 mm.; width of body whorl, 13 mm.; length of expanded lip, 8 mm.

*Occurrence*.—University of California Locality 243, *Trochocyathus zitteli* zone at type locality.

Named in honor of Mr. Walter English.

## ANCHURA GABBI, n. sp.

Plate 14, figure 4

Shell small, fusiform, spire elevated, six rounded whorls, suture deep. Surface of upper whorls strongly cancellated by transverse ribs and faintly revolving lines; body whorl strongly marked by two carinae, the upper one of which extends outward to the tip of the lip. Lip long straight perpendicular to whorls, tip acute; canal narrow, length unknown.

*Dimensions*.—Width of body whorl, 6 mm., including lip, 11.5 mm.; length of whorls, 13 mm.

*Occurrence*.—Martinez Group, one mile south of Stewartville; University of California Locality 1540.

The specimen figured occurs in hard, gray-green, glauconitic sandstone typical of the Martinez Group. It is associated with *Tellina undulifera*, *Cucullaea mathewsonii*, *Tapes(?) quadrata*, *Turritella infragranulata*, *Perissolax tricarnatus*, and *Trochocyathus zitteli*, characteristic Martinez species.

It differs from *A. transversa* Gabb in having a shorter uncurved lip and its body whorl is marked by two carinae instead of the one as in *A. transversa*.

## SERAPHS(?) THOMPSONI, n. sp.

Plate 14, figures 6a, 6b

Shell elongate, narrow, with spire almost as long as body whorl. Seven whorls rounded, cylindrical. Body whorl is decorated by fine spiral lines crossed by lines of growth. Mouth narrow, long; outer lip simple; inner lip slightly incrustated.



*Dimensions.*—Length, 20 mm.; width of body whorl, 6 mm.

*Occurrence.*—University of California Locality 784, near Lower Lake.

Named in honor of Mr. Percy W. Thomson, Geologist, Standard Oil Company.

OVULA MARTINI, n. sp.

Plate 14, figures 7a, 7b

Shell ovoid, widest about one-third of the distance from the upper end, suddenly narrowing below; under surface flattened. Mouth straight, medium width. Outer lip broad and rounded. Canal unusually long for this genus.

*Dimensions.*—Greatest width, 28 mm.; length, 42 mm.

*Occurrence.*—Martinez Group, University of California Locality 243, and two and one-half miles south of Muir Station, and one-half mile east of the road which crosses the Briones Hills going south from Muir Station, on north slope of a small tributary of a tributary of Arroyo del Hambre, elevation 550 feet, 100 yards north of Monterey-Martinez contact.

This form differs from *Cypraea bayerquei* Gabb in that its canal is much longer, it is much thicker and its shape is different.

TRITONIUM(?) BUWALDI, n. sp.

Plate 15, figure 3

Shell fusiform, robust; spire probably high; number of whorls unknown, the spire being defective. Surface of body whorl ornamented by about fourteen moderately long nodose longitudinal ribs at thickest part of whorl. These ribs are parallel with the axis. They do not extend to the impressed suture above. Slightly below the middle the body whorl is decorated by eight prominent spiral ribs with interspaces twice as wide. Mouth oval; inner lip slightly incrustated (?); outer lip, defective; canal long, slightly curved.

*Dimensions.*—Length of broken specimen, 37 mm.; width of body whorl, 25 mm.

*Occurrence.*—Only one specimen of this species was found, at University of California Locality 790, near Lower Lake.

Named in honor of Mr. J. P. Buwalda.

## TRITONIUM MARTINEZENSIS, n. sp.

Plate 15, figure 2

Shell fusiform, turreted, spire high and nearly equal in length to mouth; whorls six; suture impressed. Mouth wide above, narrowed in advance, canal slightly curved. Surface marked by prominent nodes on the angles of the whorls, prolonged markedly below, but not above. Well-marked spiral lines of uniform size cover both the nodes and surface of the shell.

*Dimensions*.—Height of shell, 20 mm.; height of spire, 7 mm.; width of body whorl, 7 mm.

*Occurrence*.—University of California Locality 1556.

This *Tritonium* resembles *T. whitneyi* Gabb in some respects. The drawings of *T. whitneyi* (Palaeontology of California, vol. 1, plate 28, figs. 210 and 210a) are strikingly like this shell, but the type specimen of *T. whitneyi* differs in the following ways: (1) *T. whitneyi* has seven or eight whorls; (2) its nodes are only "prolonged slightly below and above"; and (3) its revolving lines alternate in size and divide the nodes into two parts.

## HEMIFUSUS(?) WARINGI, n. sp.

Plate 15, figure 10

Shell fusiform, with short spire; number of whorls unknown; body whorl biangular, with about fifteen axial ribs which become nodose at the angles. One of the angles is situated at the middle of the outer lip, while the other is slightly below the suture. The suture is enveloped by the preceding whorl. Outer lip simple; columella incrustated. Canal moderately long and nearly straight. Five rounded, spiral lines ornament the body whorl.

*Dimensions*.—Height of broken specimen, 28 mm.; width of body whorl, 22 mm.

*Occurrence*.—The species was found in the upper(?) Martinez along the Santa Fé Railroad, about two miles east of Martinez. It is doubtfully referred to *Hemifusus*. When better specimens are found it may be placed in the genus *Clavella*.

Named in honor of Mr. C. A. Waring.

## FUSUS DUMBLEI, n. sp.

Plate 16, figure 6

Shell fusiform, whorls nine, angular. Spire about half length of shell. Angulation is central on whorls. Space above and below angles

is flat or slightly convex. Surface of body whorl marked by ten to twelve spiral lines with interspaces twice as wide; oblique lines of growth are found also. Canal slender, very long, straight.

*Dimensions*.—Length of spire, 12 mm.; length of body whorl from suture to constriction, 7 mm.; width of body whorl, 8 mm.

*Occurrence*.—The type specimen was found by Dr. C. E. Weaver at University of California Locality 790, Lower Lake.

*Fusus dumblei* resembles *F. mathewsonii* Gabb in its marked angulation, but it lacks the double angulation on the lower whorls and it is far less robust than *F. mathewsonii*. This is the only *Fusus* thus far reported from the Martinez of Lower Lake.

Named in honor of Professor E. T. Dumble, Consulting Geologist, Southern Pacific Company.

#### OLIVELLA CLAYTONENSIS, n. sp.

Plate 16, figure 7

Small, spire very low; whorls four, suture covered; surface marked faintly by transverse growth lines, mouth not exposed. Outer lip thickened.

*Dimensions*.—Height, 8 mm.; width of body whorl, 4 mm.

*Occurrence*.—University of California Locality 1543.

This species differs from *Olivella mathewsonii* in height of spire.

#### TURRIS LOUDERBACKI, n. sp.

Plate 16, figures 9a, 9b

Shell fusiform, with high spire which is nearly equal in length to the body whorl; eight whorls marked by twelve rounded nodes. The slightly concave space above the shoulder of the whorl slopes steeply from the impressed linear suture. In the whorls of the spire this space is twice as long as the nodose convex space below the angle. Fine rounded spiral lines decorate the whorls. Growth lines indicate a sinus at angle. Outer lip simple; inner lip incrustated; canal long, straight.

*Dimensions*.—Length of nearly complete specimen, 35 mm.; width of body whorl, 13 mm.

*Occurrence*.—University of California Locality 1540, *Trochocyathus zitteli* zone north of Mount Diablo, and same zone at type locality.

Its very graceful, long, turreted spire is its distinguishing feature. Named in honor of Professor G. D. Louderback, University of California.

SURCULA MERRIAMI, n. sp.

Plate 16, figure 10

Shell fusiform, with moderately high spire, with seven or more nodose whorls; suture line prominent and just below the nodes. About fourteen nodes ornament the body whorl, while only ten are found on the fourth whorl. The nodes are acute, and strong spiral lines mark them. The nodes on the body whorl are much longer than those on the upper whorls. The portion of the whorl between the shoulder and the suture is concave with the center of the concavity two-thirds of the total distance above the nodes. This surface is marked by the curved lines of growth of the sinus, and the apex of the curve is two-thirds the distance above the nodes, thus indicating the position of the sinus. The canal is broken but the upper portion suggests that it is a long one.

*Dimensions*.—Length of broken specimen, 21 mm.; width of body whorl, 13 mm.

*Occurrence*.—University of California localities 1556 and 1558.

The strong spiral lines on the nodes are the distinctive features of this shell. Two specimens have been found.

Named in honor of Professor J. C. Merriam.

SURCULA FAIRBANKSI, n. sp.

Plate 16, figure 12

Shell spindle-shaped, slender with eight whorls, nodose, convex and angulated in middle; suture well marked and deep. About ten nodes ornament each whorl. They extend to the suture. The whorls are but slightly swollen. The portion of the whorl between the shoulder and the surface is flat and the lines of growth of this area are curved with the apex of the curve near the suture, indicating that the sinus is above the shoulder of the whorl. The inner lip appears to be slightly incrustated.

*Dimensions*.—Length, 45 mm.; width of body whorl, 20 mm.

*Occurrence*.—University of California Locality 1540.

At first sight this shell looks like *Pleurotoma fresnoensis* Arnold, but it is much larger, the number of whorls is only eight instead of

ten of the *P. fresnoensis*, and its apical angle is decidedly greater. The nodes of this shell are not so pointed as those of *S. crenatospira* Cooper. The portion of the whorl between the shoulder and the suture in *S. crenatospira* is curved.

Named in honor of Dr. H. W. Fairbanks.

SURCULA (SURCULITES) ANDERSONI, n. sp.

Plate 16, figure 11

Shell very long, slender; spire high about two-fifths of length; nine or ten whorls, nodose, angulated, with sinus slightly above angle judging from growth lines; twelve or thirteen elongate rounded nodes mark each whorl. The body whorl is distinctly marked by revolving lines which alternate in size. A very distinct collar appears just below the channeled suture of each whorl.

*Dimensions*.—Length of broken specimen, 40 mm.; width of body whorl, 12 mm.

*Occurrence*.—The type specimen was found at University of California Locality 243, *Trochocyathus zitteli* zone of type locality. It also occurs at Selby Smelter on the Carquinez Straits.

*Surcula* (*Surculites*) *praeattenuata* Gabb of the Tejon resembles this species closely, but its body whorl is decidedly shorter in proportion to length.

Named in honor of Mr. F. M. Anderson, Curator of Invertebrate Palaeontology, California Academy of Sciences, San Francisco.

SURCULA, sp.

Plate 16, figures 13a, 13b

Shell fusiform, with moderately high spire, with seven or more nodose whorls; suture line prominent and just beneath the nodes. About fourteen nodes ornament the body whorl, while only ten are found on the fourth whorl. The nodes are acute, and strong spiral lines of growth mark them. The nodes on the body whorl are much longer than those on the upper whorls. The portion of the whorl between the shoulder and the suture is concave, with the center of the concavity two-thirds of the total distance above the nodes. This surface is marked by the curved lines of growth of the sinus and the apex of the curve is two-thirds the distance above the nodes, thus

indicating the position of the sinus. The canal is broken, but the upper portion suggests that it is a long one.

*Dimensions*.—Width of body whorl, 13 mm.

*Occurrence*.—University of California Locality 1540.

#### CEPHALOPODA

##### HERCOGLOSSA MERRIAMI, n. sp.

Plate 17, figures 5a, 5b

Shell medium in size, aperture wide; ventral saddles large and simple; lateral lobes well rounded, becoming more acute toward the posterior; lateral saddles well rounded but not so acute as the lateral lobes.

*Dimensions*.—Diameter about 90 mm.

*Occurrence*.—Two specimens have been found at University of California Locality 243, *Trochocyathus zitteli* zone, type locality of the Martinez.

This species differs from *H. tuomei* Clark and Martin and from *H. ulrichi* (White) in its more acute lateral lobes and saddles. Its aperture is narrower than that of *H. ulrichi*. In other respects it resembles this last mentioned species closely.

##### NAUTILUS STEPHENSONI, n. sp.

Plate 18, figures 2a, 2b

Shell subglobose. Whorls increasing very rapidly in size. The body whorl is large, convex, rounded on sides; the other whorls are immersed in it. Umbilicus covered. Surface decorated by very fine sinuous lines of growth. Septa slightly undulating; ventral lobe slightly concave; the lateral lobe and lateral saddle gently curved. The uniform rounding of the body whorl is a very pronounced feature of this species.

*Dimensions*.—Greatest diameter 32 mm.

*Occurrence*.—University of California Locality 243.

This species is decidedly more globose than the species described by Gabb as *Nautilus texanus*(?) Shumard.

Named in honor of the collector, Dr. L. W. Stephenson, Acting Professor of Palaeontology, University of California.

## PREVIOUSLY DESCRIBED MARTINEZ SPECIES RE-FIGURED

Several of the better preserved and characteristic species of the Martinez fauna have been figured in this paper in order that the reader might have comparative forms before him. They are as follows:

- Flabellum remondianum* Gabb. Plate 6, figures 1a, 1b, 1c, 1d.  
*Trochocyathus zitteli* (Merriam). Plate 6, figures 3a, 3b, 3c, 3d.  
*Schizaster lecontei* Merriam. Plate 6, figure 7.  
*Terebratulina tejonensis* Stanton. Plate 7, figures 2a, 2b.  
*Cucullaea mathewsonii* Gabb. Plate 7, figures 7a, 7b, 8.  
*Lima multiradiata* Gabb. Plate 8, figure 1.  
*Phalodomya nasuta* Gabb. Plate 9, figures 1a, 1b.  
*Psammobia hornii* (Gabb). Plate 11, figure 10.  
*Mytilus cf. ascia* Gabb. Plate 9, figure 2.  
*Pecten interradiatus* Gabb. Plate 9, figure 5.  
*Modiolus merriami* (Weaver). Plate 9, figure 7.  
*Cuspidaria dolabraeformis* (Gabb), Plate 9, figure 9.  
*Plicatula ostreaformis* Stanton. Plate 9, figure 12.  
*Crassatellites unioides* (Stanton). Plate 10, figure 2.  
*Glycimeris veatchii* var. *major* (Stanton). Plate 10, figure 5.  
*Phacoides turneri* (Stanton). Plate 10, figure 8.  
*Tapes* (?) *quadrata* Gabb. Plate 11, figure 5.  
*Tellina undulifera* Gabb. Plate 11, figures 7a, 7b, 7c.  
*Tellina cf. parilis* Gabb. Plate 11, figure 12.  
*Solen stantoni* Weaver. Plate 12, figure 3.  
*Maetra* (?) *tenuissima* Gabb. Plate 12, figure 5.  
*Dentalium cooperi* Gabb. Plate 12, figure 7.  
*Discohelix californicus* Weaver. Plate 12, figure 10.  
*Architectonica tuberculata* Weaver. Plate 13, figures 2a, 2b.  
*Lunatia hornii* Gabb. Plate 13, figure 5.  
*Lunatia cf. nuciformis* Gabb. Plate 13, figures 6a, 6b.  
*Xenophora zitteli* Weaver. Plate 13, figure 7.  
*Turritella infragranulata* Gabb. Plate 13, figures 9a, 9b.  
*Turritella martinezensis* Gabb. Plate 13, figure 10.  
*Turritella pachecoensis* Stanton. Plate 14, figures 1a, 1b, 1c.  
*Cypraea bayerquei* Gabb. Plate 15, figure 1.  
*Brachysphingus liratus* Gabb. Plate 15, figure 4.  
*Turbinella crassatesta* Gabb. Plate 15, figure 5.  
*Urosyca caudata* Gabb. Plate 15, figures 7a, 7b.  
*Urosyca robusta* Gabb. Plate 15, figure 8.  
*Siphonalia* (?) *lineata* Stanton. Plate 15, figure 9.  
*Neptunea mucronata* Gabb. Plate 15, figure 11.  
*Neptunea cretacea* Gabb. Plate 15, figure 12.  
*Fusus aequilateralis* Weaver. Plate 16, figure 1.  
*Fusus mathewsonii* Gabb. Plate 16, figure 2.  
*Fusus occidentalis* Gabb. Plate 16, figure 3.  
*Fusus aratus* Gabb. Plate 16, figure 4.  
*Fusus flexuosus* Gabb. Plate 16, figure 5.  
*Perissolax tricarnatus* Weaver. Plate 16, figures 8a, 8b.  
*Heteroterma gabbi* Stanton. Plate 17, figure 1.

- Actaeon lawsoni* Weaver. Plate 17, figure 2.  
*Bullinula subglobosa* Weaver. Plate 17, figure 3.  
*Ringinella pinguis* Gabb. Plate 17, figures 4a, 4b.  
*Aturia mathewsonii* Gabb. Plate 18, figure 1.

All the species figured were obtained from the Martinez Group. Several of Gabb's genera are not in accord with present usage, but they have been retained in this paper in those cases where the correct genus was uncertain.

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## APPENDIX

### LIST OF LOCALITIES\*

65. Concord Quadrangle. Martinez Group. Alhambra Valley. On ridge just east of point where Arroyo del Hambre turns to the north, two and one-quarter miles south of Muir Station. J. C. M. Loc. 65. Concord Sheet.
150. See 340.
243. Concord Quadrangle. Martinez Group. Same as 500 and 544. One and three-fourths miles due south of Muir Station.
267. Concord Quadrangle. Martinez Group. One-sixteenth mile north from Arroyo del Hambre. Two miles south 30 degrees west of Muir Station. J. C. M. Loc. 267.
337. Concord Quadrangle. One and one-quarter miles southeast of Muir Station. On hillside northeast side of Martinez-Walnut Creek road, 75 feet above road. J. C. M. Loc. 337.
340. Mount Diablo Quadrangle. Summer School, 1911. Martinez Group. SE  $\frac{1}{4}$  of NE  $\frac{1}{4}$  Sec. 4, R. 1 W, T. 1 S, Mount Diablo Sheet.
333. Concord Quadrangle. Martinez Group. Two and one-quarter miles south, 10 degrees west of Muir Station. J. C. M. Loc. 333.
500. Same as 243 and 544. See Loc. 243.
- 501 = 213. Concord Quadrangle. Martinez Group. Two and one-eighth miles southeast of Muir Station on the southwest side of Martinez-Walnut Creek road, about one and one-half miles northwest of Grayson's Creek, on side of hill near top, a little to north of Locality 343 but on same hill. J. C. M. Loc. 501 = 213. Concord Sheet.
532. Concord Quadrangle. Eocene. One and three-eighths miles southeast of Muir Station. Across road from 541, on side of hill. J. C. M. Loc. 532.
541. Concord Quadrangle. On south side of road a little over one and three-eighths miles southeast of Muir Station. J. C. M. Loc. 541. Concord Sheet.
544. See 243.

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\* The initials, J. C. M. refer to the collections of J. C. Merriam, and R. E. D. to those of R. E. Dickerson.



779. Vicinity of Lower Lake, Lake County. Martinez Group, uppermost strata. "SW  $\frac{1}{4}$  of NE  $\frac{1}{4}$  of Sec. 8, T. 12 N, R. 6 W," Map 88.
780. Vicinity of Lower Lake, Lake County. Martinez Group. NW  $\frac{1}{4}$  of SW  $\frac{1}{4}$  of Sec. 36, T. 13 N, R. 7 W; 3000 to 3300 feet (strat.) above Martinez base. Limestone in shale.
782. Vicinity of Lower Lake, Lake County. Martinez Group. SE  $\frac{1}{4}$  of SE  $\frac{1}{4}$  of Sec. 26, T. 13 N, R. 7 W, in cañon whose creek flows past old dam; 2000 to 2500 feet (strat.) above north contact line of Chico-Martinez. Map 88.
784. Vicinity of Lower Lake, Lake County. Martinez Group. NW  $\frac{1}{4}$  of NE  $\frac{1}{4}$  of Sec. 11, T. 12 N, R. 7 W, about one-fourth to one-half mile east and a little south of Lower Lake on Knoxville road, 1000 feet (horizontal distance) above the Chico-Martinez contact, well at old brick yard. (A Stanton locality.) Map 88.
785. Vicinity of Lower Lake, Lake County. Tejon Group. NW  $\frac{1}{4}$  of SW  $\frac{1}{4}$  of Sec. 6, T. 13 N, R. 6 W, in west gully near hill top. Elevation, 1750 feet. Map 88.
787. Vicinity of Lower Lake, Lake County. Martinez Group. SE  $\frac{1}{4}$  of SE  $\frac{1}{4}$  of Sec. 36, T. 13 N, R. 6 W, on south side of Cache Creek. Martinez Group, about 300 feet stratigraphically below Martinez-Tejon contact. Map 88.
788. Vicinity of Lower Lake, Lake County. Martinez Group. SW  $\frac{1}{4}$  of SW  $\frac{1}{4}$  of Sec. 1, T. 13 N, R. 7 W, 1000 feet north of Herndon Creek bridge, Knoxville road. Map 88.
790. Vicinity of Lower Lake, Lake County. Martinez Group. SE  $\frac{1}{4}$  of NE  $\frac{1}{4}$  Sec. 11, T. 12 N, R. 7 W, three-fourths of a mile east of Lower Lake, 1200 feet south from bridge over Herndon Creek, in gully on west side of creek. Map 88.
1540. Mount Diablo Quadrangle. (Loc. 91 R. E. D.) One mile south of Stewartville, 100 yards south of basal Tejon conglomerate and 600 feet north of Chico-Martinez contact. Elevation, 1000 feet. NE cor. of NW  $\frac{1}{4}$  of Sec. 15, R. 1 E, T. 1 N, Mount Diablo B. L. and M.
1547. Concord Quadrangle. Seven and one-half miles south of north edge of Concord Sheet, just south of Arroyo del Hambre Creek. Martinez sandstone.
1556. Mount Diablo Quadrangle. A little over one mile south of Stewartville, ten feet above the Martinez-Chico contact, in basal Martinez beds. Elevation, 1050 feet. NE  $\frac{1}{4}$  of NW  $\frac{1}{4}$  of Sec. 15, T. 1 N, R. 1 E, Mount Diablo B. L. and M.
1557. Mount Diablo Quadrangle. Sec. 15 R. 1 E, T. 1 N. In Martinez near Chico contact. (Map 61).
1558. Mount Diablo Quadrangle. (Loc. 41 R. E. D.) Martinez Group. Two and one-fourth miles east of Clayton. Elevation, 1450 feet, 200 feet stratigraphically above the Martinez-Chico contact. SW  $\frac{1}{4}$  of Sec. 8, T. 1 N, R. 1 E, Mount Diablo B. L. and M.
1580. Mount Diablo Quadrangle. About one mile south of Stewartville. Elevation, 1000 feet, 400 feet stratigraphically above the Martinez-Chico contact. The same stratum as Loc. 1540. NW  $\frac{1}{4}$  of NE  $\frac{1}{4}$  of Sec. 15, T. 1 N, R. 1 E, Mount Diablo B. L. and M.

1586. Mount Diablo Quadrangle. Martinez Group. South part of Sec. 8, R. 1 E, T. 1 N, Mount Diablo B. L. and M.
1592. Mount Diablo Quadrangle. Martinez Group. SW cor. Sec. 8, R. 1 E, T. 1 N, Mount Diablo B. L. and M.
1695. Mount Diablo Quadrangle. Martinez Group. On hilltop west of point where basal Tejon conglomerate crosses creek. Sec. 14, R. 1 E, T. 1 N, Mount Diablo B. L. and M.
1743. Mount Diablo Quadrangle. Martinez Group. One and one-half miles south of Somerville. Elevation, 950 feet and about twenty feet stratigraphically above the Martinez-Chico contact, in the same zone as 1556. NE cor. of Sec. 16, T. 1 N, R. 1 E, Mount Diablo B. L. and M.
1745. Mount Diablo Quadrangle. Martinez Group. One and one-half miles south of Somerville. Elevation, 900 feet, seventy-five feet stratigraphically above the Martinez-Chico contact. Sec. 16, T. 1 N, R. 1 E, Mount Diablo B. L. and M.
1746. Mount Diablo Quadrangle. (R. E. D. Loc. 506.) Martinez Group. About two and one-fourth miles east of Clayton. Elevation, 1450 feet. About 300 feet stratigraphically above the Martinez-Chico contact. SW cor. of Sec. 8, T. 1 N, R. 1 E, Mount Diablo B. L. and M.
1747. Mount Diablo Quadrangle. (R. E. D. Loc. 507.) Martinez Group. Four miles due east of Clayton. Elevation, 900 feet. About 400 feet stratigraphically above the Martinez-Chico contact in the same strata as 1540. SE cor. of Sec. 9, T. 1 N, R. 1 W, Mount Diablo B. L. and M.
1828. Concord Quadrangle. Martinez Group. On southwest side of Martinez-Walnut Creek road two and one-fourth miles southeast of Muir Station on hill slope. Elevation, 400 feet. Waud and Dickerson.
1829. Concord Quadrangle. Martinez Group. On southwest side of Martinez-Walnut Creek road two and three-eighths miles southeast of Muir Station. Elevation, 475 feet. Waud and Dickerson.
1830. Santa Cruz Quadrangle. San Mateo County between the head waters of San Lorenzo River and Pescadero Creek. See map 47. Dickerson.
1888. Napa Quadrangle. Martinez Group. On road 75 feet above the railroad



## EXPLANATION OF PLATE 6

### Fauna of Martinez Eocene

Fig. 1a. *Flabellum remondianum* Gabb.  $\times 1$ .

This species ranges from the lowermost to the uppermost Martinez in the Mount Diablo region and the type locality. As far as known it is restricted to the Martinez Group. The proportions of this species are variable.

Fig. 1b. *Flabellum remondianum* Gabb, showing a shorter specimen.  $\times 1$ .

Fig. 1c. *Flabellum remondianum* Gabb. Cross-section view after Vaughan.  $\times 2$ .

Fig. 1d. *Flabellum remondianum* Gabb. Bottom view.  $\times 1$ .

Fig. 2. *Paracyathus*(?), sp.  $\times 1$ .

Fig. 3a. *Trochocyathus zitteli* (Merriam).  $\times 1$ .

This individual coral is distinctive of the middle zone of the Martinez and restricted to it. Its variations in shape and size are noteworthy.

Fig. 3b. *Trochocyathus zitteli* (Merriam), showing high specimen.  $\times 1$ .

Fig. 3c. *Trochocyathus zitteli* (Merriam), showing stout specimen.  $\times 1$ .

Fig. 3d. *Trochocyathus zitteli* (Merriam). Cross-section view after Vaughan.  $\times 3\frac{1}{2}$ .

Fig. 4a. *Cidaris*, sp. (a).  $\times 2$ .

Fig. 4b. *Cidaris*, sp. (a), distal end.  $\times 5$ .

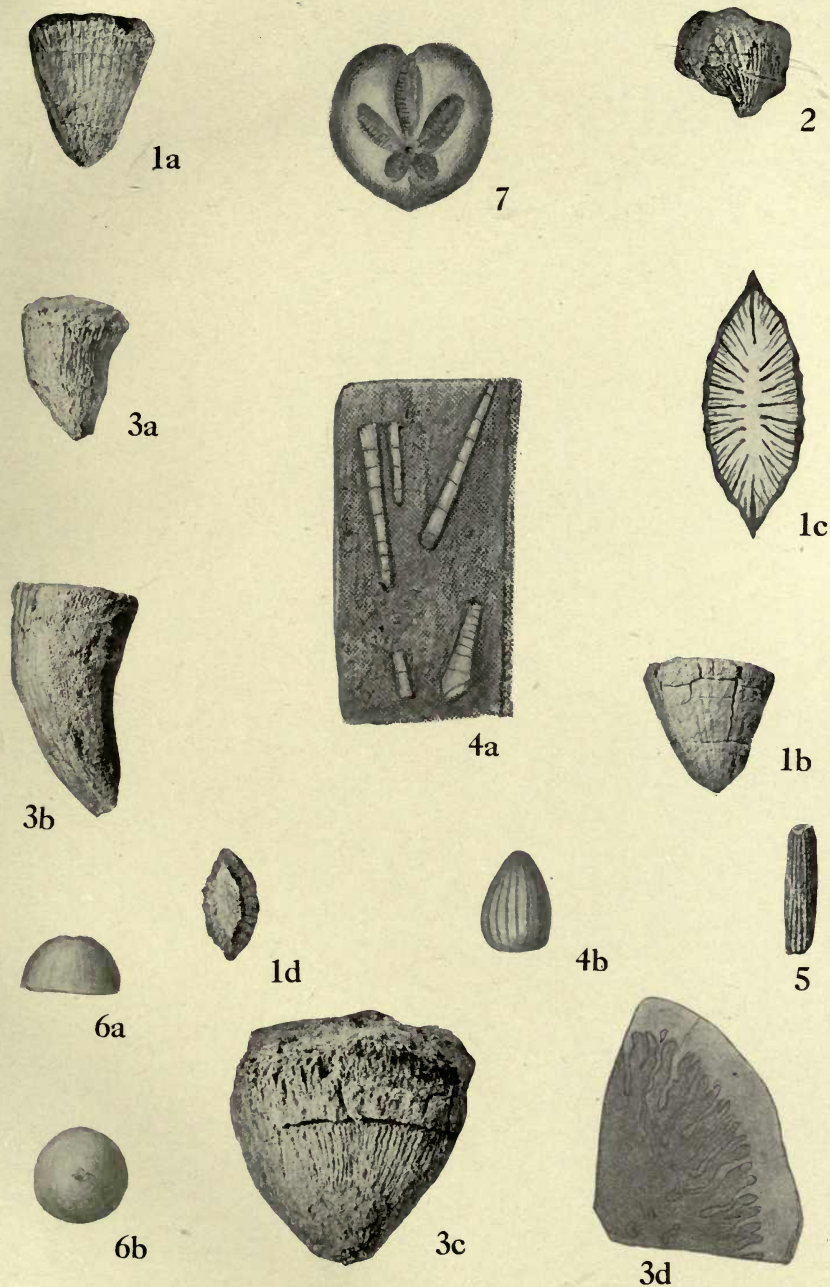
Fig. 5. *Cidaris*, sp. (d).  $\times 2$ .

Fig. 6a. *Cidaris*(?), sp. (c), side view.  $\times 2$ .

Fig. 6b. *Cidaris*(?), sp. (c), top view.  $\times 2$ .

Fig. 7. *Schizaster lecontei* Merriam.  $\times 1$ .

This echinoderm has an exceedingly great range, being found in the lowermost Martinez and in the uppermost or *Siphonalia sutterensis* zone of the Tejon Group at the Marysville Buttes.







EXPLANATION OF PLATE 7

Fauna of Martinez Eocene

Fig. 1. *Rhynconella(?)*, sp.  $\times 3$ .

Fig. 2a. *Terebratulina tejonensis* Stanton.  $\times 1$ .

This species occurs in the lowermost portion of the Martinez of Lake County and of the Mount Diablo region.

Fig. 2b. *Terebratulina tejonensis* Stanton.  $\times 1$ .

Fig. 3a. *Leda packardi*, n. sp.  $\times 2$ .

Fig. 3b. *Leda packardi*, n. sp.  $\times 2$ .

Fig. 4. *Leda milleri*, n. sp.  $\times 2$ .

Fig. 5. *Yoldia gesteri*, n. sp.  $\times 1$ .

Fig. 6. *Yoldia(?) powersi*, n. sp.  $\times 3$ .

Fig. 7a. *Cucullaea mathewsonii* Gabb, umbonal view.  $\times 1$ .

A characteristic Martinez species.

Fig. 7b. *Cucullaea mathewsonii* Gabb, side view.  $\times 1$ .

Fig. 8. *Cucullaea mathewsonii* Gabb (*Arca biloba* Weaver).  $\times 1$ .

This figure is Weaver's type of *Arca biloba* which is the young of *C. mathewsonii*. Small specimens have been recently found which show the hinge of the genus *Cucullaea*.

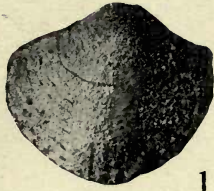
Fig. 9a. *Lima(?) claytonensis*, n. sp.  $\times 10$ .

Fig. 9b. *Lima(?) claytonensis*, n. sp.  $\times 10$ .





2b



1



5



8



3b



3a



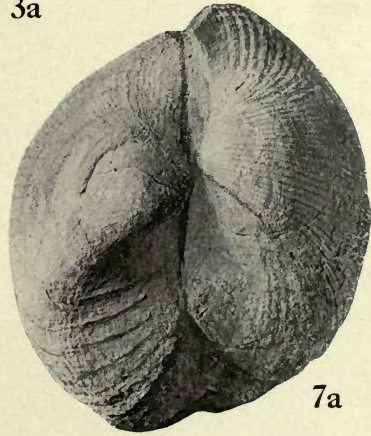
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9a



2a



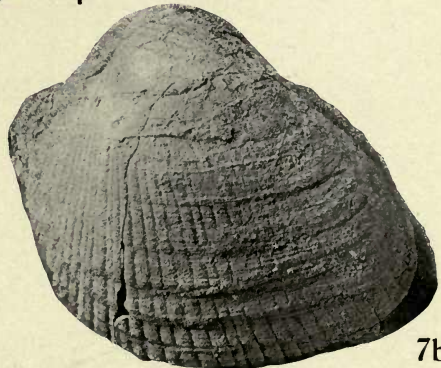
7a



4



9b



7b





EXPLANATION OF PLATE 8

Fauna of Martinez Eocene

Fig. 1. *Lima multiradiata* Gabb. × 1.

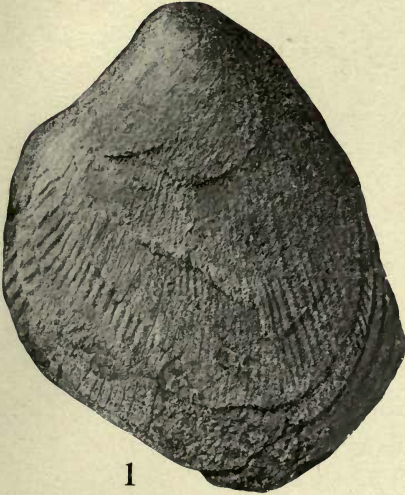
The specimen figured was found at the type locality of this species near Lower Lake.

Fig. 2. *Lima haseltinei*, n. sp. × 1.

This form is the largest pelecypod found in the California Eocene.

Fig. 3. *Pinna barrowsi*, n. sp. × 1.

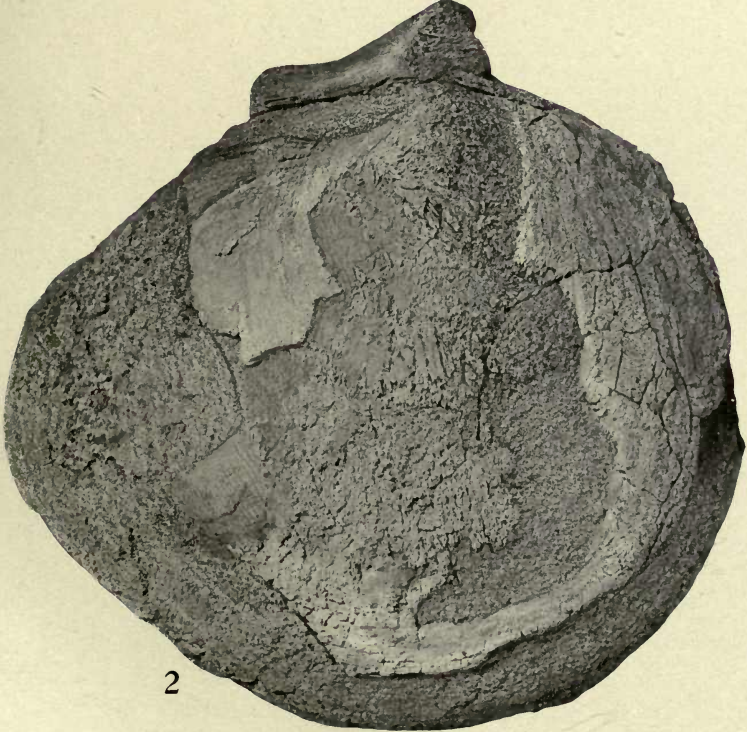
This species also occurs in the Tejon.



1



3



2





EXPLANATION OF PLATE 9

Fauna of Martinez Eocene

Fig. 1a. *Pholadomya nasuta* Gabb.  $\times 1$ .

This species ranges throughout the Martinez.

Fig. 1b. *Pholadomya nasuta* Gabb, umbonal view.  $\times 1$ .

Fig. 2. *Mytilus cf. ascia* Gabb.  $\times 1$ .

Fig. 3. *Ostrea weaveri*, n. sp.  $\times 1$ .

Fig. 4. *Ostrea buwaldana*, n. sp.  $\times 1$ .

Fig. 5. *Pecten interradiatus* Gabb.  $\times 2$ .

Range, Martinez and Tejon.

Fig. 6. *Pecten*, sp.  $\times 2$ .

Fig. 7. *Modiolus merriami* (Weaver).  $\times 1$ .

This form is also found in the lower portion of the Tejon south of Mount Diablo.

Fig. 8. *Modiolus bakeri*, n. sp.  $\times 1$ .

Fig. 9. *Cuspidaria dolabraeformis* (Gabb).  $\times 3$ .

Fig. 10. *Cuspidaria hannibali*, n. sp.  $\times 2$ .

Fig. 11. *Lima(?) haseltinei*, n. sp.  $\times 2$ .

Fig. 12. *Plicatula ostreaformis* Stanton.  $\times 1$ .

The form figured is from the type locality of the species, near Lower Lake.





9



11



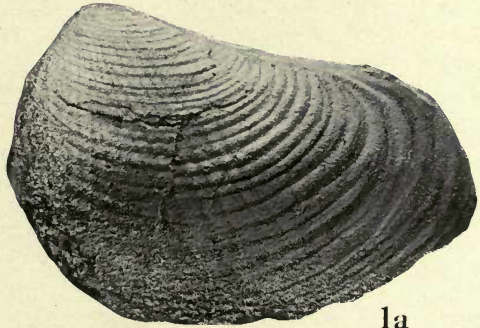
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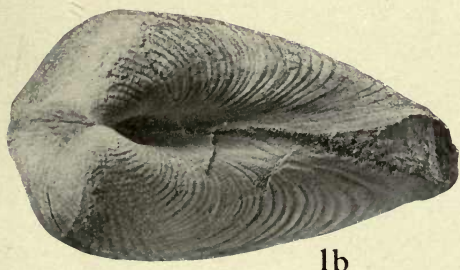
10



3



1a



1b



4



5



6



8



2



7





EXPLANATION OF PLATE 10

Fauna of Martinez Eocene

Fig. 1. *Crassatellites studleyi*, n. sp.

Fig. 2. *Crassatellites unioides* (Stanton).

This species has a great geographical range, being found in the Martinez of the Santa Ana Mountains and in the vicinity of Lower Lake, Lake County, California.

Fig. 3. *Crassatellites stewartvillensis*, n. sp.

Fig. 4a. *Crassatellites claytonensis*, n. sp. × 2.

Fig. 4b. *Crassatellites claytonensis*, n. sp. × 2.

Fig. 5. *Glycimeris veatchii* var. *major* (Stanton). × 1.

A common form restricted to the Martinez.

Fig. 6. *Phacoides quadrata*, n. sp. × 2.

Fig. 7. *Phacoides diaboli*, n. sp. × 1.

Fig. 8. *Phacoides turneri* (Stanton). × 1.

Fig. 9. *Dosinia(?) lawsoni*, n. sp. × 2.

Fig. 10. *Venus(?)*, sp. × 1.

Fig. 11a. *Phacoides muirensis*, n. sp. × 2.

Fig. 11b. *Phacoides muirensis*, n. sp., umbonal view. × 2.



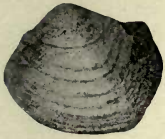
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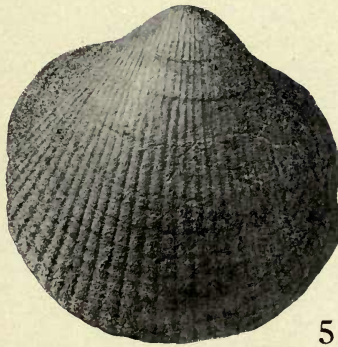
1



3



4b



5



11a



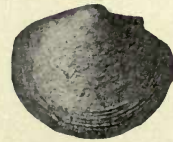
4a



8



9



7



11b



6



2





EXPLANATION OF PLATE 11

Fauna of Martinez Eocene

Fig. 1a. *Meretrix stantoni*, n. sp. × 1.

A species which occurs at nearly all localities of the lower Martinez.

Fig. 1b. *Meretrix stantoni*, n. sp. × 1.

Fig. 2a. *Meretrix dalli*, n. sp. × 1.

A species restricted to the lower Martinez.

Fig. 2b. *Meretrix dalli*, n. sp. × 1.

Fig. 3. *Meretrix*, sp. × 1.

Fig. 4. *Macrocallista(?) packi*, n. sp. × 1.

Fig. 5. *Tapes(?) quadrata* Gabb. × 1.

Range, Tejon and Martinez.

Fig. 6. *Paphia(?) clarki*, n. sp. × 2.

Fig. 7a. *Tellina undulifera* Gabb. × 1.

An abundant and easily identifiable form which is somewhat variable in shape, as the figures show. Range, throughout the Martinez.

Fig. 7b. *Tellina undulifera* Gabb. × 1.

Fig. 7c. *Tellina undulifera* Gabb. × 1.

Fig. 8. *Tellina perrini*, n. sp. × 1.

Fig. 9. *Tellina herndonensis*, n. sp. × 1.

Fig. 10. *Psammobia hornii* (Gabb). × 1.

This *Psammobia* has a range throughout both the Martinez and Tejon.

Fig. 11. *Tellina packardi*, n. sp. × 1.

Fig. 12. *Tellina cf. parilis* Gabb. × 3.





3



2a



1a



5



4



6



10



9



12



2b



7a



11



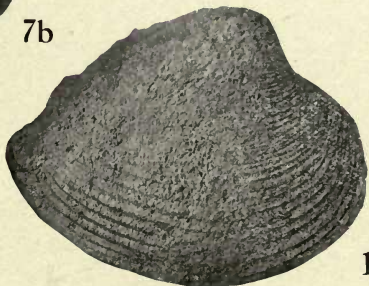
8



7b



7c



1b





EXPLANATION OF PLATE 12

Fauna of Martinez Eocene

Fig. 1. *Tellina kewi*, n. sp. × 3.

Fig. 2a. *Psammobia(?) cylindrica*, n. sp. × 1.

Fig. 2b. *Psammobia(?) cylindrica*, n. sp. × 1.

Fig. 3. *Solen stantoni* Weaver, after Weaver. × 1.

This species is abundant and rather characteristic of the uppermost Martinez.

Fig. 4a. *Spisula(?) weaveri*, n. sp. Packard. × 1.

Fig. 4b. *Spisula(?) weaveri*, n. sp. Packard. × 1.

Fig. 5. *Mactra(?) tenuissima* Gabb. × 2.

Fig. 6. *Teredo*, sp. × 1.

Fig. 7. *Dentalium cooperi* Gabb. × 1.

This smooth, large *Dentalium* is found in the Chico-Cretaceous Martinez, and the Tejon.

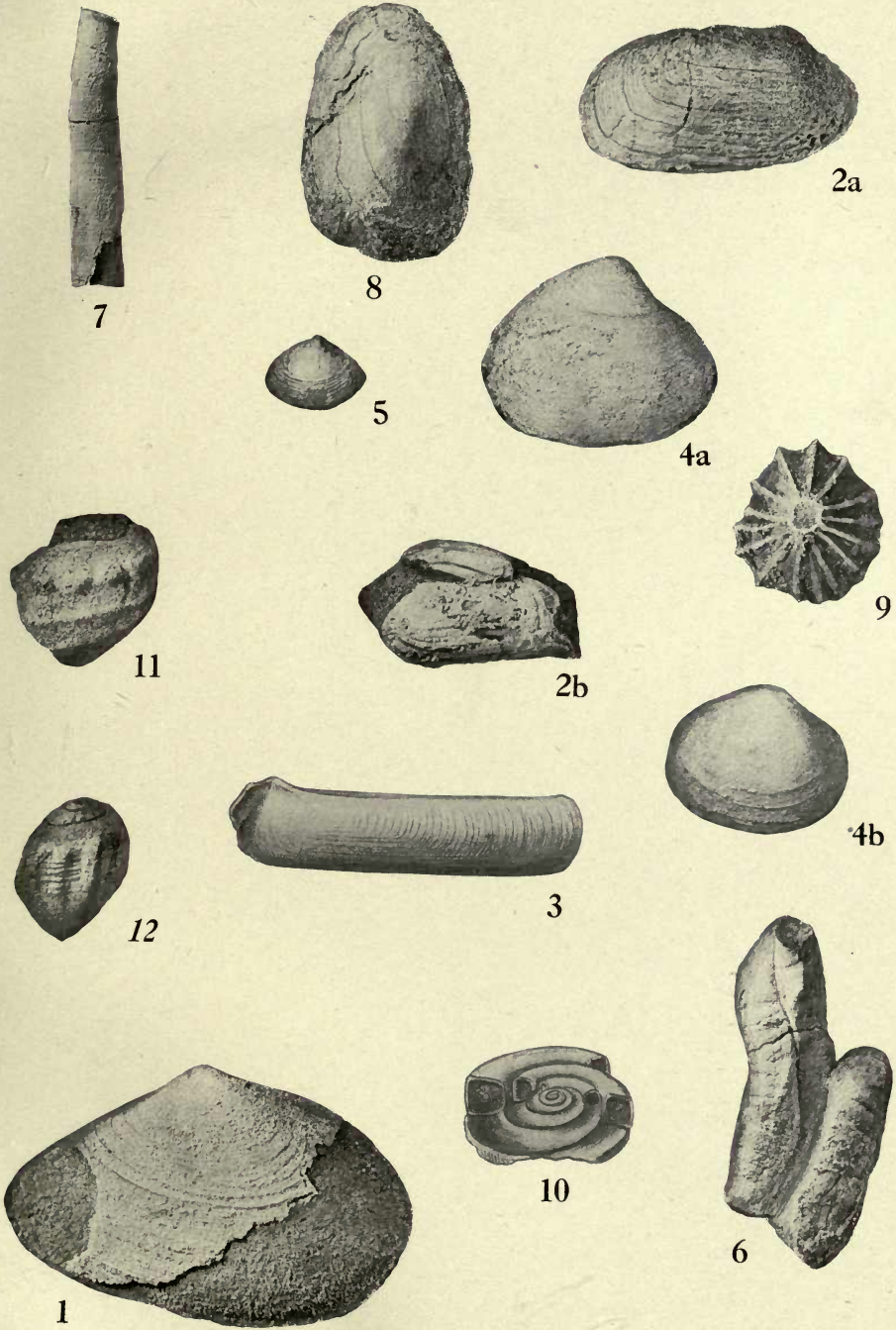
Fig. 8. *Acmaea martinezensis*, n. sp. × 1.

Fig. 9. *Fissurella(?) behri*, n. sp. × 2.

Fig. 10. *Discohelix californicus* Weaver, after Weaver. × 1.

Fig. 11. *Nerita(?)*, sp. × 2.

Fig. 12. *Nerita(?) biangulata*, n. sp. × 3.







EXPLANATION OF PLATE 13

Fauna of Martinez Eocene

- Fig. 1. *Architectonica*, sp.  $\times 1$ .
- Fig. 2a. *Architectonica tuberculata* Weaver, after Weaver.  $\times 1$ .
- Fig. 2b. *Architectonica tuberculata* Weaver. Detail.  $\times 6$ .
- Fig. 3a. *Natica (Gyrodes) lineata*, n. sp.  $\times 1$ .
- Fig. 3b. *Natica (Gyrodes)*, sp.  $\times 1$ .  
A common but poorly preserved form in the Martinez.
- Fig. 4a. *Amauropsis martinezensis*, n. sp.  $\times 1$ .  
A form which is common in the middle zone of the Martinez. It appears to be intermediate between *A. oviformis* of the Chico and *A. alveata* of the Tejon.
- Fig. 4b. *Amauropsis martinezensis*, n. sp.  $\times 1$ .
- Fig. 5. *Lunatia hornii* Gabb.  $\times 1$ .  
Range of this species is Tejon and Martinez.
- Fig. 6a. *Lunatia* cf. *nuciformis* Gabb.  $\times 3$ .
- Fig. 6b. *Lunatia* cf. *nuciformis* Gabb.  $\times 3$ .
- Fig. 7. *Xenophora zitteli* Weaver, after Weaver.  $\times 1$ .  
A form which is restricted to the middle or *Trochocyathus zitteli* and the lowermost or *Meretrix dalli* zones of the Martinez.
- Fig. 8. *Turritella clarki*, n. sp.  $\times 2$ .
- Fig. 9a. *Turritella infragranulata* Gabb.  $\times 2$ .  
The figured specimen is from the Martinez of the Santa Ana Mountains.
- Fig. 9b. *Turritella infragranulata*.  $\times 2$ .
- Fig. 10. *Turritella martinezensis* Gabb.  $\times 1$ .  
This form was found in Martinez strata near Rock Creek, Los Angeles County, California.





9a



9b



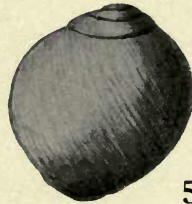
4a



3a



2a



5



4b



8



2b



3b



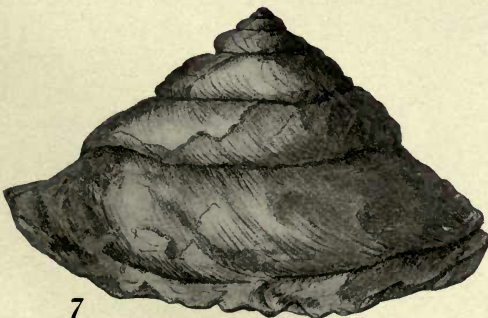
6a



10



6b



7



1





EXPLANATION OF PLATE 14

Fauna of Martinez Eocene

Fig. 1a. *Turritella pachecoensis* Stanton.  $\times 1$ .

This very characteristic *Turritella* has been erroneously reported from the Tejon. It appears to be wholly restricted to the Martinez Range, lowermost to uppermost Martinez.

Fig. 1b. *Turritella pachecoensis* Stanton.  $\times 1$ .

Fig. 1c. *Turritella pachecoensis* Stanton.  $\times 1$ .

Nodose specimen from the Santa Ana Mountains.

Fig. 2. *Cerithium*, sp.  $\times 2$ .

Fig. 3. *Alaria*, sp.  $\times 1$ .

Fig. 4. *Anchura gabbi*, n. sp.  $\times 2$ .

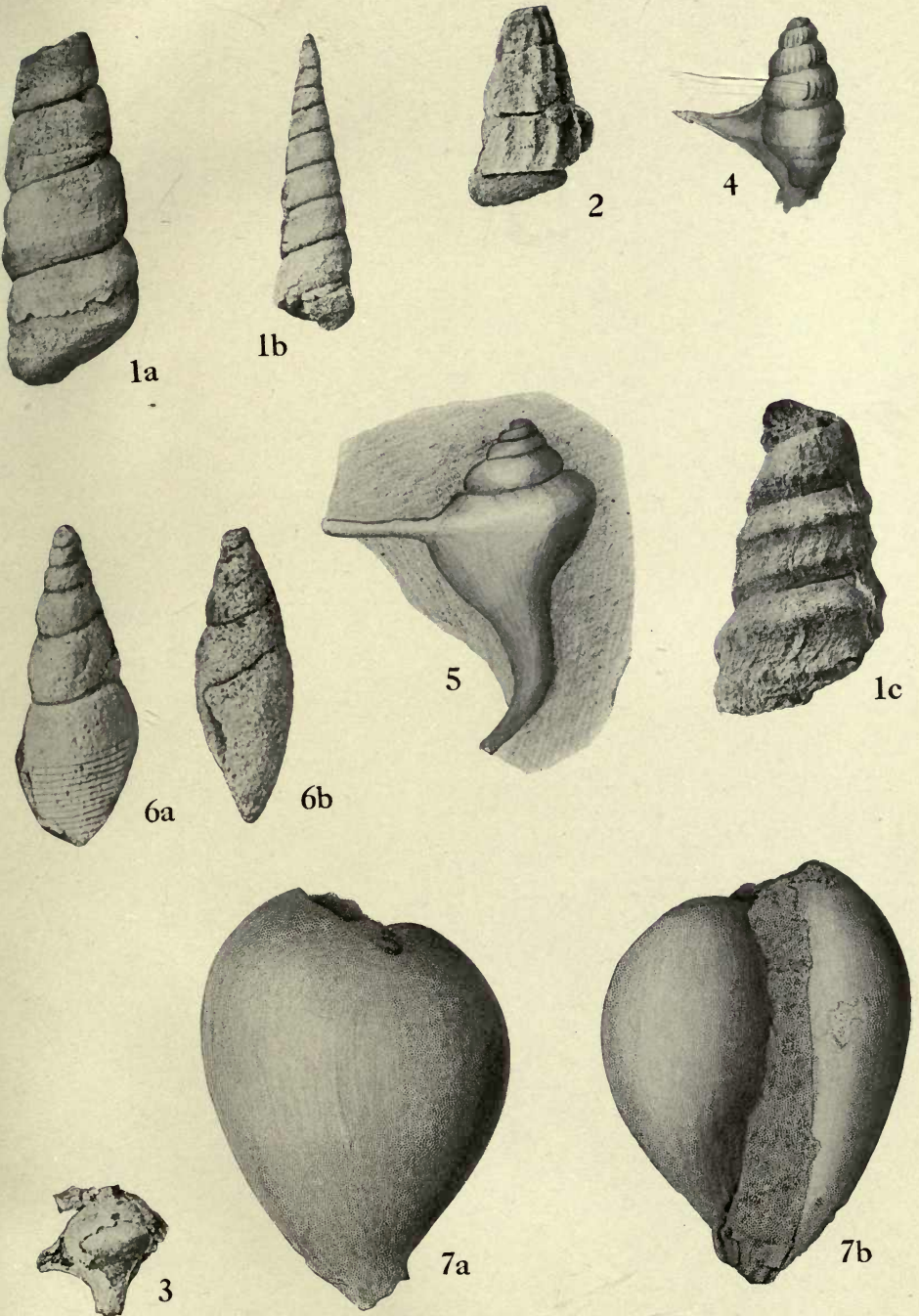
Fig. 5. *Anchura englishi*, n. sp.  $\times 3$ .

Fig. 6a. *Seraphs(?) thompsoni*, n. sp.  $\times 3$ .

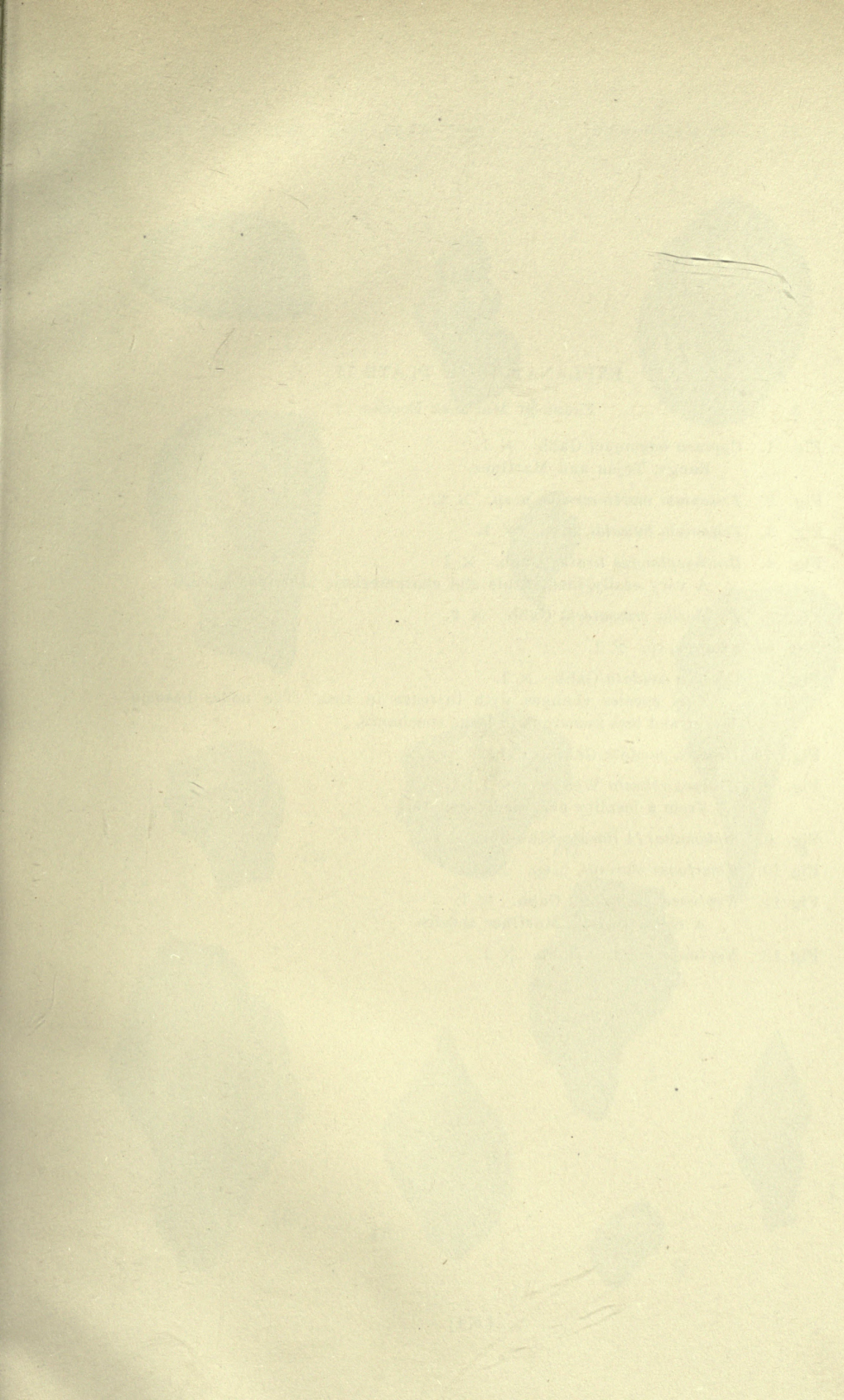
Fig. 6b. *Seraphs(?) thompsoni*, n. sp.  $\times 3$ .

Fig. 7a. *Ovula martini*, n. sp.  $\times 2$ .

Fig. 7b. *Ovula martini*, n. sp.  $\times 2$ .







EXPLANATION OF PLATE 15

Fauna of Martinez Eocene

- Fig. 1. *Cypraea bayerquei* Gabb.  $\times 1$ .  
Range, Tejon and Martinez.
- Fig. 2. *Tritonium martinezensis*, n. sp.  $\times 2$ .
- Fig. 3. *Tritonium buwaldi*, n. sp.  $\times 1$ .
- Fig. 4. *Brachysphingus liratus* Gabb.  $\times 1$ .  
A very easily identifiable and characteristic Martinez species.
- Fig. 5. *Turbinella crassatesta* Gabb.  $\times 2$ .
- Fig. 6. *Ficopsis*, sp.  $\times 1$ .
- Fig. 7a. *Urosyca caudata* Gabb.  $\times 1$ .  
This species changes with increase in size. The nodes become larger and less numerous in large specimens.
- Fig. 7b. *Urosyca caudata* Gabb.  $\times 1?$ .
- Fig. 8. *Urosyca robusta* Weaver.  $\times 1$ .  
From a locality near Selby Smelter.
- Fig. 9. *Siphonalia(?) lineata* Stanton.  $\times 1$ .
- Fig. 10. *Hemifusus waringi*, n. sp.  $\times 2$ .
- Fig. 11. *Neptunea mucronata* Gabb.  $\times 1$ .  
A characteristic Martinez species.
- Fig. 12. *Neptunea cretacea* Gabb.  $\times 1$ .





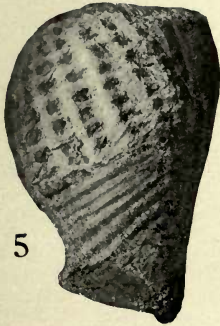
1



2



4



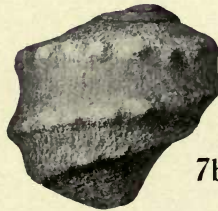
5



6



7a



7b



8



10



12



3



9



11





EXPLANATION OF PLATE 16

Fauna of Martinez Eocene

Fig. 1. *Fusus aequilateralis* Weaver.  $\times 2$ .

Fig. 2. *Fusus mathewsonii* Gabb.  $\times 1$ .  
Range Tejon and Martinez.

Fig. 3. *Fusus occidentalis* Gabb.  $\times 1$ .

Fig. 4. *Fusus aratus* Gabb.  $\times 1$ .

Fig. 5. *Fusus flexuosus* Gabb.  $\times 2$ .

Fig. 6. *Fusus dumblei*, n. sp.  $\times 2$ .

Fig. 7. *Olivella claytonensis*, n. sp.  $\times 3$ .

Fig. 8a. *Perissolax tricarnatus* Weaver.  $\times 1$ .

This species may be only a variety of *P. blakei* Conrad, as it is found in the type Tejon along with the bicarnate form. The tricarnate form is however the commoner in the Martinez.

Fig. 8b. *Perissolax tricarnatus* Weaver.  $\times 1?$ .

Fig. 9a. *Turris louderbacki*, n. sp.  $\times 1$ .

Fig. 9b. *Turris louderbacki*, n. sp.  $\times 1$ .

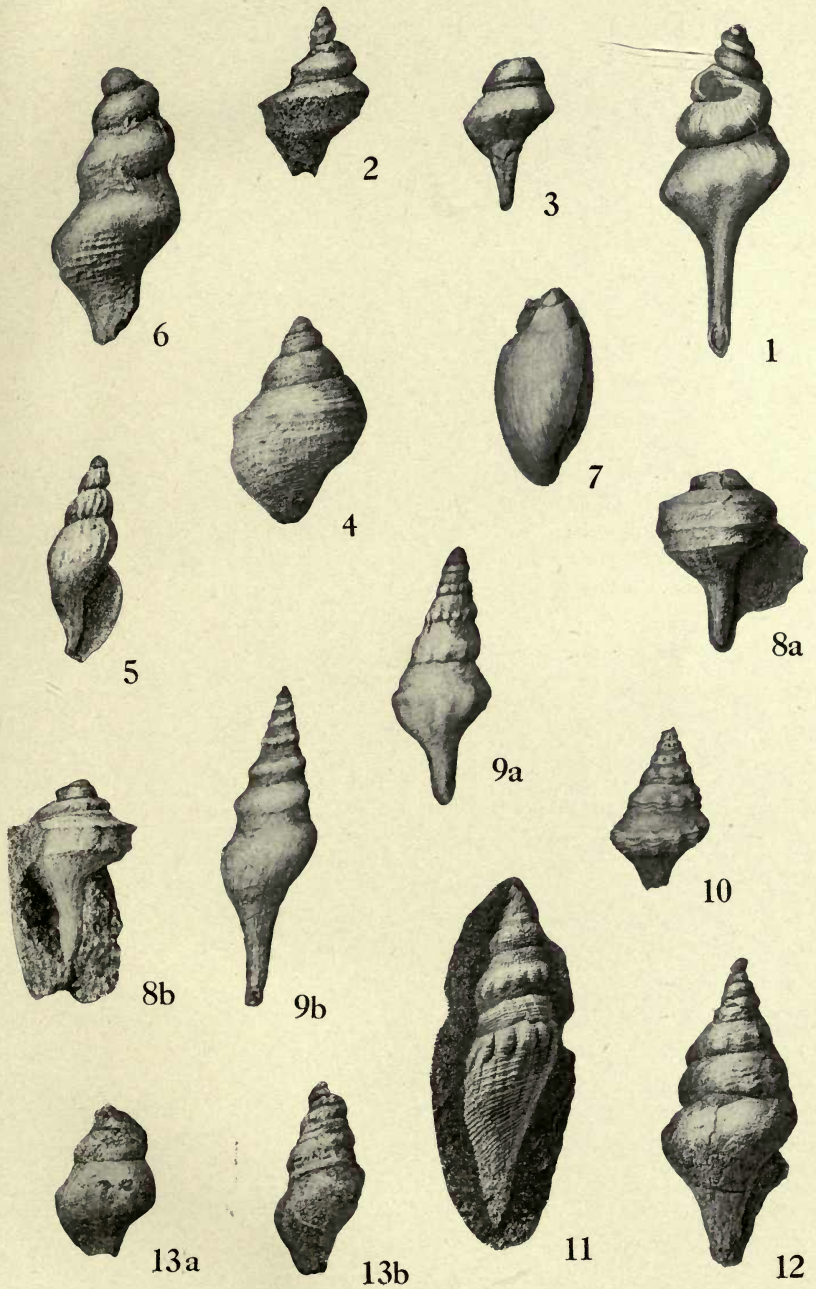
Fig. 10. *Surcula merriami*, n. sp.  $\times 1$ .

Fig. 11. *Surcula (Surculites) andersoni*, n. sp.  $\times 1$ .

Fig. 12. *Surcula fairbanksi*, n. sp.  $\times 1$ .

Fig. 13a. *Surcula*, sp.  $\times 1$ .

Fig. 13b. *Surcula*, sp.  $\times 1$ .







EXPLANATION OF PLATE 17

Fauna of Martinez Eocene

Fig. 1. *Heteroterma gabbi* Stanton. × 1.

Fig. 2. *Actaeon lawsoni* Weaver. × 3.

Fig. 3. *Bullinula subglobosa* Weaver, after Weaver. × 2.

Fig. 4a. *Ringinella pinguis* Gabb. × 2.

A species found in the middle and lower portions of the Martinez.

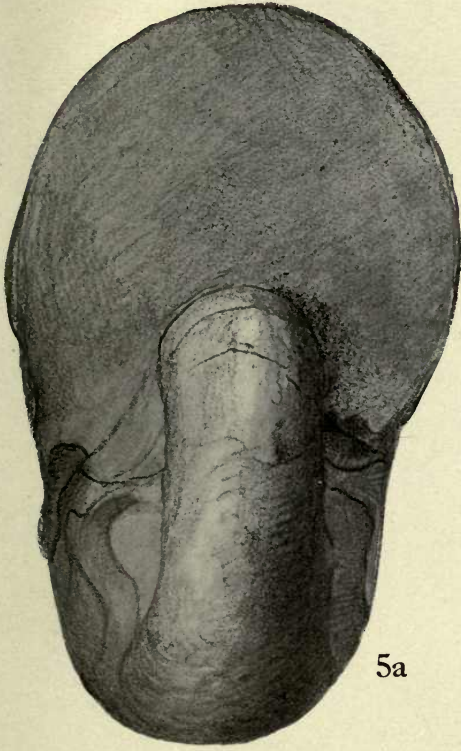
Fig. 4b. *Ringinella pinguis* Gabb. × 2.

Fig. 5a. *Hercoglossa merriami*, n. sp. × 1.

Fig. 5b. *Hercoglossa merriami*, n. sp. × 1.

This species may be related to the eastern species *Hercoglossa* (*Enclimatoceras*) *ulrichi* White.





5a



4b



1



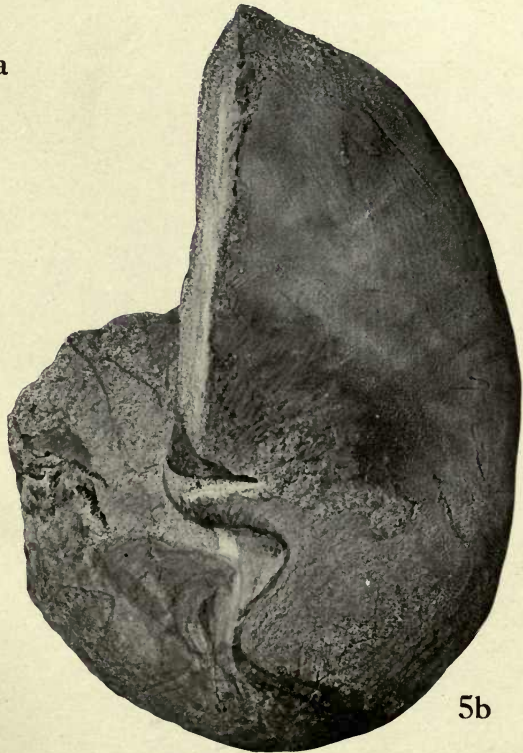
4a



3

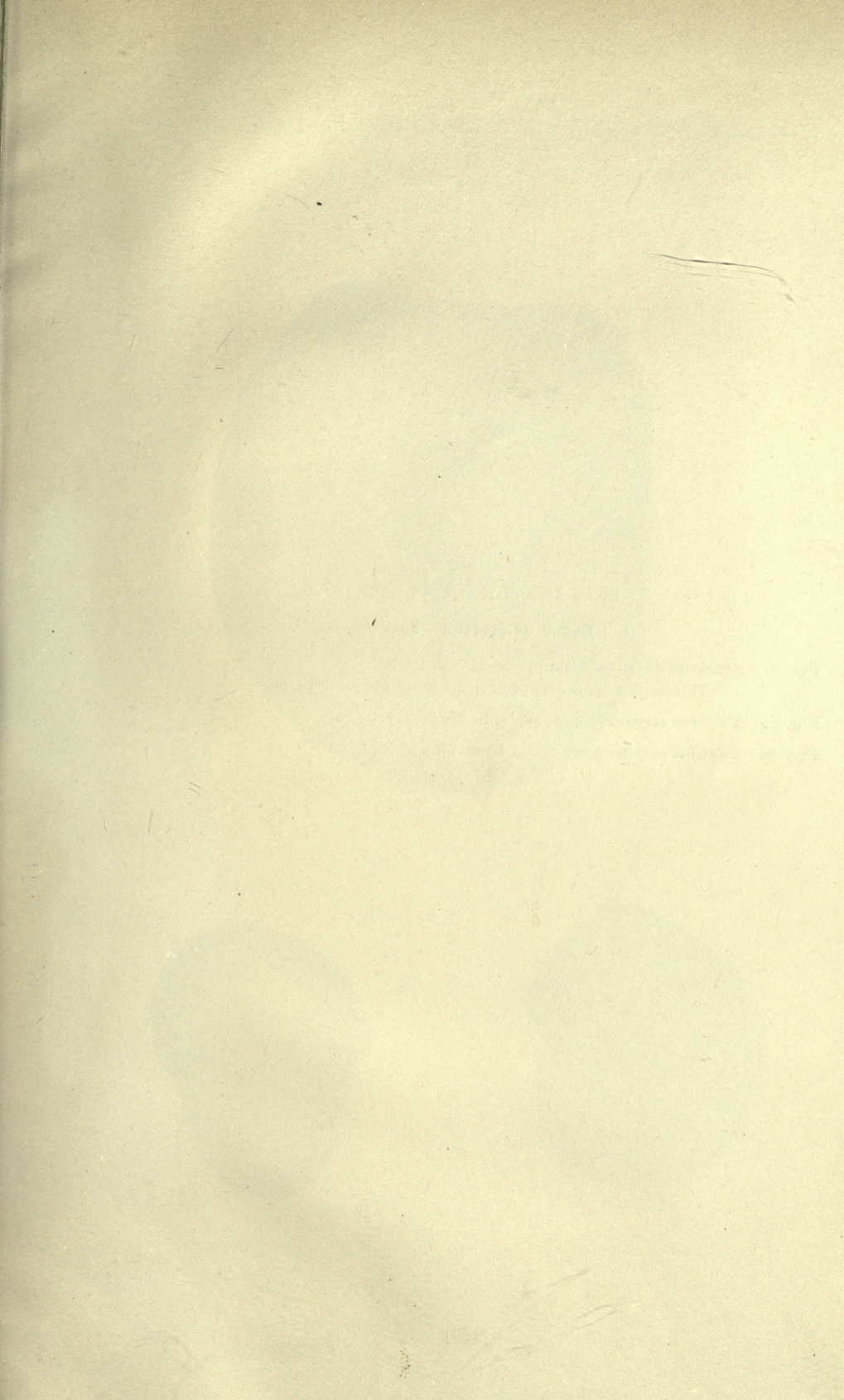


2



5b





EXPLANATION OF PLATE 18

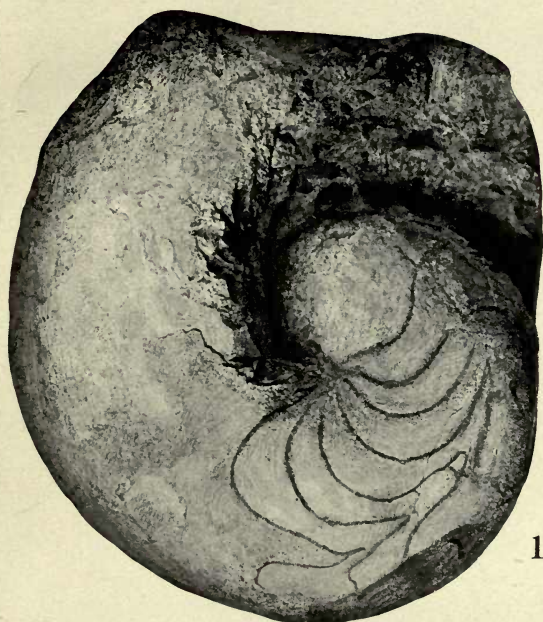
Fauna of Martinez Eocene

Fig. 1. *Aturia mathewsonii* Gabb. × 1.

This cephalopod occurs both in Martinez and Tejon.

Fig. 2a. *Nautilus stephensoni*, n. sp., side view. × 1.

Fig. 2b. *Nautilus stephensoni*, n. sp., back view. × 1.





VOLUME 5—(Continued).

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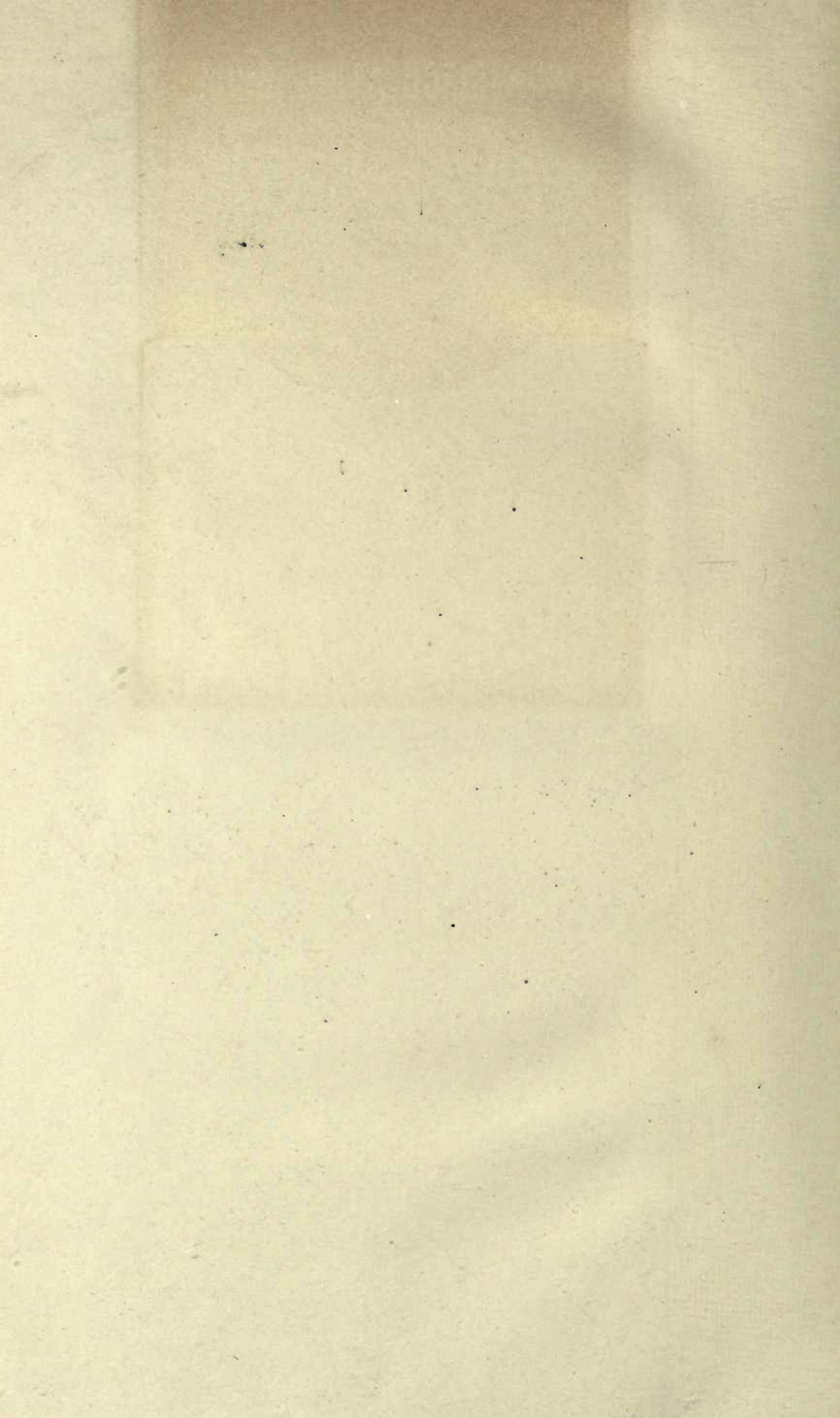
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