Oligocene Molluscan Biostratigraphy and Paleontology of the Lower Part of the Type Temblor Formation, California

GEOLOGICAL SURVEY PROFESSIONAL PAPER 791

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By WARREN O. ADDICOTT

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Marine mollusks from the basal shale (Cymric Shale Member) and the overlying sandstone (Wygal Sandstone Member) are of provincial Oligocene age. Warm-water assemblages from the Wygal Sandstone Member represent a previously unrecognized biostratigraphic unit of late Oligocene age in California

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OLIGOCENE MOLLUSCAN BIOSTRATIGRAPHY AND PALEONTOLOGY OF THE LOWER PART OF THE TYPE TEMBLOR FORMATION, CALIFORNIA

By Warren O. Addicott

ABSTRACT

The type Temblor Formation consists of about 1,800 feet of alternating shale and sandstone units exposed in the central part of the Temblor Range along the southwest margin of the San Joaquin Valley in central California. The lower part constitutes a unique stratigraphic continuum of marine middle Tertiary strata in the California Coast Ranges. Molluscan stages of provincial late Oligocene and early Miocene age can be recognized on the basis of assemblages from the lowest sandstone members of the formation. These units are directly associated with deeper water foraminiferal assemblages that constitute the type section of the Zemorrian Stage of the provincial microfaunal sequence. Elsewhere in central and southern California, the Oligocene and the earliest part of the Miocene are usually represented by nonmarine deposition.

A small assemblage from the Cymric Shale Member at the base of the Temblor Formation contains *Bruclarkia columbiana* (Anderson and Martin), the presence of which suggests correlation with the upper part of the Refugian Stage [="Lincoln Stage" of western Washington]. The Cymric Shale Member was originally included in the lower part of the overlying Zemorrian Stage of the microfaunal chronology based on meager foraminiferal data.

Assemblages from the overlying Wygal Sandstone Member comprise a biostratigraphic unit of provincial late Oligocene age that had previously been assigned to the early Miocene "Vaqueros Stage." Included in this fauna are the stratigraphically restricted species *Pecten sanctaecruzensis* Arnold, *Bruclarkia seattlensis* Durham, and *Vertipecten alexclarki* n. sp. This fauna is correlated with the lower part of the Zemorrian Stage of the microfaunal chronology.

The stratigraphically higher Agua Sandstone Member contains small assemblages referable to the early Miocene "Vaqueros Stage." Included are the stratigraphically restricted species *Crassostrea vaquerosensis* (Loel and Corey) and *Macrochlamis magnolia* (Conrad). This member is correlated with the upper part of the Zemorrian Stage.

The molluscan fauna of the Wygal Sandstone Member is indicative of a warm, shallow-water depositional environment—less than 20 fathoms and possibly much shallower at the base. Many of these genera are today restricted to subtropical and tropical latitudes along the Pacific coast of Mexico and Central America. The hermatypic coral *Favites* provides further evidence of warm-water conditions. Yet, this inner sublittoral biofacies contrasts with the middle to lower bathyal environments inferred from benthonic foraminiferal assemblages of the underlying Cymric Shale Member and the overlying Santos Shale Member.

Fifty mollusks, almost all of them previously unrecorded from the Wygal Sandstone Member, are treated systematically. Six of these represent new species, although only one, *Vertipecten alexclarki* n. sp., is represented by material adequate to permit formal description. A new tellinid subgenus, *Olcesia* (type: *Macoma piercei* Arnold), has its lowest stratigraphic occurrence in assemblages from the Wygal Sandstone Member.

INTRODUCTION

The type area of the Temblor Formation is in the central part of the Temblor Range near the western margin of the San Joaquin basin about 40 miles west of Bakersfield, Calif. (fig. 1). In this area the Temblor Formation consists of alternating shale and sandstone totaling about 1,800 feet in thickness (Woodring and others, 1940).

The most definitive biostratigraphic study of the type Temblor Formation (Kleinpell, 1938) was based on benthonic Foraminifera. In that report, and in an earlier one (Kleinpell, 1934), he showed that the lower part of the type Temblor Formation was of pre-middle Miocene age. Prior to Kleinpell's studies most workers regarded the Temblor Formation to be wholly of middle Miocene age and to be referable to what later became known as the "Temblor Zone" (Clark, 1941) or "Temblor Stage" (Weaver and others, 1944; Durham, 1954). Kleinpell's (1938) data were substantiated in a brief biostratigraphic analysis of known molluscan assemblages from the vicinity of the type Temblor Formation by Woodring, Stewart, and Richards (1940, p. 131), who concluded that the lower part of the type Temblor Formation is "of the age of the Vaqueros elsewhere" [early Miocene].

The molluscan faunas of the type Temblor Formation and its lateral correlatives in the northern part of the Temblor Range have received only cursory study. The largest recorded faunal list prior

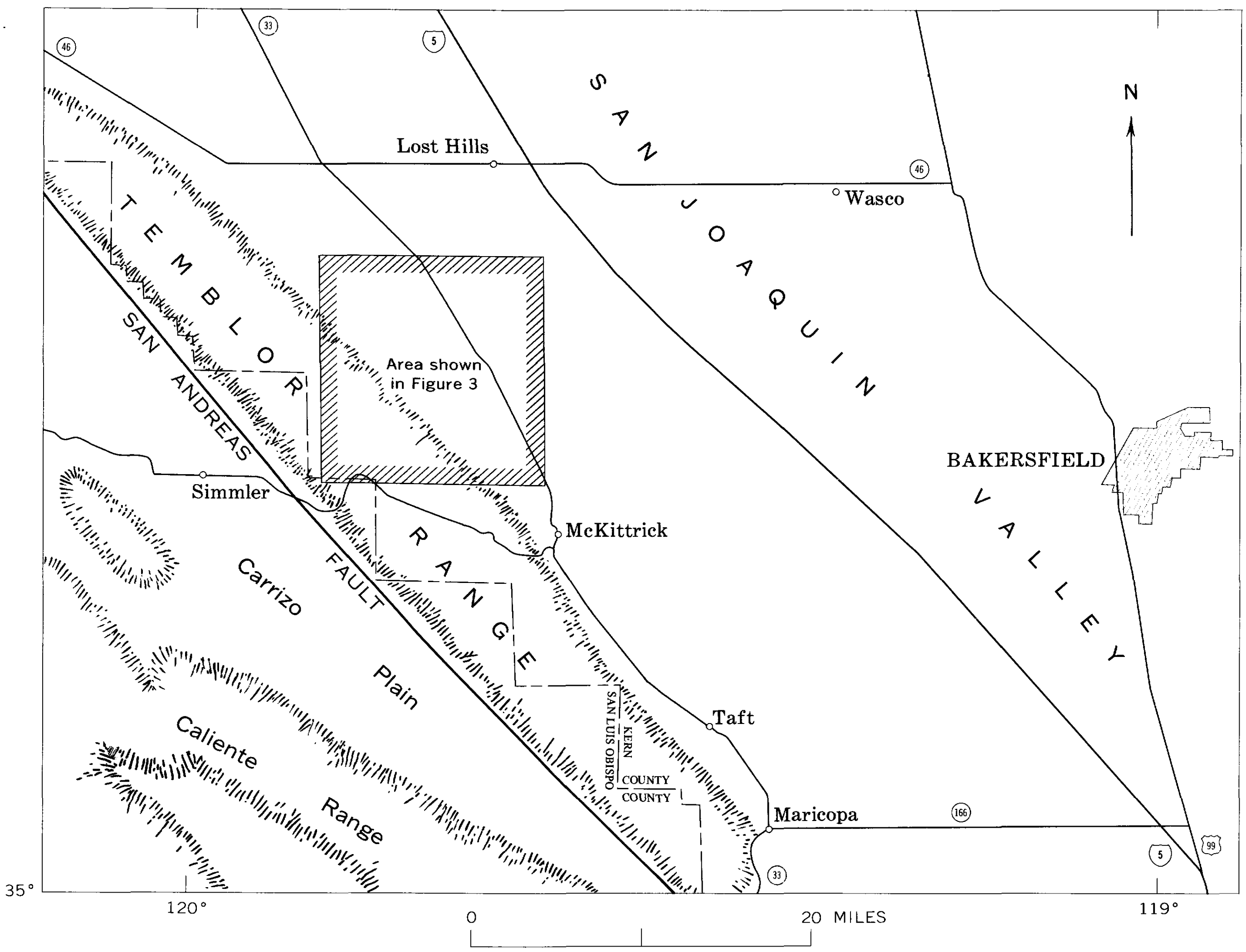


FIGURE 1.—Location of the Temblor Range.

to this study (Anderson, 1905, p. 170), for example, is from the Wygal Sandstone Member, but it includes only 11 mollusks in contrast to the 50 molluscan taxa treated in this report. The lack of intensive paleontologic and biostratigraphic study of the Temblor Formation may result from the fact that in the type area all the sandstone members except the lowest one, the so-called Phacoides Sand [Wygal Sandstone Member of this report], have sparse assemblages of larger marine invertebrates. Nevertheless, collections at hand from the type area in the central part of the Temblor Range and from more fossiliferous exposures in the northern part of the range are adequate to establish a local biostratigraphic sequence. Although this report is primarily concerned with the Wygal Sandstone Member, the sequence of Oligocene and early Miocene molluscan faunas of the Temblor Range is briefly outlined and correlated with the established provincial molluscan stages of Weaver and others (1944) and with the benthonic foraminiferal stages of Kleinpell (1938) and Schenck and Kleinpell (1936). The conclusions of this report differ from those of earlier workers in that at least one, and possibly two, Oligocene biostratigraphic units of stage magnitude are represented in the lower part of the type Temblor Formation. The next to the lowest of these two units, which is represented by the fauna of the Wygal Sandstone Member, is the subject of this report. Molluscan data from the underlying Cymric Shale Member and from the overlying Santos Shale and Agua Sandstone Members are considered in a following section on provincial age and correlation in order to establish the limits of the late Oligocene biostratigraphic unit represented by the Wygal fauna.

ACKNOWLEDGMENTS

Several people provided helpful assistance during the course of this study. The manuscript has been critically read by E. E. Brabb, T. W. Dibblee, Jr., E. J. Moore, and R. L. Pierce. Their comments and suggestions have improved the report and are deeply appreciated. Dibblee mapped the geology in this report and discussed stratigraphic relationships and formational nomenclature. Olgerts Karklins, U.S. Geological Survey, and Alan H. Cheetam, U.S. National Museum, kindly identified an encrusting bryozoan, and J. Wyatt Durham, University of California, Berkeley, identified the corals. Dibblee, Saburo Kanno, R. L. Pierce, H. S. Sonneman, and H. C. Wagner assisted in making some of the mega-invertebrate collections from the Wygal Sandstone Member. J. G. Vedder collected mollusks from the Quail Canyon Sandstone Member of the Vaqueros Formation (Dibblee, 1972) to which this report refers. M. A. Murphy, University of California, Riverside, granted access to museum collections and lent specimens for figuring in this report. A. M. Keen and N. J. Silberling, Stanford University, and J. H. Peck, Jr., University of California, Berkeley, also granted access to museum collections and type collections at their respective institutions. R. L. Pierce and C. C. Church, Bakersfield, Calif., discussed problems of foraminiferal correlation with the writer. Fossil photography is by Kenji Sakamoto.

I am particularly indebted to H. S. Sonneman, who initially suggested the biostratigraphic study of mollusks from the type Temblor Formation and who collaborated during much of the fieldwork and preparation of this report.

REPORTS DEALING WITH MOLLUSKS FROM THE LOWER PART OF THE TEMBLOR FORMATION

Annotated references to the molluscan fauna of the Wygal Sandstone Member are listed chronologically in this section. Stratal terminology and fossil names indicated in the annotations are those of the authors cited. Place names are indicated in figure 3. Complete bibliographic citations are included in the references at the end of the report.

1905. Anderson, F. M. Designated the area between Carnara Spring [Carneros Creek] and Temblor [Temblor Ranch], to the south, as the type area for his Temblor Beds. Seven species and four genera of mollusks are listed from his lower sandstones. This is the most complete published faunal list from the Wygal Sandstone Member of the Temblor Formation.

1910. Arnold, Ralph, and Johnson, H. R. The basal 25 ft of a 445-ft measured section of the Vaqueros Sandstone [Temblor Formation] between Salt Creek and Temblor Creek (W½ sec. 25, T. 29 S., R. 20 E.) contains *Ostrea* and many indeterminate, poorly preserved fossils. A collection from between Chico Martinez and Carneros Creeks (USGS 5149) made during fieldwork for this report was not recorded. Species from this locality are listed in table 1.

1921. English, W. A. Four measured sections of the Vaqueros Formation [Temblor Formation] between Salt and Media Agua Creeks are included in a correlation diagram. The basal sandstone beds contain a large [molluscan] fauna, best developed near Carneros Spring and Media Agua Creek.

1936. Hanna, G D. Abundant *Phacoides acutilineatus* occur in the basal part of Anderson's (1905) Temblor Formation. The jaw of a small-toothed whale, a zeuglodont, is reported from these strata.

1936. Schenck, H. G. Reported specimens of *Acila conradi* (Meek) var. from beds of "Vaqueros" age on the southwest flank of McDonald anticline (sec. 31, T. 27 S., R. 19 E.). The associated molluscan assemblage was regarded by Alex Clark as correlative with the lower sandstone member of the Temblor Formation on Carneros Creek [Wygal Sandstone Member], although it contains species such as *Bruclarkia barkeriana* and *Chione* cf. *C. panzana* that are indicative of a Miocene rather than Oligocene provincial age. The fossil locality is probably from near the base of the Buttonbed Sandstone Member, which unconformably overlies the Eocene Point of Rocks Formation in this area. A recent collection from the basal 5 ft of this unit (USGS loc. M3988) contains *Trophosycon kernianum, Oliva california, Amussiopecten* sp., and *Lyropecten crassicardo*, fossils suggestive of a middle Miocene ("Temblor") provincial age.

1938. Kleinpell, R. M. Four molluscan taxa including *Chlamys sespeensis* in the Phacoides reef [Wygal Sandstone Member] and *Bruclarkia barkeriana* [*B. seattlensis*] are recorded from localities in the Zemorra Creek–Chico Martinez Creek area. This assemblage occurs in the lower part of his Zemorrian Stage and was correlated with the *Turritella inezana* zone.

1940. Woodring, W. P., Stewart, Ralph, and Richards, R. W. Abundant *Lucinoma acutilineata* occur in their "*Phacoides*" reef member of local usage [Wygal Sandstone Member] near the base of a measured section of the type Temblor Formation on Zemorra Creek. Typical "Vaqueros Stage" species are not known to occur in this member, although the faunal facies is such that they might be expected to occur in it. "Vaqueros Stage" index species occur in stratigraphically higher units in this part of the Temblor Range.

1943. Curran, J. F. Six mollusks are listed from the "reef" [Wygal Sandstone Member] at the base of his lower Temblor Sandstone in the vicinity of Chico Martinez Creek.

1959. Stinemeyer, E. S., Beck, R. S., Ortalda, R. A., Espenscheid, E. K., Bainton, J. D., and O'Keefe, M. S.

Exposures of the basal part of the Phacoides Sand [Wygal Sandstone Member] on Zemorra Creek contain *Lucina acutilineata* [*Lucinoma acutilineata*], *Pecten branneri* [*Vertipecten alexclarki* n. sp.], *Ostrea* sp., and *Bruclarkia barkeriana* [*B. seattlensis*].

1963. Kleinpell, R. M., and Weaver, D. W. The mollusk-bearing lower ("Phacoides Reef") sandstone member of the Temblor Formation [Wygal Sandstone Member] is correlated with the middle sandstones of the type Alegria Formation of the Santa Barbara embayment and with their Soda Lake Sandstone of the Cuyama Valley area, eastern San Luis Obispo County.

1968. Elliott, W. J., Tripp, Eugene, and Karp, S. E. *Lucina acutilineatus* [*Lucinoma acutilineata*] is the pelecypod for which the Phacoides Sand [Wygal Sandstone Member] was named.

1968. Foss, C. D., and Blaisdell, Robert. Their "Phacoides Sand" member [Wygal Sandstone Member] of the Temblor Formation contains mollusks alleged to be referable to the *Turritella inezana* zone; seven species are listed. This member is unconformably overlain by their "Lower" Santos Shale Member of the Temblor Formation.

1969. Addicott, W. O. About 35 percent of the still-living molluscan genera from the so-called Phacoides sandstone [Wygal Sandstone Member] are today restricted to warm-water latitudes of the eastern North Pacific.

1970b. Addicott, W. O. Faunal data presented in Addicott (1969) are tabulated. Thirty-one molluscan genera occur in the so-called "*Phacoides*" reef [Wygal Sandstone Member]. The fauna is of much warmer water aspect than that of the subjacent Refugian Stage of the San Joaquin basin.

1970. Mallory, V. S. The "Lower Temblor sandstone" [Wygal Sandstone Member] unconformably overlies Eocene sandstone at Media Agua Creek. Three mollusks including *Lucinoma acutilineata* are listed.

1970c. Addicott, W. O. A significant increase in the percentage of molluscan genera of tropical and subtropical affinities occurred during the late Oligocene in the San Joaquin basin. The increase is based on comparison of the middle Oligocene fauna of the *Acila shumardi* Zone of the San Emigdio Mountains with the fauna of the so-called "Phacoides" sandstone [Wygal Sandstone Member] of the type Temblor Formation.

1972. Addicott, W. O. Mollusks from the Phacoides Sand Member of Stinemeyer and others (1959) are of post-Refugian and pre-"Vaqueros" age. This fauna is believed to represent a previously unrecognized stage in California and is coeval with the lower part of the "Blakely Stage" of western Washington. This summary report was written after the present paper was completed; the sections in it dealing with the lower part of the type Temblor Formation are summarized from this report.

1973. Addicott,W. O. The fauna of the so-called "*Phacoides* reef," formerly assigned to the "Vaqueros Stage," represents a previously unrecognized post-"Lincoln," pre-"Vaqueros" molluscan stage in California.

STRATIGRAPHY

The Temblor Formation was named (as Temblor Beds) by Anderson (1905) for exposures between Temblor Ranch and Carneros Creek in the central part of the Temblor Range about 15 miles northwest of McKittrick, Calif. The base of the formation is marked by an unconformity with the underlying Point of Rocks Sandstone of Eocene age; the top, by a conformable contact with the Monterey Shale. The Temblor Formation consists of several shale and sandstone units totaling about 1,800 feet in thickness in the type area (Woodring and others, 1940, p. 130). These units have been given informal names in the course of petroleum exploration and development in oil fields bordering the eastern flank of the Temblor Range (Cunningham and Barbat, 1932; Gester and Galloway, 1933; Goudkoff, 1941), and these names have been summarized in many publications (Woodring and others, 1940; Weaver and others, 1944; Stinemeyer and others, 1959; Foss and Blaisdell, 1968). A comparison between earlier stratigraphic nomenclature and that for the members of the Temblor Formation formally named and described by Dibblee (1973) is shown in figure 2.

Formation	Member	
	Earlier usage (Stinemeyer and others, 1959)	Dibblee (1973) and this report
Temblor Formation	Buttonbed Sand	Buttonbed Sandstone
	Media Shale	Media Shale
	Carneros Sand	Carneros Sandstone
	Upper Santos Shale	Santos Shale
	"Agua Sand" interval	Agua Sandstone
	Lower Santos Shale	Santos Shale
	Phacoides Sand	Wygal Sandstone
	Salt Creek Shale	Cymric Shale

FIGURE 2.— Stratigraphic nomenclature of the type Temblor Formation, Temblor Range, Kern County, Calif.

WYGAL SANDSTONE MEMBER

The Wygal Sandstone Member of the Temblor was named by Dibblee (1973) for exposures on Chico Martinez Creek in the central part of the Temblor Range about 8 miles southwest of South Belridge oil field. This unit was previously known by the informal local name Phacoides sand, or Phacoides reef, following Kleinpell (1938, p. 107). The informal name Phacoides was based on the abundant articulated valves of the mollusk *Lucinoma acutilineata* that characterizes this unit throughout its surface exposure. The Wygal crops out in a folded but generally northeast-dipping marine sequence extending over a 12-mile area from the west fork of Devilwater Creek on the northwest (Glover, 1953) to Temblor Creek on the southeast (fig. 3). This sandstone member is 3 or 4 feet thick on the north side of Media Agua Creek (USGS loc. M4473) near its northwestern limit and increases to as much as 85 feet on Zemorra Creek (Woodring and others, 1940). Throughout most of the area, however, the fossiliferous part of the member ranges from 20 to 40 feet in thickness. In the thicker sections, there there are usually three or four pelecypod-bearing, calcareous sandstone beds that average about 2 feet

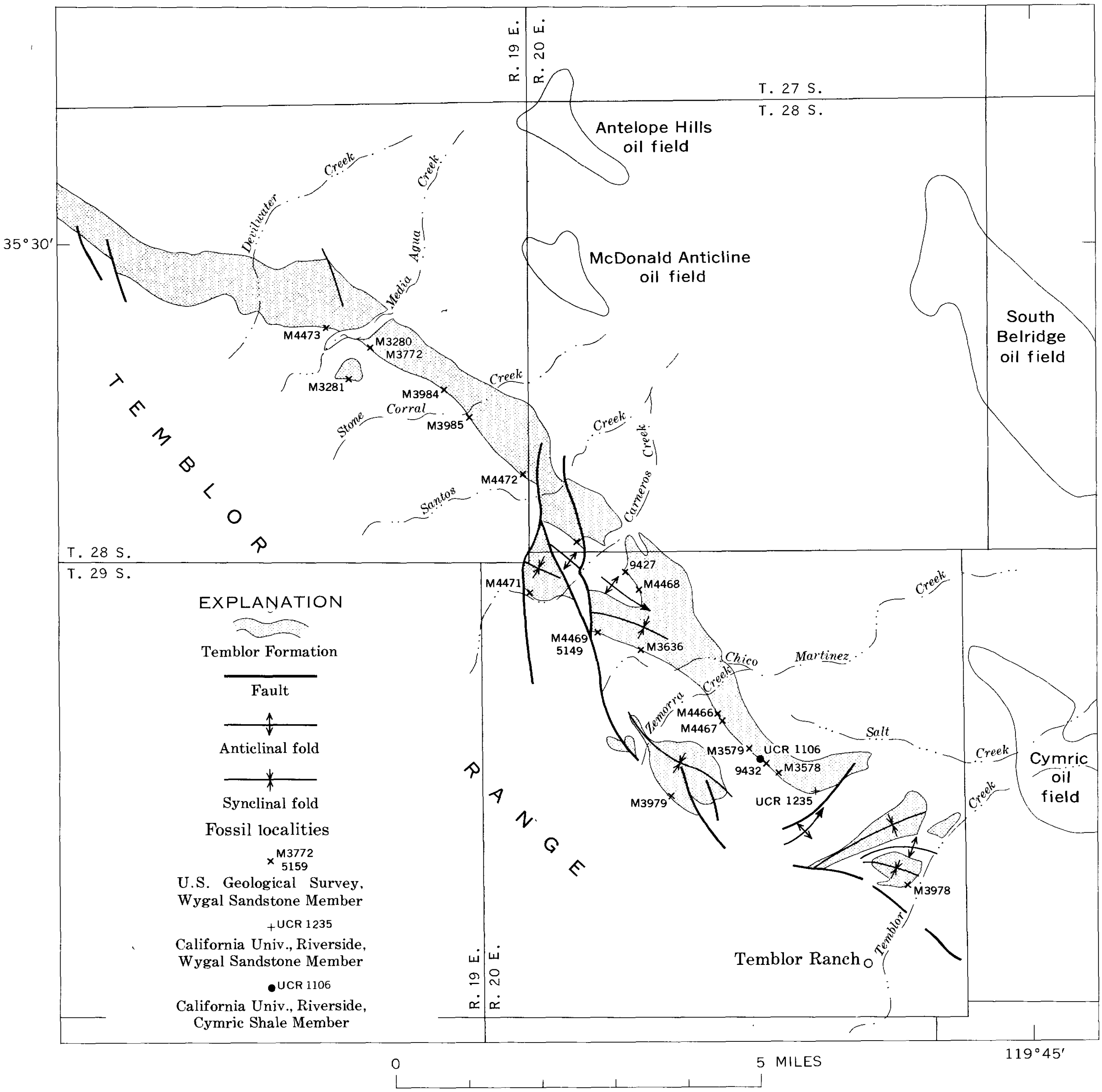


FIGURE 3.—Distribution of the Temblor Formation, central Temblor Range, Kern County, Calif., and mega-invertebrate fossil localities in the Wygal Sandstone (×) and Cymric Shale (•) Members (geology from Dibblee, 1968). The northwestern limit of the Wygal Sandstone Member is in sec. 17, T. 28 S., R. 19 E. (Glover, 1953).

in thickness, separated by more friable, less calcareous, poorly exposed sandstone. The basal sandstone bed is coarse to very coarse grained and is characterized by abundant pelecypod valves and a few mollusk-bored cobbles. In the area between Carneros and Temblor Creeks, the basal sandstone usually overlies a poorly exposed, splintery, gray shale known locally as the Salt Creek Shale but recently renamed as the Cymric Shale Member (Dibblee, 1973); locally, however, the sandstone overlaps the Cymric Shale Member and directly overlies the Eocene Point of Rocks Sandstone (Stinemeyer and others, 1959, p. 6). From Santos Creek (fig. 3) northward the basal sandstone of the Wygal unconformably overlies the Point of Rocks Sandstone; it progressively truncates about 700 feet of strata in the Point of Rocks Sandstone between Santos Creek and its northwestern limit at Devilwater Creek (Glover, 1953). This contact is well exposed where it crosses sharp ridges on the north and south sides of Media Agua Creek (fig. 3).

Although an unconformity is not recognized at the base of the Wygal [Phacoides] Sandstone Member in basinward oil fields southeast of the Temblor Creek–Chico Martinez Creek area (Weddle, 1966; Foss and Blaisdell, 1968; Anderson and Land, 1969), there is a distinct unconformity at the base of the Wygal in most of the oil fields adjacent to the northeastern flank of the central and northern parts of the Temblor Range (Ritzius, 1954; Bruce, 1956; Park and Weddle, 1959; and Land, 1968). In the subsurface, the Wygal [Phacoides] Sandstone Member progressively overlaps and truncates Oligocene and upper Eocene formations in a westerly direction.

Surface and subsurface evidence indicates, therefore, that the unconformity at the base of the Wygal Sandstone Member is an even stronger and better defined regional feature than the one at the base of the Cymric [Salt Creek] Shale Member.

The basal sandstone of the Wygal Sandstone Member is well exposed about half a mile southeast of Zemorra Creek, in the southern part of the outcrop belt. There it contains abundant *Crassostrea* and scattered valves of the stratigraphically significant species *Pecten sanctaecruzensis* Arnold (USGS loc. M4467).

The stratigraphically higher fossiliferous strata are generally poorly exposed except in gullies and in areas of southern exposure on moderate to steep slopes. Pelecypod valves occur in fine-grained to very fine grained calcareous sandstone lenses or concretions. The valves are so abundant that the Wygal Sandstone Member can usually be recognized and mapped on the basis of fossil float—generally articulated valves of *Lucinoma acutilineata* and, to a lesser extent, *Heteromacoma rostellata*—even in areas of low relief and on north-facing slopes.

The top of the Wygal Sandstone Member is marked by a 4- to 5-foot-thick bed of white-weathering glauconitic sandstone. This bed is well exposed in trenches between Media Agua Creek and Stone Corral Creek (E½E½ sec. 23, T. 28 S., R. 19 E.), on the south side of Zemorra Creek (NW¼SE¼ sec. 9, T. 29 S., R. 20 E.), and about a mile northwest of Salt Creek (SW. cor. sec. 14, T. 29 S., R. 20 E.). It is a characteristic subsurface marker bed in the Cymric oil field, the productive limits of which extend for a distance of 10 miles southeast of Temblor Creek (Anderson and Land, 1969).

Recent collections from 19 localities in the Wygal Sandstone Member, together with three older collections (USGS locs. 5149 and 9432; UCR 1235), have yielded a molluscan fauna of 50 taxa, principally pelecypods (table 1). The largest, best preserved assemblage is from the divide on the south side of Media Agua Creek (USGS locs. M3280 and M3772; 31 taxa). Here the base of the Wygal is marked by scattered calcareous sandstone concretions containing abundant pelecypod valves. In the upper part of this 6-foot-thick unit, *Lucinoma acutilineata* (Conrad) and *Heteromacoma rostellata* (Clark) are so abundant that this part can be called a *Lucinoma-Heteromacoma* bed. Gastropods are more common at this locality than elsewhere, but they constitute only a small fraction of the mollusk assemblage.

PROVINCIAL AGE AND CORRELATION

GENERAL CONSIDERATIONS

The lower part of the type Temblor Formation constitutes a unique stratigraphic continuum of marine middle Tertiary strata in the California Coast Ranges. Two molluscan stages of provincial late Oligocene and early Miocene age can be recognized from shallow-water faunal assemblages from sandstone members of the formation. These units are directly associated with benthonic foraminiferal assemblages from interbedded shale and siltstone that constitute the type section of the Zemorrian Stage of the provincial microfaunal sequence (Kleinpell, 1938). Elsewhere in the Coast Ranges of central and southern California, the Oligocene, and perhaps the early part of the Miocene, are usually represented by nonmarine strata—the Sespe Formation and correlative units—that constitute a marked hiatus between the widespread marine deposition of the Eocene and of the Miocene. The significant features of the Temblor Range sequence can be sum-

TABLE 1.—*Systematic list of mollusks from the Wygal Sandstone Member of the Temblor Formation, Temblor Range, Calif.*

Fossil	Localities[1]																				
	5149	9427	9432	M3280 and M3772	M3281	M3578	M3579	M3636	M3978	M3979	M3984	M3985	M4466	M4467	M4468	M4469	M4470	M4471	M4472	M4473	UCR 1235
Gastropods:																					
Tegula n. sp	---	---	---	---	---	×	---	---	---	---	---	---	?	---	---	---	---	---	---	---	×
Cerithiid?	---	---	---	---	---	×	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Calyptraea diegoana (Conrad)	---	---	---	×	×	---	---	---	---	---	---	---	---	---	---	---	---	×	---	---	---
Crepidula cf. *C. ungana* Dall	---	---	---	×	×	---	---	---	---	×	---	---	---	---	---	---	---	---	---	---	---
Natica (*Natica*) n. sp	---	---	---	×	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Neverita (*Glossaulax*) *thomsonae* Hickman	---	---	---	---	---	---	---	---	×	---	---	---	---	---	---	---	---	---	---	---	---
Polinices n. sp	---	---	---	×	---	---	---	---	---	---	---	---	---	---	---	---	---	---	×	---	---
Sinum cf. *S. scopulosum* (Conrad)	---	---	---	---	---	×	---	---	---	---	---	---	---	---	---	---	---	?	---	---	---
Ficus cf. *F. modesta* (Conrad)	---	---	---	---	---	×	---	---	×	---	---	---	---	---	---	---	---	---	---	---	---
Calicantharus cf. *C. branneri* (Clark and Arnold)	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	×	---	---	---
Calicantharus dalli (Clark)	---	---	---	×	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Kelletia? sp	---	---	---	×	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Siphonalia? sp	---	---	---	×	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Bruclarkia seattlensis Durham	×	---	---	×	---	×	---	×	×	×	---	---				---	×	×	---	---	---
Pelecypods:																					
Acila (*Truncacila*) *muta* Clark	---	---	---	?	---	---	?	---	---	---	---	---	×	---	---	---	---	×	---	---	---
Yoldia (*Kalayoldia*) *tenuissima* Clark	---	---	×	---	---	×	---	?	---	×	---	---	×	---	?	---	---	---	---	---	×
Anadara (*Anadara*) *submontereyana* Clark	cf.	---	---	×	×	×	×	---	×	---	---	---	---	---	---	---	---	---	---	---	---
Crenomytilus? cf. *C.*? *arnoldi* (Clark)	---	---	---	---	---	×	---	cf.	×	×	---	---	---	---	---	---	---	---	---	---	---
Crenomytilus expansus (Arnold)	---	×	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Aequipecten sp	---	---	---	×	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Pecten (*Pecten*) *sanctaecruzensis* Arnold	---	---	---	---	---	---	---	---	---	---	---	---	---	×	---	---	---	---	---	---	---
Vertipecten alexclarki Addicott, n. sp	?	---	---	×	×	---	×	×	---	---	×	×	×	---	×	---	×	---	×	---	---
Crassostrea eldridgei ynezana (Loel and Corey)	---	---	---	×	---	×	---	---	×	?	---	---	×	---	---	---	---	---	---	---	---
Crassostrea? sp	×	---	---	---	---	---	---	---	---	---	---	---	---	×	×	---	×	---	×	---	---
Here excavata (Carpenter)	---	---	×	×	---	×	×	---	×	---	---	---	×	---	---	---	---	---	---	---	---
Lucinoma acutilineata (Conrad)	×	---	×	×	×	×	×	×	×	×	×	×	×	---	×	×	×	×	×	×	---
Miltha (*Miltha*) *sanctaecrucis* (Arnold)	×	---	×	×	---	×	×	---	---	×	---	---	---	×	×	×	---	---	---	---	---
Felaniella harfordi (Anderson)	---	---	×	×	---	---	---	---	---	---	---	---	×	---	---	---	---	---	---	×	---
Pseudocardium? sp	---	---	---	---	---	---	---	---	---	---	---	---	×	---	---	---	---	---	---	---	---
Spisula cf. *S. albaria* (Conrad)	×	---	---	---	---	×	---	×	×	×	---	---	?	---	×	×	×	×	×	---	---
n. sp.?	---	---	---	×	---	---	×	---	---	×	---	---	---	---	---	---	---	---	---	---	---
ramonensis Packard	---	---	---	×	---	---	---	---	---	---	---	---	---	---	cf.	---	---	---	---	---	---
cf. *S. rushi* Wagner and Schilling	---	---	---	×	---	---	---	×	×	×	---	---	---	---	---	---	×	×	?	---	---
Solen aff. *S. gravidus* Clark	---	---	---	×	---	×	---	---	---	---	---	---	?	---	---	---	---	---	---	---	---
Tellina (*Olcesia*) *piercei* (Arnold)	---	---	×	---	---	×	---	---	×	---	---	---	---	---	---	---	---	?	---	---	---
(*Oudardia*?) *emacerata* Conrad	---	---	---	---	---	×	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
(*Tellinella*) *tenuilineata* Clark	×	---	×	---	---	×	---	---	---	---	---	---	?	---	---	---	---	---	---	---	---
cf. *T. townsendensis* Clark	---	---	---	---	---	×	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Tellina? cf. *T. vancouverensis* Clark and Arnold	---	---	---	---	---	×	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Macoma arctata (Conrad)	×	---	---	×	×	×	cf.	---	---	---	---	---	×	---	×	×	---	cf.	×	---	---
Heteromacoma rostellata (Clark)	×	---	---	×	×	×	---	---	×	×	×	---	×	---	×	×	×	×	×	×	---
Amiantis mathewsoni (Gabb)	×	---	---	×	---	×	×	---	×	×	cf.	---	?	---	cf.	cf.	---	---	---	---	---
n. sp	---	---	---	?	---	×	---	---	---	---	---	---	×	---	---	---	---	---	---	---	---
Clementia (*Egesta*) *pertenuis* (Gabb)	×	---	×	×	---	×	×	---	×	---	---	---	×	---	×	×	---	---	---	---	---
Dosinia (*Dosinia*) *whitneyi* (Gabb)	---	---	×	×	---	×	---	---	---	×	---	---	×	---	?	cf.	?	×	×	---	---
Pitar (*Katherinella*) cf. *P.* (*K.*) *californica* (Clark)	---	---	---	×	---	---	---	---	---	---	---	---	×	---	---	---	---	---	×	---	---
sp	?	---	---	---	---	---	---	---	×	---	---	---	---	---	---	---	---	---	---	---	---
Securella cf. *S. cryptolineata* (Clark)	---	---	---	×	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Panopea ramonensis (Clark)	×	---	---	×	---	×	---	---	×	---	---	---	?	---	---	cf.	---	---	---	×	---
Scaphopod:																					
Dentalium laneensis Hickman	---	---	---	×	×	×	---	---	×	---	---	---	---	---	---	---	---	---	---	---	---

[1] See p. 17 for explanation of symbols.

marized as (1) the succession of shallow-water Oligocene and early Miocene molluscan assemblages in demonstrable superpositional relationships and (2) the alternation of these molluscan assemblages with thoroughly studied foraminiferal-bearing strata. What is offered, then, is a unique framework for the stratigraphic succession of shallow-water molluscan faunas from the Oligocene into the Miocene and an opportunity to relate these directly to the deeper water benthonic foraminiferal sequences.

The biostratigraphic units in the lower part of the type Temblor Formation that are taken to represent time-stratigraphic units of stage magnitude are represented by faunal assemblages from (1) the Wygal Sandstone Member and (2) the Agua and Carneros Sandstone Members. A third stage may be represented by a meager faunal assemblage from the Cymric Shale Member near the base of the Temblor Formation. The relationship of these units, and stratigraphically higher members of the Temblor Formation, to the standard Pacific coast megainvertebrate chronology of Weaver and others

(1944) is shown in figure 4. The Miocene mega-invertebrate stages are enclosed in quotation marks here and throughout the text to differentiate them from rock-stratigraphic units bearing the same name and to signify that they have not been formally defined. The Refugian Stage (Schenck and Kleinpell, 1936), usually considered to be a microfaunal stage, was originally defined on both foraminiferal and molluscan evidence. It is not, therefore, enclosed in quotation marks as are the other molluscan stages.

Formation	Member	Molluscan stage	Foraminiferal stage
Temblor Formation (type)	Buttonbed Sandstone	"Temblor"	Relizian
	Media Shale		Saucesian
	Carneros Sandstone	"Vaqueros"	
	Santos Shale		
	Agua Sandstone		Zemorrian (type)
	Santos Shale	Unnamed	
	Wygal Sandstone		
	Cymric Shale	"Lincoln" or Refugian	

FIGURE 4.—Molluscan and foraminiferal provincial stage classification of the type Temblor Formation. Formational nomenclature is after Dibblee (1972). Molluscan control is indicated by the vertical bars; foraminiferal stage boundaries are from Stinemeyer, Beck, Ortalda, Espenscheid, Bainton, and O'Keefe (1959).

This report is concerned primarily with the fauna of the Wygal Sandstone Member and its bearing on the marine Oligocene of the provincial chronology. Heretofore this poorly known fauna had been assigned to the lower Miocene "Vaqueros Stage" of Weaver and others (1944), although the lack of "Vaqueros" index species had been noted by at least a few workers (Woodring and others, 1940). It can now be shown that the Wygal Sandstone Member, or so-called Phacoides sand, is older than the "Vaqueros Stage" and that it represents an Oligocene interval in the California provincial molluscan sequence that has never been adequately defined. Secondary objectives are (1) delineation of the boundaries of the overlying "Vaqueros Stage" in the Temblor Range and (2) discussion of molluscan evidence of the provisional reassignment of the lowermost part of the basal shale, the Cymric Shale Member, to the Refugian Stage.

CYMRIC SHALE MEMBER

The Cymric Shale Member of the type Temblor Formation (Dibblee, 1972) has been assigned to the "Vaqueros Stage" of the Pacific coast mega-invertebrate chronology (Weaver and others, 1944. as "Barren" shale member of the Temblor Formation). This assignment, together with the subsequent inference (Kleinpell and Weaver, 1963, fig. 5) that this unit falls within the biozone of *Turritella inezana* s. l., was based on the assumption that the base of the Zemorrian Stage of the provincial microfaunal sequence is coincident with the lower boundary of the "Vaqueros Stage" (see also Corey, 1954). So far as is known, however, there are no authenticated occurrences of molluscan assemblages referable to the "Vaqueros Stage" found together with Foraminifera referable to the lower part of the Zemorrian Stage. The known range of the Vaqueros fauna of Loel and Corey (1932) [= "Vaqueros Stage"] corresponds to the upper part of the Saucesian Stage (Addicott, 1967a, p. C9). Moreover, the subsequent analysis of the fauna of the Wygal Sandstone Member, which overlies the Cymric Shale Member, indicates that it represents a pre-"Vaqueros Stage" time-stratigraphic unit in the California provincial molluscan sequence.

Further revision of the age of this member in terms of the provincial sequences is suggested by a small collection of mollusks from 10 to 30 feet below the base of the Wygal Sandstone Member in an unnamed creek between Zemorra Creek and Salt Creek (California Univ., Riverside, loc. 1106). This collection includes *Bruclarkia columbiana* (Anderson and Martin) (pl. 9, figs. 22, 23), a well-defined gastropod that is restricted to the upper part of the Refugian Stage in California (Schenck and Kleinpell, 1936) and to the middle and upper part of the Refugian Stage [= *Acila shumardi* Zone and "Lincoln Stage"] of western Washington (Durham, 1944). *B. columbiana* was previously reported from this locality as *Olequahia lorenzana* (Wagner and Schilling) by Addicott (1970b), who based his identification on one by Alex Clark (unpub. rept., 1931, on file in the Geol. Dept., California Univ., Riverside), but Clark indicated that his two specimens might possibly be confused with *Bruclarkia columbiana* (Anderson and Martin). His unfigured specimen is an internal mold that is generically indeterminate; it seems to have a strongly noded penultimate whorl and could conceivably represent *Olequahia.* His other specimen, however, clearly is *B. columbiana* (pl. 9, figs. 22, 23).

The implications of this suggested stratigraphic revision are far reaching. Beds containing *Bruclarkia columbiana* can be confidently traced into the lowermost part of Kleinpell's (1938) type Zemorrian section, which is situated slightly more than a mile to the northeast (see Elliott and others, 1968, p. 111). The occurrence of this significant index species suggests that part of the type Temblor Formation must also be of Refugian age and that the two stages, as originally defined, are in part coeval. It should be noted that the lower boundary of the Zemorrian Stage was originally placed at the base of the Cymric Shale Member [lower Temblor shale member] by Kleinpell (1938).

So far as can be determined, this indicated revision does not necessarily contravene foraminiferal control used by Kleinpell (1938, p. 40–45, 54, 105–108) in defining his Zemorrian Stage. His stratigraphically lowest sample from Carneros Creek (loc. 1a, 10 ft above the base of the member) contains only the long-ranging Eocene to Miocene species *Plectofrondicularia vaughani*. The only other assemblage from the Cymric Shale Member listed by Kleinpell (1938, loc. CM70) may have been obtained from beds stratigraphically higher than those in which *Bruclarkia* occurs. Kleinpell's sample was collected from a position about 50 feet above the base of the member in nearby Chico Martinez Creek (the thickness of the Cymric Shale Member in this area is variously reported as about 35 ft (Stinemeyer and others, 1959) and 75 ft (Kleinpell, 1938)). This critical assemblage that Kleinpell (1938, p. 107, CM70) cited as indicative of the same "zone" as the diverse and stratigraphically diagnostic lower Zemorrian assemblages of the overlying lower part of the Santos Shale Member, for example, contains only seven taxa. Of these, only *Buliminella curta* seems to be restricted to post-Refugian strata (R. L. Pierce, oral commun., May 1971). *Epistomina ramonensis*, the zonal index of Kleinpell and Weaver's (1963, p. 41) lower subzone of the lower part of the Zemorrian Stage, which presumably is represented by the Cymric Shale Member, has never been recorded from the type Zemorrian. Furthermore, representatives of the stratigraphically diagnostic late Paleogene and early Neogene *Uvigerina jacksonensis* [*U. cocoaensis*]–*Siphogenerina transversa* lineage of Lamb (1964) have never been recorded from the Cymric Shale Member or from this lowest subzone (Kleinpell and Weaver, 1963; Lamb, 1964). The Cymric, in fact, represents a critical gap between the highest stratigraphic occurrence of *U. tumeyensis* Lamb or *U. vicksburgensis* Cushman and Ellisor of Kleinpell and Weaver (1963) and the lowest stratigraphic occurrence of the presumed antecedent species *S. nodifera* Cushman and Kleinpell. The highest stratigraphic occurrence of *U. tumeyensis* is in strata assigned to the Refugian Stage by Kleinpell and Weaver (1963), whose assignment is based in part on molluscan evidence; the lowest stratigraphic occurrence of *S. nodifera* is in the basal part of the Santos Shale Member in the lower part of the type Zemorrian section. Accordingly, the Cymric Shale Member, in terms of the *Uvigerina-Siphogenerina* sequence of Lamb (1964), represents a hiatus between the Refugian and the Zemorrian Stages.

The possibility that the lower boundary of the type section of the Zemorrian Stage should be revised and placed at a higher stratigraphic position—at or near the top of the Cymric Shale Member—is further suggested by analysis of fish-scale assemblages from the lower part of the Temblor Formation by R. L. Pierce. Fish scales from the Cymric Shale Member near the base of the lower part of the Zemorrian Stage are considered by Pierce to be "very characteristic of the Refugian Stage of California," whereas those from the lower part of the Santos Shale Member—near the top of lower part of the Zemorrian Stage—are much different and are considered typically Zemorrian (R. L. Pierce, written commun., Sept. 3, 1971).

In summary, the scant molluscan evidence suggests that the basal shale of the Temblor Formation may be, at least in part, referable to the earlier defined Refugian Stage of Schenck and Kleinpell (1936), a stage defined on both molluscan and foraminiferal data. This correlation is supported by studies of fish scales from the lower part of the Temblor Formation of this area and is not necessarily contravened by published data on foraminifers from exposures of the Temblor Formation of this area. The suggested upward adjustment of the lower boundary of the type Zemorrian Stage would be in keeping with the principle of priority inasmuch as the Refugian Stage (Schenck and Kleinpell, 1936) was proposed before the Zemorrian Stage was defined (Kleinpell, 1938), although the name Zemorrian Stage had been introduced a few years earlier (Kleinpell, 1934).

Part of the Cymric Shale Member may thus be correlative with Wagner and Schilling's (1923) faunal assemblages from the upper part of their San Emigdio Formation and the lower part of their Pleito Formation along the southern margin of the San Joaquin basin. These units contain both mollusks and benthonic foraminifers referable to the Refugian Stage (DeLise, 1967; Kleinpell and Weaver, 1963). A somewhat larger assemblage of Refugian mollusks has been reported from sandstone in a landslide block about 10 to 15 miles to the southeast of Zemorra Creek near Crocker Flat (Simonson and Kreuger, 1942). Refugian index species in this assemblage include *Olequahia lorenzana* (Wagner and Schilling), *Turritella lorenzana* (Wagner and Schilling), and *Epitonium condoni* Dall. Further study of this displaced stratal sequence is needed because the Refugian mollusks were said to be associated with foraminifers of Zemorrian age. Exposures of the Refugian Wagonwheel Formation of Smith (1956) in the southern part of the Diablo Range, about 30 miles to the northwest, contain an assemblage of deep-water pelecypods, principally *Lucina* aff. *L. diegoensis* Dickerson and *Thyasira* aff. *T. disjuncta*, that does not permit faunal correlation with shallow-water Refugian assemblages in the southern part of the San Joaquin basin.

WYGAL SANDSTONE MEMBER

Indirect evidence that the fauna of the Wygal Sandstone Member is of late Oligocene, pre-"Vaqueros" (early Miocene) age is that species restricted to the "Vaqueros Stage" occur only in stratigraphically higher sandstones in the type Temblor Formation. The shallow, inner sublittoral bathymetric environment indicated by the molluscan assemblages of the Wygal Sandstone Member is similar to that of the Vaqueros Formation, as previously noted by Woodring, Stewart, and Richards (1940). And, as might be expected, the generic composition of the Wygal molluscan fauna is not markedly different from that of the Vaqueros Formation of Loel and Corey (1932)[1]. Accordingly, one would expect to find some of the ubiquitous shallow-water index species of the "Vaqueros Stage" in the Wygal fauna, if it were deposited during the "Vaqueros age," particularly in view of the moderately large, diverse fauna of 50 shallow-water molluscan taxa recorded in table 2.

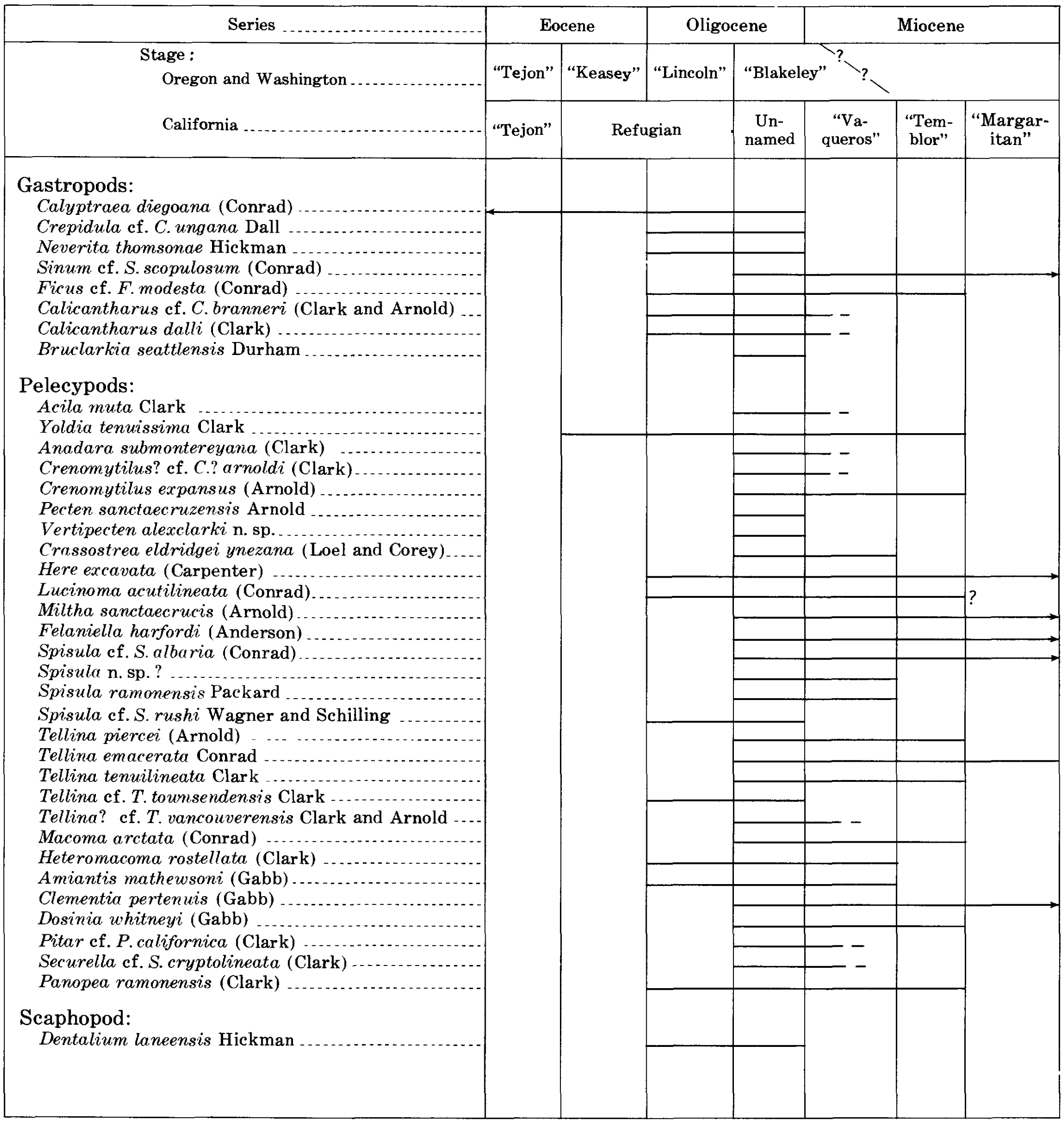
Inferred phylogenetic relationships of two stratigraphically important Oligocene to middle Miocene molluscan genera, *Bruclarkia* and *Vertipecten*, further strengthen the contention that the faunal assemblages of the Wygal Sandstone Member are older than the "Vaqueros." *Bruclarkia* is represented by *B. seattlensis* Durham, a species that seems to be a lineal antecedent of *B. barkeriana* forma *santacruzana* (Arnold), an early and middle Miocene species restricted to the "Vaqueros" and "Temblor Stages" (table 3). *B. seattlensis* occurs stratigraphically above the upper Refugian index species *B. columbiana* (Anderson and Martin), from which it may have evolved both here and in western Washington (Durham, 1944, p. 116). Likewise, the pectinid *Vertipecten alexclarki* n. sp. from the Wygal Sandstone Member seems to be the lineal antecedent of *V. perrini* (Arnold), a species that first occurs in the "Vaqueros Stage" and that has its lowest stratigraphic occurrence in the Agua Sandstone Member, higher in the Temblor Formation (table 3). The reported occurrence of *V. perrini* in the upper part of the Refugian Stage (Schenck and Kleinpell, 1936, p. 222) has never been documented in the literature. That occurrence may refer to a large pectinid from Effinger's (1935) Refugian Gaviota Formation of the Santa Ynez Mountains subsequently figured by Wilson (1954, pl. 18, figs. 1, 2) as *Pecten* (*Chlamys*) cf. *P.* (*C.*) *sespeensis* Arnold (R. M. Kleinpell, oral commun., June 1971). *Vertipecten* is represented in the region of the type section of the Refugian Stage by *V. yneziana* (Arnold) (Kleinpell and Weaver, 1963).

The occurrence of *Pecten sanctaecruzensis* Arnold at the base of the Wygal Sandstone Member (USGS loc. M4467) is further evidence of a pre-"Vaqueros" position in the provincial mega-invertebrate chronology. As indicated by Loel and Corey (1932), this species does not occur in faunal assemblages referable to their Vaqueros Formation ["Vaqueros Stage"]; they regard its occurrences in the Salinas Valley area and in the Santa Cruz Mountains as of pre-Vaqueros, Oligocene age. Although this classification was disputed by Schenck (1935, p. 521–522) based on his mapping of the type locality of *P. sanctaecruzensis* in the Vaqueros Sandstone of the Santa Cruz Mountains and by subsequent workers (Brabb, 1964; Burchfiel, 1964), the fact remains that this species has never been found associated with mollusks restricted to Loel and Corey's (1932) Vaqueros Formation [their "formation" being, as previously indicated, a time-stratigraphic unit that has subsequently become known as the "Vaqueros Stage"]. This fact was recognized initially by Arnold (1908), who emphasized that *P. sanctaecruzensis* and the associated molluscan assemblage in the Santa Cruz Mountains were more closely related to the fauna of the underlying San Lorenzo Formation than to his overlying Vaqueros Sandstone [again Arnold's (1908) Vaqueros Sandstone was essentially a time-stratigraphic unit defined on biostratigraphic criteria, and its lower boundary was defined on essentially the same criteria as Loel and Corey's Vaqueros Formation]. Moreover, the stratigraphic association of *P. sanctaecruzensis* with foraminifers

[1] Loel and Corey's (1932) Vaqueros Formation is not strictly a lithostratigraphic unit; rather, it was defined and recognized on a faunal basis and, therefore, closely fulfills the criteria for a time-stratigraphic unit (Kleinpell and Weaver, 1963; Addicott, 1970a). Accordingly, it is here referred to as "Vaqueros Stage." Quotation marks are used for this, and other stages, to indicate that they have not been formally defined and to distinguish them from rock-stratigraphic units bearing the same name.

TABLE 2.—*Ranges of specifically determined mollusks from the Wygal Sandstone Member of the Temblor Formation in terms of the Pacific coast provincial mega-invertebrate chronology*

["Stages" are modified from Weaver and others (1944), Durham (1954), and Corey (1954)]

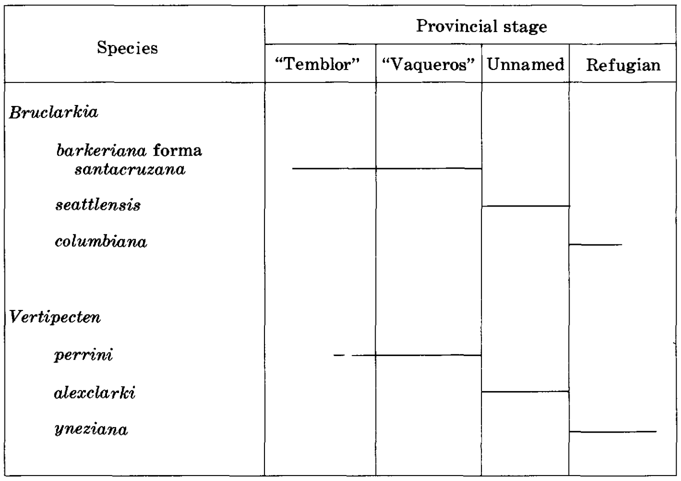


of early Zemorrian age in both the Temblor Range and the Santa Cruz Mountains (Burchfiel, 1964) is suggestive of a pre-"Vaqueros" position in the provincial mega-invertebrate sequence because "Vaqueros" index species are not known to be associated with foraminiferal assemblages below the upper part of the Zemorrian Stage (p. 8).

Unfortunately, no representatives of the stratigraphically important gastropod genus *Turritella* have been found in the Wygal Sandstone Member. Nor has it been found in the upper part of the Pleito Formation of Wagner and Schilling (1923) of the nearby San Emigdio Mountains, a unit that is regarded by myself and by at least some workers (Kleinpell and Weaver, 1963) as coeval with the lower sandstone member of the type Temblor Formation. The absence of *Turritella* from these formations complicates correlation: *Turritella* lineages (Merriam, 1941) as well as the pectinids are the most important means of correlation and age determination by mega-invertebrates in the Pacific coast Tertiary.

The post-Refugian age of the molluscan fauna of the Wygal Sandstone Member is indicated by (1) the absence of shallow-water species that are restricted to Refugian strata in other parts of the San Joaquin basin, (2) a significant number of genera and species that are not known to occur in

TABLE 3.—*Ranges of some species of* Bruclarkia *and* Vertipecten *referred to in text*



assemblages as old as Refugian in California (tables 4 and 5), and (3) the abrupt appearance of molluscan genera (post-Refugian genera and species) indicative of a much warmer water environment than occurred during the Refugian (Addicott, 1969, 1970b).

Although there are some species in common with the Refugian Stage ("Lincoln Stage" of Oregon and Washington), as might be expected, most of the Refugian species characteristic of the upper part of the San Emigdio and lower part of the Pleito Formations of Wagner and Schilling (1923) from the southern margin of the San Joaquin basin do not occur in the Wygal Sandstone Member, nor do they range upward into the upper part of the Pleito Formation that is, in part, correlative with the Wygal Sandstone Member. Some of the Refugian species recorded by Wagner and Schilling (1923) and DeLise (1967) that do not occur in the Wygal Sandstone Member are: *Acrilla dickersoni* Durham, *Bruclarkia columbiana* (Anderson and Martin), *Bullia clarki* Wagner and Schilling, *Epitonium condoni* Dall s. l., *Molopophorus dalli* (Anderson and Martin), *Olequahia lorenzana* (Wagner and Schilling), *Perse lincolnensis* (Van Winkle), *Siphonalia merriami* Wagner and Schilling, *Acila shumardi* (Dall), and *Macrocallista pittsburgensis* Dall.

There is ample evidence, therefore, that the fauna of the Wygal Sandstone Member of the Temblor Formation occupies a position between the Refugian Stage and the "Vaqueros Stage" of the provincial mega-invertebrate chronology. It is likewise clear that the molluscan fauna of the Refugian Stage is not directly succeeded by faunal assemblages of the *"Turritella inezana* zone" (= the "Vaqueros Stage" of later usage (Weaver and others, 1944)) as believed by Schenck and Kleinpell (1936) and Kleinpell and Weaver (1963).

There is no formally or informally proposed time-stratigraphic unit in the California provincial molluscan sequence to which the Wygal fauna can be assigned. It is of post-Refugian age and is, in part, coeval with the "Blakeley Stage" of western Washington, presumably the lower part, the *Echinophoria rex* Zone of Durham (1944). Correlation with the western Washington molluscan sequence, however, is based largely on stratigraphic position and foraminiferal evidence and only indirectly on molluscan data.[2]

The post-Refugian age of the type sections of the "Blakeley Stage" is well established both on molluscan (Durham, 1944) and foraminiferal evidence (Rau, 1964; Fullmer, 1965). There is, however, evidence that at least part of the "Blakeley" is coeval with the "Vaqueros Stage" (Kleinpell, 1938, p. 153;

TABLE 4.—*Molluscan species from the Wygal Sandstone Member that are not known to occur in strata of Refugian age*

[Species restricted to formations of late Oligocene age in California are indicated by an asterisk (*). The other species range upward in strata of "Vaqueros" and (or) younger age]

Gastropods:
- *Calicantharus dalli* (Clark)
  - cf. *C. branneri* (Clark and Arnold)

Pelecypods:
- *Anadara submontereyana* (Clark)
- *Crassostrea eldridgei yneziana* (Loel and Corey)
- *Crenomytilus expansus* (Arnold)
- *Dosinia whitneyi* (Gabb)
- *Felaniella harfordi* (Anderson)
- *Macoma arctata* (Conrad)
- *Miltha sanctaecrucis* (Arnold)
- **Pecten sanctaecruzensis* (Arnold)
- *Spisula* n. sp.?
  - cf. *S. albaria* (Conrad)
  - cf. *S. rushi* Wagner and Schilling
- *Tellina piercei* (Arnold)
  - *emacerata* (Conrad)
- **Vertipecten alexclarki* Addicott n. sp.

[2] The difficulty in post-Refugian molluscan correlation between the southern part of California and western Washington is the result of the intensification of latitudinal taxonomic gradients, which began during the late Oligocene (Addicott, 1970c). This intensification is reflected in the decidedly warm-water aspect of the Wygal assemblages as contrasted with the temperate aspect of those of the type area of the "Blakeley Stage." Moreover, the bathymetric environment indicated by the "Blakeley" fauna, particularly the lower part—the *Echinophoria rex* Zone of Durham (1944) —is relatively deeper than that represented by the Wygal assemblages and further complicates correlation.

TABLE 5.—*Molluscan genera and subgenera from the Wygal Sandstone Member that are not known to occur in strata of Refugian age*

Gastropod:	
Tegula	
Pelecypods:	
Egesta	*Oudardia*
Leptopecten?	*Pecten* s. s.
Miltha	*Securella*
Olcesia	

Vanderhoof, 1942; Kleinpell and Weaver, 1963; Addicott, 1967b). Although this equivalence can be rather convincingly demonstrated by foraminiferal correlation, the latitudinal taxonomic gradient in molluscan faunas (footnote, p. 12) reduces the number of species common to both sequences to such a point that this supposed equivalence may never be proven or disproven. Many, if not most, of the generic lineages used in the time-stratigraphic subdivision of the Oligocene and early Miocene of western Washington (Durham, 1944, p. 115–116) are either incompletely represented or are not present at all in the warmer water assemblages of the San Joaquin basin. Among these critical lineages are *Aforia, Ancistrolepis, Liracassis* [*Echinophoria* of authors], *Molopophorus, Bathybembix* [*Turcicula* of authors], and *Turritella.* The one direct line of evidence supporting correlation with the "Blakeley Stage" of western Washington is the occurrence of the gastropod *Bruclarkia seattlensis* Durham in the Wygal assemblages. This species is restricted to the lower part of the "Blakeley Stage" (the *Echinophoria rex* Zone) of western Washington. It seems probable that the fauna of the Wygal Sandstone Member falls within the biozone of *Acila gettysburgensis*, but this species which ranges from the late Oligocene to middle Miocene and which is so characteristic of late Oligocene and early Miocene strata in Oregon and Washington, has been recorded from only two areas in California: a doubtful locality in the Santa Cruz Mountains (Schenck, 1936) and the San Ramon Sandstone near Mount Diablo (Clark, 1918). The San Ramon Sandstone, however, seems to be somewhat younger than the Wygal Sandstone Member and coeval units in western Washington assigned to the *Echinophoria rex* Zone, according to a reanalysis of its invertebrate fauna by Primmer (1965, p. 52–53), who assigned it to the upper part of the "Blakeley Stage" (the *Echinophoria apta* zone).

In view of the difficulty in correlating late Oligocene molluscan faunas of California with those of western Washington, it seems appropriate to establish a separate time-stratigraphic unit in California. The evidence presented in this report is judged adequate for recognition of a unit of stage magnitude, even though it is based on a fauna that has an extremely limited stratigraphic range. But because thoroughgoing biostratigraphic study of the coeval shallow-water molluscan fauna from the upper part of the Pleito Formation (Wagner and Schilling, 1923) of the southern margin of the San Joaquin basin has not been carried out, this time-stratigraphic unit must, for the time being, remain unnamed. In fact, the dominantly shallow-water sequence of Refugian through "Vaqueros" molluscan faunas of the San Emigdio Mountains should provide the best standard section for a late Oligocene provincial stage in California. Other molluscan faunas of this age from the California Coast Ranges are known to occur in the tuff member of the Kirker Formation of Primmer (1965), in the lower part of the Vaqueros Formation of Burchfiel (1964) and of Brabb (1964), and in the Santa Lucia Range (Edwards, 1940). Reported occurrences in the Alegria Formation of Dibblee (1950) of the western Santa Ynez Mountains (Kleinpell and Weaver, 1963) were later reassigned to the Refugian Stage (Weaver and Franz, 1967).

Molluscan data do not seem to support the claim that the Wygal Sandstone Member [lower Temblor sandstone of Curran (1943)] is coeval with the Quail Canyon Sandstone Member of the Vaqueros Formation (Dibblee, 1973) [formerly the Soda Lake Sandstone Member] of the Cuyama Valley area west of the San Andreas fault (Kleinpell and Weaver, 1963), and by inference, of pre-"Vaqueros" age. Molluscan assemblages from exposures of this unit in the eastern Caliente Range collected by J. G. Vedder include *Crassostrea* sp. and the "Vaqueros" index species *Chlamys hertleini* (Loel and Corey) (USGS loc. M3511). Accordingly, the Quail Canyon Sandstone Member of the Vaqueros Formation is younger than the Wygal Sandstone Member and should be correlated with the Agua Sandstone Member or with stratigraphically higher portions of the type Temblor Formation.

SANTOS SHALE MEMBER

The lower part of the Santos Shale Member, below the Agua Sandstone Member, includes the boundary between the lower part and the upper part of Kleinpell's (1938) Zemorrian Stage. Only one molluscan assemblage has been collected from the Santos Shale Member (USGS loc. M3983) less than 200 feet stratigraphically above the Wygal Sandstone Member on Temblor Creek. This small assemblage con-

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tains some specifically indeterminate gastropods and pelecypods (*Calyptraea, Cancellaria, Bruclarkia?, Leptopecten?*, and *Spisula* sp.) as well as the long ranging pelecypods *Lucinoma acutilineata* and *Macoma arctata*. None of these genera or species permits unqualified assignment to either the unnamed stage represented by the fauna of the Wygal Sandstone Member or the "Vaqueros Stage" represented by mollusks from the stratigraphically higher Agua and Carneros Sandstone Members. The boundary between these two molluscan units is arbitrarily placed in the lower part of the Santos Shale Member so as to correspond to the boundary between the lower and upper parts of the Zemorrian Stage (Kleinpell, 1938, p. 111). The reason for this placement is that, elsewhere in California, mollusk assemblages of the "Vaqueros Stage" have their lowest stratigraphic occurrence in strata referable to the upper part of the Zemorrian Stage (Addicott, 1967a).

AGUA SANDSTONE MEMBER

The lowest stratigraphic occurrence of mollusks characteristic of Loel and Corey's (1932) Vaqueros Formation [= "Vaqueros Stage" of later usage (p. 10)] in the Temblor Formation of the central and northern parts of the Temblor Range is in the Agua Sandstone Member. The initial recognition of the "Vaqueros" index species *Crassostrea vaquerosensis* (Loel and Corey) and *Macrochlamis magnolia* (Conrad) from unspecified localities between Carneros Creek and Bitterwater Canyon (Clark and Clark, 1935) has been verified by subsequent collections: *Macrochlamis magnolia* occurs near the mouth of Cedar Canyon (USGS loc. M2631; Stanford Univ. loc. 2682, Heikkila and MacLeod, 1951), and *Crassostrea vaquerosensis* occurs between Stone Corral Canyon and Media Agua Creek (USGS loc. M4464) several miles to the southeast. The "Vaqueros" and "Temblor" species *Vertipecten perrini* (Arnold) also has been collected from USGS locality M2631. These and other molluscan taxa collected from the Agua Sandstone Member are listed in table 6. These species are also represented in faunal assemblages from the so-called Vaqueros Formation of the San Emigdio Mountains of the southern margin of the San Joaquin basin (Loel and Corey, 1932) and from the Jewett Sand of the southeastern margin of the basin (Loel and Corey, 1932; Addicott, 1970a).

The Agua Sandstone Member of the type Temblor Formation is assigned to the upper part of the Zemorrian Stage of the provincial microfaunal sequence (Kleinpell, 1938; Stinemeyer and others, 1959; Kleinpell and Weaver, 1963).

TABLE 6.—*Mollusks from the Agua Sandstone Member of the Temblor Formation*

Pelecypods	USGS loc. No.		
	M2631	M3982	M4464
Crassostrea aff. *C. titan* (Conrad)	-----	-----	×
vaquerosensis (Loel and Corey)	-----	-----	×
?*Crassostrea* (fragments)	×	×	-----
Heteromacoma rostellata (Clark)	-----	×	-----
?*Katherinella*	-----	×	-----
Lucinoma acutilineata (Conrad)	-----	×	-----
Macrochlamis magnolia (Conrad)	×	-----	-----
Vertipecten perrini (Arnold)	×	?	-----

PALEOBATHYMETRY

Larger invertebrates from the Wygal Sandstone Member are indicative of a relatively shallow-water depositional environment, according to present-day bathymetric ranges of those genera that are still living in the eastern North Pacific. Almost without exception modern depth ranges of these genera define an overlap in the upper part of the inner sublittoral zone—between about 10 and 20 fathoms.

A few genera are restricted to, or are more characteristic of, environments shallower than 10 fathoms: *Crassostrea, Crenomytilus* (an extinct genus similar to *Mytilus*), and *Tegula*. However, of these, *Crenomytilus* and *Tegula* are of uncommon occurrence in the Wygal Sandstone Member, and *Crassostrea* is usually represented by disarticulated, broken valves possibly indicative of displacement from an initially very shallow water site of deposition into somewhat deeper water.

Genera of deeper water aspect—*Acila, Lucinoma*, and *Miltha*—are generally found living at somewhat greater depths than 10 to 20 fathoms in warm-water latitudes along the Pacific coast. Species of *Acila* are recorded from as shallow as 10 to 15 fathoms (Smith and Gordon, 1948; Schenck, 1936), but these records are generally from temperate latitudes. *Lucinoma*, by far the most abundant mollusk in the Wygal assemblages, occurs in middle sublittoral depths, 28 to 45 fathoms, in tropical latitudes of the eastern Pacific (Keen, 1971), but in the upper reaches of the sublittoral in temperate latitudes, 8 to 10 fathoms, (Smith and Gordon, 1948). The indicated present-day equatorward bathymetric gradient based on these records of *Lucinoma annulata*, a modern analog of the fossil species *L. acutilineata*, seems to be an example of equatorial submergence. Although there are a few genera of tropical aspect in the Wygal Sandstone Member (p. 16), the composition of the fauna is more suggestive of warm-temperate to subtropical conditions. Therefore, a generalized interpolation between the 8- to 10-fathom records of modern *Lucinoma* in temperate latitudes and the 30- to 50-fathom records of it in tropical latitudes would suggest an upper limit of bathymetric occurrence within the postulated 10- to 20-fathom depth range of the Wygal faunal assemblages. Keen (1971) recorded *Miltha* as occurring in water depths of about 30 fathoms or greater in the northern part of the Tropical or Panamic molluscan province of Mexico. Significantly shallower modern occurrences are suggested, however, by an intertidal record of this genus near the tip of Baja California, Mexico (Pilsbry and Lowe, 1933).

The Wygal faunal assemblages bear some similarity to late Pleistocene molluscan communities of the Californian Province (Valentine, 1961; Valentine and Mallory, 1965). Comparisons are difficult, however, because a number of the Pleistocene genera do not occur in pre-Neogene assemblages of the Pacific coast area and because these Pleistocene assemblages seem to be of cooler water aspect than those of the Wygal Sandstone Member. Nevertheless, many of the late Oligocene species are represented by analogs in the *Dosinia ponderosa* element of Valentine's (1961) shallow inner sublittoral community, a sandy substrate association representative of depths between 5 and 15 fathoms.

Bathymetric inferences based on benthonic foraminiferal assemblages from shales underlying and overlying the Wygal Sandstone Member are suggestive of significantly greater depths. Foraminifers from the underlying Cymric Shale Member listed by Kleinpell (1938, locs. 1a and CM70), for example, are indicative of the middle to lower part of the bathyal zone (about 3,000 to 6,000 feet), according to the classification of San Joaquin basin foraminiferal biofacies by Bandy and Arnal (1969, p. 787–791). These inferences are based on the deep-water species *Cyclamina incisa, Gyroidina soldanii,* and *Plectofrondicularia vaughani.* Additional foraminiferal assemblages from the Cymric Shale Member studied by R. L. Pierce (written commun., April 1969) are also indicative of middle bathyal or deeper depositional environment, according to the classification of Bandy and Arnal. An assemblage from the basal part of the Santos Shale Member directly overlying the Wygal Sandstone Member in Chico Martinez Creek also studied by Pierce (written commun., April 1969) includes species listed by Bandy and Arnal (1969) as characteristic of their lower bathyal and abyssal biofacies. Included are *Siphogenerina nodifera, Cibicides floridanus, Gyroidina soldanii,* and *Plectofrondicularia* cf. *P. californica.*

When these depths are contrasted with the indicated inner sublittoral depositional environment of the intervening Wygal Sandstone Member, late Oligocene vertical oscillation of the basin floor amounting from 3,000 to as much as 6,000 feet is indicated. Comparable downwarping of the floor of the San Joaquin basin in areas west of Bakersfield and southeast of Taft during the Zemorrian Stage has been inferred by Bandy and Arnal (1969, fig. 5) based on analysis of isopach data and inferred foraminiferal biofacies. However, their inferences of little or no differential vertical movement of the basin floor and continuous deep-water facies in the vicinity of the type section of the Zemorrian Stage at this time (Bandy and Arnal, 1969, fig. 5) are contrary to the evidence indicated by the larger invertebrate fauna of the Wygal Sandstone Member. Rather, it seems that an extensive oscillatory vertical movement of the basin floor must have occurred during the Oligocene in the vicinity of what is now the northeastern margin of the Temblor Range. The strong erosional unconformity at the base of the Wygal Sandstone Member and the shallow inner sublittoral depths indicated by molluscan assemblages of this member contrast sharply with the middle to lower bathyal foraminiferal biofacies of the underlying Cymric Shale Member and the overlying Santos Shale Member.

The possibility that the Wygal assemblages were displaced downslope and redeposited in bathyal depths indicated by the foraminiferal assemblages seems remote. The extremely abundant and relatively well-preserved mollusk shells, for example, generally are not fragmented and disarticulated, as are the scattered shallow-water pectinids and broken valves of *Tivela*? found in the stratigraphically higher Carneros Sandstone Member, which also occurs between deep-water foraminiferal assemblages of the Santos and Media Shale Members.

ZOOGEOGRAPHY AND PALEOCLIMATOLOGY

The molluscan fauna of the Wygal Sandstone Member of the Temblor Formation marks the beginning of a late Oligocene to late Miocene period during which molluscan faunas of the San Joaquin basin were characterized by a sizeable element of warm-water genera. These shallow-water genera are termed extralimital in the sense that their modern limits of geographic distribution along the Pacific coast do not reach as far north as the latitude of the fossiliferous exposures (lat 35.5° N.). Extralimital, warm-water taxa make up 41 percent of the still-living molluscan genera represented in the Wygal faunal assemblages. They are almost equally divided, in terms of the northernmost present-day geographic limits of range between the Panamic, Surian, and Californian molluscan provinces of Valentine (1966). The shallow-water marine climates of these provinces are characterized, respectively, as inner tropical, outer tropical, and warm temperate (Hall, 1964).

During the late Oligocene, the central California area seems to have been a northern outpost for almost all these genera. Only a scattering of warm-water genera reached as far north as western Washington during the late Oligocene where a very small percentage (11 percent) of the still-living genera of the presumably coeval *Echinophoria rex* Zone of Durham (1944) are considered to be of warm-water aspect (Addicott, 1970c).

Warm-water genera represented in the Wygal assemblages and their northernmost limits of distribution in modern shallow-water molluscan provinces of the eastern North Pacific are as follows: Panamic—*Ficus, Miltha, Clementia*; Surian—*Natica* s. s., *Anadara* s. s., *Crassostrea, Dosinia*; Californian—*Neverita, Kelletia, Here, Tellinella, Amiantis*. In this late Oligocene fauna a substantial number of the extinct genera, or of genera that are no longer living along the margin of the eastern North Pacific, may also be of warm-water aspect: *Siphonalia*?, *Crenomytilus, Vertipecten*, and *Olcesia*. This judgment is based both on the modern distribution of closely related molluscan genera and on the geographic distribution of these extinct genera in warm-water Tertiary assemblages along the Pacific coast.

Further evidence of very warm, shallow-water conditions during deposition of the Wygal Sandstone Member is furnished by the occurrence of the hermatypic coral *Favites* in collections from USGS locality M3280 near Media Agua Creek. Modern occurrences of this inner sublittoral genus are restricted to the tropical latitudes of the Indo-Pacific region and the Red Sea. According to J. Wyatt Durham (oral commun., Jan. 1971), who identified these specimens, and Durham and Allison (1960, p. 72), *Favites* has not previously been reported from the Cenozoic of the eastern Pacific margin.

The zoogeographic relationship of the warm-water molluscan genera in the Wygal fauna to the temperate-water middle Oligocene fauna of the San Joaquin basin and to subsequent warm-water Miocene faunas of this area is depicted in figure 5. The present study has refined the systematic classification of the Wygal fauna to the extent that a more accurate zoogeographic analysis than was presented in a recent report (Addicott, 1970a, fig. 4) can be made. Accordingly, cumulative percentages of late Oligocene warm-water genera (Panamic and Surian) are somewhat higher than previously calculated and are almost the same as those for the fauna of the overlying "Vaqueros Stage." However, zoogeographic relationships of these two successive faunal units—late Oligocene and early Miocene—are still clouded by the fact that the late Oligocene fauna is relatively poorly known, having only about half as many taxa as the early Miocene fauna. The disparity in size seems to be in the lack of a diverse gastropod element in the Wygal assemblages.

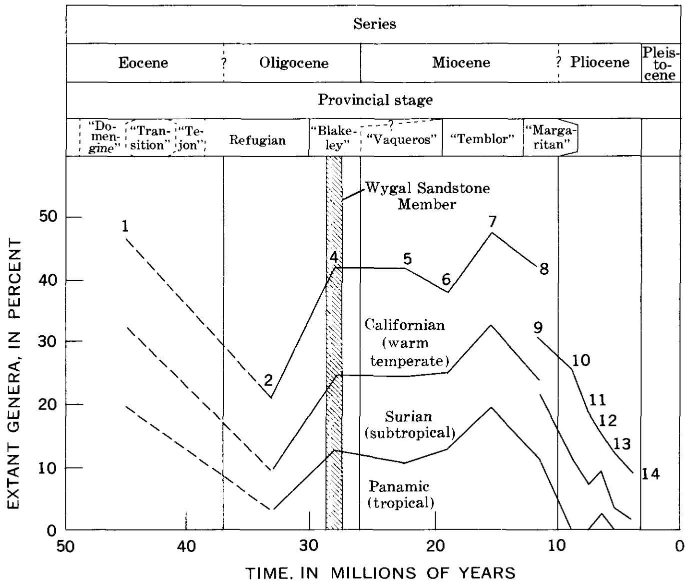

FIGURE 5.—Zoogeographic profiles for selected Tertiary faunal assemblages from the San Joaquin basin, California (Addicott, 1970a). Cumulative percentages express the modern warm-water zoogeographic provinces in which northern end points of range of extant genera occur: Panamic, 6° S.–23° N.; Surian, 23° N.–28° N.; Californian, 28° N.–34.5° N. The sequence of provincial molluscan stages is modified from Weaver and others (1944) and Corey (1954). Numbers refer to faunal assemblages as follows: (1) Domengine Formation, southern Diablo Range; (2) San Emigdio and Pleito Formations of Wagner and Schilling (1923), San Emigdio Mountains; (4) Wygal Sandstone Member of the Temblor Formation, Temblor Range; (5) Jewett Sand, Kern River area; (6) lower part of the Olcese Sand, Kern River area; (7) upper part of the Olcese Sand and lower part of the Round Mountain Silt, Kern River area; (8) Santa Margarita Formation, Tejon Hills; (9) Santa Margarita Formation, Coalinga area; (10–12) Etchegoin Formation, Coalinga area; (13) Etchegoin Formation, Kettleman Hills; (14) San Joaquin Formation, Kettleman Hills.

SYSTEMATIC DESCRIPTIONS

Only those references accompanied by illustrations of specimens are included in the following synonymies. Reports that list some of the more common molluscan taxa from the Wygal Sandstone Member of the Temblor Formation are reviewed in an annotated list of literature (p. 3). The plates include a few illustrations of Oligocene and Miocene mollusks from other stratal units for comparative purposes. Entries in the synonymies are as originally used by the authors; a few contain lapses.

Fifty molluscan taxa are treated systematically; all but one of these are figured. One new species and a new tellinid subgenus are described: *Vertipecten alexclarki* n. sp. and *Olcesia* n. subgen. Five additional taxa—*Tegula* n. sp., *Natica* (*Natica*) n. sp., *Polinices* n. sp., *Spisula* n. sp.?, and *Amiantis* n. sp.—seem to be undescribed but are represented by material that is too incomplete or too poorly preserved to permit formal description. The systematic arrangement of gastropods is after Keen (1963); of pelecypods, after McCormick and Moore (1969). Other larger marine invertebrates from the Wygal Sandstone Member include the hermatypic coral *Favites*, and undetermined solitary, branching coral, and an encrusting bryozoan *Antropora*? sp.

Abbreviations used in tabulating the occurrences of molluscan taxa in the type Temblor Formation are:

USGS ------U.S. Geological Survey, Washington, D.C., locality register (locality numbers have no letter prefix).
USGS M ---U.S. Geological Survey, Menlo Park, Calif., Cenozoic locality register.
UCMP ------California University Museum of Paleontology, Berkeley, Calif.
UCR --------California University, Riverside, Calif.

Other fossil depositories are:

UO ---------Oregon University, Eugene, Oreg.
SU ---------Stanford University, Stanford, Calif.
CAS --------California Academy of Science, San Francisco, Calif.
ANSP ------Academy of Natural Sciences, Philadelphia, Pa.

Class GASTROPODA
Order ARCHAEOGASTROPODA
Family TROCHIDAE
Genus TEGULA Lesson, 1835

Tegula n. sp.

Plate 8, figures 2, 4

Two incompletely preserved specimens of a moderately small, smooth-shelled trochid represent the shallow-water genus *Tegula*; a fragment in USGS collection M4466 may also be this trochid. The two specimens have somewhat different whorl profiles. The better preserved specimen (pl. 8, fig. 4) has an almost flat whorl profile; the more poorly preserved specimen (pl. 8, fig. 2) has a more strongly convex whorl profile and a faint subsutural tabulation on the body whorl. Because the inner margin of the aperture on one of the specimens shows a fairly strong tooth, the specimen can be assigned to *Tegula*.

This *Tegula* was first recorded from the Wygal Sandstone Member of the Temblor Formation by Alex Clark (unpub. data, 1931 and 1932, deposited at California University, Riverside), who first recognized that it was an undescribed species. Clark's localities (EC–89 [= UCR 1235] and EC–125A) and USGS locality M3578 are from exposures about ¾ to 1¼ miles southeast of Zemorra Creek (fig. 3). One of his specimens is figured on plate 8 (fig. 4).

Tegula n. sp. is similar to the smooth-shelled middle Miocene species *T. laevis* Addicott (1970a, p. 41–42, pl. 1, figs. 2, 3, 5–7) from the Kern River area of the eastern margin of the San Joaquin basin. The Miocene species differs, however, in having strongly convex whorls and a narrow, but well-defined, subsutural tabulation.

This is the oldest record of the genus *Tegula*. The oldest previously known record was in the Miocene (Knight and others, 1960, p. 254); it may have been based on the early Miocene species *T. malibuensis* Loel and Corey (1932) from the Vaqueros Formation of California.

Localities.—USGS M3578, M4466?, UCR 1235.

Order MESOGASTROPODA
Family CERITHIIDAE?

Cerithiid?

Plate 8, figure 5

This moderately small, very poorly preserved conispiral gastropod which has a flat whorl profile seems to be a cerithiid. The body whorl is broken, and there are no traces of sculpture on the whorls of the spire.

Locality.—USGS M3578.

Family CALYPTRAEIDAE
Genus CALYPTRAEA Lamarck, 1799

Calyptraea diegoana (Conrad)

Plate 8, figures 8, 10, 17, 18

1855. *Trochita diegoana* Conrad, U.S. 33rd Cong., 1st sess., H. Ex. Doc. 129, p. 17.
1857. *Trochita diegoana* Conrad. Conrad, U.S. 33rd Cong., 2d sess., S. Ex. Doc. 78, p. 327, pl. 5, fig. 42.
1864. *Galerus excentricus* Gabb, California Geol. Survey, Paleontology, v. 1, sec. 4, p. 136, pl. 20, fig. 95, pl. 29, figs. 232, 232a.
1907. *Galerus excentricus* Gabb. Arnold, U.S. Geol. Survey Bull. 321, pl. 10, figs. 3a, 3b.
1910. *Galerus excentricus* Gabb. Arnold, U.S. Geol. Survey Bull. 396, p. 112, pl. 4, fig. 8 [Imprint 1909.]
1910. *Galerus excentricus* Gabb. Arnold and Anderson, U.S. Geol. Survey Bull. 398, pl. 26, fig. 8.
1916. *Calyptraea washingtonensis* Weaver, Washington Univ. [Seattle] Pubs. Geology, v. 1, p. 44, pl. 3, fig. 44.

1927. *Calyptraea diegoana* (Conrad). Stewart, Acad. Nat. Sci. Philadelphia Proc., v. 78, p. 340–341, pl. 27, fig. 15.
1933. *Calyptraea washingtonensis* Weaver, California Univ. Pubs. Geol. Sci. Bull., v. 23, no. 3, p. 137, pl. 14, fig. 25.
1938. *Calyptraea diegoana* (Conrad). Turner, Geol. Soc. America Spec. Paper 10, p. 89–90, pl. 20, figs. 1, 2.
1942. *Calyptraea diegoana* (Conrad). Weaver, Washington Univ. [Seattle] Pubs. Geology, v. 5, p. 351–352, pl. 71, figs. 16, 20, pl. 103, fig. 3.
1942. *Calyptraea washingtonensis* Weaver. Weaver, Washington Univ. [Seattle] Pubs. Geology, v. 5, p. 352–353, pl. 71, figs. 19, 22.
1963. *Calyptraea diegoana* (Conrad). Weaver and Kleinpell, California Univ. Pubs. Geol. Sci. Bull., v. 43, p. 186, pl. 24, fig. 7.
1969. *Calyptraea diegoana* (Conrad). Hickman, Oregon Univ. Mus. Nat. History Bull. 16, p. 79, 82, pl. 11, figs. 7, 8.

Type.—USNM 1856 (designated by Keen and Bentson, 1944).

Type locality.—San Diego, Calif. Eocene.

Calyptraea diegoana is a variable species characterized by a high, pointed spire and an excentric apex. The lectotype (Keen and Bentson, 1944, p. 204) is an immature specimen almost as high as it is broad. Specimens from the Wygal Sandstone Member of the Temblor Formation have a straight-sided to somewhat convex profile and little, if any, constriction of the shell wall at the suture. In lateral aspect, the narrowly excentric side of the shell is slightly convex whereas the broadly excentric side is relatively much flatter and even somewhat concave on certain specimens.

Stewart (1927) synonymized several names applied to this early Tertiary taxon, which is widespread in and characteristic of strata of Eocene age but which also occurs in Oligocene strata of Oregon and Washington (Hickman, 1969). The highest stratigraphic occurrence of this species is in the upper Oligocene, lower part of the "Blakeley Stage" of western Washington (Tegland, 1933; Durham, 1944), a unit with which the fauna of the Wygal Sandstone Member is believed to be coeval.

Calyptraea mammilaris vancouverensis Clark and Arnold (1923, p. 167, pl. 36, figs. 3a, 3b) from the Sooke Formation of southwestern Vancouver Island, British Columbia, differs from *C. diegoana* by its very thick, evenly and more highly conical shell and more or less centrally located apex. The California early Miocene species *C. coreyi* Addicott (1970a, p. 60–61, pl. 4, figs. 1, 4, 18) that is also characterized by an eccentric apex and a moderately high spire can be distinguished from *C. diegoana* by its shouldered whorl profile.

Localities.—USGS M3280, M3281, M4471.

Crepidula cf. C. ungana Dall

Plate 8, figures 6, 7, 9, 11, 15, 16

Specimens of thin-shelled *Crepidula* in the collections are similar to the Alaska Oligocene species *C. ungana* Dall (1904, p. 118, pl. 10, figs. 8, 9) from the Aleutian Islands. They have been compared with the type specimens (USNM 164918) and with a large suite of topotypes from Unga Island (USGS loc. 2103). The California specimens differ slightly from the types, an incomplete chain consisting of three specimens, in having a relatively finer, less swollen beak. The orientation of the beaks is similar—more or less parallel to the plane of the aperture. On some of the topotypes of *C. ungana*, however, the beak tends to point upwards. A comparable upward orientation has been found on only one of the specimens from the basal sandstone member of the Temblor Formation. As noted by Hickman (1969, p. 82), specimens preserved in colonial form are more highly arched and narrower than those that occur as individual specimens.

The configuration and size of the internal septum of *Crepidula* cf. *C. ungana* is unknown. Viewed aperturally, the insertion of the septum is near the middle of the left side of the aperture as on *C. ungana*, which has an open S-shaped septal margin. The point of insertion on the opposite side of *C.* cf. *C. ungana* has not been observed.

Crepidula cf. *C. ungana* can be distinguished from the early Miocene species *C. sookensis* Clark and Arnold (1923) from Vancouver Island, British Columbia, and the northwestern Olympic Peninsula (Durham, 1944) by its much thinner and narrower shell and more delicate, less swollen beak. The septal configuration of specimens of *C. sookensis* from the Sooke Formation (USGS loc. M4060) is similar to that of the variable early Miocene to Holocene *C. princeps* Conrad.

Occurrences of *Crepidula ungana* in the conterminous Pacific Coast States range from the middle Oligocene "Lincoln Stage" (Hickman, 1969) to the late Oligocene lower part of the "Blakeley Stage" (Tegland, 1933; Durham, 1944).

Localities.—USGS M3280, M3281, M3979.

Family NATICIDAE

Poorly preserved naticids on which it has not been possible to expose the umbilical area occur in the collections from USGS localities M3280, M3578, M3772, M3978, M3979, M4466, and M4468. The size and whorl profiles of these suggest either *Natica* or *Polinices*.

Genus NATICA Scopoli, 1777
Subgenus NATICA s. s.

Natica (Natica) n. sp.

Plate 8, figures 12, 13

At least five specimens of a moderately large, heavy-shelled *Natica* from USGS locality M3280 represent an undescribed species. They differ from known middle Tertiary species of *Natica* in their relatively large adult size, widely open umbilicus, and heavy funicular rib. These specimens are too poorly preserved to permit formal description as a new species: most of the surface of the shells is missing, and the spire is incompletely preserved.

There are distinct similarities to the middle Tertiary species *Natica teglandae* Hanna and Hertlein (1938, p. 108) and *N. vokesi* Addicott (1966, p. 638–639, pl. 77, figs. 2–5), but both of these small species have shouldered body whorls and only weakly or very weakly developed funicular ribs. The middle Miocene species *N. posuncula* Hanna and Hertlein (1938, p. 107–108, pl. 21, fig. 6) from the Kern River area on the southeastern margin of the San Joaquin basin has a similar profile but a narrow umbilical area that is filled by a relatively larger and broader funicular rib.

Natica s. s. is a warm-water genus restricted to the modern Surian and Panamic molluscan provinces of Valentine (1966) of the Pacific coast. Its occurrence in the fauna from the Wygal Sandstone Member of the Temblor Formation is suggestive of much warmer marine temperatures during the late Oligocene than occur along this part of the Pacific coast today.

Locality.—USGS M3280.

Genus NEVERITA Risso, 1826
Snbgenus GLOSSAULAX Pilsbry, 1929

Neverita (Glossaulax) thomsonae Hickmau

Plate 9, figure 4

1969. *Neverita* (*Glossaulax*) *thomsonae*, Hickman, Oregon Univ. Mus. Nat. History Bull. 16, p. 84, pl. 11, figs. 20–23.

1972. *Neverita thomsonae* Hickman. Addicott, Soc. Econ. Paleontologists and Mineralogists, Pacific Sec., Bakersfield, Calif., 1972, Proc., pl. 1, fig. 10.

Types.—Holotype, UO 27366; paratypes, UO 26367–26370, 27371, 27372.

Type locality.—UO 2567, northwestern Oregon. Pittsburg Bluff Formation, Oligocene.

As noted by Hickman (1969), this large species is very close to the living *Neverita recluziana*, a warm-water species that ranges from the west coast of Mexico to southern California (Smith and Gordon, 1948; Keen, 1971). The extremely large body whorl of *N. thomsonae*, which has a smooth, flattened profile, is the principal morphologic feature used to differentiate the two species. *N. thomsonae* seems most closely related, morphologically, to the large form of *N. recluziana* figured by Pilsbry (1929, pl. 6, fig. 1) and differs from it, as noted by Hickman (1969), in having a relatively broader body whorl.

Neverita thomsonae differs from *N. andersoni* (Clark), a common species in early Miocene to Pliocene molluscan assemblages from California (Addicott, 1970a), in having a flattened, nonshouldered profile. The range of this species is from the middle to the upper Oligocene.

Locality.—USGS M3978.

Genus POLINICES Montfort, 1810

Polinices n. sp.?

Plate 9, figure 10

A moderately large *Polinices* which has a widely open umbilical area was collected from USGS localities M3280 and M4472. The heavy parietal callus thins and tapers uniformly toward the base of the aperture. The body whorl does not appear to be shouldered.

This species differs from *Polinices victoriana* Clark and Arnold (1923, p. 170, pl. 33, figs. 1a, 1b, 5a, 5b) and *P. canalis* Moore (1963, p. 28, pl. 2, figs. 18, 20), Miocene species from the Pacific coast, in having a much larger, widely open umbilical area and a relatively narrow, but equally heavy, parietal callus. *Natica* n. sp.? Hickman (1969, p. 83–84, pl. 10, figs. 15, 16) from the early and middle Oligocene Eugene Formation of Oregon has a much narrower umbilical opening and lacks the heavy parietal-umbilical callus.

Localities.—USGS M3280, M4472.

Genus SINUM Röding, 1798

Sinum cf. S. scopulosum (Conrad)

Plate 9, figures 16, 17

Two internal molds from USGS locality M3578 seem to represent *Sinum scopulosum* (Conrad, 1849, p. 727, pl. 19, figs. 6, 6a), an upper Oligocene to Holocene species. The fine spiral sculpture is faintly preserved on both specimens. *Sinum scopulosum* is distinguished from the Eocene and Oligocene species, *S. obliquum* (Gabb, 1864, p. 109, pl. 21, fig. 112), by its larger adult size and less flattened shell.

The lowest stratigraphic record of this species is from the upper Oligocene *Echinophoria rex* Zone (lower part of the "Blakeley Stage") of the northern Olympic Peninsula, Wash. (Durham, 1944), a unit that is believed to be coeval with the fauna of the Wygal Sandstone Member.

Localities.—USGS M3578, M4471?.

Family FICIDAE
Genus FICUS Röding, 1798

Ficus cf. F. modesta (Conrad)

Plate 9, figures 18, 19

Two crushed specimens of a delicately ornamented *Ficus* are compared with *F. modesta* (Conrad, 1848, p. 433, fig. 12), an Oligocene and Miocene species from the Pacific coast. This species differs from the middle Oligocene species *Ficus* (*Trophosycon*) *gesteri* Wagner and Schilling (1923, p. 258, pl. 49, figs. 1–3) from the nearby San Emigdio Mountains in lacking nodes on the shoulder of the body whorl. There is no evidence of nodes on the body whorl of the larger of the two specimens (pl. 9, fig. 19).

Ficus modesta was recorded by Wagner and Schilling (1923, p. 246, as *F. pyriformis* Gabb) from the upper part of their Pleito Formation in the San Emigdio Mountains, a unit that is believed to be coeval with the Wygal Sandstone Member of the type Temblor Formation. It is also recorded from the San Ramon Sandstone of the Mount Diablo area, California.

Ficus modesta ranges from the middle Oligocene "Lincoln Stage" (Hickman, 1969) to the middle Miocene "Temblor Stage" (Schenck and Keen, 1940; Moore, 1963).

Localities.—USGS M3578, M3978.

Order NEOGASTROPODA
Family NEPTUNEIDAE

Genus CALICANTHARUS Clark, 1938

Calicantharus, an early Tertiary to Quaternary genus, is similar to *Searlesia*, a genus that occurs in temperate and cool-water molluscan provinces along the Pacific coast. Although reassignment of the following two species to *Calicantharus* constitutes the initial recognition of this genus in the late Oligocene of the Pacific coast, the genus is known to occur in the Eocene Markley Sandstone Member of the Kreyenhagen Formation of central California. *Calicantharus* is here discriminated from *Searlesia* on the basis of its collared or clasping suture.

Calicantharus dalli (Clark)

Plate 9, figure 24

1918. *Searlesia dalli* Clark, California Univ. Pubs., Dept. Geology Bull., v. 11, no. 2, p. 175, pl. 20, figs. 5, 9, 15.

Types.—Holotype, UCMP 11215; paratypes, UCMP 11214, 11214a.

Type locality.—UCMP 2754, branch of San Pablo Creek on Sobrante Ridge, 1⅜ miles northeast of California and Nevada Railroad, lat 37°56′54″ N., long 122°14′01″ W. Altitude 350 feet. San Ramon Sandstone, early Miocene(?).

Specimens of *Calicantharus* from USGS localities M3280 and M3772 are conspecific with Clark's (1918) *C. dalli* from the Mount Diablo area, Contra Costa County, Calif. *C. dalli* is larger than the type specimens but has the fine, channeled spiral ribbing, the sutural overlap, and the evenly convex whorl profile characteristic of this species. Moreover, the spire appears to bear very fine nodes at the point of greatest whorl convexity. The principal difference from Clark's (1918) types is the relatively greater size attained by the late Oligocene specimens from the Temblor Range.

Calicantharus dalli is quite distinct from Pacific coast Miocene species of this genus. Compared to specimens of *C. branneri* (Clark and Arnold, 1923, p. 159, pl. 30, figs. 3a, 3b), an equally large species from the Sooke Formation of southwestern British Columbia (USGS loc. M2544), it differs in having a broader body whorl, finer spiral sculpture, and virtually no angulation on the body whorl. *C. kernensis* (Anderson and Martin, 1914, p. 78–79, pl. 4, figs. 6a, 6b), a middle Miocene species from the California Coast Ranges, is characterized by a sinuous, rather than relatively straight, growth line and much narrower shell. Another middle Miocene species from central California, *C. woodfordi* Addicott (1970a, p. 93–94, pl. 10, fig. 6, pl. 11, figs. 17, 18), is of similar size of *C. dalli* but has very strongly angulated, noded whorls.

Localities.—USGS M3280, M3772.

Calicantharus cf. C. branneri (Clark and Arnold)

Plate 9, figure 13

An incomplete specimen from USGS locality M4471 is identical to Clark and Arnold's (1923, p. 159, pl. 30, figs. 3a, 3b) species from the Sooke Formation of southwestern Vancouver Island, British Columbia. The body whorl is characterized by rounded spiral ribs that are separated by rather deep interspaces containing a fine intercalary riblet. As on the holotype, the axial folds are irregularly spaced and almost obsolete on the abapertural side of the body whirl.

This taxon differs from specimens of *Calicantharus dalli* (Clark) from the Wygal Sandstone Member in having high, rounded spiral ribs rather than relatively broad, straplike ribs separated by channeled interspaces.

The subsutural collar of this species indicates assignment to *Calicantharus* rather than *Searlesia* to which it was originally assigned (Clark and Arnold, 1923).

Locality.—USGS M4471.

Genus KELLETIA Fischer, 1884

Kelletia? sp.

Plate 9, figures 7, 11, 12

Two incomplete specimens of a moderately large neptuneid may represent the Eocene (Ruth, 1942) to Holocene genus *Kelletia*. The spiral sculpture of fine, flattened ribs separated by deeply channeled interspaces and the development of nodes on the whorl angulation are similar to late Cenozoic species of *Kelletia* described from California. The two specimens differ considerably in details of spiral and axial ribbing but are tentatively taken to represent a variable species. One specimen (pl. 9, figs. 11, 12) has relatively broad, straplike ribs that bear a medial groove; the other (pl. 9, fig. 7) has much finer spiral ribs, only a few of which bear a medial groove. The axial folds are very prominent on the penultimate whorl of one specimen (pl. 9, figs. 11, 12) but are very weak on the other one (pl. 9, fig. 7). Both specimens have a relatively broad apical angle and a moderately strong angulation near the middle of the whorls.

Localities.—USGS M3280, M3772.

Genus SIPHONALIA Adams, 1863

Siphonalia? sp.

Plate 9, figures 5, 6

A small, crushed specimen from USGS locality M3280 may represent *Siphonalia*. However, the generic assignment of this neptuneid is doubtful. The body whorl is constricted and apparently twisted to form a distinctive anterior canal very much like specimens of this genus figured by Ruth (1942). However, *Siphonalia*? sp. differs from Oligocene and Miocene species included in Ruth's monograph in having only one row of very weakly developed nodes on the whorls of the spire.

Locality.—USGS M3280.

Genus BRUCLARKIA Stewart, 1927

Bruclarkia seattlensis Durham

Plate 9, figures 1, 2, 8, 9, 14

1944. *Bruclarkia seattlensis* Durham, California Univ. Pubs., Geol. Sci. Bull., v. 27, no. 5, p. 173–174, pl. 16, fig. 15.

1972. *Bruclarkia seattlensis* Durham. Addicott, Soc. Econ. Paleontologists and Mineralogists, Pacific Sec., Bakersfield, Calif., 1972, Proc., pl. 1, figs. 8, 13.

Type.—UCMP 35397.

Type locality.—UCMP A1803, behind the Olympic Foundry, Georgetown, Seattle, King County, Wash. Blakeley Formation, Oligocene.

Bruclarkia seattlensis is the most abundant gastropod in assemblages from the Wygal Sandstone Member. Many of the specimens are heavily encrusted with the bryozoan *Antropora*? sp. (O.L. Karklins, written commun., January 1971). Earlier identifications of *B. barkeriana* (Cooper) from exposures of the Wygal Sandstone Member (the so-called *Phacoides* reef) in the vicinity of Zemorra Creek (Kleinpell, 1938; Stinemeyer and others, 1959; Foss and Blaisdell, 1968) are almost certainly of this species.

Specimens from the Wygal Sandstone Member differ slightly from the type of *Bruclarkia seattlensis* in having a somewhat stronger subsutural collar and in lacking fine nodes on the whorls of the spire. The form and sculptural detail of the body whorl, however, is the same: a faint angulation devoid of nodes and spiral sculpture of fine ribs that alternate in strength. Moore (1963, p. 36) showed that both the strength of the subsutural collar and the presence or absence of nodes are highly variable morphologic characters on Miocene species of *Bruclarkia*. Variation within *B. seattlensis* was previously unknown because this species was known only from the holotype.

This species very closely resembles the early and middle Miocene species *Bruclarkia santacruzana* (Arnold, 1908, p. 379–380, pl. 34, fig. 7), a smooth, strongly collared gastropod that has recently been treated as a form of the common middle Miocene species, *B. barkeriana* (Addicott, 1970a). *Bruclarkia seattlensis* differs from *B. barkeriana* forma *santacruzana* (pl. 9, fig. 3) in having a consistently much higher spire, a smooth collar that has no nodes, and, usually, a perceptibly angulated body whorl. Yet the morphologic similarities to *B. santacruzana* are so striking that *B. seattlensis* is very likely a direct precursor of the Miocene species. Durham (1944, p. 173–174) commented on the close degree of similarity of *B. seattlensis* to the middle Oligocene *B. columbiana*, and this similarity may imply an ancestral relationship.

Other species of *Bruclarkia* of common occurrence in formations of Oligocene age in the southern part of the San Joaquin basin (Wagner and Schilling, 1923, p. 244, 248) can be readily distinguished from *B. seattlensis*. *B. acuminata* (Anderson and Martin, 1914, p. 73, pl. 5, figs. 4a, 4b) has strongly noded, angulated whorls and either no subsutural collar or a very weak one.

Bruclarkia gravida (Clark, 1918, p. 182–183, pl. 19, figs. 1, 3, 5) is likewise a strongly sculptured species on which there are three equally spaced rows of heavy, rounded nodes, the uppermost of which is born relatively high on the body whorl (pl. 9, figs. 15, 20, 21). The possibility that *B. seattlensis* is a weakly sculptured form of *B. gravida* and might bear a relationship similar to that between *B. barkeriana* forma *santacruzana* and *B. barkeriana* (Addicott, 1970a) seems unlikely in view of the relatively low position of the angulation on the body whorl of specimens of *B. seattlensis* from the Wygal Sandstone Member. The position of this angulation is closer to that of the Oligocene *B. columbiana* (Anderson and Martin, 1914, p. 73, pl. 5, figs. 6a, 6b), an index species for the Refugian Stage. *B. columbiana* differs, however, in usually having a low spire that has a flat profile, a weak collar, and a long and concave subsutural segment on the body whorl terminating in a strongly noded angulation.

Some of the smooth forms of the Early and Middle Miocene species *Bruclarkia oregonensis* (Conrad) are of similar size and sculptural aspects to *B. seattlensis*, but the subsutural collar on this species is very subdued, if developed at all, and the upper part of the body whorl tends to be convex rather than concave (Etherington, 1931, pl. 11, figs. 1, 3, 4, 5, 7).

This is the only known record of *Bruclarkia seattlensis* from California. Prior to its discovery in the Wygal (Addicott, 1973), it was known only from the type locality near Seattle, Wash., where it occurs with a diverse molluscan assemblage referable to the upper Oligocene *Echinophoria rex* Zone of the "Blakeley Stage" (Durham, 1944).

Localities.—USGS 5149, M3280, M3578, M3636, M3772, M3978, M3979, M4470, M4471.

Class PELECYPODA
Order NUCULOIDA
Family NUCULIDAE
Genus ACILA Adams and Adams, 1858
Subgenus TRUNCACILA Grant and Gale, 1931

Acila (Truncacila) mnta Clark

Plate 1, figures 4, 15

1918. *Acila muta* Clark, California Univ. Pubs., Dept. Geology Bull., v. 11, no. 2, p. 119–120, pl. 13, figs. 6, 12, 13.
1918. *Acila muta* var. *markleyensis* Clark, California Univ. Pubs., Dept. Geology Bull., v. 11, no. 2, p. 121, pl. 13, fig. 3.
1936. *Acila* (*Truncacila*) *muta* B. L. Clark. Schenck, Geol. Soc. America Spec. Paper 4, p. 74–75, pl. 8 (figs. 4, 11; text fig. 7, nos. 20, 21.

Types.—Holotype, UCMP 11196; paratypes, UCMP 11199, 11200.

Type locality.—UCMP 1131, ½ mile southwest of Walnut Creek, Contra Costa County, Calif., in creekbed about 100 yards east of Oakland and Antioch bridge. Altitude 150 feet. San Ramon Sandstone, early Miocene(?).

Two specimens of *Acila* from the Wygal Sandstone Member are identified as *A. muta* Clark, a species heretofore known only from the San Ramon Sandstone near Mount Diablo, Contra Costa County, Calif. The outline of the valves and details of surface sculpture agree closely with Clark's (1918, pl. 13, figs. 6, 12, 13) types.

As indicated by Schenck (1936), the species that most closely resembles *Acila muta* is the middle Miocene *A. conradi* from the Temblor Formation ("Temblor Stage") of California and from the Astoria Formation of Oregon and Washington. Schenck differentiated these two species on the relatively greater thickness of the valves of *A. muta*. They are differentiated here by the significantly smaller angle of bifurcation of *A. muta* evident from Clark's (1918) and Schenck's (1936) illustrated specimens. This difference is reflected by the fact that the primary line of bifurcation on specimens of *A. conradi* intersects the ventral margin in a more anterior position than on specimens of *A. muta*.

Two fragmentary specimens of *Acila* from USGS localities M3280 and M3579 are doubtfully referred to this species on the basis of similar radial sculpture and what appears to be a similarly oriented primary line of bifurcation. One of these specimens (USGS loc. M2380) is intensely deformed.

Localities.—USGS M3280?, M3579?, M4466, M4471.

Family NUCULANIDAE
Genus YOLDIA Möller, 1842
Subgenus KALAYOLDIA Grant and Gales, 1931

Yoldia (Kalayoldia) tenuissima Clark

Plate 1, figures 2, 3, 5, 8

1869. *Yoldia cooperii* Gabb. Gabb, California Geol. Survey, Paleontology, v. 2, sec. 1, pt. 1, p. 31, pl. 9, fig. 4 [not *Yoldia cooperii* Gabb, 1865, California Acad. Sci. Proc., 1st ser., v. 3, p. 189].
1918. *Yoldia cooperi* var. *tenuissima* Clark, California Univ. Pubs., Dept. Geology Bull., v. 11, no. 2, p. 125–126, pl. 11, fig. 10, pl. 12, figs. 8, 14.
1925. *Yoldia tenuissima* Clark. Clark, California Univ. Pubs. Geol. Sci., v. 15, no. 4, p. 78–79, pl. 8, figs. 5, 9.
1930. *Yoldia cooperii* Gabb subsp. *supramontereyensis* Arnold. Stewart, Acad. Nat. Sci. Philadelphia Spec. Pub. 3, p. 62–64 [in part], pl. 15, fig. 2.
1931. *Yoldia* (*Portlandia*) *oregona* (Shumard). Etherington, California Univ. Pubs., Dept. Geol. Sci. Bull., v. 20, no. 5, p. 67, pl. 1, fig. 8.
1942. *Yoldia* (*Portlandia*) *oregona* (Shumard). Weaver, Washington Univ. [Seattle] Pubs. Geology, v. 5, p. 49 [in part], pl. 9, fig. 8.
1963. *Yoldia tenuissima* Clark. Kleinpell and Weaver, California Univ. Pubs. Geol. Sci., v. 43, p. 196, pl. 28, fig. 4.
1969. *Yoldia* (*Kalayoldia*) *tenuissima* (Clark). Hickman, Oregon Univ. Mus. Nat. History Bull. 16, p. 32–33, pl. 1, fig. 18.

Types.—Holotype, UCMP 11110; paratypes, UCMP 11163 and 11170.

Type locality—UCMP 798, lat 37.2° N., long 122.1° W. San Ramon Sandstone, early Miocene(?) (no other data in the University of California locality register).

Specimens of *Yoldia tenuissima* from the Wygal Sandstone Member of the Temblor Formation are of uniform size and morphology; the umbo is situated posteriorly to the middle of the valve. In the similar Oligocene species from Oregon, *Y. oregona* (Shumard, 1858), the umbo is centrally located, or nearly so. Hickman (1969, p. 32) carefully considered the morphologic differences between these species. Another middle Tertiary species that has been included with *Y. tenuissima* by Stewart (1930, p. 63), *Y. supramontereyensis* Arnold (1908, p. 382, pl. 35, fig. 9) from middle Miocene strata near Stanford University, California, has a medially situated umbo and a deeply concave posterior dorsal margin. These characters seem to permit differentiation from *Y. tenuissima.*

The earliest occurrence of this species is in rocks of Oligocene age. It was used to name a molluscan subzone of the Refugian Stage in the western Santa Ynez Mountains by Kleinpell and Weaver (1963). It also commonly occurs in the upper part of the San Emigdio Formation (Wagner and Schilling, 1923; DeLise, 1967) in strata that are at least in large part referable to the *Acila shumardi* Zone of the Refugian Stage of Schenck and Kleinpell (1936) and the "Lincoln Stage" of Weaver and others (1944). *Yoldia tenuissima* is also recorded from the northern part of the Diablo Range (Clark, 1918, 1925; Weaver, 1949; Primmer, 1964). Hickman (1969) summarized Oligocene occurrences in Oregon and Washington and also assigned to this species a middle Miocene specimen from the Astoria Formation (Etherington, 1931, pl. 1, fig. 8) that had previously been assigned to *Y. temblorensis* by Trumbull (1958). Some specimens of middle Miocene age from the Kern River area, California (Addicott, 1956), also seem to represent *Y. tenuissima.* A specimen from a locality near the base of the Round Mountain Silt is figured in this report (pl. 1, fig. 8). Another specimen from about the same stratigraphic position in the Olcese Sand (pl. 1, fig. 12), characterized by a uniquely short posterior dorsal slope and a posteriorly situated beak, may represent Clark's (1915, p. 446, pl. 48, fig. 6) *Y. carnarosensis* from the San Pablo Formation, Napa County, Calif.

Fragments of a large *Kalayoldia* from the Salt Creek Shale of Foss and Blaisdell (1968) (UCR loc. 1106) seem to represent a different species because they are relatively larger and more coarsely ribbed than specimens of *Y. tenuissima* from the overlying Wygal Sandstone Member. They also have medially located beaks, unlike *Y. tenuissima.* These fragments might represent *Y. oregona.*

Localities.—USGS 9432, M3578, M3636?, M3978, M4466, M4468?; UCR 1235.

Order ARCOIDA
Family ARCIDAE
Genus ANADARA Gray, 1847
Subgenus ANADARA s. s.

Anadara (Anadara) submontereyana (Clark)

Plate 1, figures 6, 7, 11, 16, 17

1918. *Arca (Scapharca) submontereyana* Clark, California Univ. Pubs., Dept. Geology Bull., v. 11, no. 2, p. 128–129, pl. 16, fig. 2.

1938. *Anadara (Anadara) mediaimpressa* var. *submontereyana* (Clark). Schenck and Reinhart, Mus. Royal Histoire Nat. Belgique Mem., ser. 2, no. 14, p. 38.

1943. *Anadara (Anadara) mediaimpressa* subsp. *montereyana* (Clark). Reinhart, Geol. Soc. America Spec. Paper 47, p. 40–41, pl. 4, fig. 7.

1972. *Anadara submontereyana* (Clark). Addicott, Soc. Econ. Paleontologists and Mineralogists, Pacific Sec., Bakersfield, Calif. 1972, Proc., pl. 1, fig. 7.

Types.—Holotype, UCMP 11186; paratype, UCMP 11186A.

Type locality.—UCMP 52, near top of first ridge west of Walnut Creek, 1¼ miles south of Walnut Creek, Contra Costa County, Calif. Long 122°1′39″ W., lat 37°52′44″ N. Altitude 350 feet. San Ramon Sandstone, early Miocene?.

Representatives of this species from localities near the base of the type section of the Temblor Formation are characterized by about 23 broad, flat-topped ribs that are generally wider than the interspaces, particularly on the posterior part of the valves. The number of ribs varies from as few as 21 or 22 to as many as 25. Both the ribs and interspaces are seen to be very finely noded on a few of the better preserved specimens. The Wygal specimens differ from the types principally by their relatively larger size. As noted by Reinhart (1943), the beaks are located about one-third of the distance from the anterior extremity of the valves.

Although the only reported occurrences of this species is from the type locality in the San Ramon Sandstone near Walnut Creek, Calif., poorly preserved minute specimens of an unnamed species from rocks of probable late Oligocene age in the Santa Lucia Range (SU type colln. 7574) are very similar to this species. They have been compared with *Anadara strongi* (Loel and Corey) (Reinhart, 1943, p. 43). The unnamed species is from rocks mapped as Vaqueros Formation by Edwards (1940) that contain *Pecten sanctaecruzensis* Arnold, a pectinid whose presence implies correlation with the Wygal Sandstone Member of the Temblor Formation and with strata assigned to the lower part of Kleinpell's (1938) Zemorrian Stage. *A. submontereyana* differs from *A. strongi*, a somewhat similar species of early Miocene age, in having a few more radial ribs that are not strongly grooved.

Poorly preserved specimens of *Anadara* from USGS localities M4466 and M4469 in the Wygal Sandstone Member may represent *A. submontereyana* but are specifically indeterminate.

Localities.—USGS 5149 cf., M3280, M3281, M3578, M3579, M3772, M3978.

Order MYTILOIDA
Family MYTILIDAE
Genus CRENOMYTILUS Soot-Ryen, 1955

Crenomytilus? cf. C.? arnoldi (Clark)

Plate 1, figures 1, 18; plate 3, figure 2

A large mytilid characterized by thin valves and a broad umbonal angle is similar to *Crenomytilus arnoldi* (Clark, 1918, p. 135, pl. 12, fig. 1), an Oligocene species from the Kirker Tuff near Mount Diablo, Calif. Unfortunately, all the specimens from the Wygal Sandstone Member are strongly deformed and broken, but they differ from Clark's species principally in size—they are more than twice the height of the holotype of *C. arnoldi.* The smaller specimens, however, seem almost indistinguishable from the holotype. They also resemble a form of the large early to middle Miocene species *C. expansus* (Arnold, 1907, p. 528, pl. 43, fig. 2). Although the umbonal angles are similar, the late Oligocene specimens from the Wygal Sandstone Member lack the finely striated surface characteristic of *C. expansus.* Another large species from the lower Miocene "Vaqueros Stage" of California, *C. loeli* (Grant), differs from these specimens in having a strongly concave rather than straight ventral margin.

Poorly preserved, incomplete mytilids from USGS localities M4466, M4469, M4470, and M4472 may represent this taxon.

Assignment of these specimens to *Crenomytilus,* an extinct middle and late Tertiary genus from the North Pacific rim is doubtful because details of the resilial ridge and shell margins are unknown. It is, however, very similar to Tertiary species from the Pacific coast assigned to this genus by Soot-Ryen (1955).

Crenomytilus arnoldi is reported from several Oligocene formations in California: the Kirker Tuff and the San Ramon Sandstone of the Mount Diablo area (Clark, 1918; Weaver, 1949; Primmer, 1964), the upper part of the San Emigdio Formation and the lower part of the Pleito Formation of the San Emigdio Mountains (Wagner and Schilling, 1923), and the San Juan Bautista Formation of the northern end of the Gabilan Range (Schenck in Allen, 1945).

Localities.—USGS M3578, M3636 cf., M3978, M3979, M4468.

Crenomytilus expansus (Arnold)

Plate 4, figure 15

1907. *Mytilus mathewsoni* Gabb var. *expansus* Arnold, U.S. Natl. Museum Proc., v. 32, no. 1545, p. 528, pl. 43, fig. 2.

1907. *Mytilus mathewsoni* Gabb var. *expansus* Arnold. Arnold, U.S. Geol. Survey Bull. 309, pl. 30, fig. 2.

1909. *Mytilus mathewsoni* Gabb var. *expansus* Arnold. Arnold, U.S. Geol. Survey Bull. 396, pl. 5, fig. 3.

1910. *Mytilus mathewsoni* Gabb var. *expansus* Arnold. Arnold and Anderson, U.S. Geol. Survey Bull. 398, pl. 27, fig. 3.

1932. *Mytilus expansus* Arnold. Loel and Corey, California Univ. Pubs., Dept. Geol. Sci. Bull., v. 22, no. 3, p. 205, pl. 34, fig. 1.

Type.—USNM 164968.

Type locality.—Near Torrey Canyon oil wells, southwest of Piru, Ventura County, Calif. Vaqueros Formation, lower Miocene.

One specimen was collected from the Wygal Sandstone Member near Carneros Springs. It differs from *Crenomytilus*? cf. *C. arnoldi* (Clark), a relatively common species in the Wygal, in having a recurved beak and a finely striated surface. This stratigraphic occurrence of *C. expansus* extends the range into the provincial upper Oligocene, previous records being from strata assigned to the lower Miocene "Vaqueros Stage" (Loel and Corey, 1932; Fritsche, 1967; Adegoke, 1969). Fritsche (1967) suggested that *C. expansus* might be a synonym of *C. coalingensis* (Arnold, 1909, p. 73–74, pl. 19, fig. 5 and pl. 22, fig. 6), a Pliocene species from near Coalinga, Calif. Although the very strongly recurved and greatly thickened beak of *C. coalingensis* seem to distinguish it from *C. expansus,* the relationship of these two species certainly merits further study.

Locality.—USGS 9427.

Order PTERIOIDA
Family PECTINIDAE
Genus PECTEN Müller, 1776
Suubgenus PECTEN s. s.

Pecten (Pecten) sanctaecruzensis Arnold

Plate 2, figures 4, 7

1906. *Pecten* (*Pecten*) *sanctaecruzensis* Arnold, U.S. Geol. Survey Prof. Paper 47, p. 54–55, pl. 3, figs. 12, 13.

1909. *Pecten* (*Pecten*) *sanctaecruzensis* Arnold, U.S. Geol. Survey Folio 163, illus. II, fig. 18.

1923. *Pecten (Pecten) dickersoni* Wagner and Schilling, California Univ. Pubs., Dept. Geol. Sci. Bull., v. 14, no. 6, p. 253, pl. 45, fig. 1.
1940. *Pecten dickersoni* Wagner and Schilling. Schenck and Keen, California fossils for the field geologist, pl. 28, fig. 1.
1972. *Pecten sanctaecruzensis* Arnold. Addicott, Soc. Econ. Paleontologists and Mineralogists, Pacific Sec., Bakersfield, Calif., 1972, Proc., pl. 1, fig. 2.

Types.—Holotype, SU 360; paratype, SU 361.

Type locality.—SU locality 111, Two Bar Creek, 1/4 mile above junction with San Lorenzo River, Santa Cruz County. Vaqueros Formation, about 600 feet above base (Burchfiel, 1964, text fig. 2); late Oligocene. The paratype is from float collected in Bear Creek about 2 miles from the holotype locality.

Several disarticulated valves of *Pecten sanctaecruzensis* have been collected from exposures of a 3-foot-thick *Crassostrea*-bearing sandstone bed at the base of the Wygal Sandstone Member in a tributary of Zemorra Creek (USGS loc. M4467). These specimens are similar to the type material from the Vaqueros Formation of the Santa Cruz Mountains (Arnold, 1906, p. 54–55, pl. 3, figs. 12, 13) except for their larger adult size.

Right valves of the pectinid range from about 45 to 85 mm (millimeters) in length. They have 12 or 13 strong ribs which have gently rounded upper surfaces and vertical sides. The interspaces are deep, relatively flat bottomed, and somewhat narrower than the ribs. On two of the larger specimens, there is a suggestion of fine radial sculpture on a few of the ribs.

Two left valves in the USGS collection from locality M4467 are relatively flat. The interior of the better preserved valve is characterized by strong cardinal crura that extend almost to the ligamental pit. Each valve has 12 prominent radial ribs that are much sharper than those of the right valve and that are separated by relatively wide interspaces. These valves measure about 48 and 73 mm long.

Pecten sanctaecruzensis is a potentially valuable species for stratigraphic correlation in California Coast Range basins. Its local stratigraphic range, or teilzone, and position in the provincial foraminiferal chronology are well known (Burchfiel, 1964). Although the record in the Wygal Sandstone Member is the first reported from east of the San Andreas fault, this species also occurs at a locality in the Pleito Formation of the San Emigdio Mountains. It was originally described from "a faulted block of the San Emigdio Formation on Salt Creek" by Wagner and Schilling (1923, p. 253, pl. 45, fig. 1) as *Pecten dickersoni*. Detailed mapping of this area (Dibblee, 1961) shows that the type locality is in the Pleito Formation of Wagner and Schilling (1923), and study of several topotypes from USGS locality M3747 indicates that the pattern of ribbing and the number of ribs are identical to *P. sanctaecruzensis*. This *Pecten* occurs with an assemblage that is comparable to the fauna of the Wygal Sandstone Member and that has no species restricted to the Refugian Stage. The only other known occurrences are from the type area in the Santa Cruz Mountains (Arnold, 1906; Brabb, 1964; Burchfiel, 1964) and from the Salinas Valley (Edwards, 1940). Both of these occurrences are in rocks mapped as Vaqueros Sandstone and assigned to the Zemorrian Stage of the foraminiferal chronology. It should be noted, however, that the Santa Cruz Mountains occurrence may be in strata generally older than the Vaqueros Sandstone of other areas in the California Coast Ranges. In fact, Arnold (1908, p. 349) originally noted that the fine-grained sandstones from which *P. sanctaecruzensis* was collected contained a faunal assemblage that appeared to be transitional between that of the San Lorenzo Formation below and his Vaqueros Sandstone above. He concluded that the assemblage resembled the fauna of the San Lorenzo more closely than that of his Vaqueros Sandstone; his Vaqueros fauna (Arnold, 1908, p. 350) consisted of assemblages that are referable to the present-day "Vaqueros" and "Temblor Stages" of Weaver and others (1944).

In addition to Arnold's (1908) molluscan evidence, benthonic foraminifers from his transitional fine-grained sandstones include at least one species, *Cibicides pseudoungerianus evolutus* (Brabb, 1964, p. 677) that is suggestive of an early Zemorrian age (Kleinpell, 1938, p. 140). As discussed in the section on provincial age and correlation, indications are that the fauna of the "Vaqueros Stage" corresponds to the upper part of the Zemorrian and lower part of the Saucesian Stages of the provincial foraminiferal chronology. The subsequent mapping of Arnold's (1908) transitional sandstone in the Vaqueros Sandstone (Brabb, 1964; Burchfiel, 1964) is not, therefore, indicative of an exclusively "Vaqueros" age for occurrences of *Pecten sanctaecruzensis* in the Santa Cruz Mountains.

The indicated cooccurrence of this species with foraminiferal assemblages of early Zemorrian age in the Santa Cruz Mountains and in the Temblor Range (Kleinpell, 1938) suggests that the lower part of the Vaqueros Sandstone of Brabb (1964) and Burchfiel (1964) is correlative with the Wygal Sandstone Member of the type Temblor Formation.

Locality.—USGS M4467.

Genus LEPTOPECTEN Verrill, 1897

Leptopecten? sp.

Plate 1, figure 14

1972. *Leptopecten*? sp. Addicott, Soc. Econ. Paleontologists and Mineralogists, Pacific Sec., Bakersfield, Calif., 1972, Proc., pl. 1, fig. 11.

A fragment of a small pectinid from USGS locality M3280 is doubtfully identified as *Leptopecten* sp. on the basis of similarity of the ribbing pattern to *L. andersoni* (Arnold, 1906, p. 82–83, pl. 26, figs. 5, 7), a widespread middle Miocene species from the California Coast Ranges. Eleven ribs are preserved on this incomplete specimen; they are V-shaped in cross section and rise to an angular crest. The interspaces contain microscopic growth lamellae that resemble those developed on specimens of *L. andersoni* from the so-called Barker's Ranch fauna of middle Miocene age along the southeastern margin of the San Joaquin basin. A more complete specimen from the lower part of the Santos Shale (Addicott, 1972, pl. 1, fig. 11; USGS loc. M3983) seems to represent this species.

Locality.—USGS M3280.

Genus VERTIPECTEN Grant and Gale, 1931

Vertipecten alexclarki Addicott, n. sp.

Plate 1, figures 9, 10, 13; plate 2, figures 1, 3, 5, 8, 9; plate 3, figures 1, 4

1905. *Pecten* sp. Anderson, California Acad. Sci. Proc., 3d ser., v. 2, no. 2, p. 170.
1906. *Pecten* (*Chlamys*) *branneri* Arnold, U.S. Geol. Survey Prof. Paper 47, p. 55–56 (in part), [not pl. 3, figs. 9–11].
1972. *Vertipecten* n. sp. Addicott, Soc. Econ. Paleontologists and Mineralogists, Pacific Sec., Bakersfield, Calif., 1972, Proc., pl. 1, figs. 16, 18.

Moderately large, reaching as much as 115 mm in height, higher than long. Apical angle narrow, averaging about 70°. Right valve relatively flat; has 20 to 30 or more flat-topped, scaly ribs that tend to be dichotomous in the central portion of the disk but more irregular in development toward the sides. Scales are fine and closely spaced near beak but become coarser and more widely spaced toward base. Secondary riblets usually developed in the interspaces between the paired ribs. Anterior auricle long, set off by deep byssal notch. Auricle sculptured by five strong ribs bearing heavy flanges. Left valve convex and has rather uniform sculpture of primary, secondary, and tertiary rounded ribs bearing strong, rather widely spaced flanges toward the base. Medial primary and two lateral primaries that tend to divide the disk into quadrants are somewhat stronger than other primary ribs.

This species is assigned to *Vertipecten* because of the distinct inequality of the valves, the right valve being relatively flat and the left being moderately convex (pl. 1, fig. 10), and because of the relatively greater strength of the central and two lateral primary ribs on the left valve, the three of which tend to divide the valve into quadrants. In sculptural detail and in the size of the right anterior ear, the species resembles *Chlamys*.

The right valve of *Vertipecten alexclarki* n. sp. is characterized by narrow, flat-topped ribs that are highly irregular in their development, whereas the left valve has a more or less orderly development of rounded primary, secondary, and tertiary ribs. The ribs of both valves are scaly.

This species seems to be a lineal antecedent of the early and middle Miocene species *Vertipecten perrini* (Arnold). The Miocene specifies differs, however, by having fewer, much coarser ribs on the right valve that also tend to be smooth and generally are not dichotomous. The medial portion of the right valve of *V. perrini* also has a depression coinciding with an interspace and reflecting a relatively much more strongly raised medial rib on the left valve.

The sculpture of the right valve of *Chlamys branneri* (Arnold, 1906, p. 55–56, pl. 3, figs. 9–11), a middle Miocene species from the eastern foothills of the Santa Cruz Mountains, is similar to that of the *Vertipecten alexclarki.* In fact, some workers (Kleinpell, 1938; Stinemeyer and others, 1959; Foss and Blaisdell, 1968) identified *C. branneri* from the Wygal Sandstone Member. Although the type material of *C. branneri* is poorly preserved, it is an equivalved species and, therefore, is properly assigned to *Chlamys* and not to the subsequently proposed genus *Vertipecten,* which is characterized by a relatively flat right valve and a convex left valve (see pl. 1, fig. 10). Other differences are the similar sculpture of both valves of *C. branneri,* the lack of an accentuated medial rib on the left valve, and the greater number of radial ribs on the auricles of that species—6 to 10 rather than 5. It is possible that a specimen, or specimens, identified by Arnold (1906, p. 56) as *C. branneri* from the lower part of what is now mapped as Vaqueros Sandstone (Brabb, 1964) on Twobar Creek in the Santa Cruz Mountains, may represent *V. alexclarki* n. sp. The material is from rocks of approximately the same age. *C. branneri,* on the other hand, is from unnamed rocks of middle Miocene age from Coyote Hills near the Stanford University campus (Dibble, 1966).

This species is named for Alex Clark, who made extensive unpublished studies of Oligocene and Miocene mollusks of the southern part of the San

Joaquin basin for Shell Oil Co. during the 1930's (1931-1935, Department of Geology, California University, Riverside).

Localities.—USGS 5149?, M3280, M3281, M3579, M3636, M3772, M3984, M3985, M4466, M4468, M4470, M4472.

Family OSTREIDAE
Genus CRASSOSTREA Sacco, 1897

Crassostrea eldridgei ynezana (Loel and Corey)

Plate 2, figures 2, 10

1907. *Ostrea eldridgei* Arnold. Arnold and Anderson, U.S. Geol. Survey Bull. 322, pl. 18, figs. 6a, 6b.

1932. *Ostrea eldridgei* (Arnold) var. *ynezana* Loel and Corey, California Univ. Pubs., Dept. Geol. Sci. Bull., v. 22, no. 3, p. 188–189, pl. 11, fig. 3; pl. 12, figs. 1a–1c; pl. 13, figs. 1, 2a, 2b.

Type.—UCMP 31745.

Type locality.—UCMP A317. At west end of hill that is poorly defined on the topographic map about 0.5 mile northwest of Rancho Atascoso house. 1.2 miles S. 80° E. from 603-foot bench mark on road. Vaqueros Formation, early Miocene.

Specimens of *Crassostrea eldridgei ynezana* are characterized by their relatively thin valves, the left being moderately convex and somewhat larger than the right. The largest specimen is about 100 mm in height. During an early stage of growth the axis of the valve undergoes a gradual rotation through about 45°, the result being posteriorly situated beaks and, on many specimens, a subquadrate outline.

This species is similar to *Crassostrea sookensis* (Clark and Arnold, 1923, p. 138, pl. 17, figs. 1, 2) from the early Miocene(?) Sooke Formation of southern Vancouver Island, British Columbia. The northern species has a thicker shell in general and a less quadrate outline than specimens of *C. eldridgei ynezana* from the Wygal Sandstone Member. *C. sookensis* may represent a prior name for *C. eldridgei ynezana*, but the holotype is too poorly preserved to determine possible relationships confidently.

Fragments of a large, very thick shelled oyster from several localities in the Wygal Sandstone Member seem to represent a different species from *Crassostrea eldridgei ynezana*.

Localities.—USGS M3280, M3578, M3772, M3978, M3979?, M4466?.

Crassostrea? sp.

Fragments of a large, very thick shelled ostreid occur commonly in exposures of the Wygal Sandstone Member, particularly in the coarse-grained basal sandstone. The fragments range from about 15 to 25 mm thick; many are more than 100 mm long. Judging from these dimensions and the heavy ligamental groove, these fragments represent *Crassostrea.* The listing of occurrences is by no means an accurate index of the occurrence of this ostreid in the Wygal Sandstone Member; specimens were observed in the field at almost every locality but, because of the indeterminate nature of the fragments, were not collected.

Localities.—USGS 5149, M4467, M4468, M4470, M4472.

Order VENEROIDA
Family LUCINIDAE
Genus HERE Gabb, 1866

Here excavata (Carpenter)

Plate 3, figures 6, 8, 9

1857. *Lucina excavata* Carpenter, Catalogue of the Reigen Collection of Mazatlan Mollusca, in the British Museum, p. 98.

1866. *Lucina* (*Here*) *Richthofeni* Gabb, California Geol. Survey, Paleontology, v. 2, sec. 1, pt. 1, p. 29, pl. 8, figs. 49a, 49b.

1884. *Lucina richthofeni* Gabb. Tryon, Structural and systematic conchology, v. 3, p. 210, pl. 119, figs. 46, 53.

1901. *Phacoides* (*Here*) *richthofeni* (Gabb). Dall, U.S. Natl. Mus. Proc., v. 23, no. 1237, p. 810, 827, pl. 40, figs. 7, 9.

1904. *Phacoides richthofeni* Gabb. Keep, West American shells, p. 58, fig. 45.

1905. *Lucina richthofeni* Gabb. Anderson, California Acad. Sci. Proc., 3d ser., v. 2, no. 2, p. 170.

1907. *Phacoides richthofeni* Gabb. Arnold, U.S. Natl. Mus. Proc., v. 32, no. 1545, p. 543, pl. 45, fig. 4.

1907. *Phacoides richthofeni* Gabb. Arnold, U.S. Geol. Survey Bull. 309, p. 236, pl. 32, fig. 4.

1911. *Phacoides richthofeni* Gabb. Keep, West coast shells, p. 69, fig. 45.

1915. *Phacoides richthofeni* Gabb. Clark, California Univ. Pubs., Dept. Geology Bull. v. 8, no. 22, p. 419, pl. 62, fig. 2.

1930. *Lucina* (*Here*) *excavata* Carpenter. Stewart, Acad. Nat. Sci. Philadelphia Spec. Pub. 3, p. 181–182, pl. 15, fig. 3, pl. 17, fig. 5.

1931. *Lucina* (*Here*) *excavata* Carpenter. Grant and Gale, San Diego Soc. Nat. History Mem., v. 1, p. 290–291, pl. 14, figs. 2, 5, 10.

1932. *Phacoides* (*Here*) *richthofeni* Gabb. Loel and Corey, California Univ. Pubs., Dept. Geol. Sci. Bull., v. 22, no. 3, p. 210, pl. 36, fig. 4.

1935. *Lucina* (*Here*) *richthofeni* Gabb. Keep and Bailey, West coast shells, p. 84, fig. 57.

1958. *Lucina* (*Here*) *excavata* Carpenter. Keen, Sea shells of tropical west America, p. 94, fig. 188.

1966. *Lucina excavata* Carpenter. Brann, Illustrations to "Catalogue of the Collection of Mazatlan shells" by Philip P. Carpenter, p. 37, pl. 12, fig. 140.

1969. *Here* (*Here*) *excavata* (Carpenter). Chavan, Treatise on invertebrate paleontology, Part N, v. 2, p. N496, fig. E3, 1a, 1b.

Type.—British Museum (Palmer, 1958).

Type locality.—Mazatlan, Mexico. Holocene.

This small, strongly inflated lucinid is usually represented by articulated specimens. There is some variation in the degree of inflation of the valves and in the umbonal angle on specimens from the Wygal Sandstone Member. They are similar to, but somewhat more inflated than, specimens of middle Miocene age from the upper part of the Olcese Sand of the Kern River area on the southeastern margin of the San Joaquin basin.

Here excavata occurs commonly in rocks of Miocene and Pliocene age in California. Many of the occurrences are listed by Stewart (1930, p. 181). The species is one of the longest ranging Tertiary bivalves on the Pacific coast. Its earliest occurrence is in the middle Oligocene fauna of the San Emigdio Formation of Wagner and Schilling (1923) at the southern margin of the San Joaquin basin (Wagner and Schilling, 1923) where it occurs in the *Acila shumardi* Zone of the Refugian Stage of Schenck and Kleinpell (1936).

Localities.—USGS 9432, M3280, M3578, M3579, M3978, M4466.

Genus LUCINOMA Dall, 1901

Lucinoma acutilineata (Conrad)

Plate 2, figure 6; plate 3, figures 3, 7

1849. *Lucina acutilineata* Conrad, U.S. Explor. Exped., Geology, v. 10, app. p. 725, atlas pl. 18, figs. 2, 2a, 2b.

1849. *Pectunculus patulus* Conrad, U.S. Explor. Exped., Geology, v. 10, app. p. 726, atlas, pl. 18, figs. 8, 8a.

?1857. *Cyclas permacra* Conrad, U.S. 33rd Cong., 2d sess., H. Ex. Doc. 91, no. 7, pt. 2, p. 192, pl. 6, fig. 6.

1903. *Lucina borealis* Linnaeus. Yates, Southern Calif. Acad. Sci. Bull., v. 2, no. 7, pl. 8, fig. 13.

1909. *Phacoides acutilineatus* Conrad. Dall, U.S. Geol. Survey Prof. Paper 59, p. 116–117, pl. 12, fig. 6.

1909. *Phacoides acutilineatus* Conrad. Arnold, U.S. Geol. Survey Bull. 396, p. 122, pl. 8, fig. 4.

1910. *Phacoides acutilineatus* Conrad. Arnold and Anderson, U.S. Geol. Survey Bull. 398, p. 294, pl. 30, fig. 4.

1929. *Phacoides acutilineatus* (Conrad). Clark, Stratigraphy and faunal horizons of the Coast Ranges of California, pl. 23, fig. 7.

1931. *Phacoides (Lucinoma) acutilineatus* (Conrad). Etherington, California Univ. Pubs., Dept. Geol. Sci. Bull., v. 20, no. 5, p. 76–77, pl. 4, fig. 5.

1931. *Lucina (Myrtea) acutilineata* Conrad. Grant and Gale, San Diego Soc. Nat. History Mem., v. 1, p. 286–287 (in part), [not pl. 14, figs. 22a, 22b].

1932. *Phacoides (Lucinoma) acutilineatus* (Conrad). Loel and Corey, California Univ. Pubs., Dept. Geol. Sci. Bull., v. 22, no. 3, p. 211, pl. 36, fig. 3.

1947. *Lucinoma acutilineata* (Conrad). Stewart, U.S. Geol. Survey Prof. Paper 205–C, pl. 15, fig. 9. [Imprint 1946.]

1964. *Lucinoma acutilineata* (Conrad). Moore, U.S. Geol. Survey Prof. Paper 419, p. 70–71, pl. 15, figs. 7–10, 12. [Imprint 1963.]

1969. *Lucinoma acutilineata* (Conrad). Hickman, Oregon Univ. Mus. Nat. History Bull. 16, p. 39–40, pl. 3, figs. 1, 4.

1972. *Lucinoma acutilineata* (Conrad). Addicott, Soc. Econ. Paleontologists and Mineralogists, Pacific Sec., Bakersfield, Calif. 1972, Proc., pl. 1, figs. 3, 15.

Type.—USNM 3519 (designated by Woodring, 1938).

Type locality.—Astoria, Oreg. Astoria Formation, Miocene.

This is the species most characteristic of the basal sandstone member of the type Temblor Formation. It is very abundant at most localities, notably at USGS M3280. It was initially listed from the Wygal Sandstone Member by Anderson (1905, p. 170) as *Lucina borealis.*

Lucinoma acutilineata is characterized by regularly spaced, sharp concentric lamellae. The interspaces are packed with extremely fine concentric threads. The spacing of the primary lamellae is variable, as noted by Moore (1963). On a few specimens, these ribs are spaced twice as far apart as on others, almost as if alternate ribs had been omitted as the shell was being deposited (pl. 3, fig. 3).

Lucinoma acutilineata has its initial and lowest stratigraphic occurrence in rocks assigned to the middle Oligocene "Lincoln Stage" of western Oregon (Hickman, 1969). It ranges at least through the middle Miocene. Pliocene and Quaternary specimens that resemble *L. acutilineata* are generally identified as *L. annulata* (Reeve) on the basis of a somewhat longer posterior dorsal margin and a less strongly developed hinge which includes weaker anterior teeth (Tegland, 1933; Moore, 1963). The relative length of the posterior dorsal margin on specimens from USGS locality M3280 is variable (pl. 3, figs. 3, 7) owing, at least in part, to postburial deformation of the valves.

Localities.—USGS 5149, 9432, M3280, M3578, M3579, M3636, M3772, M3978, M3979, M3984, M3985, M4466, M4468, M4469, M4470, M4471, M4472, M4473.

Genus MILTHA Adams and Adams, 1857

Miltha (Miltha) sanctaecrucis (Arnold)

Plate 3, figures 5, 10

1910. *Phacoides (Miltha) sanctaecrucis* Arnold, U.S. Geol. Survey Bull. 396, p. 57–58, pl. 6, fig. 6. [Imprint 1909.]

1910. *Phacoides (Miltha) sanctaecrucis* Arnold. Arnold and Anderson, U.S. Geol. Survey Bull. 398, pl. 28, fig. 6.

1932. *Phacoides (Miltha) sanctaecrucis* Arnold. Loel and Corey, California Univ. Pubs., Dept. Geol. Sci. Bull., v. 22, no. 3, p. 211, pl. 36, fig. 5.

1947. *Miltha sanctaecrucis* (Arnold). Stewart, U.S. Geol. Survey Prof. Paper 205–C, pl. 17, fig. 8. [Imprint 1946.]

Type.—USNM 165569.

Type locality.—USGS 4861. In "reef beds," 1/4 mile south and southeast of Barton's cabin, in the NW1/4 sec. 23, T. 25 S., R. 18 E., Devils Den district, Kern County, Calif. "Vaqueros" [Temblor] Formation, middle Miocene.

This large, very slightly inflated lucinid is characterized by very fine, somewhat irregular concentric sculpture. A network of extremely fine, irregular, radial riblets is evident on a few well-preserved specimens (pl. 3, fig. 10). This species is very similar to the present-day *Miltha xantusi* (Dall) from the Cape San Lucas area at the tip of Baja California, Mexico. It is generally distinguished from the living species by its relatively longer shell: *M. xantusi* tends to be somewhat higher than long. The specimens at hand from the Wygal Sandstone Member of the Temblor Formation also seem to have a somewhat longer posterior dorsal slope.

Although the figured specimens are uniformly less inflated than Arnold's (1909) holotype (USNM 165569), a suite of 10 specimens from USGS locality M3578 includes two individuals that are at least as inflated as the type; the degree of inflation seems to be a variable morphologic character.

The occurrence of *Miltha* in the basal sandstone of the type Temblor Formation marks the lowest stratigraphic occurrence of the genus in the California Tertiary. The genus ranges through the Miocene into the early Pliocene of the San Joaquin basin and the Ventura basin (Grant and Gale, 1931). It is recognized in paleoclimatic analyses as a warm-water indicator because it occurs in the tropical Panamic molluscan province (Durham, 1950; Addicott and Vedder, 1963).

Localities.—USGS 5149, 9432, M3280, M3578, M3579, M3772, M3979, M4466, M4468, M4469.

Family UNGULINIDAE
Genus FELANIELLA Dall, 1899

Felaniella harfordi (Anderson)

Plate 4, figures 2, 7

1905. *Diplodonta harfordi* Anderson, California Acad. Sci. Proc., 3d ser., v. 2, no. 2, p. 197, pl. 17, figs. 88, 89.

?1910. *Diplodonta harfordi* Anderson. Arnold, U.S. Geol. U.S. Geol. Survey Bull. 398, pl. 39, fig. 6. [Imprint 1909.]

?1910. *Diplodonta harfordi* Anderson. Arnold and Anderson, U.S. Geol. Survey Bull. 396, pl. 39, fig. 6.

1932. *Diplodonta harfordi* Anderson. Loel and Corey, California Univ. Pubs., Dept. Geol. Sci. Bull., v. 22, no. 3, p. 212, pl. 36, figs. 11a, 11b.

Types.—CAS 62, 63 (syntypes).

Type locality.—Three miles west of Coalinga, Fresno County, Calif. Coalinga Beds of Anderson (1905) [Temblor Formation], middle Miocene.

The valves of *Felaniella harfordi* from the basal sandstone member of the type Temblor Formation are somewhat variable in outline and are only slightly inflated. Generally, they are subquadrangular and have a distinctly flattened segment posteriorly (pl. 4, fig. 2). Although the interior of these specimens is unknown, assignment to *Felaniella* is indicated by the characteristic inequilateral profile of the valves and the prominent beaks.

The stratigraphic range of this species in the San Joaquin basin is from the upper Oligocene to the Pliocene. Prior to recent records from the Etchegoin Formation (Adegoke, 1969), this species has been recognized from only one locality of Pliocene age (Arnold, 1909, pl. 17, fig. 6), a record that had been considered doubtful by Grant and Gale (1931, p. 294).

Localities.—USGS M3280, M3772, M4466, M4472.

Family MACTRIDAE
Genus PSEUDOCARDIUM Gabb, 1866

Pseudocardium? sp.

Plate 5, figure 5

An internal mold of a moderately large, inequilateral pelecypod from USGS locality M4466 near Zemorra Creek is doubtful identified as *Pseudocardium* on the basis of strongly inflated valves and deeply sunken muscle scars.

Locality.—USGS M4466.

Genus SPISULA Gray, 1837
Spisula cf. S. albaria (Conrad)

Plate 4, figures 3, 4, 8

Several small, poorly preserved specimens (30 to 50 mm long) resemble the Miocene and Pliocene species *Spisula albaria* (Conrad) more closely than any of the species described from the Oligocene of the Pacific coast. Although somewhat variable in outline, the valves have a trigonal outline and medially to slightly anteriorly situated beaks. They are relatively much higher than the elongate trigonal late Oligocene species *S. ramonensis attenuata* Clark (1918, p. 158–159, pl. 9, fig. 6) and *S. pittsburgensis frustra* Tegland (1933, p. 121, pl. 9, figs. 9–12). Moreover, the posterior dorsal slope is relatively longer and less convex than on *S. ramonensis attenuata*. A figure of a specimen of *S. albaria* (Conrad) from the middle Miocene Astoria Formation of coastal Oregon is included for comparison (pl. 4, fig. 6).

Localities.—USGS 5149, M3578, M3636, M3978,

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M3979, M4466?, M4468, M4469, M4470, M4471, M4472.

Spisula n. sp.?

Plate 4, figure 1

1932. *Spisula* aff. *hemphilli* (Dall) n. sp.? Loel and Corey, California Univ. Pubs., Dept. Geol. Sci. Bull., v. 22, no. 3, p. 232, pl. 45, fig. 3.

Figured specimen.—UCMP 31791.

Locality.—UCMP A562. Pelecypod bed at about the 500-foot contour on the north wall of large east-west bend of Malibu Canyon north of dam. Western Los Angeles County, Calif. Vaqueros Formation, early Miocene.

A large, inflated *Spisula* represented by single specimens from three localities is identical to the poorly known taxon from the Vaqueros Formation in the central Santa Monica Mountains. As recognized by Loel and Corey (1932, p. 232), this *Spisula* seems to be uniquely different from any of the described middle Tertiary species from the Pacific coast.

Localities.—USGS M3579, M3772, M3979.

Spisula ramonensis Packard

Plate 4, figure 5

1916. *Spisula albaria* (Conrad) var. *ramonensis* Packard, California Univ. Pubs., Dept. Geology Bull., v. 9, no. 15, p. 291–292, pl. 23, fig. 5, pl. 25, figs. 1, 2.

1918. *Spisula ramonensis* Packard. Clark, California Univ. Pubs., Dept. Geology Bull., v. 11, no. 2, p. 158, pl. 9, figs. 4, 5.

Type.—UCMP 11118.

Type locality.—UCMP 1687. One and one-half mile south of Walnut Creek in valley leading from San Ramon Valley to Tice Valley. On bank of Walnut Creek, 3/8 mile west of the point where it turns and flows west. Contra Costa County, Calif. Altitude 225 feet. San Ramon Sandstone, early Miocene(?).

A few specimens from USGS locality M3280 have the long, nearly straight anterior dorsal slope and posteriorly located beaks characteristic of this species. *Spisula ramonensis* occurs in several formations of Oligocene age in California (Wagner and Schilling, 1923; Allen, 1945; Primmer, 1964; DeLise, 1967) and has been recorded from the lower Miocene part of the Poul Creek Formation in the Gulf of Alaska Tertiary province (Clark, 1932).

Localities.—USGS M3280, M4468 cf.

Spisula cf. S. rushi Wagner and Schilling

Plate 4, figure 14

A few large *Spisula* from localities in the Wygal Sandstone Member of the Temblor Formation are similar to a species from the Oligocene formations exposed in the foothills of the San Emigdio Mountains, *S. rushi* Wagner and Schilling (1923, p. 256, pl. 47, fig. 2). These specimens are much larger than *S. rushi.* They are distinguished from *Spisula* n. sp., with which one specimen occurs in the collection from USGS locality M3979, by the subquadrate outline of the valves and by the anterior location of the beaks.

A similar species from the San Ramon Sandstone of the San Francisco Bay area to the north, *Spisula occidentalis* (Gabb) (Stewart, 1930, pl. 15, fig. 5), has a more oblique umbonal angle and has a prominent sulcus extending from near the beaks to the posterior dorsal extremity.

Spisula rushi ranges from the middle Oligocene into the late Oligocene in southern part of the San Joaquin basin. It occurs with the Refugian Stage (Schenck and Kleinpell, 1936) index fossil *Acila shumardi* in the upper part of the San Emigdio and the lower part of the Pleito Formations of Wagner and Schilling (1923) at the southern margin of the San Joaquin basin (Wagner and Schilling, 1923; DeLise, 1967).

Localities.—USGS M3280, M3636, M3978, M3979, M4470, M4471, M4472?.

Family SOLENIDAE
Genus SOLEN Linné, 1758

Solen aff. S. gravidus Clark

Plate 4, figure 9

Fragments of a large *Solen* from USGS localities M3280 and M3578 are similar to *S. gravidus* Clark (1918, p. 156–157, pl. 10, fig. 7) from the San Ramon Formation of the Mount Diablo area, Contra Costa County, Calif. The anterior margin is gently rounded and is bordered by a weak, shallow sulcus that extends from near the beaks to the anterior ventral margin. The strength of the sulcus is variable in the few specimens available for study. The height of the valves is proportionately greater than that of the holotype of *S. gravidus* (UCMP 11133). There are additional fragments of a large *Solen* in the collections from USGS localities M3772 and M3979 that are specifically indeterminate but presumably represent this taxon.

Localities.—USGS M3280, M3578, M4466?.

Family TELLINIDAE
Genus TELLINA Linné, 1758

Subgenus OLCESIA Addicott, n. subgen.

Type.—*Tellina piercei* (Arnold) [= *T. nevadensis* Anderson and Martin]. Middle Miocene, California.

Shell large and heavy. Posterior side longer than anterior side. Posterior portion of valves flexed to the right, flexing much stronger in right valve. Surface sculptured by fine concentric lines of growth and very faint radial striae. Anterior dorsal margin broadly convex, posterior margin long and relatively straight. Hinge plate broad and very heavy. Right valve has a long anterior lateral, a weak anterior cardinal, a heavy, bifid main cardinal, and a weak posterior lateral. Left valve has a weak anterior lateral, a simple cardinal, a weak posterior cardinal, and a strong, slightly curved posterior lateral terminating near the base of the hinge plate. Left valve flattened in dorsal aspect, has slight convexity; anterior part of right valve convex, posterior part concave. Right valve has an elongate, weak lunule. Pallial line deeply impressed, extending to base of the anterior muscle scar. Pallial sinus deep, has slight convexity dorsally, extending anteriorly to a prominent internal rib bordering the anterior muscle scar. Anterior muscle scar elongate, tear shaped; posterior scar subquadrate. Ligament elongate, sunken, base deeply set on hinge plate.

Olcesia seems to be most similar to the European Oligocene to Holocene genus *Peronaea* Poli (Afshar, 1969, p. 30–31, pl. 5, figs. 6–10). The valves are of very similar shape and sculpture, but there are significant differences internally. The hinge of *Olcesia* is relatively much heavier, particularly anterior to the beaks, the pallial sinus is also lower and does not form a prominent peak, and the anterior margin of the posterior muscle scar is straight rather than highly contorted.

The shape of the valves and external sculpture also resemble the Eocene to Holocene northern Pacific subgenus *Peronidia* Dall (1900), but the deeply sunken ligamental groove, heavy hinge plate, and strong dentition of *Olcesia* are strikingly different.

Olcesia ranges from the upper Oligocene to the upper Miocene in California. It is named for the Olcese land holdings near the type locality of *Tellina nevadensis*. The name has also been applied to the middle Miocene Olcese Sand from which this species was described.

Tellina (Olcesia) piercei (Arnold)

Plate 4, figures 10, 12; plate 5, figures 12, 13

1910. *Macoma piercei* Arnold, U.S. Geol. Survey Bull. 396, p. 55–56, pl. 7, fig. 6. [Imprint 1909.]

1910. *Macoma piercei* Arnold. Arnold and Anderson, U.S. Geol. Survey Bull. 398, pl. 7, fig. 6.

1914. *Tellina nevadensis* Anderson and Martin, California Acad. Sci. Proc., 4th ser., v. 4, no. 3, p. 61–62, pl. 2, figs. 3a–3c.

1929. *Tellina nevadensis* Anderson and Martin. Clark, Stratigraphy and faunal horizons of the Coast Ranges of California, pl. 24, fig. 3.

1932. *Tellina ocoyana* Conrad. Loel and Corey, California Univ. Pubs., Dept. Geol. Sci. Bull., v. 22, no. 3, p. 148 (in part), pl. 43, fig. 4.

1932. *Macoma nasuta* (Conrad). Loel and Corey, California Univ. Pubs., Dept. Geol. Sci. Bull., v. 22, no. 3, p. 228 (in part), pl. 43, fig. 7 (not fig. 8).

1965. *Tellina nevadensis* Anderson and Martin. Addicott, U.S. Geol. Survey Prof. Paper 525–C, fig. 4e.

Type.—USNM 165595.

Type locality.—USGS 4631, *Turritella* bed on east flank of high hill northeast of Oil City, in SE¼NE¼ sec. 16, T. 19 S., R. 15 E. Vaqueros [Temblor] Formation, middle Miocene.

This species has been generally identified as *Tellina nevadensis* Anderson and Martin (1914) from the middle Miocene Olcese Sand of the Kern River area on the southeast margin of the San Joaquin basin. Arnold's (1909, pl. 7, fig. 6) *T. piercei* has remained a poorly known taxon because the holotype is incomplete and poorly preserved. Moreover, it was originally compared with the Holocene species *Macoma secta*. The holotype, a left valve, clearly is not allied to *M. secta*. It lacks the convex posterior dorsal margin characteristic of that species and has an extremely long, deeply set ligamental groove. Although the hinge is not exposed on the holotype, there can be little doubt that it is idenical to *T. nevadensis* owing to the long, deeply excavated ligamental groove, the strong ridge below the posterior dorsal margin, the anteriorly located beak, and the surface sculpture of fine concentric ribs. The types of both species are from stratigraphic units referable to the "Temblor Stage."

Only four specimens of *Tellina piercei* from the Wygal Sandstone Member of the Temblor Formation are available for study. They are identical in all respects to well-preserved specimens from the upper part of the middle Miocene Olcese Sand from the Kern River area on the east side of the San Joaquin Valley (pl. 5, figs. 12, 13).

This large, thick-shelled species is characterized by a very heavy hinge plate that has well-developed lateral teeth. The valves are boat shaped and are pointed posteriorly. On the left valve, the sharp posterior dorsal margin is bordered by a weak ridge, below which is a narrow sulcus; on the right valve, it is bordered by a much stronger sulcus below which occurs a prominent ridge that extends to the posterior extremity.

Tellina piercei [as *T. nevadensis*] has been confused with a poorly known middle Miocene species from the Kern River area, *T. ocoyana* Conrad (1857d, pl. 8, figs. 75, 75a). The identity of Conrad's species may never be satisfactorily determined because the type has apparently been lost (Keen and Bentson, 1944, p. 115) and the original figures appear to be somewhat stylized line drawings that do not indicate the critical details of internal morphology. Conrad's description (1855, p. 19) and illustrations are of a more trigonal shell that has a pointed, rather than broadly rounded anterior extremity, and the hinge of *T. ocoyana* does not seem nearly so broad and heavy as that of *T. piercei.* Most subsequent records of *T. ocoyana* are presumed to be of *T. piercei.*

This species ranges from the upper Oligocene to the middle Miocene in the San Joaquin basin. It has not previously been recorded from strata of Oligocene age. A record of *Tellina nevadensis* from the upper Miocene Santa Margarita Formation near Coalinga, Calif. (Adegoke, 1969, p. 131), is not of this species. It is based on an internal mold (UCMP 36765) that is much more acute posteriorly than *T. piercei* and that can only doubtfully be identified as a tellinid.

Localities.—USGS 9432, M3578, M3978, M4471?.

Subgenus OUDARDIA Monterosato, 1884

Tellina (Oudardia) emacerata Conrad

Plate 4, figure 11

1848. *Tellina oregonensis* Conrad, Am. Jour. Sci., 2d ser., v. 5, p. 432, fig. 5 [nomen dubium, Moore, 1963, p. 79].
1849. *Tellina emacerata* Conrad, U.S. Explor. Exped., Geology, v. 10, app. p. 725, atlas pl. 18, fig. 4.
1909. *Tellina clallamensis* Reagan, Kansas Acad. Sci. Trans., v. 22, p. 186–187, pl. 2, fig. 18.
1918. *Tellina oregonensis* Conrad. Clark, California Univ. Pubs., Dept. Geology Bull., v. 11, no. 2, p. 152–153, pl. 13, fig. 1, 4.
1923. *Tellina bodegensis* Hinds n. subsp.? Clark and Arnold, California Univ. Pubs., Dept. Geol. Sci. Bull., v. 14, no. 5, p. 149, pl. 22, figs. 7 and ?8.
1931. *Tellina (Peronidia) oregonensis* Conrad. Etherington, California Univ. Pubs., Dept. Geol. Sci. Bull., v. 20, no. 5, p. 83–84, pl. 10, figs. 6, 7.
1942. *Tellina emacerata* Conrad. Weaver, Washington Univ. [Seattle] Pubs. Geology, v. 5, p. 206, pl. 48, fig. 20, [not pl. 48, fig. 18].
1964. *Tellina emacerata* Conrad. Moore, U.S. Geol. Survey Prof. Paper 419, pl. 29, figs. 6, 7, 13, 14. [Imprint 1963.]

Type.—USNM 3494.

Type locality.—Astoria, Oreg. Astoria Formation, Miocene.

This species is represented by three specimens from USGS locality M3578 that are identical to specimens of middle Miocene age from the Astoria Formation near Newport, Oreg. (USGS loc. M2604). It is characterized by a prominent ridge running from the beaks to the posterior extremity and a flattened area between this ridge and the convex posterior dorsal margin.

Tellina emacerata has been perhaps more commonly known as *T. oregonensis* Conrad (1848), a poorly illustrated species that seems best regarded as a nomen dubium because the type has been lost (Moore, 1963, p. 79). *T. emacerata* is assigned to the subgenus *Oudardia* on the basis of the slanting internal rib near the anterior margin of the valves. This rib is only faintly discernible on the specimen from the Wygal Sandstone Member of the Temblor Formation, apparently because of poor preservation.

This is the first record of *Tellina emacerata* from strata of Oligocene age in the San Joaquin basin. It ranges from the late Oligocene to the late Miocene (Trask, 1922) in California but has a much shorter range in Oregon and Washington, having been reported only from strata of early and middle Miocene age (Durham, 1944; Moore, 1963).

Locality.—USGS M3578.

Subgenus TELLINELLA Mörch, 1853

Tellina (Tellinella) tenuilineata Clark

Plate 5, figures 2, 8

1918. *Tellina tenuilineata* Clark, California Univ. Pubs., Dept. Geology Bull., v. 11, no. 2, p. 153–154, pl. 10, figs. 1, 3, 5.
1929. *Tellina tenuilineata* Clark. Clark, Stratigraphy and faunal horizons of the Coast Ranges of California, pl. 16, fig. 1.

Types.— Holotype, UCMP 31169; paratype, UCMP 11128.

Type locality.—UCMP 1131, ½ mile southwest of Walnut Creek, Contra Cosa County, Calif., in creek bed about 100 yards east of Oakland and Antioch bridge. Altitude 150 feet. San Ramon Sandstone, early Miocene(?).

Three specimens of this distinctive tellinid are in the collections from the lowest sandstone member of the Temblor Formation. They are relatively more elongate than Clark's type specimen from the San Ramon Sandstone, and one specimen (pl. 5, fig. 2) is much more strongly flexed posteriorly than the holotype. This condition is attributed to deformation because the other specimens are only very slightly flexed.

In addition to occurrences in the San Ramon Sandstone (Clark, 1918), *Tellina tenuilineata* has been reported from the San Juan Bautista Formation (Allen, 1945) and from middle Miocene localities in the Temblor Formation (Loel and Corey, 1932).

Localities.—USGS 5149, 9432, M3578, M4466?.

Subgenus?

Tellina cf. T. townsendensis Clark

Plate 6, figure 7

Two poorly preserved specimens of an elongate tellinid from USGS locality M3578 seem to represent the Oligocene species *Tellina townsendensis* Clark (1925, p. 94, pl. 12, figs. 11, 12) from Washington. Records of this species from Washington (Durham, 1944; Clark, 1925) are from the lower part of the "Lincoln Stage": Durham's (1944) *Molopophorus stephensoni* and *Molopophorus gabbi* Zones. This taxon differs from the "Lincoln Stage" species *Tellina aduncanasa* Hickman (1969, p. 55–56, pl. 6, figs. 7–12) in being somewhat longer and in having a broadly convex posterior dorsal margin.

Locality.—USGS M3578.

Tellina? cf. T. vancouverensis Clark and Arnold

Plate 4, figure 13

A very poorly preserved tellinid from USGS locality M3578 appears to be conspecific with *Tellina vancouverensis* Clark and Arnold (1923, p. 149–150, pl. 22, figs. 5, 6) from the Sooke Formation of southwestern Vancouver Island, British Columbia.

Locality.—USGS M3578.

Genus MACOMA Leach, 1819

Macoma arctata (Conrad)

Plate 5, figures 4, 7

1849. *Tellina arctata* Conrad, U.S. Explor. Exped., Geology, v. 10, app. p. 725, atlas pl. 18, figs. 3, 3a.

1909. *Tellina arctata* Conrad. Reagan, Kansas Acad. Sci. Trans., v. 22, p. 184, 186, pl. 2, figs. 16, 16a.

1909. *Tellina arctata* Conrad var. *juana* Reagan, Kansas Acad. Sci. Trans., v. 22, p. 186, pl. 1, fig. 17.

1912. *Macoma wynootcheensis* Weaver [in part], Washington Geol. Survey Bull. 15, p. 66, pl. 15, fig. 130 [not figs. 128, 129].

1929. *Macoma arctata* (Conrad). Clark, Stratigraphy and faunal horizons of the Coast Ranges of California, pl. 22, figs. 4, 6.

1931. *Macoma (Psammacoma) arctata* (Conrad). Etherington, California Univ. Pubs., Dept. Geol. Sci. Bull., v. 20, no. 5, p. 84–85, pl. 10.

?1932. *Macoma arctata* (Conrad). Loel and Corey, California Univ. Pubs., Dept. Geol. Sci. Bull., v. 22, no. 3, p. 227 (in part), pl. 43, fig. 2 [not fig. 1].

1942. *Macoma arctata* (Conrad). Weaver, Washington Univ. [Seattle] Pubs. Geology, v. 5, p. 208–209, pl. 49, figs. 3, 5, 12, pl. 59, fig. 15.

1942. *Macoma arctata* (Conrad) var. *wynoocheensis* Weaver. Weaver, Washington Univ. [Seattle] Pubs. Geology, v. 5, p. 209, pl. 49, fig. 8.

1958. *Macoma arctata* (Conrad). Hall, California Univ. Pubs., Dept. Geol. Sci. Bull., v. 34, no. 1, p. 55, pl. 8, fig. 4.

1964. *Macoma arctata* (Conrad). Moore, U.S. Geol. Survey Prof. Paper 419, p. 81, pl. 28, figs. 6, 7, 10, 11, 13, pl. 29, fig. 8. [Imprint 1964.]

1972. *Macoma arctata* (Conrad). Addicott, Soc. Econ. Paleontologists and Mineralogists, Pacific Sec., Bakersfield, Calif., 1972, Proc., pl. 1, fig. 14.

Type.—USNM 3489.

Type locality.—Astoria, Oreg. Astoria Formation, Miocene.

This species is characterized by moderately large, elongated valves that have posteriorly situated beaks and a fairly strong posterior flexure. It is somewhat similar to the living species, *Macoma nasuta* (Conrad), which has a higher shell and more centrally located beaks and which is more acute and more strongly flexed posteriorly.

Specimens in the Wygal Sandstone Member of the Temblor Formation constitute a range extension of this species. The lowest previously known stratigraphic occurrence in California is from the early Miocene "Vaqueros Stage" (Loel and Corey, 1932, p. 227). *Macoma arctata* also occurs in strata of early Miocene age in northwestern Oregon where it is found in the Nye Mudstone of the Newport embayment in association with mollusks referable to the upper part of the "Blakeley Stage" (USGS loc. M3630). This species is widespread in strata of middle Miocene age from southern California to the Gulf of Alaska where there is an unrecorded occurrence in the lower part of the Yakataga Formation (Saburo Kanno, written commun., July 1970). It is not known to occur in the late Miocene.

This is one of the few stratigraphic records of large species of *Macoma* from pre-Miocene strata of the Pacific coast. None is recorded from the Oligocene of western Washington (Tegland, 1933; Durham, 1944) or western Oregon (Warren and others, 1945; Vokes and others, 1949). There is, however, a middle Oligocene record from the San Emigdio Mountains at the southern margin of the San Joaquin basin in California—*Macoma* cf. *M. nasuta* (Conrad) by Wagner and Schilling (1923, p. 248). This taxon, which occurs with *Acila shumardi* in the lower part of the Pleito Formation of Wagner and Schilling (1923), could conceivably represent *M. arctata*.

The holotype of Weaver's *Macoma wynootcheensis* (1912, p. 66, pl. 15, fig. 130) is *M. arctata*. The other specimens from the type locality (Weaver, 1912, pl. 15, figs. 128, 129), which is in the Astoria Formation (Gower and Pease, 1965) in the vicinity of Montesano, Wash., have extremely elongate valves and beaks that are situated unusually close to the posterior margin. These may represent an extremely variable form of *M. arctata*, or an entirely different species.

Localities.—USGS 5149, M3280, M3281, M3578, M3579 cf., M3772, M4466, M4468, M4469, M4471 cf., M4472?.

Genus HETEROMACOMA Habe, 1952

Heteromacoma rostellata (Clark)

Plate 5, figures 1, 3, 6, 9–11;
plate 6, figures 2, 4, 14

1918. *Metis rostellata* Clark, California Univ. Pubs., Dept. Geology Bull., v. 11, no. 2, p. 154–155, pl. 9, fig. 7.
1923. *Metis vancouverensis* Clark and Arnold, California Univ. Pubs., Dept. Geol. Sci. Bull., v. 14, no. 5, p. 150, pl. 22, figs. 3, 4.
1932. *Macoma sespeensis* Loel and Corey, California Univ. Pubs., Dept. Geol. Sci. Bull., v. 22, no. 3, p. 228–229, pl. 43, figs. 10–12.
1933. *Poromya* n. sp. Tegland, California Univ. Pubs., Dept. Geol. Sci. Bull., v. 23, no. 3, p. 92.
1942. *Poromya teglandae* Weaver, Washington Univ. [Seattle] Pubs. Geology v. 5, p. 121–122, pl. 25, fig. 23.
1942. *Apolymetis vancouverensis* (Clark and Arnold). Weaver, Washington Univ. [Seattle] Pubs. Geology, v. 5, p. 221, pl. 50, fig. 17.
1944. *Apolymetis twinensis* Durham, California Univ. Pubs., Dept. Geol. Sci. Bull., v. 27, no. 5, p. 150, pl. 13, fig. 7.
1951. *Macoma sespeensis* Loel and Corey. Lutz, California Univ. Pubs., Dept. Geol. Sci. Bull., v. 28, no. 13, p. 387–388, pl. 16, figs. 5, 6.
1963. *Apolymetis* cf. *A. sespeensis* (Loel and Corey). Kleinpell and Weaver, California Univ. Pubs., Dept. Geol. Sci. Bull., v. 43, p. 207, pl. 38, fig. 2.
1966. *Macoma (Heteromacoma) vancouverensis* (Clark and Arnold). Addicott, Jour. Paleontology, v. 40, no. 3, p. 644–645, pl. 76, figs. 1, 4.
1969. *Macoma (Heteromacoma) vancouverensis* (Clark and Arnold). Hickman, Oregon Univ. Mus. Nat. History Bull. 16, p. 58–59, pl. 7, figs. 3, 5, 7.
1972. *Heteromacoma rostellata* (Clark). Addicott, Soc. Econ. Paleontologists and Mineralogists, Pacific Sec. Bakersfield, Calif., 1972, Proc., pl. 1, figs. 1, 6.

Type.—UCMP 11120.

Type locality.—UCMP 1131, ½ mile southwest of Walnut Creek, Contra Costa County, Calif., in creek bed about 100 yards east of Oakland and Antioch bridge. Altitude 150 feet. San Ramon Sandstone, early Miocene(?).

Heteromacoma rostellata is an unusually variable species, as suggested by the number of specific names included in the synonymy. A large population of mature individuals represented in the collection from USGS locality M3280 clearly demonstrates the range of variation in outline of the valves. The most common forms are of subquadrate (pl. 5, figs. 10 and 11; pl. 6, fig. 2) and elongate shape (pl. 5, fig. 9; pl. 6, fig. 4); a less common form is suborbicular in outline (pl. 5, figs. 1, 3, 6; pl. 6, fig. 14).

Some of the subquadrate specimens resemble the veneroid genus *Pitar*, particularly those in which the posterior part of the valve has been broken off. This form was originally described by Clark (1918, p. 154–155, pl. 9, fig. 7) as *Metis rostellata* from the San Ramon Sandstone of Contra Costa County, Calif.

The elongate form was described by Loel and Corey (1932, p. 228–229, pl. 43, figs. 10–12) as *Macoma sespeensis* from the Vaqueros Formation of coastal California.

The suborbicular form that was named *Metis vancouverensis* by Clark and Arnold (1923, p. 150, pl. 22, figs. 3, 4) was based on specimens from the lower Miocene(?) Sooke Formation of southwestern Vancouver Island, British Columbia. An extreme variant of this form, almost suborbicular in outline, from the upper member of the Twin River Formation of western Washington (Addicott, 1966), was named *Poromya teglandae* by Weaver (1942, p. 121–122, pl. 25, fig. 23).

Variation in this taxon was first recognized by Kleinpell and Weaver (1963, p. 207), who suggested that *Poromya teglandae, Macoma sespeensis*, and *Apolymetis twinensis* were synonyms. Subsequently, Addicott (1966) and Hickman (1969) extended this treatment to include the suborbicular species *Metis vancouverensis* Clark and Arnold in this taxon. The present concept of this species further includes *Metis rostellata* Clark.

Primmer (1965) first assigned *Macoma sespeensis* and *Metis rostellata* to *Heteromacoma*, a very shallow-water genus that is living off Japan and Korea (Kira, 1962, p. 172), and included these two species in a new subgenus, which he differentiated from *Heteromacoma* s. s. principally because of a somewhat shorter ligament and related hinge structure. In recognizing these as distinct species, he contrasted the elongate shape of *H. sespeensis* with the subquadrate shape of *H. rostellata* and further indicated minor differences in ligamental width and surface of the nymph plate. However, specimens from the middle Oligocene, lower part of the Pleito Formation of Wagner and Schilling (1923, their loc. 3179) of the San Emigdio Mountains seemed to indicate that these differences were not constant and that the two taxa might intergrade (Primmer, 1965, p. 137).

The genus *Heteromacoma* is characterized by a prominent sulcus extending from near the beaks to the posterior ventral region of the valves where it is reflected by a shallow indentation in the margin, an immersed ligament set on a deeply sunken ligamental groove, and a pseudolunule (Keen, 1962). Along the Pacific coast of North America the genus ranges from the middle Oligocene "Lincoln Stage" or Refugian Stage to the middle Miocene "Temblor Stage." Its geographic distribution during the Oligocene and the early Miocene extended from southern California (Kleinpell and Weaver, 1963; Loel and Corey, 1932) to southwestern British Columbia (Clark and Arnold, 1923). The highest stratigraphic occurrence, in strata of middle Miocene age, is in northern California where it occurs in the Sobrante Sandstone of the San Francisco Bay area (Lutz, 1951).

Localities.—USGS 5149, M3280, M3281, M3578, M3772, M3978, M3979, M3984, M4466, M4468, M4469, M4470, M4471, M4472, M4473.

Family VENERIDAE
Genus AMIANTIS Carpenter, 1864
Amiantis mathewsoni (Gabb)

Plate 7, figures 1, 4, 8, 13, 14

1866. *Chione mathewsonii* Gabb, California Geol. Survey, Paleontology, v. 2, sec. 1, pt. 1, p. 23, pl. 5, fig. 39.

1918. *Antigona (Artena) mathewsonii* (Gabb). Clark, California Univ. Pubs., Dept. Geology Bull., v. 11, no. 2, p. 143–144, pl. 15, figs. 5–7.

?1918. *Antigona (Artena) neglecta* Clark, California Univ. Pubs., Dept. Geology Bull., v. 11, no. 2, p. 144, pl. 8, figs. 3, 4, 6.

?1918. *Antigona (Ventricola) undosa* Clark, California Univ. Pubs., Dept. Geology Bull., v. 11, no. 2, p. 145, pl. 8, figs. 1, 2, 5.

1930. *Amiantis? mathewsonii* (Gabb). Stewart, Acad. Nat. Sci. Philadelphia Spec. Pub. 3, p. 245–246, pl. 14, fig. 2.

1963. *Amiantis(?) mathewsonii* (Gabb). Kleinpell and Weaver, California Univ. Pubs. Geol. Sci., v. 43, p. 204, pl. 35, figs. 8, 9.

Lectotype.—ANSP 4532 (designated by Stewart, 1930).

Type locality.—Miocene(?) Martinez, Calif. Presumably from the San Ramon Sandstone.

This species occurs abundantly in most of the collections from the Wygal Sandstone Member of the Temblor Formation. Well-preserved specimens are characterized by coarse, somewhat irregular concentric lamellae between which are very fine concentric threads. The coarse lamellae are sharp edged and closely spaced anteriorly, posteriorly, and ventrally. In the middle part of the valve, these lamellae terminate in a sharp edge that is reflected dorsally. There is a well-developed escutcheon that is bordered, on the left valve, by a strong cord. The pallial sinus is deep, and the apex reaches the anterior half of the valve.

Assignment to *Amiantis* has been questioned by some previous workers (Stewart, 1930, 1946; Kleinpell and Weaver, 1963), possibly because the nature of the pallial sinus and the dentition of the right valve were not known. The pallial sinus is similar to that of the type of *Amiantis, A. callosa* (Conrad) but differs in having a less sharply pointed apex. There are anterior lateral teeth in both valves; the right anterior lateral, however, is rather weak. The right anterior cardinal and the middle cardinal are sharply bifid (pl. 7, fig. 13), differing from *A. callosa.*

A wide range of variation in the shape of the valves is exhibited by the specimens at hand. Most are subtrigonal to subquadrate depending on the convexity of the posterior dorsal slope. Specimens of *Amiantis* from USGS locality M3578 are especially variable. They can be segregated into two taxa, one of which is relatively much more elongated posteriorly than *A. mathewsoni* (pl. 7, figs. 6, 7) and may represent a new species.

The range of variation in shape and sculpture within individual collections seems sufficiently broad to regard Clark's (1918) species *Antigona neglecta* and *A. undosa* as probable synonyms of *A. mathewsoni* with which they occur in the San Ramon Sandstone of Contra Costa County, Calif., the probable formation from which the latter species was described by Gabb (1866).

Records of this species from the middle Miocene "Temblor Stage" (Schenck and Keen, 1940; Stewart, 1946; Adegoke, 1969) are doubtful. Schenck and Keen's record from the Olcese Sand of the eastern margin of the San Joaquin basin are based on a relatively smooth, subquadrate taxon whose dentition is entirely different from *Amiantis mathewsoni.* The middle Miocene taxon (pl. 7, figs. 2, 3, 11) has a much narrower hinge plate and a broad, rather than bladelike middle cardinal in the right valve, and the right posterior cardinal is not sharply bifid as on *A. mathewsoni.* The specimens from the Olcese Sand are similar to *A. diabloensis* (Anderson, 1905) but seem to represent an undescribed species because of the much heavier middle and posterior cardinal teeth in the left valve and the more elongate, less tumid valves.

A doubtful record from the Temblor Formation on Reef Ridge, Fresno County, Calif. (Stewart, 1946, USGS loc. 14402), is of a relatively smooth, quadrate specimen whose partially exposed hinge plate is much narrower anteriorly than on *A. mathewsoni.* Adegoke's (1969) unfigured hypotype from the Temblor Formation at Reef Ridge (UCMP 32532) is a poorly preserved specimen that is generically indeterminate.

Amiantis mathewsoni ranges from the middle Oligocene to the late Oligocene or early Miocene. Its lowest stratigraphic occurrences are in the middle part of the Gaviota Formation of Kleinpell and Weaver (1963) and the upper part of the San Emigdio Formation of Wagner and Schilling (1923). The highest occurrence is in the San

Ramon Sandstone of Clark (1918), which may be as young as early Miocene in the sense of the Pacific megafaunal chronology of Weaver and others (1944). There are no authenticated records, however, in the lower Miocene Vaqueros Formation of Loel and Corey (1932).

Localities.—USGS 5149, M3280, M3578, M3579, M3772, M3972, M3978, M3979, M3984 cf., M4466?, M4468 cf., M4469 cf.

Amiantis n. sp.?

Plate 6, figure 6; plate 7, figures 6, 7

Several poorly preserved specimens in the collection from USGS locality M3578 have exceptionally elongate valves and a relatively long posterior dorsal slope. Although the valves appear to be somewhat decorticated and are clearly thinner than on *A. mathewsoni,* the sculptural pattern is similar as are details of the escutcheon, lunule, and pallial sinus. There are several other specimens in this collection that are clearly referable to *A. mathewsoni.* They are variable in outline but do not seem to be intergradational with the elongate specimens that are here doubtfully considered to represent a new species. The hinge of this taxon is not known, but the pallial sinus is typical of *Amiantis*; it is deep and consists of a linear dorsal limb and slightly concave ventral limb (pl. 7, fig. 6). The apex, as in *A. mathewsoni,* is not sharply pointed.

Localities.—USGS M3578, M3772?, M4466.

Genus CLEMENTIA Gray, 1842
Subgenus EGESTA Conrad, 1845

Clementia (Egesta) pertenuis (Gabb)

Plate 7, figures 9, 12; plate 8, figures 1, 3, 19

1866. *Venus kennerlyi* Reeve?. Gabb, California Geol. Survey, Paleontology, v. 2, sec. 1, pt. 1, p. 22, pl. 5, fig. 37.
1869. *Venus pertenuis* Gabb, California Geol. Survey, Paleontology, v. 2, sec. 1, pt. 2, p. 55–56, pl. 5, fig. 37.
1910. *Venus pertenuis* Gabb. Arnold, U.S. Geol. Survey Bull. 396, pl. 8, fig. 3. [Imprint 1909.]
1910. *Venus pertenuis* Gabb. Arnold and Anderson, U.S. Geol. Survey Bull. 398, pl. 30, fig. 3.
1926. *Clementia (Egesta) pertenuis* (Gabb). Woodring, U.S. Geol. Survey Prof. Paper 147–C, p. 40–42, pl. 16, figs. 1–6.
1940. *Clementia pertenuis* (Gabb). Schenck and Keen, California fossils for the field geologist, pl. 34, figs. 1, 2.
1958. *Clementia pertenuis* (Gabb). Hall, California Univ. Pubs. Geol. Sci. Bull., v. 34, no. 1, p. 54, pl. 3, fig. 2.

Type.—UCMP 12000.

Type locality.—At Griswold's [Ranch] on road to New Idria, San Benito County, Calif. Temblor Formation, Miocene.

Specimens of *Clementia pertenuis* from the Wygal Sandstone Member are subquadrate to subtrigonal in outline. They are sculptured by broad concentric folds on the dorsal part of the valves that grade, ventrally, into fine, irregular lines of growth.

This is the initial record of the genus *Clementia* from strata of Oligocene age along the Pacific coast of North America. The lowest previously recorded stratigraphic occurrence in this region is from strata assigned to the provincial lower Miocene (Woodring, 1926; Cushman and LeRoy, 1938). A late Oligocene occurrence from the Pacific coast of South America has been noted, however, by Woodring (1926, p. 31).

Localities.—USGS 5149, 9432, M3280, M3578, M3579, M3772, M3978, M4466, M4468, M4469.

Genus DOSINIA Scopoli, 1777
Subgenus DOSINIA s. s.

Dosinia (Dosinia) whitneyi (Gabb)

Plate 6, figures 1, 3, 9, 12, 13;
plate 7, figures 5, 10

1866. *Chione whitneyi* Gabb, California Geol. Survey, Paleontology, v. 2, sec. 1, pt. 1, p. 23–24, pl. 5, fig. 40.
1866. *Dosinia mathewsonii* Gabb, California Geol. Survey, Paleontology, v. 2, p. 57, pl. 15, fig. 16.
1918. *Dosinia (Dosinidia) mathewsoni* Gabb. Clark, California Univ. Pubs., Dept. Geology Bull., v. 11, no. 2, p. 141–142, pl. 7, figs. 1, 2, 5, 6, 9.
1918. *Dosinia (Dosinidia) whitneyi* (Gabb). Clark, California Univ. Pubs., Dept. Geology Bull., v. 11, no. 2, p. 143, pl. 7, figs. 3, 4.
1930. *Dosinia mathewsonii* Gabb. Stewart, Acad. Nat. Sci. Spec. Pub. 3, p. 230–232, pl. 14, fig. 7.
1951. *Dosinia (Dosinidia) whitneyi* (Gabb). Lutz, California Univ. Pubs., Dept. Geol. Sci. Bull., v. 28, no. 13, p. 389–390, pl. 16, figs. 1, 2.
1959. *Dosinia (Dosinidia) mathewsonii* Gabb. Durham, Veliger, v. 2, no. 2, pl. 4, figs. 2, 3.
1964. *Dosinia (Dosinia) whitneyi* (Gabb). Moore, U.S. Geol. Survey Prof. Paper 419, p. 73–74, pl. 24, figs. 1–10. [Imprint 1963.]
1972. *Dosinia whitneyi* (Gabb). Addicott, Soc. Econ. Paleontologists and Mineralogists, Pacific Sec., Bakersfield, Calif., 1972, Proc., pl. 1, fig. 4.

Type.—UCMP 11999.

Type locality.—Near Martintez Creek, Contra Costa County, California. San Ramon Sandstone, early Miocene(?).

Types of Dosinia mathewsonii *Gabb.*—ANSP 4485 (syntypes).

Type locality.—Probably from the San Ramon Sandstone near Walnut Creek, Contra Costa County, Calif. (Stewart, 1930, p. 231).

Discrimination of *Dosinia mathewsoni* Gabb (1866), also from the San Ramon Sandstone, from *D. whitneyi* principally on the basis of a more angular dorsal margin (Clark, 1918; Adegoke, 1969) seems to have been made on comparison of differently oriented figures. Moore's (1963) illustrations of the type of *D. whitneyi* and of one of Clark's (1918) specimens of *D. mathewsoni* indicate that one, rather than two, species is represented.

Dosinia whitneyi is represented by poorly preserved specimens from the so-called Phacoides Sand. These vary somewhat in the degree of inflation of the valves and in the angularity of the dorsal margin. The exterior is well preserved only on a few of the smaller specimens (pl. 7, fig. 5).

This species ranges from the upper Oligocene to the middle Miocene in California. During the middle Miocene, it ranged as far north as northwestern Washington (Arnold and Hannibal, 1913).

Localities.—USGS 9432, M3280, M3578, M3772, M3979, M4466, M4468?, M4469 cf., M4470?, M4471, M4472.

Genus PITAR Römer, 1857

Pitar sp.

Plate 6, figure 10

An internal mold from USGS locality M3978 may represent *Pitar*. It is very strongly inflated and has a subquadrate outline that is more nearly equidimensional than *P.* (*Katherinella*) cf. *P.* (*K.*) *californica*. It might represent *P. lorenzana* (Clark, 1918, p. 147–148, pl. 10, figs. 2, 4), a comparably large species from the San Ramon Sandstone, but it appears to have a much less convex posterior dorsal slope and to be more produced anteriorly.

Locality.—USGS M3978.

Subgenus KATHERINELLA Tegland, 1929

Pitar (Katherinella) cf. P. (K.) californica (Clark)

Plate 6, figures 8, 11

Several poorly preserved specimens from localities in the Wygal Sandstone Member are similar to *Pitar californica* (Clark, 1918, pl. 11, figs. 2, 3, 4, 11) from the San Ramon Sandstone of Contra Costa County, Calif. The figured specimens differ, however, in being relatively more produced anteriorly. Both specimens are more elongate than any species described from the middle Tertiary of the Pacific Coast States.

Assignment of this species to *Katherinella* is suggested by the pouting lunule that is set off by an incised line (Clark, 1918, p. 148), a feature similar to that on specimens of *Pitar* (*Katherinella*) *angustifrons* (Conrad) from the Astoria Formation of coastal Oregon (USGS loc. M2116). A similar, faintly incised line occurs on one of the specimens from USGS locality M3280.

Localities.—USGS 5149?, M3280, M3772?, M4466, M4472.

Genus SECURELLA Parker, 1949

Securella cf. S. cryptolineata (Clark)

Plate 6, figure 5

A poorly preserved specimen of *Securella* in the collection from USGS locality M3280 resembles, very closely, some of the topotypes of *S. cryptolineata* (Clark) described and figured by Parker (1949, p. 589–590, pl. 94, figs. 10, 11, 13) from the San Ramon Formation of the Mount Diablo area, California. The specimen is heavy shelled and has a relatively broad hinge plate. Although the surface is deeply eroded and the consequent pattern of widely spaced ribs does not appear to be that of *Securella*, there is a small area near the anterior margin of the shell on which the original surface sculpture of closely spaced concentric lamellae characteristic of this genus is preserved.

This species has been doubtfully identified from the presumably correlative upper part of the Pleito Formation of Wagner and Schilling (1923) of the San Emigdio Mountains at the southern margin of the San Joaquin basin (Wagner and Schilling, 1923, p. 245–246) as *Chione* cf. *C. lineolata* Clark.

Locality.—USGS M3280.

Order MYOIDA
Family MYIDAE
Genus PANOPEA Menard, 1807

Panopea ramonensis (Clark)

Plate 8, figure 20

1925. *Panope ramonensis* Clark, California Univ. Pubs., Dept. Geol. Sci. Bull., v. 15, no. 4, p. 106, pl. 10, figs. 2, 3.
1929. *Panope ramonensis* Clark. Clark, Stratigraphy and faunal horizons of the Coast Ranges of California, pl. 15, figs. 5, 7.
1942. *Panope ramonensis* Clark. Weaver, Washington Univ. [Seattle] Pubs. Geology, v. 5, p. 263–264, pl. 59, fig. 11.
1969. *Panopea* (*Panopea*) *ramonensis* Clark. Hickman, Oregon Univ. Mus. Nat. History Bull. 16, p. 65–66, pl. 8, figs. 8, 12.

Types. — Holotype, UCMP 30330; paratype, UCMP 30331.

Type locality.—UCMP 1131, ½ mile southwest of Walnut Creek, Contra Costa County, Calif. in creek bed about 100 yards east of Oakland and Antioch bridge. Altitude 150 feet. San Ramon Sandstone, early Miocene(?).

An elongate *Panopea* from the Wygal Sandstone Member of the Temblor Formation differs from the common middle and late Cenozoic species *P. abrupta* (Conrad) by having consistently longer valves. Some of the specimens have medially situated beaks as on the holotype from the San Ramon Sandstone. On other specimens (pl. 8, fig. 20), the beaks are

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located anterior to the middle of the valves. Specimens from USGS locality M3280 have a faint sulcus extending from near the beaks to the posterior ventral margin similar to the sulcus on the paratype of *P. ramonensis* (Clark, 1925, pl. 10, fig. 2).

Panopea estrellana (Conrad, 1857b, p. 194, pl. 7, fig. 5), a late Miocene species from the California Coast Ranges, is less elongate than *P. ramonensis*. Although recognized by some workers as a separate and distinct species (Durham, 1944; Adegoke, 1969), it seems to be best treated as a synonym of *P. abrupta* as concluded by Moore (1963).

This species ranges from strata of middle Oligocene (Primmer, 1964) to middle Miocene (Weaver, 1942) age on the Pacific coast. It may be represented in the Pleito Formation of Wagner and Schilling (1923, check list 2) of the southern margin of the San Joaquin basin by their *Panope* cf. *P. estrellana*.

Localities.—USGS 5149, M3280, M3578, M3772, M3978, M4466?, M4469, cf., M4473.

Class SCAPHOPODA
Family DENTALIIDAE
Genus DENTALIUM Linné, 1758

Dentalium laneensis Hickman

Plate 8, figure 14

1969. *Dentalium* (*?Fissidentalium*) *laneensis* Hickman, Oregon Univ. Mus. Nat. History Bull. 16, p. 74, pl. 9, figs. 1–6.

1972. *Dentalium laneensis* Hickman. Addicott, Soc. Econ. Paleontologists and Mineralogists Pacific Sec., Bakersfield, Calif., 1972, Proc., pl. 1, fig. 9.

Types.—Holotype, UO 27332; paratypes, UO 27333–27339.

Type locality.—UO 2538, roadcut at 30th Ave. and Agate St., Eugene, Oreg. (NW¼ sec. 8, T. 18 S., R. 3 W., Eugene 15′ quad.). Eugene Formation, Oligocene.

Dentalium laneensis is represented by a few incomplete specimens from the Wygal Sandstone Member. They are characterized by a relatively large, thick shell sculptured by numerous broad longitudinal ribs between which are intercalated finer secondary ribs. *D. radiolineata* Clark (1918, p. 191, pl. 22, fig. 12) from the early Miocene(?) San Ramon Sandstone of central California differs from *D. laneensis* in having fewer radial ribs that are narrow and crested in cross section.

This is the only record of this species from California as well as the only record from strata of late Oligocene age, previous records being from the lower and middle Oligocene Eugene Formation of western Oregon. The species also occurs in the middle Oligocene Pittsburg Bluff Formation of western Oregon (E. J. Moore, written commun., Oct. 1971).

Localities.—USGS M3280, M3281, M3578, M3772, M3978.

FOSSIL LOCALITIES

USGS localities (Washington, D.C., register)

Locality *Description*

4941. Three-fourths of a mile north of Miller Brothers ranch house beside their grade road, 6 miles east of Annette [south side of road between Franciscan Creek and Miller Flats, about 200 ft south of ridge crest; SW¼SW¼ sec. 36, T. 26 S., R. 17 E., Packwood Creek 7½′ quad.]. Vaqueros Sandstone [Carneros Sandstone Member(?) of the Temblor Formation, about 1,000 ft stratigraphically below the base of the Media Shale Member.] Same as USGS loc. M2633. Collected by Ralph Arnold, 1905.

5149. Three-fourths of a mile southwest of Carneros Spring, SW¼ sec. 5, T. 29 S., R. 20 E. Vaqueros Sandstone [Wygal Sandstone Member of the Temblor Formation]. Same as USGS loc. M4469. Collected by Ralph Arnold, 1908.

6622. North bank of Kern River, 10–11 miles northeast of Bakersfield. Float rock at base of bluff below where fossils were collected at USGS loc. 6623. Middle part of lower Miocene. These fossils are unquestionably from beds in the cliffs at whose foot they lie and are from the same horizon as those of USGS loc. 6623 [lower part of the Round Mountain Silt, middle Miocene]. Collected by R. W. Pack and J. D. Northrop, October 1911.

6627. Twelve miles N. 30° E. of Bakersfield. In center W½ sec. 36, T. 27 S., R. 28 E. In small arroyo tributary to Adobe Canyon from west. About 1 mile above its mouth. In first arroyo upstream from 1,070-ft hill. Middle part of lower Miocene [lower part of the Olcese Sand, middle Miocene]. Collected by R. W. Pack, Sept. 2, 1911, and A. T. Schwennessen, Aug. 31, 1911.

9427. Basal beds of the Vaqueros [Temblor Formation], on hill slope just south of Carneros Spring near center of sec. 5, T. 29 S., R. 20 E. Collected by Walter English, 1916.

9432. On east side of creek near streambed, about 125 ft east of bluff of Point of Rocks Sandstone. Near center of west line of SE¼ sec. 18, T. 29 S., R. 20 E. Basal Vaqueros Sandstone [Wygal Sandstone Member of the Temblor Formation]. Collected by W. S. W. Kew, 1916.

USGS Cenozoic localities (Menlo Park, Calif., register)

M1596. Pelecypod biostrome on east side of southerly trending canyon, 1,400 ft north, 100 ft west of SE. cor. sec. 24, T. 28 S., R. 28 E., Oil Center quad. (1954 ed.). Near the top of the Olcese Sand. Same as UCMP loc. 1603. Collected by W. O. Addicott, 1962.

M1599. Bottom of southeasterly trending gully 900 ft south, 150 ft east of NW. cor. sec. 33, T. 28 S., R. 29 E., Rio Bravo Ranch quad. (1954 ed.). Near the top of the Olcese Sand, 17 ft stratigraphically below USGS loc. M1600. Same as UCMP loc. B1599. Collected by W. O. Addicott, 1962.

Locality	Description
M1802.	Seacliff exposure north of Marine Gardens, a locally named point east of Gull Rock, 350 ft south, 3,900 ft west of NE. cor. sec. 32, T. 9 S., R. 11 W., Cape Foulweather 15' quad. Oregon. Astoria Formation. Collected by W. O. Addicott, 1963.
M2544.	Intertidal and spray zone exposure at mouth of Kirby Creek about 7,200 ft west of provincial highway 14 bridge over Muir Creek, Sooke 92 B/5 quad. Renfrew District, Vancouver Island, British Columbia. Sooke Formation. Collected by W. O. Addicott, 1965.
M2631.	About one-fourth of a mile south of the mouth of Cedar Canyon on east side of road, 1,800 ft south, 1,550 ft east of NW. cor. sec. 28, T. 27 S., R. 18 E., Packwood Creek 7½' quad. Agua Sandstone Member of the Temblor Formation, basal conglomeratic sandstone. Collected by W. O. Addicott, 1965.
M2632.	West-trending ridge south of Bitterwater Creek, 600 ft south, 1,400 ft east of NW. cor. sec. 27, T. 27 S., R. 18 E., Packwood Creek 7½' quad. Alt. 1,820 ft. Buttonbed Sandstone Member of the Temblor Formation. Collected by W. O. Addicott, 1965.
M2633.	On south side of Franciscan Creek–Miller Flats road, 600 ft north, 1,000 ft east of SW. cor. sec. 36, T. 26 S., R. 17 E., Packwood Creek 7½' quad. Carneros(?) Sandstone Member of the Temblor Formation, about 1,000 ft stratigraphically below the base of the Media Shale Member. Same as USGS loc. 4941. Collected by T. W. Dibblee, Jr., and W. O. Addicott, 1965.
M3280.	Minor saddle in northeast-trending ridge on south side of Media Agua Creek, 900 ft south, 500 ft east of NW. cor. sec. 23, T. 28 S., R. 19 E., Las Yeguas Ranch 7½' quad. Wygal Sandstone Member of the Temblor Formation, 6-ft-thick fossiliferous sandstone unconformably overlying the Eocene Point of Rocks Sandstone. Collected by Howard Sonneman and W. O. Addicott, 1967; H. C. Wagner, Saburo Kanno, and W. O. Addicott, 1969; W. O. Addicott, 1971.
M3281.	On south side of hill 2259 just below summit, 2,200 ft north, 1,000 ft west of SE. cor. sec. 22, T. 28 S., R. 19 E., Las Yeguas Ranch 7½' quad. Base of Wygal Sandstone Member of the Temblor Formation. Collected by Howard Sonneman and W. O. Addicott, 1967.
M3511.	8,900 ft south, 2,900 ft west of lat 35°00' N., long 119°32'30" W. East of Cuyama Ranch 7½' quad. Alt about 3,250 ft. Quail Canyon Sandstone Member of the Vaqueros Formation. Collected by J. G. Vedder, 1960.
M3578.	About 30–40 ft above unnamed stream flowing southwestward through the SW¼ sec. 15, T. 29, S., R. 20 E., 1,100 ft north, 2,200 ft west of SE. cor. sec. 15, T. 29 S., R. 20 E., Carneros Rocks 7½' quad. Wygal Sandstone Member of the Temblor Formation, collection from about 200 ft along strike in southwest-trending gullies. Collected by W. O. Addicott, May 1967.
M3579.	Northeast bank of southeast-flowing stream about 15 ft above bottom, 2,200 ft south 850 ft east of NW. cor. sec. 15, T. 29 S., R. 20 E., Carneros Rocks 7½' quad. Wygal Sandstone Member of the Temblor Formation. Collected by W. O. Addicott, 1967.
M3636.	North side of Chico Martinez Creek, approximately 2,100 ft west, 250 ft south of NE. cor. sec. 8, T. 29 S., R. 20, E., Carneros Rocks 7½' quad. Wygal Sandstone Member of the Temblor Formation. Collected by R. L. Pierce and T. W. Dibblee, Jr., 1967; W. O. Addicott, 1971.
M3747.	East-west-striking pelecypod biostrome on hillside west of Salt Creek, 850 ft north, 1,850 ft east of SW. cor. sec. 21, T. 10 N., R. 20 W., Pleito Hills 7½' quad. Pleito Formation of Wagner and Schilling (1923). Collected by W. O. Addicott, J. G. Vedder, and T. W. Dibblee, Jr., 1966.
M3772.	On southeast side of ridge paralleling Media Agua Creek about 200 feet above dirt road, 1,025 ft south, 200 ft east of NW. cor. sec. 23, T. 28 S., R. 19 E., Las Yeguas Ranch 7½' quad. Wygal Sandstone Member of the Temblor Formation. Same as USGS loc. M3280. Collected by W. O. Addicott, 1968.
M3978.	In bed of Temblor Creek, 1,000 ft south, 1,900 ft east of NW. cor. sec. 25, T. 29 S., R. 20 E., Carneros Rocks 7½' quad. Alt about 1,350 ft. Fossiliferous concretions at the top of the Wygal Sandstone Member of the Temblor Formation. Collected by H. S. Sonneman and W. O. Addicott, 1968.
M3979.	Top of prominent ledge above southeast-trending segment of first creek south of Zemorra Creek, 750 ft north, 2,750 ft west of SE. cor. sec. 16, T. 29 S., R. 20 E., Carneros Rocks 7½' quad. Alt about 2,450 ft. Wygal Sandstone Member of the Temblor Formation, collection from about 300 ft along the strike of a concretionary stratum about 20 ft above base of the Wygal. Collected by H. S. Sonneman and W. O. Addicott, 1968.
M3981.	On southwest side of northwest-trending ridge, 2,300 ft north, 800 ft west of SE. cor. sec. 25, T. 28 S., R. 19 E., Carneros Rocks 7½' quad. Alt about 1,460 ft. Lower part of the Carneros Sandstone Member of the Temblor Formation. Collected by H. S. Sonneman and W. O. Addicott, 1968.
M3982.	In bottom of north fork of Santos Creek, 1,300 ft north, 300 ft west of SE. cor. sec. 25, T. 28 S., R. 19 E., Carneros Rocks 7½' quad. Alt about 1,300 ft. Agua Sandstone Member of the Temblor Formation. Collected by H. S. Sonneman and W. O. Addicott, 1968; W. O. Addicott, 1971.
M3984.	Southwest side of small knoll encircled by 1,400-ft contour, 1,600 ft north of SE. cor. sec. 23, T. 28 S., R. 19 E., Las Yeguas Ranch 7½' quad. Alt about 1,330 ft. Basal 10 ft of the Wygal Sandstone Member of the Temblor Formation; collection from along 300 to 400 feet of strike of beds. Collected by H. S. Sonneman and W. O. Addicott, 1968.
M3985.	On south side of Stone Corral Creek, 600 ft south, 1,900 ft east of NW. cor. sec. 25, T. 28 S., R. 19 E., Las Yeguas Ranch 7½' quad. Alt about 1,330

Locality	Description
	ft. Wygal Sandstone Member of the Temblor Formation, basal 6–10 ft. Collected by H. S. Sonneman and W. O. Addicott, 1968.
M3986.	In bottom of gulch northeast of old side of MacDonalds Ranch (see USGS Bull. 406), 2,600 ft north 750 ft east of SW. cor. sec. 32, T. 27 S., R. 19 E., Shale Point 7½' quad. Alt about 1,235 ft. About 40 ft stratigraphically above the base of the Buttonbed Sandstone Member of the Temblor Formation. Collected by H. S. Sonneman and W. O. Addicott, 1968.
M3987.	Hillside west-southwest of stream junction, 500 ft north, 2,700 ft east of SW. cor. sec. 30, T. 27 S., R. 19 E., Shale Point 7½' quad. Alt about 1,350 ft. Buttonbed Sandstone Member of the Temblor Formation, brown sandstone concretions occurring about 30 ft above the base of the member. Collected by H. S. Sonneman and W. O. Addicott, 1968.
M3988.	Hillside west-southwest of stream junction, 550 ft north, 2,600 ft east of SW. cor. sec. 30, T. 27 S., R. 19 E., Shale Point 7½' quad. Alt about 1,375–1,950 ft. Buttonbed Sandstone Member of the Temblor Formation, basal 5 ft. Collection from about 150 ft along strike of beds. Collected by H. S. Sonneman and W. O. Addicott, 1968.
M4060.	Abundantly fossiliferous conglomeratic sandstone exposed in low sea cliff and isolated rock on east side of mouth of Kirby Creek, in land parcel 52, Sooke 92 B/5 quad., Renfrew District, Vancouver Island, British Columbia. Sooke Formation. Collected by W. O. Addicott, 1968.
M4464.	On northwest plunge of small northwest-trending ridge, 1,250 ft north, 1,350 ft east of SW. cor. sec. 24, T. 28 S., R. 19 E., Las Yeguas Ranch 7½' quad. Agua Sandstone Member of the Temblor Formation, *Crassostrea* bed. Collected by H. S. Sonneman and W. O. Addicott, 1968.
M4466.	East wall of north-northwest-trending tributary to Zemorra Creek, about 50 ft above gully bottom, 400 ft north, 1,200 ft west, of SE. cor. sec. 9, T. 29 S., R. 20 E., Carneros Rocks 7½' quad. Wygal Sandstone Member of the Temblor Formation, about 10–30 ft above the base. Collected by W. O. Addicott, 1971.
M4467.	In north-northwest-trending tributary to Zemorra Creek, 250 ft south, 950 ft west of NE. cor. sec. 16, T. 29 S., R. 20 E., Carneros Rocks 7½' quad. Wygal Sandstone Member of the Temblor Formation, basal 3 ft. Collected by W. O. Addicott, 1971.
M4468.	Southwest-facing hillside on east flank of Carneros Rocks anticline, 3,100 ft north, 800 ft west of SE. cor. sec. 5, T. 29 S., R. 20 E., Carneros Rocks 7½' quad. Wygal Sandstone Member of the Temblor Formation, lowest 20 ft. Collected by W. O. Addicott, 1971.
M4469.	Crest of east-trending ridge on north side of Chico Martinez Creek, 350 ft north, 1,200 ft east of SW. cor. sec. 5, T. 29 S., R. 20 E., Carneros Rocks 7½' quad. Alt about 1,960 ft. Wygal Sandstone Member of the Temblor Formation. Same as USGS loc. 5149. Collected by W. O. Addicott, 1971.
M4470.	East-northeast-trending ridge about one-fourth mile northwest of Carneros Creek, 450 ft north, 2,500 ft west of SE. cor. sec. 31, T. 28 S., R. 20 E., Carneros Rocks 7½' quad. Alt about 1,580 ft. Wygal Sandstone Member of the Temblor Formation. Collected by W. O. Addicott, 1971.
M4471.	South side of road along Carneros Creek, 2,200 ft south, 150 ft west of SE. cor. sec. 36, T. 28 S., R. 19 E. [in sec. 6, T. 29 S., R. 20 E.], Carneros Rocks 7½' quad. Wygal Sandstone Member of the Temblor Formation. Collected by W. O. Addicott, 1971.
M4472.	Near crest of 1,480-ft knoll on north side of Santos Creek, 550 ft north, 1,100 ft west of SE. cor. sec. 25, T. 28 S., R. 19 E., Carneros Rocks 7½' quad. Wygal Sandstone Member of the Temblor Formation. Collected by W. O. Addicott, 1971.
M4473.	Crest of south-trending ridge on north side of Media Agua Creek (about 200 ft south of hill 1814), 550 ft north, 2,750 ft east of SW. cor. sec. 15, T. 28 S., R. 19 E., Las Yeguas Ranch 7½' quad. Wygal Sandstone Member of the Temblor Formation, basal 2–3 ft. Collected by W. O. Addicott, 1971.
	California University Museum of Paleontology (Berkeley) localities (UCMP)
B1598.	At mouth of short Y-shaped gully approximately 200 yds north of abandoned sand and gravel plant, 1,200 ft south, 300 ft west of of NE. cor. sec. 5, T. 29 S., R. 29 E., Oil Center quad. (1950 ed.). Gray clean fine to very fine sand. Upper part of the Olcese Sand. Collected by W. O. Addicott, 1953, 1954.
B1599.	In second southeast-trending gully due east of hill 933 (Bakersfield quad.), NW¼NW¼ sec. 33, T. 28 S., R. 29 E., Caliente quad. (1914 ed.). Upper part of the Olcese Sand, approximately 80 ft stratigraphically below the base of the Round Mountain Silt. Same as USGS loc. M1599. Collected by W. O. Addicott, 1953, 1954.
	California University, Riverside, localities (UCR)
1106.	About 150 ft east of creekbed on east side of small shoulder which forms a bend in the creek, NE. cor. SW¼ sec. 15, T. 29 S., R. 20 E. Dark-brown-weathering, blue-gray limestone concretions in soft siltstone [Cymric Shale Member of the Temblor Formation]. About 10–30 ft stratigraphically below the "basal Miocene" [Wygal Sandstone Member of the Temblor Formation]. Collected by Eric Craig (field loc. EC 89A), 1931.
1235.	150 ft north, 50 ft east of SW. cor. sec. 14, T. 29 S., R. 20 E. Wygal Sandstone Member of the Temblor Formation. Collection from a 50-ft stratigraphic interval directly overying soft gray siltstone of the Cymric Shale Member. Collected by Eric Craig (field loc. EC 89), 1931.

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[Italic page numbers indicate major references and descriptions]

PLATES 1-9

[Contact photographs of the plates in this report are available, at cost, from U.S. Geological Survey Library, Federal Center, Denver, Colorado 80225]

PLATE 1

[Specimens are from the Wygal Sandstone Member of the Temblor Formation unless otherwise indicated]

FIGURES 1, 18. *Crenomytilus*? cf. *C.*? *arnoldi* (Clark) (p. 24).
1. Length 83 mm, height 35 mm. USNM 646511. USGS loc. M3578.
18. Length 120 mm, height 68 mm. USNM 646512. USGS loc. M3979.

2, 3, 5, 8. *Yoldia* (*Kalayoldia*) *tenuissima* Clark (p. 22).
2. Length 45 mm, height 24.5 mm. USNM 646513. USGS loc. M3578.
3. Length 48 mm, height 25.5 mm. USNM 646514. USGS loc. M3578.
5. Length 43 mm, height 23.5 mm. USNM 646515. USGS loc. M3578.
8. Length 31 mm, height 16 mm. USNM 646516. USGS loc. 6622. Round Mountain Silt, Kern River area, California, middle Miocene.

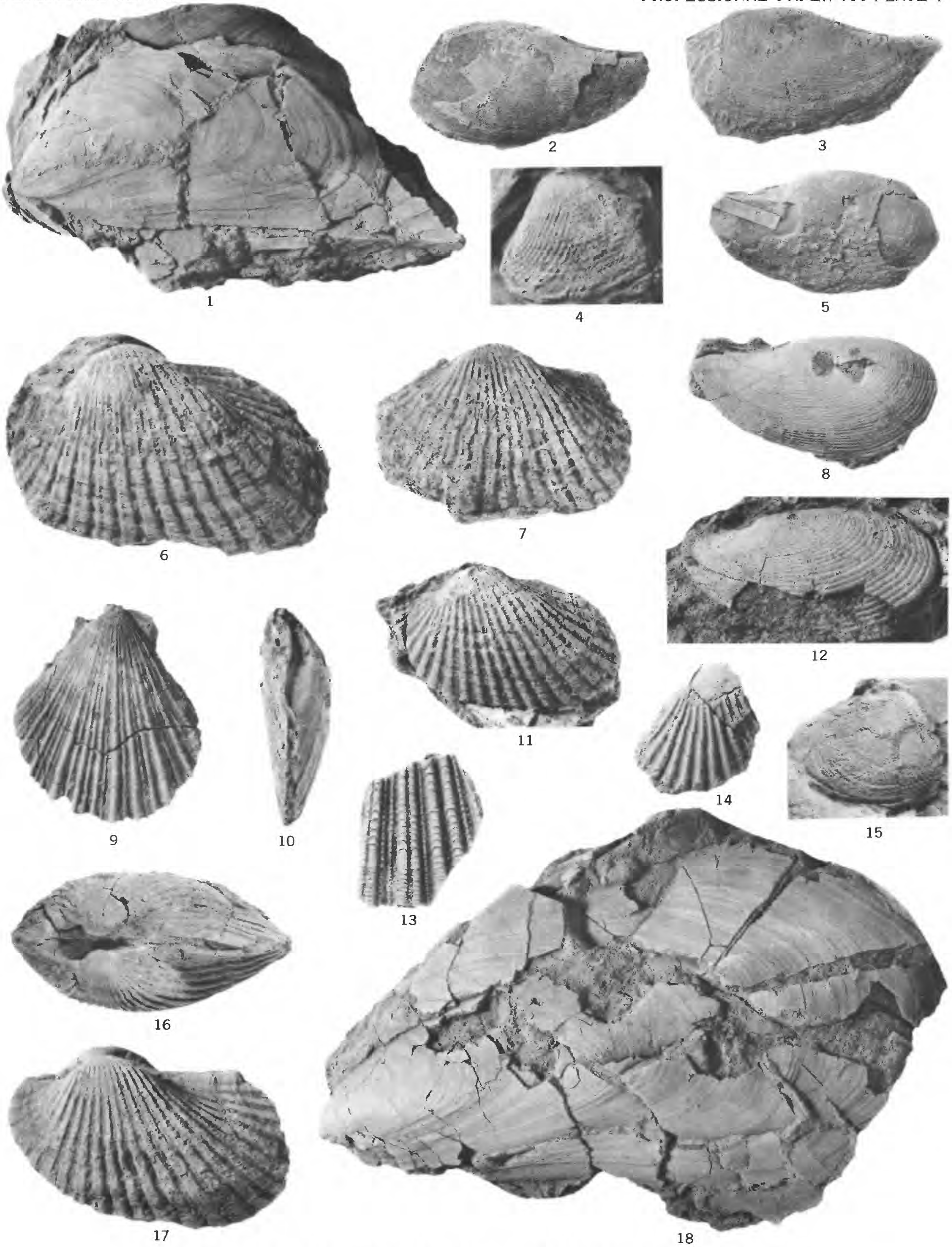
4, 15. *Acila* (*Truncacila*) *muta* Clark (p. 22).
4. Length 12 mm, height 10.5 mm. USNM 646517. USGS loc. M4471.
15. Length 12.2 mm, height 10.5 mm. USNM 646518. USGS loc. M4466.

6, 7, 11, 16, 17. *Anadara* (*Anadara*) *submontereyana* (Clark) (p. 23).
6. Length 30 mm, height 20 mm. USNM 646519. USGS loc. M3978.
7. Length 32 mm, height 22.5 mm. USNM 646520. USGS loc. M3978.
11. Length 20 mm, height 13 mm. USNM 646521. USGS loc. M3978.
16, 17. Length 26 mm, height 17 mm. USNM 646522. USGS loc. M3772.

9, 10, 13. *Vertipecten alexclarki* Addicott, n. sp. (p. 26).
9. Length 24 mm, height 28 mm. USNM 646523. USGS loc. M3280.
10. Height 42 mm, thickness 13.5. USNM 646524. USGS loc. M3636.
13. Height of fragment 33 mm. USNM 646525. USGS loc. M3280.

12. *Yoldia* (*Kalayoldia*) cf. *Y.* (*K.*) *carnarosensis* Clark (p. 23).
Length 32 mm. USNM 646526. USGS loc. M1596. Olcese Sandstone, Kern River area, California, middle Miocene.

14. *Leptopecten*? sp. (p. 26).
Height 24 mm. USNM 646527. USGS loc. M3280.



ACILA, ANADARA, CRENOMYTILUS?, LEPTOPECTEN, VERTIPECTEN, YOLDIA

PLATE 2

[All specimens are from the Wygal Sandstone Member of the Temblor Formation]

FIGURES 1, 3, 5, 8, 9. *Vertipecten alexclarki* Addicott, n. sp. (p. 26).

1. Length 89 mm, height 80 mm. USNM 646528. USGS loc. M3285.
3. Length 63 mm, height 82 mm. USNM 646529. USGS loc. M3772. Specimen deformed.
5. Height 40 mm. USNM 646530. USGS loc. M3579.
8. Length 66 mm, height 69 mm. USNM 646531. USGS loc. M3281.
9. Height 68 mm. USNM 646532. USGS loc. M3280.

2, 10. *Crassostrea eldridgei ynezana* (Loel and Corey) (p. 27).

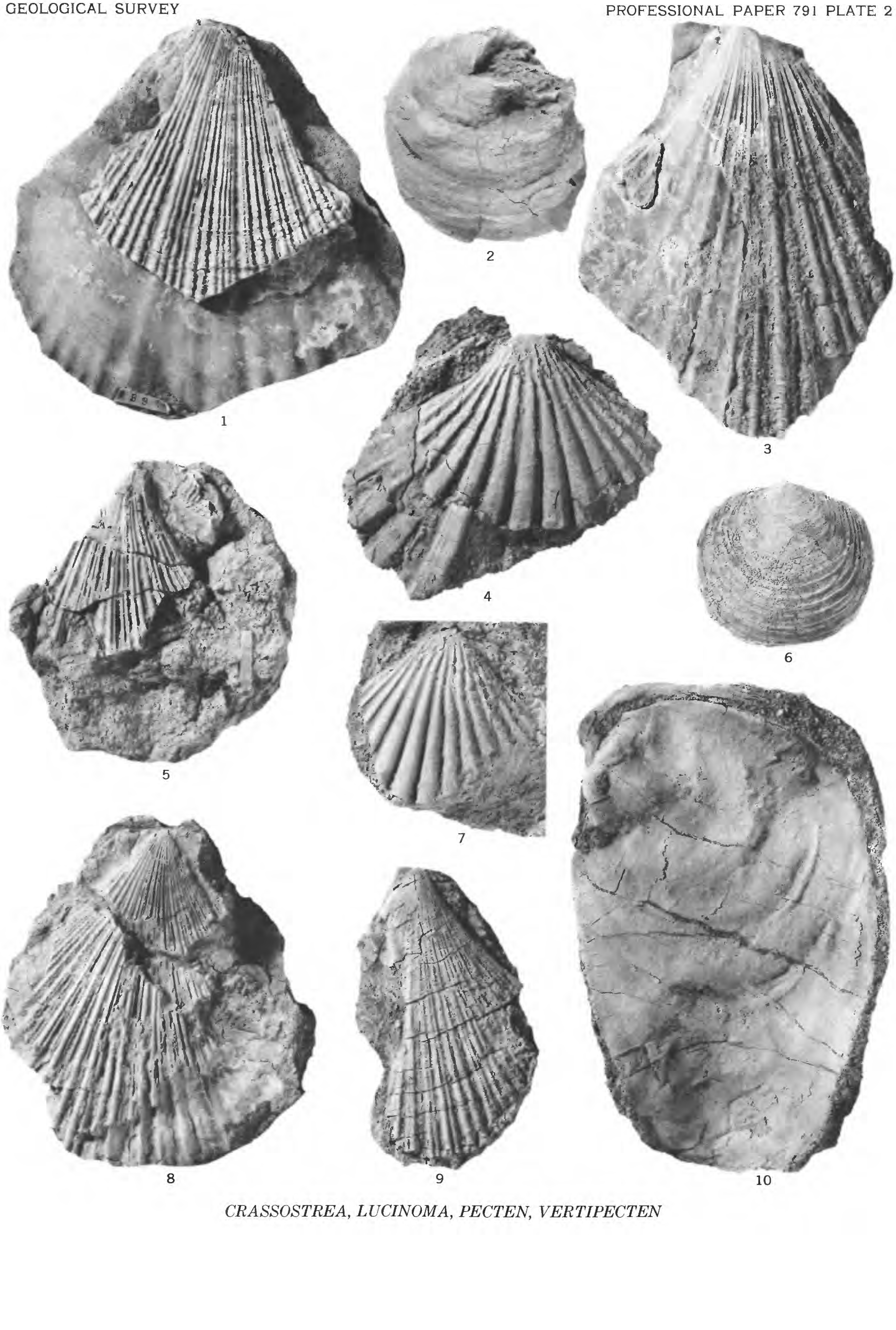
2. Immature specimen. Length 41 mm, height 45 mm. USNM 646533. USGS loc. M3280.
10. Length 60 mm, height 101 mm. USNM 646534. USGS loc. M3280.

4, 7. *Pecten (Pecten) sanctaecruzensis* Arnold (p. 24).

4. Length 65 mm. USNM 646535. USGS loc. M4467.
7. Height 36 mm. USNM 646536. USGS loc. M4467.

6. *Lucinoma acutilineata* (Conrad) (p. 28).

Length 35 mm, width 33 mm. USNM 646537. USGS loc. M3280.



CRASSOSTREA, LUCINOMA, PECTEN, VERTIPECTEN

PLATE 3

[All specimens are from the Wygal Sandstone Member of the Temblor Formation]

FIGURES 1, 4. *Vertipecten alexclarki* Addicott, n. sp. (p. 26).

- 1. Height 84 mm. USNM 646538. USGS loc. M3281.
- 4. Length of fragment 66 mm. USNM 646539. USGS loc. M3985.

2. *Crenomytilus*? cf. *C.*? *arnoldi* (Clark) (p. 24).

Length 81 mm, height 37.5 mm. USNM 646540. USGS loc. M3978.

3, 7. *Lucinoma acutilineata* (Conrad) (p. 28).

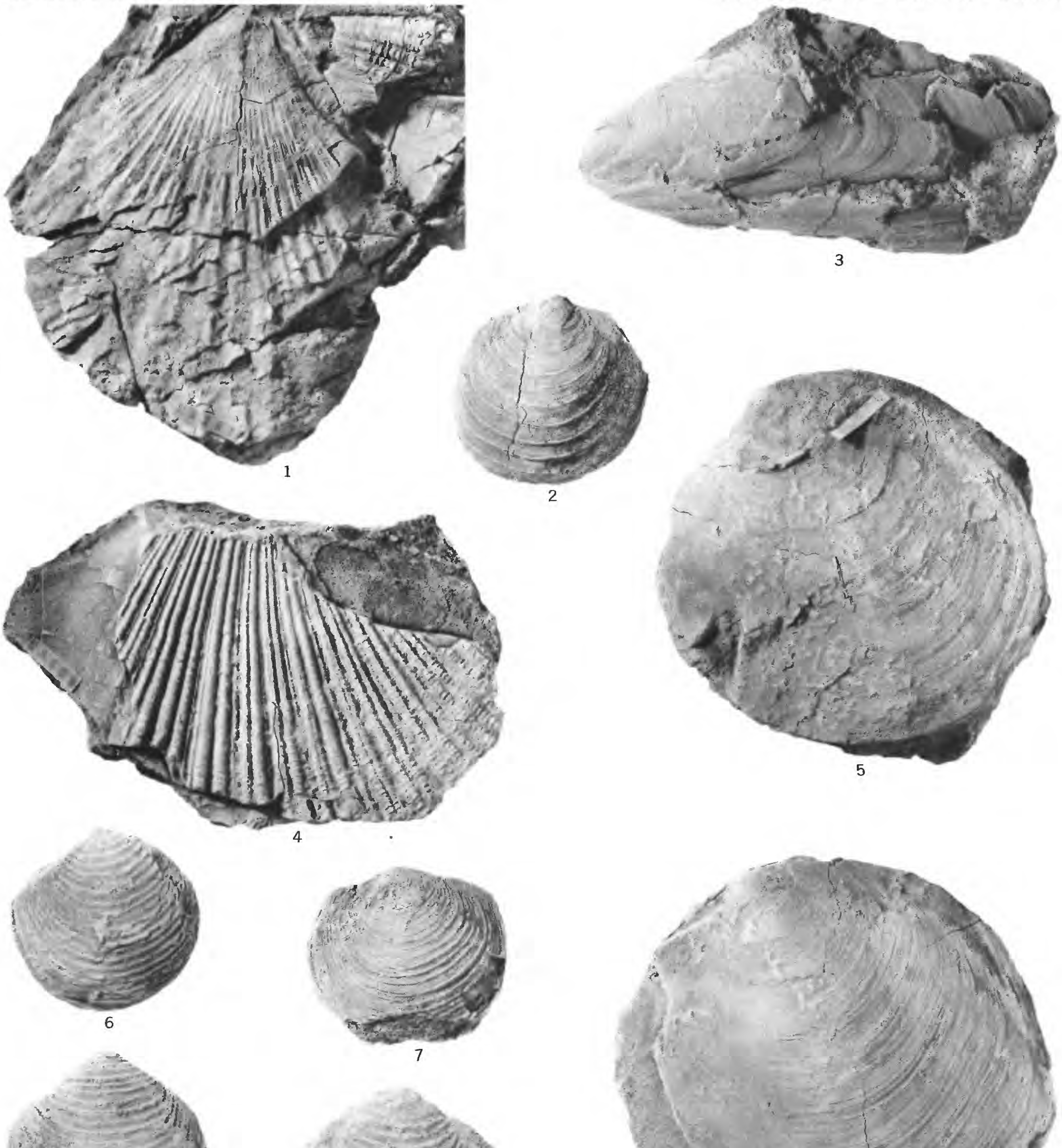
- 3. Length 33 mm, height 31.5 mm. USNM 646541. USGS loc. M3280.
- 7. Length 34 mm, height 29.5 mm. USNM 646542. USGS loc. M3280.

5, 10. *Miltha* (*Miltha*) *sanctaecrucis* (Arnold) (p. 28).

- 5. Length 65 mm, height 64 mm. USNM 646543. USGS loc. M3579.
- 10. Length 68 mm, height 65 mm. USNM 646544. USGS loc. 9432.

6, 8, 9. *Here excavata* (Carpenter) (p. 27).

- 6. Length 16 mm, height 15.5 mm. USNM 646545. USGS loc. M3578.
- 8. Length 17 mm, height 17 mm. USNM 646546. USGS loc. M3578.
- 9. Length 17.5 mm, height 17.5 mm. USNM 646547. USGS loc. M3578.



CRENOMYTILUS?, HERE, LUCINOMA, MILTHA, VERTIPECTEN

PLATE 4

[Specimens are from the Wygal Sandstone Member of the Temblor Formation unless otherwise indicated]

FIGURE 1. *Spisula* n. sp.? (p. 30).
Length 91 mm, height 68 mm. USNM 646548. USGS loc. M3579.

2, 7. *Felaniella harfordi* (Anderson) (p. 29).
2. Length 19.5 mm, height 17.5 mm. USNM 646550. USGS loc. M3280.
7. Length 24 mm, height 21.5 mm. USNM 646551. USGS loc. M3280.

3, 4, 8. *Spisula* cf. *S. albaria* (Conrad) (p. 29).
3. Length 47 mm, height 35.5 mm. USNM 646552. USGS loc. M3578.
4. Length 37 mm, height 28.5 mm. USNM 646553. USGS loc. M3578.
8. Length 36 mm, height 28 mm. USNM 646554. USGS loc. M3979.

5. *Spisula ramonensis* Packard (p. 30).
Length 49 mm, height 37 mm. USNM 646555. USGS loc. M3280.

6. *Spisula albaria* (Conrad) (p. 29).
Length 46.5 mm, height 36.5 mm. USNM 646556. USGS loc. M1802, Astoria Formation, middle Miocene, Oregon.

9. *Solen* aff. *S. gravidus* Clark (p. 30).
Height 25.5 mm. USNM 646557. USGS loc. M3280.

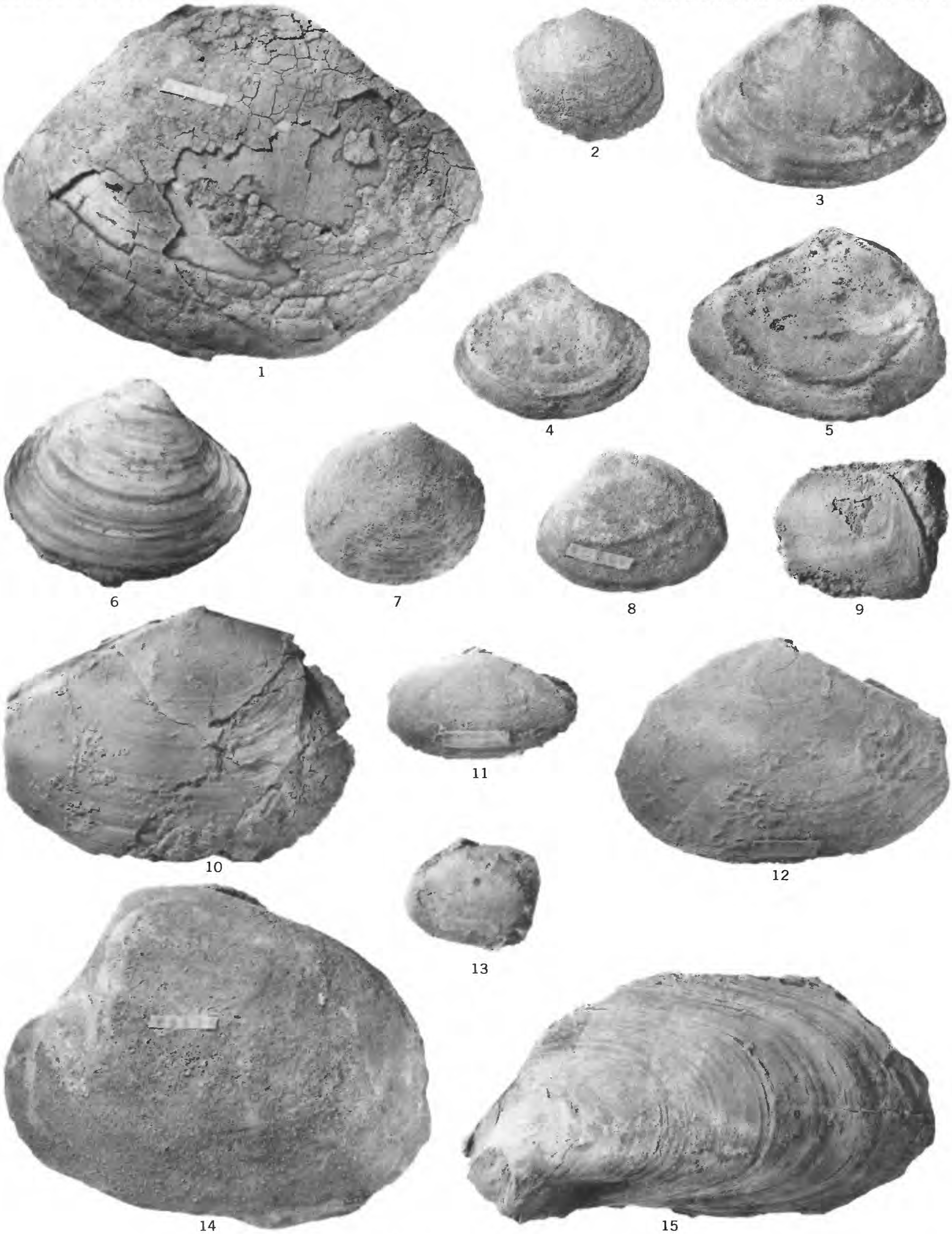
10, 12. *Tellina* (*Olcesia*) *piercei* (Arnold) (p. 31).
10. Height 49 mm. USNM 646558. USGS loc. M3978.
12. Length 63 mm, height 43.5 mm. USNM 646559. USGS loc. M3578.

11. *Tellina* (*Oudardia*) *emacerata* Conrad (p. 32).
Length 35 mm, height 20 mm. USNM 646560. USGS loc. M3578.

13. *Tellina*? cf. *T. vancouverensis* Clark and Arnold (p. 33).
Height 19 mm. USNM 646561. USGS loc. M3578.

14. *Spisula* cf. *S. rushi* Wagner and Schilling (p. 30).
Length 83 mm, height 63.5 mm. USNM 646562. USGS loc. M3979.

15. *Crenomytilus expansus* (Arnold) (p. 24).
Length 116 mm, height 60 mm. USNM 646549. USGS loc. 9427.



CRENOMYTILUS, FELANIELLA, SOLEN, SPISULA, TELLINA, TELLINA?

PLATE 5

[Specimens are from the Wygal Sandstone Member of the Temblor Formation unless otherwise indicated]

FIGURES 1, 3, 6, 9–11. *Heteromacoma rostellata* (Clark) (p. 34).

1. Suborbicular form. Length 55.5 mm, height 47 mm. USNM 646563. USGS loc. M3280.
3. Suborbicular form. Length 51 mm, height 46 mm. USNM 646564. USGS loc. M3280.
6. Suborbicular form. Length 53.5 mm, width 45 mm. USNM 646565. USGS loc. M3281.
9. Elongate form. Length 57.5 mm, height 42 mm. USNM 646566. USGS loc. M3772.
10. Subquadrate form. Length 65 mm, height 44 mm. USNM 646567. USGS loc. M3280.
11. Subquadrate form. Length 67 mm, height 55 mm. USNM 646568. USGS loc. M3280.

2, 8. *Tellina* (*Tellinella*) *tenuilineata* Clark (p. 32).

2. Length 53.5 mm, height 29 mm. USNM 646569. USGS loc. M3578.
8. Length 53 mm, height 28.5 mm. USNM 646570. USGS loc. 9432.

4, 7. *Macoma arctata* (Conrad) (p. 33).

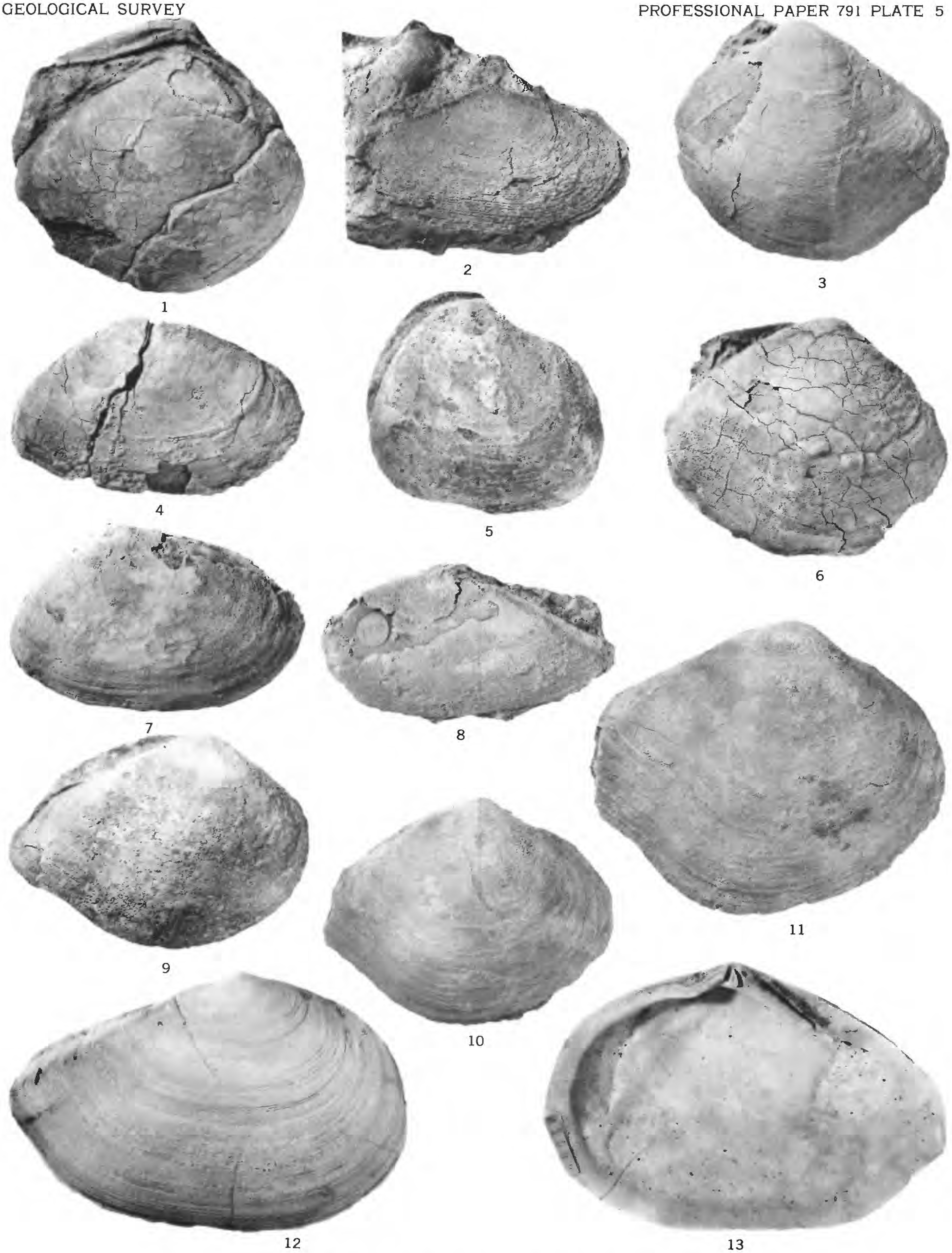
4. Length 56.5 mm, height 37 mm. USNM 646571. USGS loc. M3280.
7. Length 56 mm, height 38 mm. USNM 646572. USGS loc. M3280.

5. *Pseudocardium*? sp. (p. 29).

Length 45 mm, height 42.5 mm. USNM 646573. USGS loc. M4466.

12, 13. *Tellina* (*Olcesia*) *piercei* (Arnold) (p. 31).

12. Length 74.5 mm, height 55 mm. USNM 646574. USGS loc. M1599. Olcese Sand, Kern River area, California, middle Miocene.
13. Length 76 mm, height 51 mm. USNM 646575. USGS loc. M1599. Olcese Sand, Kern River area, California, middle Miocene.



HETEROMACOMA, MACOMA, PSEUDOCARDIUM?, TELLINA

PLATE 6

[All specimens are from the Wygal Sandstone Member of the Temblor Formation]

FIGURES 1, 3, 9, 12, 13. *Dosinia* (*Dosinia*) *whitneyi* (Gabb) (p. 36).

1. Length 71 mm, height 61 mm. USNM 646576. USGS loc. 9432.
3. Length 44.5 mm, height 48.5 mm. USNM 646577. USGS loc. M3280.
9. Length 48 mm, height 46 mm. USNM 646578. USGS loc. M3280.

12, 13. Length 58 mm, height 58.5 mm. USNM 646579. USGS loc. M3280.

2, 4, 14. *Heteromacoma rostellata* (Clark) (p. 34).

2. Subquadrate form. Height 54 mm. USNM 646580. USGS loc. M3280.
4. Elongate form. Length 74 mm, height 47 mm. USNM 646581. USGS loc. M3280.
14. Suborbicular form. Length 74 mm, height 60 mm. USNM 646582. USGS loc. M3280.

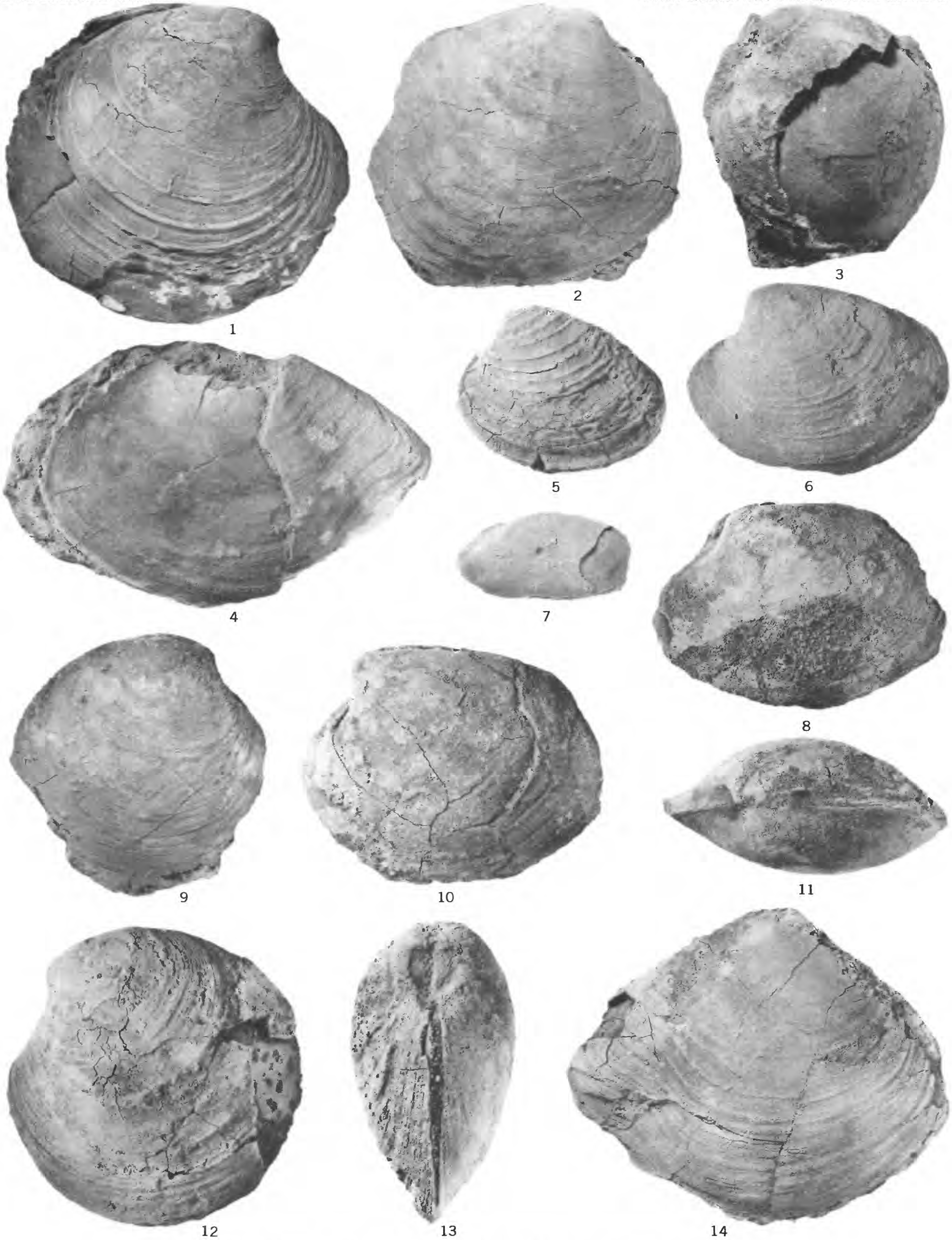
5. *Securella* cf. *S. cryptolineata* (Clark) (p. 37).
Length 40 mm, height 32 mm. USNM 646583. USGS loc. M3280.

6. *Amiantis* n. sp.? (p. 36).
Length 50 mm, height 38.5 mm. USNM 646584. USGS loc. M3578.

7. *Tellina* cf. *T. townsendensis* Clark (p. 32).
Length 32 mm, height 17.5 mm. USNM 646585. USGS loc. M3578.

8, 11. *Pitar* (*Katherinella*) cf. *P.* (*K.*) *californica* (Clark) (p. 37).
Length 67 mm, height 41.5 mm. USNM 646586. USGS loc. M3280.

10. *Pitar* sp. (p. 37).
Length 58 mm, height 45.5 mm. USNM 646587. USGS loc. M3978.



AMIANTIS, DOSINIA, HETEROMACOMA, PITAR, SECURELLA, TELLINA

PLATE 7

[Specimens are from the Wygal Sandstone Member of the Temblor Formation unless otherwise indicated]

FIGURES 1, 4, 8, 13, 14. *Amiantis mathewsoni* (Gabb) (p. 35).

1. Length 54 mm, height 61.5 mm. USNM 646588. USGS loc. M3280.

4, 8. Length 64.5 mm, height 60.5 mm. USNM 646589. USGS loc. M3978.

13. Hinge, natural size. USNM 646590. USGS loc. M3978.

14. Length 67 mm, height 60.5 mm. USNM 646591. USGS loc. M3772.

2, 3, 11. *Amiantis* n. sp.? aff. *A. diabloensis* (Anderson) (p. 35).

2, 3. Length 54.5 mm, height 46.5 mm. USNM 646592. USGS loc. 6627. Olcese Sand, Kern River area, California, middle Miocene.

11. Hinge, natural size. UCMP 14090. UCMP loc. B1599. Olcese Sand, Kern River area, California, middle Miocene.

5, 10. *Dosinia* (*Dosinia*) *whitneyi* (Gabb) (p. 36).

5. Length 45.5 mm, height 42 mm. USNM 646593. USGS loc. M3280.

10. Hinge, natural size. USNM 646594. USGS loc. M3772.

6, 7. *Amiantis* n. sp.? (p. 36).

6. Length 59 mm, height 43 mm. USNM 646595. USGS loc. M3578.

7. Length 54 mm, height 41 mm. USNM 646596. USGS loc. M3578.

9, 12. *Clementia* (*Egesta*) *pertenuis* (Gabb) (p. 36).

9. Length 65.5 mm, height 54 mm. USNM 646597. USGS loc. M3280.

12. Length 72.5 mm, height 53.5 mm. USNM 646598. USGS loc. 9432.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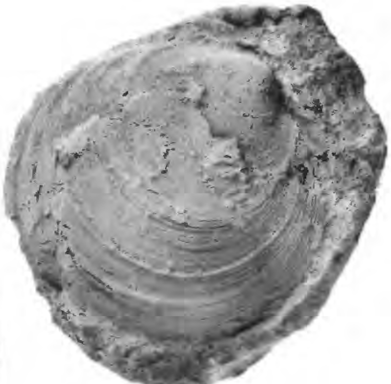
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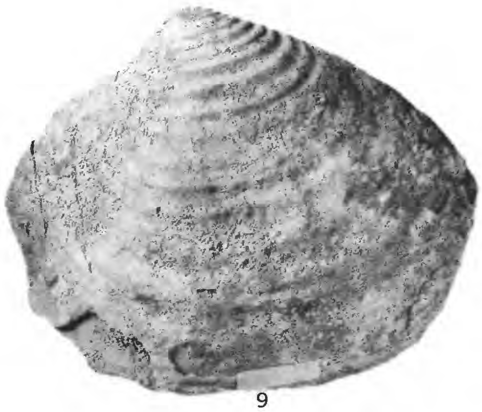
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14

AMIANTIS, CLEMENTIA, DOSINIA

PLATE 8

[All specimens are from the Wygal Sandstone Member of the Temblor Formation]

FIGURES 1, 3, 19. *Clementia* (*Egesta*) *pertenuis* (Gabb) (p. 36).
- 1. Length 70.5 mm, height 62 mm. USNM 646599. USGS loc. M4466.
- 3. Length 71 mm, height 62.5 mm. USNM 646600. USGS loc. M4466.
- 19. Length 71.5 mm, height 60 mm. USNM 646601. USGS loc. M3578.

2, 4. *Tegula* n. sp. (p. 17).
- 2. Height 17 mm, width 19.5 mm. UCR 1235. UCR loc. 1235.
- 4. Height 20.5 mm, width 21.5 mm. USNM 646602. USGS loc. M3578.

5. Cerithiid? (p. 17).
Height 19 mm. USNM 646603. USGS loc. M3578.

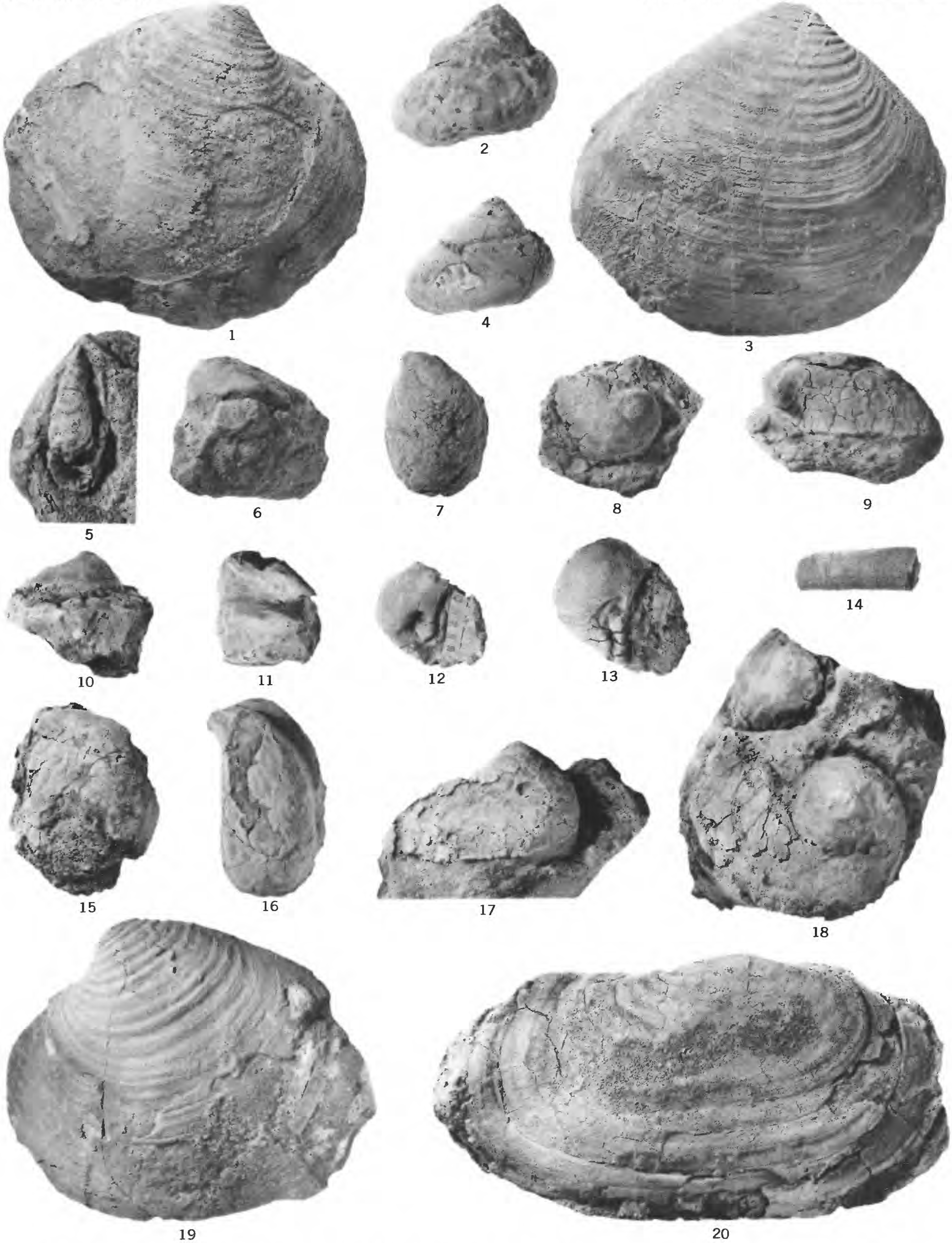
6, 7, 9, 11, 15, 16. *Crepidula* cf. *C. ungana* Dall (p. 18).
- 6, 15. Width 25.5 mm. USNM 646604. USGS loc. M3280.
- 7. Length 28.5 mm, width 20 mm. USNM 646605. USGS loc. 3979.
- 9, 11, 16. Length 37.5 mm, width 20 mm. USNM 646606. USGS loc. M3281.

8, 10, 17, 18. *Calyptraea diegoana* (Conrad) (p. 17).
- 8, 10. Height 10.5 mm, width 22 mm. USNM 646607. USGS loc. M3280.
- 17, 18. Height 19 mm, diameter 48 mm. USNM 646608. USGS loc. M3281.

12, 13. *Natica* (*Natica*) n. sp. (p. 19).
- 12. Height 21 mm, width 20.5 mm. USNM 646609. USGS loc. M3280.
- 13. Height 28 mm, width 25.5 mm. USNM 646610. USGS loc. M3280.

14. *Dentalium laneensis* Hickman (p. 38).
Length 23.5 mm, width 8 mm. USNM 646611. USGS loc. M3772.

20. *Panopea ramonensis* (Clark) (p. 37).
Length 92 mm, height 52.5 mm. USNM 646612. USGS loc. M3280.



CALYPTRAEA, CERITHIID?, CLEMENTIA, CREPIDULA, DENTALIUM, NATICA, PANOPEA, TEGULA

PLATE 9

[Specimens are from the Wygal Sandstone Member of the Temblor Formation unless otherwise indicated]

FIGURES 1, 2, 8, 9, 14. *Bruclarkia seattlensis* Durham (p. 21).

1. Height 46 mm, width 33 mm. USNM 646613. USGS loc. M3979.
2. Height 45.5 mm, width 30.5 mm. USNM 646614. USGS loc. M3772.

8, 9. Height 30.5 mm, width 24.5 mm. USNM 626615. USGS loc. M3772.

14. Height 33 mm, width 26 mm. USNM 646616. USGS loc. M3280.

3. *Bruclarkia barkeriana* forma *sanctacruzana* (Arnold) (p. 21).
Height 46 mm, width 28.5 mm. UCMP 36556. UCMP loc. B1598. Olcese Sand, Kern River area, California, middle Miocene.

4. *Neverita* (*Glossaulax*) *thomsonae* Hickman (p. 19).
Height 32.5 mm, width 38.5 mm. USNM 646617. USGS loc. M3978.

5, 6. *Siphonalia*? sp. (p. 21).
Height 25 mm, width 18 mm. USNM 646618. USGS loc. M3280. Specimen deformed.

10. *Polinices* n. sp.? (p. 19).
Height 29 mm, width 29 mm. USNM 646619. USGS loc. M3280. Specimen deformed.

7, 11, 12. *Kelletia*? sp. (p. 21).

7. Height 32 mm, width 30 mm. USNM 646620. USGS loc. M3280.

11, 12. Width 28 mm. USNM 646621. USGS loc. M3772.

13. *Calicantharus* cf. *C. branneri* (Clark and Arnold) (p. 20).
Height 31.5 mm, width 23 mm. USNM 646622. USGS loc. M4471.

15, 20, 21. *Bruclarkia gravida* (Gabb) (p. 21).

15. Lectotype. Height 32 mm, width 21 mm. ANSP 4345. San Ramon Sandstone, Contra Costa County, Calif., early Miocene(?).

20, 21. Height 42 mm, width 29 mm. ANSP 4345a. San Ramon Sandstone, Contra Costa County, Calif., early Miocene(?).

16, 17. *Sinum* cf. *S. scopulosum* (Conrad) (p. 19).

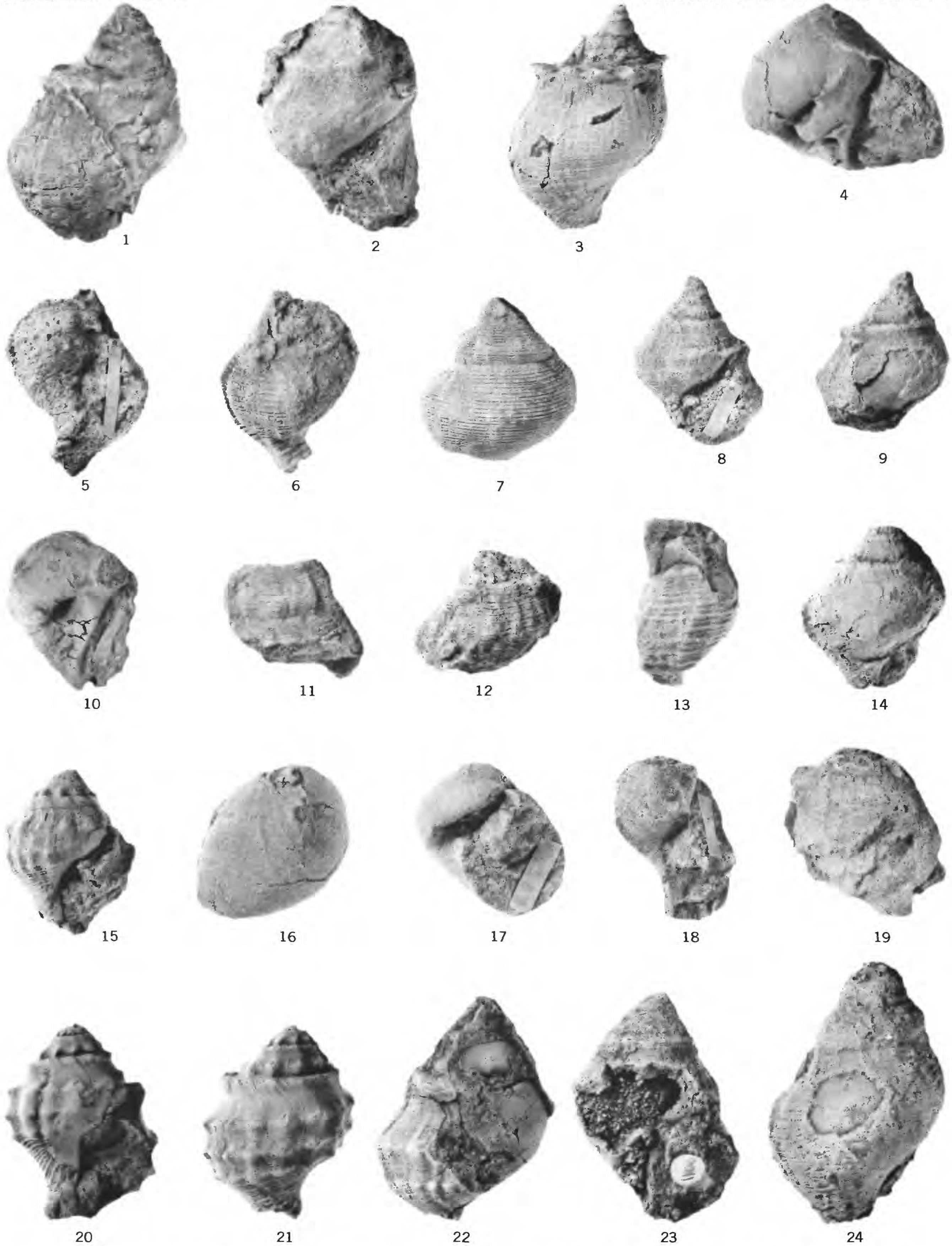
16. Height 20 mm, width 22 mm. USNM 646623. USGS loc. M3578. Specimen deformed.
17. Height 17 mm, width 20 mm. USNM 646624. USGS loc. M3578.

18, 19. *Ficus* cf. *F. modesta* (Conrad) (p. 20).

18. Height 32 mm, width 22 mm. USNM 646625. USGS loc. M3578. Specimen deformed.
19. Height 33.5 mm, width 28.5 mm. USNM 646626. USGS loc. M3978. Specimen deformed.

22, 23. *Bruclarkia columbiana* (Anderson and Martin) (p. 8).
Height 43.5 mm, width 32.5 mm. UCR 1106. UCR loc. 1106. Cymric Shale Member of the Temblor Formation, Oligocene.

24. *Calicantharus dalli* (Clark) (p. 20).
Height 53.5 mm, width 36 mm. USNM 646628. USGS loc. M3772.



BRUCLARKIA, CALICANTHARUS, FICUS, KELLETIA?, NEVERITA, POLINICES, SINUM, SIPHONALIA?