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Additions to the Late Paleocene Molluscan Fauna from the Santa Monica Mountains, Los Angeles County, Southern California

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Abstract. Several previously unreported shallow-marine, warm-water gastropods and bivalves from the upper part of the Santa Susana Formation, east–central Santa Monica Mountains, Los Angeles County, southern California, are described and discussed. The gastropods are *Diodora* sp. nov.? (Fissurellidae) and *Terebralia* ***susana*** sp. nov. (Potamididae). The bivalves are *Solena* (*Eosolen*) *stantoni* (Weaver, 1905) (Solenidae), *Martesia* sp. (Pholadidae), and *Nototeredo*(?) sp. (Teredinidae). These mollusks are of late Paleocene (Thanetian Stage) age. For the Pacific Coast of North America, the specimens of *Diodora* and *Martesia* represent the earliest records, the specimens of *Terebralia* the first confirmed record, and the specimens of *Nototeredo*(?) the first record. The specimens of *Solena* (*Eosolen*) *stantoni* are the best preserved and largest of this species.

INTRODUCTION

The late Paleocene was a time of a large influx of migrant shallow-marine mollusks into the Pacific Coast region of North America via circum-global tropical circulation, and this influx continued on into the early Eocene (Zinsmeister, 1983a; Squires, 1988). Upper Paleocene marine rocks are uncommon on the Pacific Coast of North America but are well represented in the Palisades Highlands area in the east-central Santa Monica Mountains, southern California (Figure 1). Although natural outcrops are scarce due to extensive vegetative cover, shallow-marine mollusks have been found locally, particularly in new exposures temporarily uncovered by bulldozer activity during the construction of homesites. Most of the specimens of rare and previously unreported mollusks that are the focus of this paper were collected during the past 15 years by J. M. Alderson and W. L. Rader, who donated them to local museums. These mollusks are the gastropods *Diodora* sp. nov.? and *Terebralia* ***susana*** sp. nov., and the bivalves *Solena* (*Eosolen*) *stantoni* (Weaver, 1905), *Martesia* sp., and *Nototeredo*(?) sp.

The following institutional acronyms are used: CSUN, California State University, Department of Geological Sciences, Northridge; LACMIP, Natural History Museum of Los Angeles County, Section of Invertebrate Paleontology, Los Angeles; and UWBM, University of Washington, Thomas Burke Memorial Museum, Seattle.

STRATIGRAPHY

The mollusks discussed in this report were collected from the area east of Santa Ynez Canyon, in the tributaries of Quarry Canyon, Trailer Canyon, Pulga Canyon, and other unnamed tributaries (Figure 1). All the localities plot within the upper part of the Santa Susana Formation as mapped by Dibblee (1992). Colburn et al. (1988) and Colburn (1996) assigned the Paleocene rocks here to the Santa Susana Formation, in its broad sense, although other recent workers (e.g., Saul, 1983; Strathearn et al., 1988) referred to them as the Coal Canyon Formation of Yerkes & Campbell (1979).

The upper part of the Santa Susana Formation in the Santa Ynez Canyon area is a marine unit consisting mostly of olive to gray-green, fine-grained sandstone and siltstone, which are bluish gray when unweathered. Megafossils are either in thin lenses or scattered throughout the beds. Within the upper part of the formation there are outcrops of coralline-algal limestone, which are white and resistant. These might represent a single stratigraphic unit that is present in minor fault blocks and/or landslide blocks, or they might represent multiple units of similar lithology. Previous geologic studies in the area have failed to clarify the stratigraphic relationships. Colburn et al. (1988), in a study of the Santa Susana Formation in the Santa Monica Mountains, considered the algal limestone to make up a single 10 m-thick marker bed in the formation. Strathearn et al. (1988) reported several lenses of algal limestone. Mack (1993) reported that the algal limestones (10 to 30 m thick) apparently represent several stratigraphic levels. Strathearn et al. (1988) and Mack (1993), however, grouped all of the algal limestones into a single stratigraphic unit in their generalized stratigraphic columns.

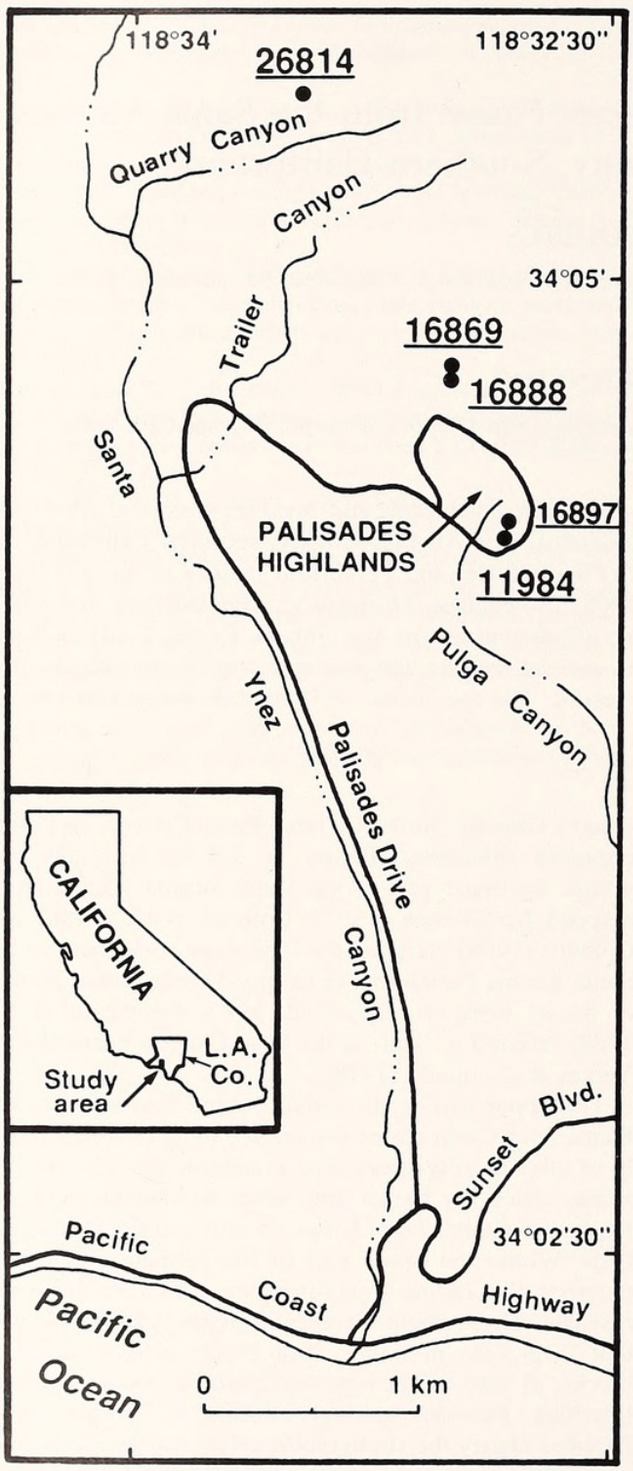


Figure 1

Index map showing LACMIP collecting localities in the upper Santa Susana Formation, Palisades Highlands and vicinity, east–central Santa Monica Mountains, Los Angeles County, southern California. Base map from Dibblee (1992).

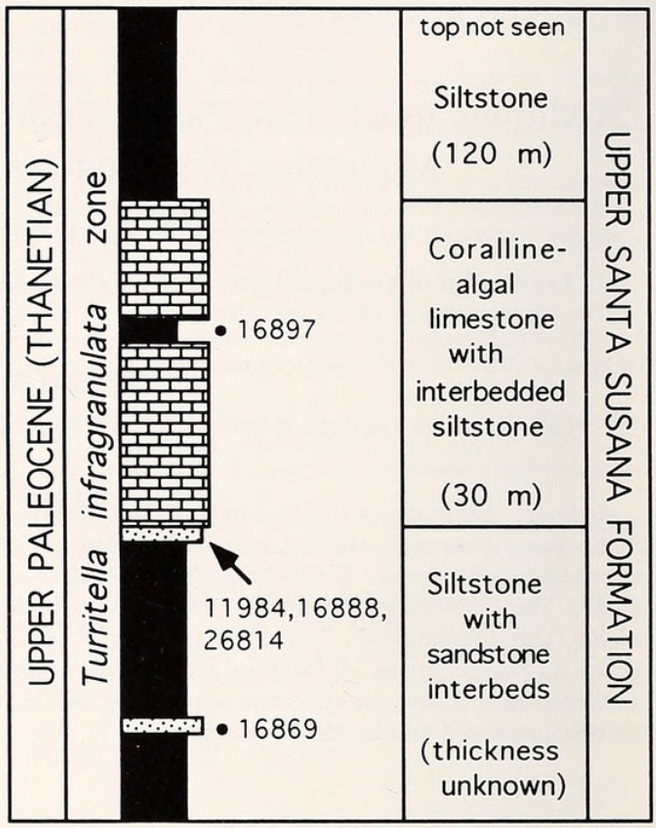


Figure 2

Generalized columnar section showing relative stratigraphic positions of the cited megafossil localities in the upper Santa Susana Formation in the Palisades Highlands and vicinity, east-central part of the Santa Monica Mountains, southern California.

Recent reconnaissance work by the senior author to resolve the algal-limestone problem in the immediate study area was uninformative because all of the outcrops had been obliterated by extensive housing-tract development. Pending future information, it seems best to refer to the algal limestone(s) as the "algal-limestone interval." Although the exact stratigraphic position of this interval is not known because structural complications make it impossible to identify the upper contact of the Santa Susana Formation, the interval is approximately 120 m below the stratigraphically highest outcrops of the Santa Susana Formation in the area (Mack, 1993).

The mollusks described in this report were collected from rocks stratigraphically near or within the algal-limestone interval, and their positions are shown in Figure 2. The pholadid bivalve *Martesia* sp. and the teredinid bivalve *Nototeredo*(?) sp. are from a richly fossiliferous lens within the gray-green very fine-grained sandstone at LACMIP loc. 16869 (Figures 1,2). This lens is approximately 20 m below the algal-limestone interval. The fauna at this locality is much more diverse than those from other units and yielded numerous specimens of the bi-

valves *Cucullaea mathewsonii* Gabb, 1864, *Crassatella unioides* (Stanton, 1896), *Saulella undulifera* (Gabb, 1869), and *Pholadomya* (*P.*) *nasuta* Gabb, 1864, and the gastropods *Turritella infragranulata* Gabb, 1864, and various species of naticids. A few small specimens of the solenid bivalve *Solena* (*Eosolen*) *stantoni* were also present.

The two gastropods treated herein are from fine-grained sandstone immediately subjacent to the algal limestone and are from slightly higher in the stratigraphic section than where *Martesia* and *Nototeredo* were found. Most of the specimens of the fissurellid gastropod *Diodora* sp. nov.? were found at LACMIP loc. 16888. One other specimen of *Diodora* sp. nov.? was found at LACMIP loc. 11984, and a single specimen of the potamidid gastropod *Terebralia* ***susana*** sp. nov. was found at LACMIP loc. 26814 in the Quarry Canyon area and below an algal limestone that Dibblee (1992) mapped as the only algal limestone in that area. This specimen of *Terebralia* ***susana*** is somewhat worn.

The largest and best preserved specimens of the solenid bivalve *Solena* (*Eosolen*) *stantoni* are from gray-green muddy silstone in the upper Pulga Canyon area at LACMIP loc. 16897. This siltstone appears to be a major interbed within the algal-limestone interval and, if so, would be slightly higher stratigraphically than the other discussed mollusks. Unfortunately, there have been no detailed stratigraphic sections in the critical area of upper Pulga Canyon where Dibblee's (1992) geologic map shows four vertically stacked lenses of algal limestone with intervening, mostly fine-grained siliciclastic units that dip consistently to the southwest. This is the only area where there are more than two vertically stacked outcrops of algal limestone, and this is the area where there has been extensive housing-tract construction since about 1988. The homes now make up the Summit and Enclave communities of Palisades Highlands in the city of Los Angeles. The siltstone at LACMIP loc. 16897 might represent a landslide or fault block and is from the same stratigraphic level as LACMIP loc. 16869. The siltstone at locality 16987, however, is muddier and has yielded a less diverse megafauna. In this paper, the siltstone at locality 16897, where the large *S.* (*E.*) *stantoni* specimens were found, will be considered tentatively as being within the algal-limestone interval.

The fossils in the muddy siltstone at LACMIP loc. 16897 are in poorly defined lentils containing bivalves and some gastropods. Three specimens of *S.* (*E.*) *stantoni* were found. Their valves are open and positioned next to each other in parallel fashion, with the anterior and posterior ends matching each other ("butterflied"). The specimens also lie parallel to the original bedding. Other bivalves here include *Nuculana* sp., a thin-shelled *Ostrea* sp., and *Venericardia* sp. Some of these bivalves are complete and are partially to completely closed, whereas others are unbroken single valves. Gastropods are represented by a few large specimens of *Turritella infragranulata* Gabb, 1864, (very near to *T. i. pachecoensis* Stanton, 1896, fide L. R. Saul, personal communication) and some small specimens of *Tornatellaea pinguis* (Gabb, 1864).

DEPOSITIONAL ENVIRONMENT

Colburn et al. (1988) and Colburn (1996) concluded that the upper part of the Santa Susana Formation in the Santa Ynez Canyon area was deposited in a low-energy protected bay, no deeper than 40 m, with the bay situated behind a barrier bar. They based their conclusion on the following: condition of the megafossils, fine grain size of the deposits, presence of well-developed horizontal laminae within the deposits, and lack of sedimentary structures associated with strong wave or current action. Their megafossil evidence consists of articulated bivalve shells, both adult and juvenile specimens of the same species, and absence of both preferred orientation and current-size sorting of the shells. They also concluded that branching calcareous algae developed shoals on the bay floor.

Strathearn et al. (1988) concluded that the upper part of the Santa Susana Formation in the Santa Ynez Canyon area accumulated in an unrestricted, muddy, middle-shelf environment near or below storm-wave base and no deeper than 70 m. They based their conclusions on the taxonomic composition of the dinoflagellates and benthic foraminifera in the deposits, as well as on the predominantly non-transported condition of the megafossils. They also concluded the algal limestones, which formed when there was interruption of the deposition of the terrigenous siliciclastics, represent *in situ* buildups in subtropical to tropical waters of about 20 m depth.

A relatively low-energy depositional environment is in keeping with the presence of complete and unabraded bivalves found associated with the bivalves treated herein. This is especially true for the "butterflied" condition of most of the specimens of *Solena* (*Eosolen*) *stantoni* found in siltstone at LACMIP loc. 16897 within the algal-limestone interval. Although "butterflied" specimens of bivalves can be transported, the distance of post-mortem transport cannot be great and the water cannot be too agitated; otherwise the valves will break apart. Modern solenids have a mostly tropical distribution and live from the intertidal zone to depths of 60–110 m; most species are found just below the low-water mark in the lower part of the intertidal zone or in shallow inner sublittoral depths (20–30 m) on the shelf. Some species live in coralline-algal sediment, whereas others live around mangroves (Von Cosel, 1990).

The other bivalves treated herein are not all that useful in paleoenvironmental studies. *Martesia* and *Nototeredo* are wood borers that live today in tropical to temperate seas (Turner, 1966; Cvancara, 1966, 1970). Their presence does not necessarily indicate proximity to land because drift wood can disperse widely in oceanic settings.

The two gastropods treated herein, and which were found immediately subjacent to algal limestone, belong to genera that one might expect to have lived in tropical to subtropical shallow-marine waters in the vicinity of algal-carbonate buildups. *Diodora*, a herbivorous gastropod that requires a hard substrate, is widespread today, ranging from cool-temperate to tropical waters. Along the Pacific Coast of North America only *D. aspera* (Rathke, 1833) lives north of California, and it is usually found intertidally on wave-swept rocky habitats. In California, *D. aspera* and *D. arnoldi* McLean, 1966, live subtidally (McLean, 1978). Species of *Diodora* show a greater diversity in the warmer waters of the Gulf of California to Peru, where they usually live in shallow subtidal settings (Keen, 1971). The specimens of *Diodora* found in the Santa Susana Formation are complete and do not show any signs of abrasion due to post-mortem transport.

Modern species of *Terebralia* are restricted to circumtropical regions that extend from eastern Africa to the western Pacific Ocean. They usually live in great numbers on fine substrate in brackish water on coastal mudflats in mangrove regions. Some specimens live on the roots of mangroves, and others live on intertidal sand and rocky habitats throughout the salt-marsh environment. Specimens can also be found in tidal channels, where they appear to have been washed in from adjacent environments (Houbrick, 1991). *Terebralia sulcata* Born, 1778, from throughout the western Pacific, is a hardy generalist and able to tolerate a wide range of substrate types and diet, with algae being one of its food sources. It can live in protected bays from which mangroves are absent (Houbrick, 1991). The single specimen of *Terebralia* found in the Santa Susana Formation is somewhat worn, indicating some post-mortem transport.

Another habitat-distinctive gastropod found just below algal limestone in the study area is *Campanile greenellum* Hanna & Hertlein, 1939, reported from the Santa Ynez Canyon area (i.e., Quarry Canyon and Trailer Canyon) by Squires (1993). *Campanile* is a primarily Old World Tethyan genus that is indicative of warm waters and very shallow depths.

AGE

Biostratigraphic age assignments for the Santa Susana Formation in the Santa Ynez Canyon area have previously relied upon mollusks, even though the megafauna is incompletely known. Early collections of mollusks were assigned to the Eocene (*sensu lato*) by Hoots (1931), but that was before the Paleocene Epoch was a formally recognized time interval. These "Eocene" mollusks are now widely regarded as mostly late Paleocene in age (e.g., Saul, 1983; Strathearn et al., 1988; Colburn et al., 1988; Dibblee, 1992). Saul (1983:fig. 8) restricted the algal limestones in the Coal Canyon Formation [= the Santa Susana Formation of herein] to the upper Paleocene *Turritella infragranulata* Zone, which is correlative to the European Thanetian Stage. The *T. infragranulata* Zone also corresponds to the Standard Planktonic Foraminferal Zone P4 (Saul, 1983) and to the upper part of the provincial "Martinez Stage" (Saul, 1983).

Our work also supports a late Paleocene age for the upper part of the Santa Susana Formation in the Santa Ynez Canyon area. The most useful locality in the study area for geologic age control is LACMIP loc. 16869, approximately 20 m downsection from the algal limestone (Figure 2). In addition to *Turritella infragranulata*, other age-diagnostic mollusks found at this locality include the gastropods *Prisoficus caudatus* (Gabb, 1869) and *Fulgoraria* (*Psephaea*) *zinsmeisteri* Mount, 1976, as well as the bivalves *Cucullaea mathewsonii, Crassatella unioides, Saulella undulifera,* and *Pholadomya* (*P.*) *nasuta*. These species are among the most characteristic species found in upper Paleocene rocks along the Pacific Coast of North America (Dickerson, 1914; Mount, 1976; Zinsmeister, 1983a; and Saul, 1983).

Most of the specimens of *Diodora* sp. nov.? were found at LACMIP loc. 16888, immediately below the algal limestone. The gastropod *Campanile greenellum* was also found at this locality, and it is confined to upper Paleocene rocks elsewhere in California (Squires, 1993).

At LACMIP loc. 11984, where a specimen of *Diodora* sp. nov.? was found immediately below the algal limestone, a fragmentary specimen of either a late form of *Turritella infragranulata pachecoensis* or an early form of *Turritella infragranulata* sensu stricto was found. At LACMIP loc. 16897, where specimens of *Solena* (*Eosolen*) *stantoni* were found in the middle of the algal-limestone interval (Figure 2), this same turritellid is also present. This turritellid indicates a late Paleocene (middle Thanetian) age (L. R. Saul, personal communication). The bivalve *Solena* (*Eosolen*) *stantoni* also indicates this age, as it is found elsewhere in California in rocks of late Paleocene age (Weaver, 1905; Dickerson, 1914; Zinsmeister, 1983a). This present study, therefore, shows that all the available megafossil evidence indicates that mollusks found near and immediately associated with algal limestones are late Paleocene in age.

Benthic foraminiferal, dinoflagellate, and pollen studies of the Santa Susana Formation in the study area have yielded conflicting geochronologic results. Mack (1993) reported benthic foraminifers that indicated the entire algal-limestone interval to be upper Paleocene, although the overlying rocks in the Santa Susana Formation might also range into the lower Eocene. Mack (1993) and Mack & Colburn (1993) reported also that benthic foraminifers indicate the Paleocene/Eocene boundary to be within the algal-limestone interval but did not discuss their reasoning.

Strathearn et al. (1988), based on dinoflagellate and pollen studies, suggested that the Paleocene-Eocene boundary might be several meters below the algal-lime-

stone interval, but this determination was based on a single genus of fungal spore, whose geologic range is somewhat open to question and primarily based on specimens in nonmarine outcrops in the continental interior. If Strathearn et al. (1988), Mack (1993), and Mack & Colburn (1993) are correct, then the molluscan fauna in the algal limestone and younger parts of the Santa Susana Formation in the Santa Ynez Canyon area should contain species found in the provincial molluscan "Meganos Stage" that overlies the upper Paleocene "Martinez Stage." There is no molluscan evidence to support this conclusion. The molluscan fauna associated with the algal limestones in the Santa Ynez Canyon area is unlike that from "Meganos Stage" strata in the upper part of the Santa Susana Formation on both the north and south sides of Simi Valley, 27 km northwest of the Santa Monica Mountains (Squires, 1991).

Strathearn et al. (1988:table 3) also reported the gastropod *Mesalia clarki* (Dickerson, 1914) in rocks they considered to be within the lower Eocene part of the Santa Susana Formation in the Trailer Canyon area (Figure 1). A study of the collections at LACMIP revealed this species to be in strata immediately below, and possibly within, the single algal-limestone exposure mapped in this area by Dibblee (1992). *Mesalia clarki* was known previously only from its type locality in the upper Paleocene Martinez Formation on the north side of Mount Diablo, northern California.

In summary, the age of the molluscan fauna discussed herein is considered to be late Paleocene (Thanetian). There is no molluscan evidence, nor is there any compelling microfossil evidence, to support a younger, early Eocene age for the Santa Susana Formation in the eastern Santa Monica Mountains.

SYSTEMATIC PALEONTOLOGY

Class GASTROPODA Cuvier, 1797

Order VETIGASTROPODA Salvini-Plawén, 1980

Family FISSURELLIDAE Fleming, 1822

Genus *Diodora* Gray, 1821

Type species: *Patella apertura* Montagu, 1803 [= *Patella graeca* Linnaeus, 1758], by original designation; Recent, British Isles.

Diodora sp. nov.?

(Figures 3–5)

Description: Shell medium in size (up to 3.4 cm in length and 5 mm in height), profile low, height about one-sixth of length, base flat, aperture oval. Apex situated slightly anterior to middle of shell. Anterior slope slightly steeper than posterior slope. Perforation moderately large, just anterior of apex, anterior end of perforation rounded, posterior end narrower. Interior apertural callus truncate posteriorly. Sculpture shown on internal mold consists of numerous closely spaced, equal strength primary radial ribs originating at apex; ribs slightly stronger near ventral margin. Stronger radial ribs alternate with slightly weaker ones on posterior slope. Concentric ornamentation weak, imparting a minute cancellate pattern on shell.

Distribution: Upper part of Santa Susana Formation, Pulga Canyon area, east-central Santa Monica Mountains (LACMIP locs. 11984 and 16888).

Geologic age: Late Paleocene (Thanetian).

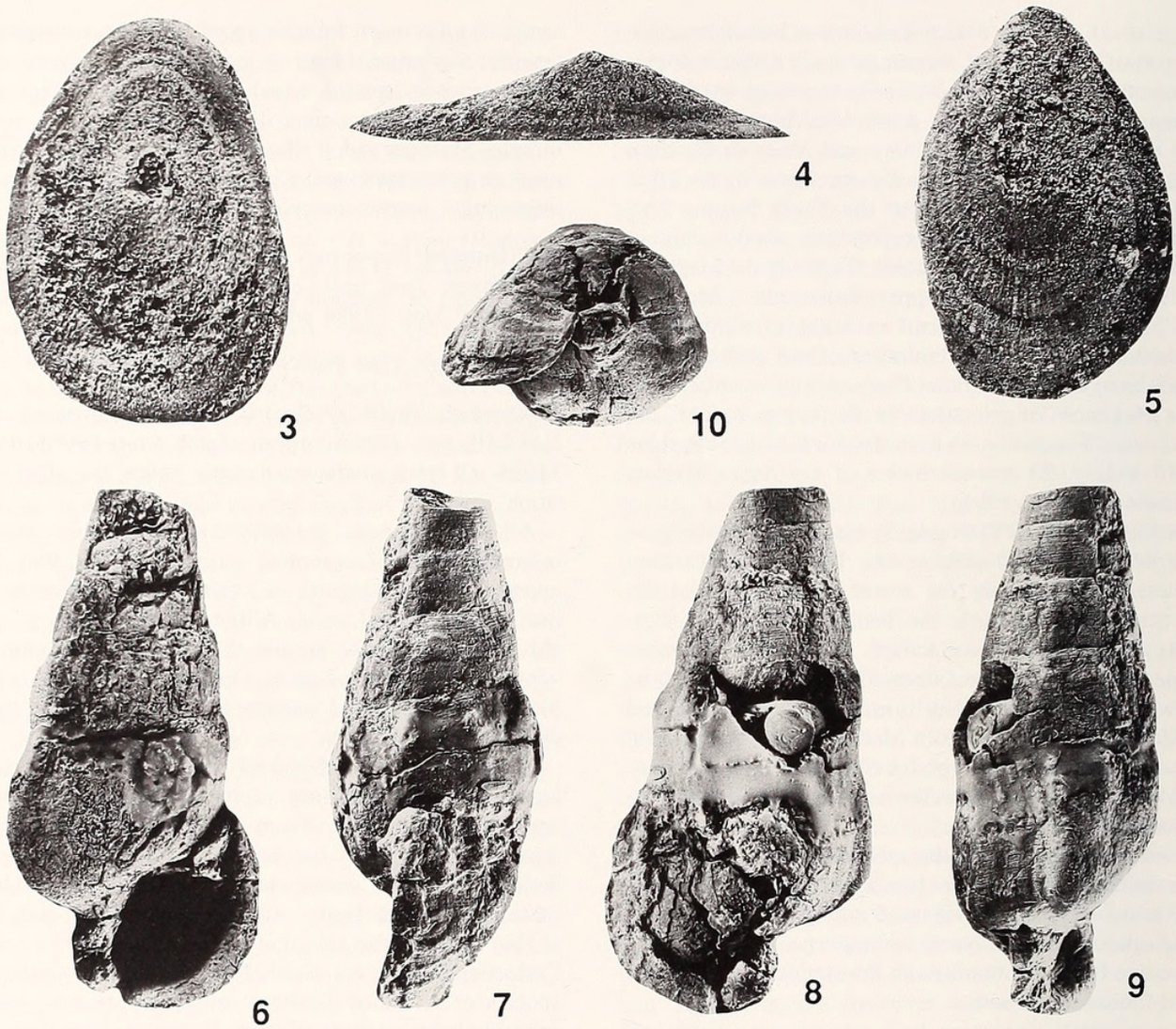
Discussion: Eight specimens were found, seven from LACMIP loc. 16888 and an eighth from LACMIP loc. 11984, all from sandstone directly below the algal limestone.

All the specimens of *Diodora* sp. nov.? are essentially internal molds of complete individuals, but they have taken on the impression of external ornamentation, and thus are functional casts. Although the specimens probably represent a new species, their poor preservation prevents confirmation of such. Only one specimen (Figure 3) shows evidence of the truncate internal callus that is diagnostic of *Diodora*.

The specimens of *Diodora* sp. nov.? from the upper Santa Susana Formation represent the earliest known specimens of *Diodora* from the Pacific Coast of North America. The genus has been reported from Paleocene and Eocene rocks in the eastern and southeastern United States (Palmer & Brann, 1966). Wenz (1938) and Keen (1960) reported the geologic range of *Diodora* to be Late Cretaceous to Recent. Sohl (1992) noted that Cretaceous species of so-called *Diodora* are very rare and that the generic status of most of them is open to question. Two of the earliest known species that can be assigned positively to *Diodora* are from Upper Cretaceous (Maastrichtian Stage) strata, from Puerto Rico and Jamaica (Sohl, 1992).

The Santa Susana Formation specimens most closely resemble specimens of *Diodora* sp. aff. *D. stillwaterensis* (Weaver & Palmer, 1922) of Squires & Deméré (1991: figs. 3A, B) from the middle Eocene ("Transition Stage") Friars Formation in San Diego County, southern California, but differs in having fewer primary radial ribs and in having secondary radial ribs on the posterior slope.

Only two Paleogene species of *Diodora* have been described from the Pacific Coast of North America. One is *Diodora stillwaterensis* (Weaver & Palmer, 1922:27, pl. 11, figs. 3, 6; Weaver, 1942 [1943]:284, pl. 63, fig. 20; pl. 64, figs. 4, 7, 12), from the Cowlitz Formation of Lewis and Cowlitz Counties in western Washington, which Nesbitt (1995) has assigned to the upper middle Eocene. The Santa Susana Formation specimens differ from *D. stillwaterensis* by having a larger shell, a lower profile, secondary radial ribs confined to the posterior re-



Explanation of Figures 3 to 10

All specimens coated with ammonium chloride. Figures 3–5. *Diodora* sp. nov.?, LACMIP loc. 16888. Figures 3–4. LACMIP hypotype 7940, length 33.2 mm, height 5 mm. Figure 3. dorsal view of internal mold, ×1.6. Figure 4. left-lateral view of internal mold, ×1.7. Figure 5. LACMIP hypotype 7941, length 26.9 mm, dorsal view of internal mold, ×1.9. Figures 6–10. *Terebralia* ***susana*** Squires & Kennedy, sp. nov., LACMIP holotype 7942, LACMIP loc. 26814, length 65 mm (incomplete), width 31.7 mm, ×1.1, low-level lighting used to show subdued sculpture. Figure 6. apertural view. Figure 7. right-lateral view. Figure 8. apertural view. Figure 9. left-lateral view. Figure 10. anterior view.

gion, and lack of tertiary radial ribs. Comparison with the holotype (UWBM 194) of *D. stillwaterensis* is not possible because the specimen is missing (R. C. Eng, personal communication).

The second Paleogene *Diodora* is *D. batequensis* Squires & Demetrion (1994:127, 129, figs. 3–6) from the middle lower Eocene ("Capay Stage") part of the Bateque Formation in the eastern Laguna San Ignacio area of Baja California Sur, Mexico (Squires & Demetrion, 1994). The Santa Susana Formation specimens differ from *D. batequensis* by having a larger shell, a lower profile, many fewer and much weaker primary radial ribs, secondary ribs confined to posterior region, a lack of tertiary radial ribs, and weaker concentric sculpture.

Squires & Goedert (1994a: 15, fig. 28) reported poorly preserved internal molds of *Diodora* sp. indet. from sandstone interbedded with basalt flows in the middle lower Eocene ("Capay Stage") part of the upper Crescent Formation in the Little River area, southwestern Washington. Similarly poorly preserved specimens of *Diodora* sp. indet. are also present in coralline algae-rich sandstone interbedded with basalt flows at CSUN loc. 1563 in the upper Crescent Formation at Larch Mountain, Black

Hills, near Olympia in southwestern Washington (Squires & Goedert, 1994b).

Superorder CAENOGASTROPODA Cox, 1959

Order NEOTAENIOGLOSSA Haller, 1882

Superfamily CERITHIOIDEA Férussac, 1819

Family POTAMIDIDAE Adams & Adams, 1854

Genus *Terebralia* Swainson, 1840

Type species: *Strombus palustris* Linnaeus, 1758, by subsequent designation (Sacco, 1895); Recent, tropical waters, eastern Africa to western Pacific Ocean.

Terebralia ***susana*** Squires & Kennedy, sp. nov.

(Figures 6–10)

Diagnosis: *Terebralia* whose adult whorls have numerous weak, very closely spaced spiral threads and about 11 axial ribs.

Description: Shell large in size, 6.5 cm high (incomplete, upper spire missing; projected height about 9.5 cm), thick-shelled; turreted-conical, consisting of at least five whorls. Upper spire unknown. Whorls convex, suture distinct and slightly inset into each successive whorl. Last five whorls with numerous weak, very closely spaced spiral threads; body whorl near outer lip with widely spaced, coarse spiral ribs, about seven in number, decreasing in strength anteriorly and with three spiral ribs in interspaces. Last three whorls with axial ribs (indeterminate in number, estimated to be about 11 per whorl), most strongly developed on posterior half of whorl. Last three whorls with aligned varices on both sides of shell. Base of body whorl rounded. Aperture large, ovate, with a posterior groove; anterior siphonal canal short and nearly closed at junction with outer lip. Inner lip smooth, concave. Outer lip flared, with varix; interior of outer lip smooth.

Holotype: LACMIP 7942.

Type locality: LACMIP loc. 26814, upper part of Santa Susana Formation, upper Quarry Canyon, east-central Santa Monica Mountains, latitude 34°05′24″N, longitude 118°33′30″W.

Dimensions: Height 65 mm (incomplete), width 31.7 mm.

Distribution: Known only from the type locality (LACMIP loc. 26814).

Geologic age: Late Paleocene (Thanetian).

Discussion: Only a single specimen was found at LACMIP loc. 26814, in sandstone immediately below the algal limestone. The specimen is somewhat worn and the upper spire is missing. No other megafossils were found in association with the holotype at the type locality.

Terebralia ***susana*** is very similar to *T. pathani* Iqbal (1969:20, pl. 12, figs. 11–12) from littoral to sublittoral mudstone of the lower Eocene Ghazij Formation east of Quetta in Pakistan, but *T.* ***susana*** differs by having a larger shell, weak and closely spaced spiral threads on adult whorls, and fewer, weaker, and more widely spaced spiral ribs near the outer lip.

A tentatively identified terebralid, *Terebralia*? *juliana* Dailey & Popenoe (1966:22, pl. 6, figs. 7, 8) from the Upper Cretaceous (upper Campanian Stage to lower Maastrichtian Stage) Jalama Formation in Santa Barbara County of southern California, represents what may be the only other report of this genus from the Pacific Coast of North America. *Terebralia* ***susana*** differs from *T. juliana* by having a much larger and thicker shell, poorly developed spiral ribbing rather than four well-developed spiral ribs bearing numerous prominent nodes, and axial ribbing.

According to Houbrick (1991), the geologic range of *Terebralia* is early Miocene to Recent. Cossmann (1906) and Wenz (1940), however, cited the genus from rocks as old as Late Cretaceous (Maastrichtian Stage). Pervinquière (1912:pl. 1, figs. 26–28) reported specimens of *Cerithium* (*Terebralia*) *sanctiarromani* Thomas et Peron, 1889, from slightly older, Turonian (Upper Cretaceous) rocks in Tunisia, northern Africa. Positive generic assignment of that particular species cannot be made because the aperture is unknown. The shell does resemble that of *Terebralia*. *Terebralia* ***susana*** differs from the Tunisian species by having many fewer axial ribs.

Etymology: The species is named for the Santa Susana Formation.

Class BIVALVIA Linnaeus, 1758

Order VENEROIDA Adams & Adams, 1856

Family SOLENIDAE Lamarck, 1809

Genus *Solena* Mörch, 1853

Type species: *Solen obliquus* Spengler, 1794, by subsequent designation (Stoliczka, 1871); Recent, Caribbean Sea.

Subgenus *Eosolen* Stewart, 1930

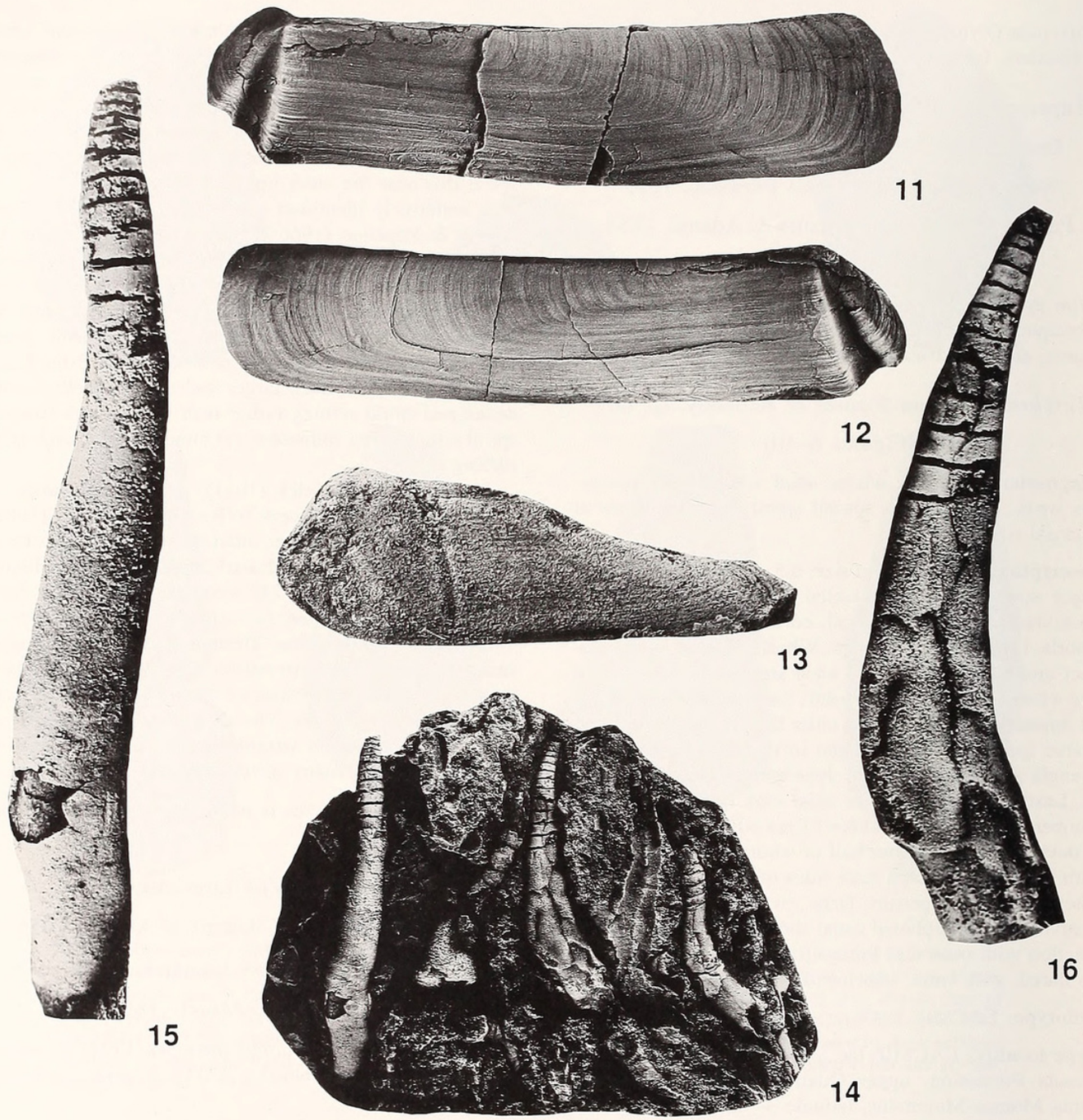
Type species: *Solen plagiaulax* Cossmann, 1906, by original designation; middle to upper Eocene (Lutetian to Bartonian Stages), Paris Basin, France.

Solena (*Eosolen*) *stantoni* (Weaver, 1905)

(Figures 11–12)

Solen stantoni Weaver, 1905:116, pl. 12, fig. 1. Dickerson, 1914:151 (table), pl. 12, fig. 3. Keen & Bentson, 1944: 108.

Solena (*Eosolen*) *stantoni* (Weaver). Zinsmeister, 1983a:63 (table), pl. 1, fig. 18.



Explanation of Figures 11 to 16

Figures 11–12. *Solena* (*Eosolen*) *stantoni* (Weaver, 1905), LACMIP hypotype 7943, LACMIP loc. 16897, closed-valve specimen, length 65 mm, height 15 mm, ×1.6. Figure 11. left valve. Figure 12. right valve. Figure 13. *Martesia* sp., LACMIP hypotype 7944, LACMIP loc. 16869, internal mold of left valve, length 33.8 mm, height 11.4 mm, ×2.4. Figures 14–16. *Nototeredo*(?) sp., LACMIP hypotype 7945, LACMIP loc. 16869. Figure 14. hand specimen of a cluster of individuals, two of which are shown in the following figures, ×1.3. Figure 15. side view of individual on left side of hand specimen, height 45 mm, maximum width 4.9 mm, ×3.2. Figure 16. side view of individual in center of hand specimen, height 32 mm, maximum width 6 mm, ×3.5

Not *Solen* (*Plectosolen*) *stantoni* Weaver. Clark & Woodford, 1927:103–104, pl. 18, fig. 10.

Not *Solen* cf. *parallelus* Gabb. Clark & Woodford, 1927: 104, pl. 18, fig. 9 [=*Solen* (*Plectosolen*) *stantoni* (Weaver), *in errata* fide Keen & Bentson, 1944].

Original description: "The shell is thin, elongated and moderately convex. The cardinal and basal margins are nearly parallel. The beaks are anterior. The base is straight and the ends somewhat rounded. The posterior end is more abruptly truncated than the anterior. The surface is marked by faint concentric lines of growth. Passing down from the beak to the base of the anterior margin there is on each side a deep, sharp constriction which is nearly at right angles to the hinge line. The maximum length of the type specimen was found to be 50 mm. The greatest width is 7 mm" (Weaver, 1905:p. 116).

Supplementary description: Shell moderately large in size, up to 6.6 cm in length, shell thin, elongate, ornamented by concentric growth lines; dorsal and ventral margins nearly parallel, dorsal margin slightly concave; beaks anterior; posterior end somewhat truncate; anterior area on both valves separated from remainder of shell by a deep and wide umbonal groove, widest at the ventral margin, set at an angle of about 105 to 110° to the dorsal margin; a distinct ridge and a second weaker, groove lie parallel and immediately anterior to the primary umbonal groove; anterior end produced, gaping, and bent posteriorly. Dentition unknown.

Holotype: UCMP 11941.

Type locality: UCMP loc. 532, upper Vine Hill Sandstone between Martinez and Walnut Creek at mouth of Vaca Canyon, Contra Costa County, northern California.

Geographic distribution: Contra Costa County, northern California to Santa Monica Mountains, Los Angeles County, southern California.

Geologic age: Late Paleocene (Thanetian).

Stratigraphic distribution: Upper Vine Hill Sandstone, near Pacheco, Contra Costa County (Weaver, 1953); middle part of Santa Susana Formation, south side of Simi Valley, Ventura County (Zinsmeister, 1974, 1983a); upper part of Santa Susana Formation, Santa Ynez Canyon area (LACMIP loc. 16869), east-central Santa Monica Mountains; upper part of Santa Susana Formation in Pulga Canyon (LACMIP loc. 16897), east–central Santa Monica Mountains.

Discussion: The subgenus *Eosolen* is characterized by having an oblique umbonal groove on the anterior end.

Two small specimens of *S.* (*E.*) *stantoni* were found at LACMIP loc. 16869 in the Santa Ynez Canyon area. One is an external mold of a complete late-juvenile specimen (20 mm long and 6 mm high) that consists of an open pair of valves, arranged in parallel fashion immediately next to each other ("butterflied"). The second specimen is a fragment of a slightly larger individual. Three large specimens were also found at LACMIP loc. 16897 in the upper Pulga Canyon area. These are complete, early to late adult, ranging from 5.5 to 6.6 cm in length and 13 to 15.5 mm in height, and they represent the largest known specimens of this species. Each consists of an open and "butterflied" pair of valves. Only the exteriors are visible. The specimens are essentially internal molds, but have impressions of the exterior sculpture, and thus are functional casts. Tiny remnants of the original shell material remain in a few places.

Both juvenile and adult specimens of *Solena* (*Eosolen*) *stantoni* are alike in their morphologic features in that they all have a slightly curved dorsal margin and a produced anterior end with two grooves. Morphologically they resemble the holotype but are better preserved. The holotype is a closed-valved early adult (length 5 cm) whose shell is mostly decorticated.

Clark & Woodford (1927:103–104, pl. 18, fig. 10 = UCMP hypotype 31324) illustrated a specimen of *Solen* (*Plectosolen*) *stantoni* (Weaver) from "division D strata of the Meganos Formation" in Deer Valley, Contra Costa County, northern California. Almgren et al. (1988:fig. 4) assigned "division D strata of the Meganos Formation," as used by Clark & Woodford (1927), to the CP9 Zone (lowest Eocene) of the standard calcareous nannofossil zonation. These shallow-marine strata are now referred to the Margaret Hamilton Sand (Edmondson, 1984). Clark & Woodford (1927:104, pl. 18, fig. 9 = UCMP hypotype 31325) also illustrated another specimen from the same formation as *Solen* sp. cf. *parallelus* Gabb. According to Stewart (1930) and Keen & Bentson (1944), Clark & Woodford noted *in errata* that UCMP hypotype 31325 should have been identified as *S.* (*Plectosolen*) *stantoni*. Examination of the two hypotypes reveals that they are unlike *S.* (*E.*) *stantoni* because the dorsal margin of each is straight rather than slightly curved and the anterior end of each is too rounded. The hypotypes of Clark & Woodford (1927) are herein tentatively identified as *Solena* (*E.*) *subverticala* Vokes (1939:96–97, pl. 15, fig. 8), which is known from the middle lower Eocene ("Capay Stage") to middle Eocene ("Domengine Stage") rocks in southern California (Givens, 1974), and from "Domengine" rocks in central California (Vokes, 1939).

Keen (1969) and Davies & Eames (1971) reported that *Eosolen* was restricted to the Eocene of Europe and North America. The lower limit of the geologic range is revised to late Paleocene by the presence of *Solena* (*Eosolen*) *stantoni* in upper Paleocene rocks in California.

The only other Paleocene solenid of which we are aware is "*Solen*" *parallelus* Gabb (1864:146–147, pl. 22, fig. 117), the lectotype of which is not well preserved, especially anteriorly. "*Solen*" *parallelus* was also figured by Stewart (1930:291–292, pl. 7, fig. 1), who reported that there is a faint suggestion of a diagonal groove on the anterior end. The type locality of "*S.*" *parallelus* is

controversial, and the species has been confused with Eocene solenids from the Pacific coast of North America. The type locality of "*S.*" *parallelus* is most likely from the Martinez area in Contra Costa County of northern California and is from upper Paleocene rocks (Stewart, 1930; Keen & Bentson, 1944). Due to poor preservation of existing material, this species is not assignable to a subgenus. *Solena* (*Eosolen*) *stantoni*, therefore, is the only confirmed representative of *Eosolen* in the Paleocene.

"*Solen*" *cuneatus* Gabb (1869:175–176, pl. 29, fig. 61), possibly from Cretaceous rocks near the Martinez area, is very poorly preserved (Stewart, 1930:292, pl. 5, fig. 12), and the confirmation of its solenid status (which seems doubtful) awaits better preserved material.

Dailey & Popenoe (1966) reported a late Campanian or possibly early Maastrichtian *Leptosolen* sp. from the Jalama Formation in Santa Barbara County of southern California. *Leptosolen* Conrad, 1867, resembles *Eosolen* but is characterized by wider valves, less terminal beaks, and the presence of a strong internal rib, and, in some species, with concentric imbricating sculpture (Conrad, 1867; Stephenson, 1941; Dailey & Popenoe, 1966). *Leptosolen*, which is known only from the Cretaceous and is widely distributed, belongs to the family Cultellidae, which is closely related to family Solenidae (Keen, 1969). *Leptosolen* sp. from the Jalama Formation is represented by a few internal molds, and examination of the best specimens (LACMIP hypotypes 40425 and 40426) reveals that they might belong to *Eosolen*. They are similar to *Eosolen* in narrow valves, and the beaks are more anterior than on *Leptosolen*. In addition, the internal molds show a sulcus on each valve that resembles the anterior umbonal groove of *Eosolen* in that it is nearly vertical and close to the end of the shell. If the sulcus had been formed by the diagnostic internal rib of *Leptosolen*, it would be nearer the center of the shell. Better preserved specimens of *Eosolen*-like shells from the Jalama Formation are needed to confirm their generic assignment. If they do prove to belong to *Eosolen*, they would represent its earliest record.

Order MYOIDA Stoliczka, 1870

Family PHOLADIDAE Lamarck, 1809

Subfamily MARTESIINAE Grant & Gale, 1931

Genus *Martesia* Sowerby, 1824

Type species: *Pholas clavata* Lamarck, 1818 [= *Martesia striata* (Linnaeus, 1758)], by original monotypy; Recent, "seas of Western Europe and America" (Turner, 1955).

Martesia sp.

(Figure 13)

Description: Small to medium in size, reaching approximately 3.4 cm in length and 1.5 cm in height, elongate, pear-shaped and tapering posteriorly. Umbones near anterior end. Shell divided by umbonal-ventral sulcus extending obliquely and posteroventrally from umbo to ventral margin. Anterior slope broad, rounded, with broad V-shaped notch on growth margin, about one-third of entire shell length; anterior slope sculptured by fine, concentric ridges, too finely denticulated to express radial sculpture. Disc and posteror slope with numerous, closely spaced, fine concentric ridges. Callum smooth, entire, without ellipsoidal notch on margin. Funnel-shape pit below umbonal reflection present on one specimen. Umbonal regions on all specimens too poorly preserved for description. Accessory plates lacking.

Distribution: Upper part of Santa Susana Formation, Santa Ynez Canyon area (LACMIP loc. 16869), east-central Santa Monica Mountains.

Geologic age: Late Paleocene (Thanetian).

Discussion: Fossil specimens of the wood-boring genus *Martesia* are rare in Paleogene deposits of the Pacific Coast of North America (Kennedy, 1974:58). The six specimens recovered from the upper part of the Santa Susana Formation in the Santa Ynez Canyon area (LACMIP loc. 16869) represent only the fifth confirmed record of typical *Martesia* from the Pacific Coast region and, more significantly, they represent the earliest record for the genus in this region. Although the genus has been reported in Jurassic and Cretaceous rocks, all Mesozoic specimens thus far examined (by the junior author) are assignable to *Opertochasma* Stephenson, 1952, another wood-boring genus similar in some respects to *Martesia* (Kennedy, 1974).

The six specimens from the Santa Susana Formation in the Santa Monica Mountains are all isolated single valves of adults preserved in sandstone. Associated carbonaceous material and one small piece of wood suggest proximity to peaty, vegetative, or wood debris. It is probable that the isolated valves separated and dispersed following disintegration of their original water-logged woody substrate. The umbonal regions of all specimens are poorly preserved, and most of the original shell material is missing on the specimens. The posterior-dorsal margin of the figured specimen (Figure 13, LACMIP hypotype 7944) is crushed and folded out of view. Accessory plates, such as the mesoplax, metaplax, and hypoplax, that fit around the margins of the paired valves, and which are useful in species identification, were not preserved or recovered.

Species of *Martesia* all have similar elongate, pear-shaped valves, an anterior margin with a broad V-shaped notch, a funnel-shaped pit below the umbonal reflection, and a wood-boring habit that makes them readily identifiable at the generic level. Kennedy (1974) recognized three subgenera of *Martesia*. Two of these, *Martesia* sensu stricto and *Particoma* Bartsch & Rehder, 1945, are

distinguished by differences in their mesoplax (the dorsal accessory plate that fits above the umbones), in addition to characteristics of their umbonal regions. The posterior-dorsal margins of *Martesia* and *Particoma* are not reflected, as they are in the third subgenus, *Paramartesia* Kennedy, 1974, whose posterior-dorsal margin is folded over upon itself, forming an elongae enclosure similar to that found in the modern rock-boring genus *Parapholas* Conrad, 1848. The type species of *Paramartesia*, namely *Martesia* (*Paramartesia*) *tolkieni* Kennedy (1974:59–60, figs. 67–70, frontispiece), is from the Lodo Formation on the west side of the San Joaquin Valley in central California. The Lodo Formation ranges from upper Paleocene to lower Eocene, but the type locality of *M.* (*P.*) *tolkieni* plots in the upper part of the formation (Payne, 1974:pl. 1), thus placing it in the lower Eocene part of the formation. The Santa Ynez Canyon specimens of *Martesia* sp. differ from *M.* (*P.*) *tolkieni* by not having a reflected posterior-dorsal margin.

Martesia meganosensis Clark & Woodford (1927:103, pl. 18, figs. 7, 8; Kennedy, 1974:58–59, figs. 65, 66) from the Margaret Hamilton Sand [= division D of Meganos Formation as used by Clark & Woodford (1927)] in Contra Costa County of northern California, is the only described California Paleogene Martesia that actually belongs to "typical" *Martesia*. The type specimens (Kennedy, 1974:58–59, figs. 65, 66) of *M. meganosensis*, however, do not have any characters distinctive below the generic level, and thus the name should be considered a *nomen dubium*. Almgren et al. (1988:fig. 4) assigned "division D strata of the Meganos Formation," as used by Clark & Woodford (1927), to the CP9 Zone (lowest Eocene) of the standard calcareous nannofossil zonation.

Forty-two specimens of *Martesia* sp. cited by Hickman (1969:69, pl. 8, figs. 4, 6) from the Eugene Formation near Eugene, Oregon, belong to *Martesia* sensu stricto based on the mesoplax of several specimens preserved in a single piece of fossil wood. Kennedy (1974:58) also reported one small, poorly preserved specimen of *Martesia* sp. from the Keasey Formation at Rock Creek, near Keasey, northwestern Oregon. Armentrout et al. (1983) assigned both the Eugene Formation and the Keasey Formation to the upper Eocene.

Other Paleogene records of *Martesia* from the Pacific coast lower Tertiary are more properly assigned to other genera. As reported by Kennedy (1974:61), Nelson's (1925:facing p. 402) record of "*Martesia* (?) species" from the "Martinez marine member" on the south side of Simi Valley in Ventura County, southern California, was based on a single poorly preserved specimen that is probably assignable to *Opertochasma*. Zinsmeister (1983a, 1983b) and Saul (1983:94) assigned the "Martinez marine member" to the Paleocene (Thanetian).

Martesia turnerae Hickman (1969:68, pl. 8, figs. 10–11, 13–14, 16), from the upper Eocene Eugene Formation in Oregon is also an *Opertochasma*, as demonstrated by Kennedy (1974:61, figs. 71–72).

"*Martesia*(?) sp." of Dickerson (1914:96, 140; see Kennedy, 1974:72, fig. 99), from the Paleocene Martinez Formation at Little Lake in Lake County of northern California, can be assigned to *Teredina* Lamarck, 1818, (Kennedy, 1974; S. R. A. Kelley, personal communication). *Teredina* is well represented and best known from the Eocene of the Paris Basin, France.

Family Teredinidae Rafinesque, 1815

Subfamily Bankiinae Turner, 1966

Genus *Nototeredo* Bartsch, 1923

Type species: *Teredo edax* Hedley, 1895, by original designation; Recent, Australia and New Zealand.

Nototeredo(?) sp.

(Figures 14–16)

Description: A cluster of seven calcareous tubes, either separate or touching, up to 4.5 cm in length and 6 mm in diameter; gently to moderately curved, tapered posteriorly. Tubes without constrictions, except at the concamerate posterior (siphonal) end. Concamerate part about 25 to 40 percent of length of tubes (incomplete); consisting of 10 to 12 concentrically arranged, internal restrictions (concamerations) that are spaced up to 1.5 mm apart.

Distribution: Upper part of Santa Susana Formation, Santa Ynez Canyon area (LACMIP loc. 16869), east-central Santa Monica Mountains.

Geologic age: Late Paleocene (Thanetian).

Discussion: A single hand specimen (Figure 14) containing a cluster of concamerate tubes was found at LACMIP loc. 16869. The specimens in Figure 14 are tubes that have been filled with sediment and subsequently leached (dissolved) away, leaving a cavity where the original shell once was. All the tubes in the cluster are oriented with the posterior ends (siphonal openings) in the same direction, indicative of their original aligned position within the enclosing substrate. Although teredinids are typically wood borers, the absence of preserved wood suggests they might have been colonizing an organic-rich, peaty substratum rather than wood.

The concamerate tubes at LACMIP loc. 16869 resemble those belonging to genus *Nototeredo* Bartsch, 1923, and as far as we know, this is the only genus to have tubes similar to those from the Santa Susana Formation. Nevertheless, a positive identification cannot be made because the valves of the shell are missing, as are the pallets, which are used for generic and species identification, at least among modern teredinids (Turner, 1966). On the basis of figure 13D of Turner (1966:39), one could infer

that the concamerations are designed to fit closely around the extended siphons in wider, down-hole parts of the tube that accommodate other organs or structures, but which are otherwise too cavernous for the slender siphons.

The tubes closely resemble those of *Nototeredo globosa* (Meek & Hayden, 1858:53; Meek, 1876:264–265, figs. 31, 32 and pl. 30, fig. 13), a wood-boring teredinid from the upper Paleocene (Danian) Cannonball Formation from North Dakota. Cvancara (1970:620–621, pl. 121, fig. 12) illustrated the pallets and concamerate tubes of this species and noted that the tubes are present both in well-preserved petrified wood as well as in very fine-grained detrital rocks in which little, if any, original organic material remains. The Santa Susana Formation specimens differ by being more curved and more tapered, but this is probably related to the original substratum rather than being of taxonomic significance. The calcareous tubes of most wood-boring teredinids are of very little taxonomic use, and generic and specific determinations are typically based on the periostracal parts of the pallets, which are rarely preserved in the fossil record (Turner, 1966).

Similar concamerated tubes of "*Gastrochaena amphisbaena*" Goldfuss, 1837, have been illustrated by Geinitz (1874:pl. 52, figs. 8–12). Goldfuss' species is from the Pläner beds in southeastern Germany, which Gignoux (1950:421) assigned to the Upper Cretaceous (Cenomanian Stage to Turonian Stage). The Santa Susana Formation specimens differ from Goldfuss's specimens by their greater consistency in the spacing of the concamerate segments. In addition, none of the Santa Susana Formation specimens has the close spacing found in some of the German specimens, although the taxonomic significance, if any, of this spacing has not been evaluated.

Nototeredo(?) sp. from the Santa Susana Formation in the Santa Ynez Canyon area represents the first record of fossil concamerate tubes from the Pacific Coast of North America. If the species is correctly assigned, it would be one of the earliest known records for this genus.

Two additional hand specimens from LACMIP loc. 16869 also contain aligned teredinid tubes, but none shows the concamerations of the tubes shown in Figure 14. They might represent another, unidentified (genus and) species of teredinid, or they might be tubes of juvenile animals that had yet to develop the concamerations. They might also simply represent differences in preservation. The shell material of the tubes on the additional hand specimens is still present.

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APPENDIX

LOCALITIES CITED

WASHINGTON

CSUN 1563. At elevation of 680 m (2230 ft.), roadcut exposure on NE side of logging road, 300 m N and 50 m E of SW corner of section 1, T. 17 N, R. 4 W, WBM, and 500 m S32°E of Larch Mountain, U. S. Geological Survey 7.5-minute Capitol Peak, Washington quadrangle,

1986 edition (provisional), Thurston County, Washington. Crescent Formation. Age: Middle early Eocene ("Capay Stage"). Collectors: J. L. Goedert & G. H. Goedert, July, 1992. [= LACMIP loc. 16655].

CALIFORNIA

The following information is applicable to the following localities: U. S. Geological Survey, 7.5-minute Topanga, California quadrangle, 1952 (photorevised 1981) edition, Palisades Highlands and vicinity, east–central Santa Monica Mountains, Los Angeles County, southern California. Upper part of the Santa Susana Formation. Age: Late Paleocene (Thanetian Stage).

LACMIP loc. 11984. Locality now covered by a homesite in a housing tract called "The Summit"; just below algal limestone at an elevation of about 419 m (1375 ft.), about 488 m (1600 ft.) S50°W of hill 1672, slightly E of the SE edge of the first "e" in the word "FIRE-BREAK," on a ridge between forks of upper Pulga Canyon. City of Los Angeles. Collector: J. M. Alderson, 1988.

LACMIP loc. 16869. Locality now covered by 2 to 3 m of fill underlying a homesite in a gate-guarded housing tract called "The Enclave," which is part of the community of Palisades Highlands; at the west end of Calle Bellevista at 16865 Calle Bellevista; approximately 20 m below algal limestone at elevation 450 m (1475 ft.), on the east side of Trailer Canyon, which is a tributary to Santa Ynez Canyon, in an unsurveyed area 5.6 km (3.47 mi.) E and 1.15 km (0.71 mi.) S of the SW corner of section 7, T. 1 S, R. 16 W, SBBM. City of Los Angeles. Collector: W. L. Rader, 1992. [= CSUN loc. 1590].

LACMIP loc. 16888. Locality now covered by 2 to 3 m of fill underlying homesites in a gate-guarded housing tract called "The Enclave," which is part of the community of Palisades Highlands; along the south side of Calle Bellevista; just above algal limestone and about 20 m (estimated) stratigraphically above LACMIP loc. 16869. City of Los Angeles. Collector: W. L. Rader, 1992.

LACMIP loc. 16897. In unweathered bluish gray siltstone above the "B" in southernmost word "FIRE-BREAK," 290 m (950 ft.) S and 335 m (1100 ft.) W of hill 1672 along E side of upper Pulga Canyon. Locality is about 100 m NW of corner of Chastian Parkway and Calle Jermaine in the Summit housing tract of Palisades Highlands. City of Los Angeles. Locality is now covered by homesites. Collectors: W. L. Rader & R. L. Squires, June 16, 1996.

LACMIP loc. 26814. Just below algal limestone, 853 m (2800 ft.) W of hill 2036, bottom of south-flowing tributary of Quarry Canyon, latitude 34°05′24″N, longitude 118°33′30″W. Collector: J. M. Alderson, January, 1981.