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A NEW PSEUDOLIVINE GASTROPOD GENUS FROM THE LOWER TERTIARY OF NORTH AMERICA

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ABSTRACT—A new genus, *Calorebama*, is proposed for a clade of pseudolivine gastropods (family Buccinidae) that has its earliest species in the lower Paleocene (Danian) of Alabama, its next earliest species in the upper Paleocene (Thanetian) of Alabama, and its subsequent species in the Eocene of California, Oregon, and Washington. *Calorebama* is characterized by an inflated biconical shape, a biangulate body whorl usually with strong nodes on the shoulder, and fine to medium spiral ribbing that is coarser anterior to the medial pseudolivine groove.

Previously, these pseudolivines now being placed in *Calorebama* were assigned to the genus *Pseudoliva*. Study of the literature and every available museum specimen showed *Calorebama* to have five species and two subspecies, all of which have biostratigraphic integrity.

Calorebama unicarinata (Aldrich) is the earliest species, and it, along with *C. tuberculifera* (Conrad), are the only known Gulf Coast species. *Calorebama dilleri dilleri* (Dickerson) is the earliest representative of the genus on the West Coast of North America, and it arrived during the early Eocene (Ypresian). Probable geographic isolation of *C. dilleri dilleri* in central and southern California resulted in lineage splitting and the appearance of *C. dilleri lineata* (Gabb), which phyletically evolved into *C. inornata* (Dickerson). *Calorebama dilleri dilleri* persisted in northern California and phyletically evolved into *C. dilleri kirbyi* (Clark), which similarly evolved into *C. volutaeformis* (Gabb).

Calorebama inornata and *C. volutaeformis*, the youngest species of the genus, became widely distributed along the West Coast of North America before becoming extinct by the end of the earliest late Eocene.

INTRODUCTION

PSEUDOLIVINE GASTROPODS are present worldwide in early Tertiary marine molluscan faunas although the number of specimens may be low. The earliest known species is probably a new species currently being described by Kase (personal commun.) from the uppermost Campanian or Maastrichtian Izumi Group, western Japan. Pseudolivines were most prolific during the widespread warm-water conditions of the Paleocene and Eocene, and they became rare in later Cenozoic faunas. Today, they are restricted to a few rare species of *Pseudoliva* in western Africa (Melvill, 1903) and two species of the closely related *Zemira* in eastern Australia (Ponder and Darragh, 1975).

Previously, the Paleogene pseudolivines studied in the present report and now allocable to a new genus, *Calorebama*, were assigned to *Pseudoliva*. A total of 215 specimens were examined, including all the type specimens and every available museum specimen.

The place of origin of *Calorebama* is presently unknown. *Calorebama* probably originated in the Caribbean region during earliest Paleocene time and subsequently immigrated (perhaps at slightly different times) to the Gulf–Atlantic and Pacific coastal regions. The earliest known species of this genus is *Calorebama unicarinata* (Aldrich) from the lower Paleocene (Danian) of Alabama. The next earliest species is *C. tuberculifera* (Conrad) from the upper Paleocene of Alabama. By the early Eocene, the genus had immigrated to the West Coast, resulting in the appearance of *C. dilleri dilleri* in northern California and southwestern Oregon. It must have been living in central and southern California at the same time (or before?), but the fact that *C. dilleri dilleri* has not been found in central and southern California may only be an artifact of an imperfect fossil record. Near the end of the early Eocene, populations of *C. dilleri dilleri* in central and southern California may have become geographically isolated enough to form *C. dilleri lineata*. This subspecies phyletically evolved into *C. inornata*. *Calorebama dilleri lineata* intergrades morphologically with *C. dilleri dilleri* and *C. inornata*. *Calorebama inornata* became widespread throughout the West Coast, but became extinct by the end of the earliest late Eocene. Evolutionary changes in this lineage include more streamlined shape and loss of both the subsutural swelling and nodes on the body whorl.

Calorebama dilleri dilleri persisted in northern California until the early middle Eocene when it phyletically evolved into *C. dilleri kirbyi*, with which it intergrades in morphology. *Calorebama dilleri kirbyi* was widespread throughout the West Coast. It phyletically evolved into *C. volutaeformis*, which was also widely distributed before it became extinct by the end of the earliest late Eocene. Evolutionary changes in this lineage include more volutiform shape, increase in strength of nodes, and loss of both the subsutural swelling and smooth sunken spiral bands on the body whorl.

In the "Occurrence" sections of this report, geologic stage ranges of the various species/subspecies of *Calorebama* are given in terms of provincial megainvertebrate stages of the Gulf Coast or the West Coast. Correlations of the Gulf Coast stages to the European standard stages are illustrated in Siesser et al. (1985). Correlations of the West Coast stages to the European standard stages are illustrated in Givens and Kennedy (1979), Saul (1983), and Squires (1984, 1987). A refinement of the lower boundary of the "Meganos Stage" is taken from Almgren et al. (1988). Based on calcareous nannofossils, they placed this boundary at the beginning of the Eocene. A refinement of the upper boundary of the "Tejon Stage" is taken from Armentrout et al. (1983). They placed the lower boundary of the provincial benthic foraminiferal Refugian Stage, which chronostratigraphically overlies the "Tejon Stage," within the basal part of the European Priabonian Stage.

Abbreviations used for catalog and/or locality numbers are: ANSP, Academy of Natural Sciences of Philadelphia; CAS, California Academy of Sciences; CSUN, California State University, Northridge; LACMIP, Natural History Museum of Los Angeles County, Invertebrate Paleontology Section; PRI, Paleontological Research Institution; SDNHM, Natural History Museum of San Diego County; SU, Stanford University (collections now housed at the California Academy of Sciences); UCMP, University of California Museum of Paleontology, Berkeley; UCLA, University of California, Los Angeles (collections now housed at the Natural History Museum of Los Angeles

County); UCR, University of California, Riverside; USGS, United States Geological Survey, Menlo Park, California.

Locality data for the formations listed in the "Occurrence" sections can be found by consulting the literature cited. For those cases where new stratigraphic occurrences and/or new localities for previously known stratigraphic occurrences have been discovered, the data are so indicated and the specific localities are listed.

SYSTEMATIC PALEONTOLOGY

Phylum MOLLUSCA Cuvier, 1797
Class GASTROPODA Cuvier, 1797
Order NEOGASTROPODA Wenz, 1938
Superfamily BUCCINACEA Rafinesque, 1815
Family BUCCINIDAE Rafinesque, 1815
Subfamily PSEUDOLIVINAE Cossmann, 1901

Discussion.—The familial classification of *Pseudoliva* has long been uncertain with the families Purpuridae, Muricidae, Olividae, Buccinidae, and ?Pseudolividae suggested as the possible candidates. A thorough discussion of this complex and unresolved classification problem is beyond the scope of this paper. In accordance with prevailing usage, family Buccinidae is used in this paper. Regardless of their familial position, *Pseudoliva, Calorebama, Buccinorbis,* and *Pegocomptus* comprise a distinctive group of genera characterized by the deep spiral groove on the body whorl. It is useful to emphasize this distinctiveness by recognizing the subfamily Pseudolivinae as proposed by Cossmann (1901). Thiele (1931), Davies (1935, 1975), Wenz (1938–1943), and Stewart (1927) also recognized this subfamily.

Genus CALOREBAMA n. gen.

Diagnosis.—Inflated biconical pseudolivine covered with closely spaced fine to medium spiral ribs; body whorl can also have any combination of subsutural swollen rim, concave ramp area, nodes on shoulder.

Description.—Fusiform to volutiform pseudolivine with moderate height spire and teleoconch covered with closely spaced fine to medium spiral ribs; body whorl usually with an angulation, and also biangulate when usually concave ramp area has subsutural swollen rim; ramp area may be flat or even partly filled with a callus-like thickening; angulation on body whorl, as well as on spire whorls, can be nodose; growth lines faint; growth lines and outer lip strongly prosocline in body whorl-ramp area, orthocline in pseudolivine-groove region, and prosocline just posterior to siphonal fasciole.

Discussion.—*Pseudoliva* Swainson, 1840, is the name given to nearly all fossil and Recent forms of pseudolivines. The type species of this genus is the modern *P. plumbea* (Dillwyn, 1817, p. 617). In this present study two specimens (ANSP 50965) and a third specimen (CAS 063184) (Figure 1.1, 1.2) of *P. plumbea* were examined. *Calorebama* n. gen. differs from these specimens and the published descriptions of *Pseudoliva* (Swainson, 1840; Reeve, 1846; Sowerby, 1859; Melvill, 1903) in the following features: more fusiform shape; higher spire; presence of closely spaced fine to medium spiral ribs (which coarsen anteriorly) over the entire teleoconch; usually an angulation on the body whorl with a variable degree of concavity in the ramp area; common presence of a subsutural swelling on the body whorl; pseudolivine groove more posteriorly located on the body whorl; no posterior gutter in the aperture; less channeled sutures; and stronger growth lines.

Paleocene pseudolivines of the West Coast belong to the genus *Pegocomptus* Zinsmeister, 1983. *Calorebama* n. gen. differs from *Pegocomptus* in the common presence of a subsutural swelling

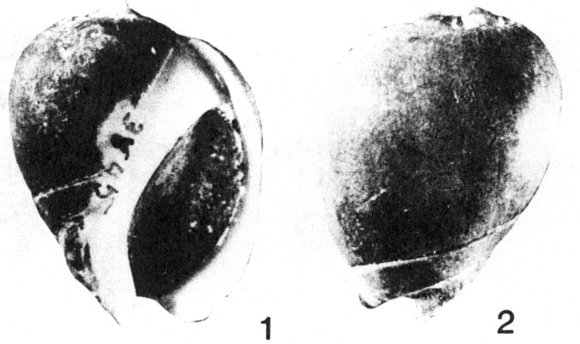

FIGURE 1—*1, 2, Pseudoliva plumbea* (Dillwyn), hypotype, CAS 063184, Recent, West Africa, apertural and abapertural views, ×1.7.

on the body whorl and in the lack of coarse collabral and spiral ribs.

Buccinorbis Conrad, 1865, was originally used by Conrad (1865) and Cossmann (1901) as a subgenus for certain Gulf Coast *Pseudoliva,* and Adegoke (1977) used it as a subgenus for certain African *Pseudoliva.* Davies (1935), however, used *Buccinorbis* as a genus. *Calorebama* n. gen. differs from *Buccinorbis* in the common presence of a subsutural swelling on the body whorl, common presence of nodes on the body whorl angulation, and lack of an umbilicus.

Pseudoliva packardi Van Winkle (1918, p. 90, Pl. 7, fig. 16; Weaver, 1943, p. 460, Pl. 89, fig. 26), from the Lincoln Creek Formation Gries Ranch beds of the middle Galvinian Stage (uppermost Eocene), southwestern Washington (Armentrout, 1975), does not belong in *Pseudoliva.* The holotype, CAS 7607, has at least two and possibly four teeth on the columellar lip and has no pseudolivine groove.

Pseudoliva? umpquaensis Turner (1938, p. 78, Pl. 18, figs. 9, 10; Weaver, 1943, p. 459, Pl. 89, fig. 13), from the lower Eocene Lookingglass Formation, southwestern Oregon (Heller and Dickinson, 1985), is a junior synonym of *Strepsidura ficus* (Gabb, 1864). Turner's species has all the characteristics of *S. ficus,* including an inflated pyriform shape and a rounded shoulder area on the body whorl where the fine spiral ribs are obsolete. There is no pseudolivine groove.

Pseudoliva sp. Smith (1975, Pl. 1, figs. 14, 15), from the Paleocene Lodo Formation, central California, does not belong in *Pseudoliva.* Examination of hypotypes CAS 10229 and UCMP 14202 revealed that there is no pseudolivine groove. These specimens may belong in *Brachysphingus.*

Etymology.—The new genus is named for the states of California, Oregon, and Alabama.

Type species.—*Calorebama dilleri dilleri* (Dickerson, 1914).

Material.—*Calorebama* n. gen. includes *C. unicarinata* (Aldrich), *C. tuberculifera* (Conrad), *C. dilleri dilleri* (Dickerson), *C. inornata* (Dickerson), and *C. volutaeformis* (Gabb). It also includes the transitional *C. dilleri lineata* (Gabb) and *C. dilleri kirbyi* (Clark).

Occurrence.—Lower Paleocene (Danian) to upper Paleocene (Thanetian) in Alabama; lower Eocene (Ypresian) to the lowest upper Eocene (basal part of Priabonian) on the West Coast.

CALOREBAMA UNICARINATA (Aldrich, 1886)
Figure 2.1, 2.2

Pseudoliva unicarinata ALDRICH, 1886, p. 19, Pl. 5, fig. 17; HARRIS, 1896, p. 98, Pl. 9, fig. 16; TOULMIN, 1977, p. 169, Pl. 7, fig. 5.

Supplementary description.—Moderately small-sized, shell height up to 20 mm; subfusiform; 6–7 concave whorls; suture

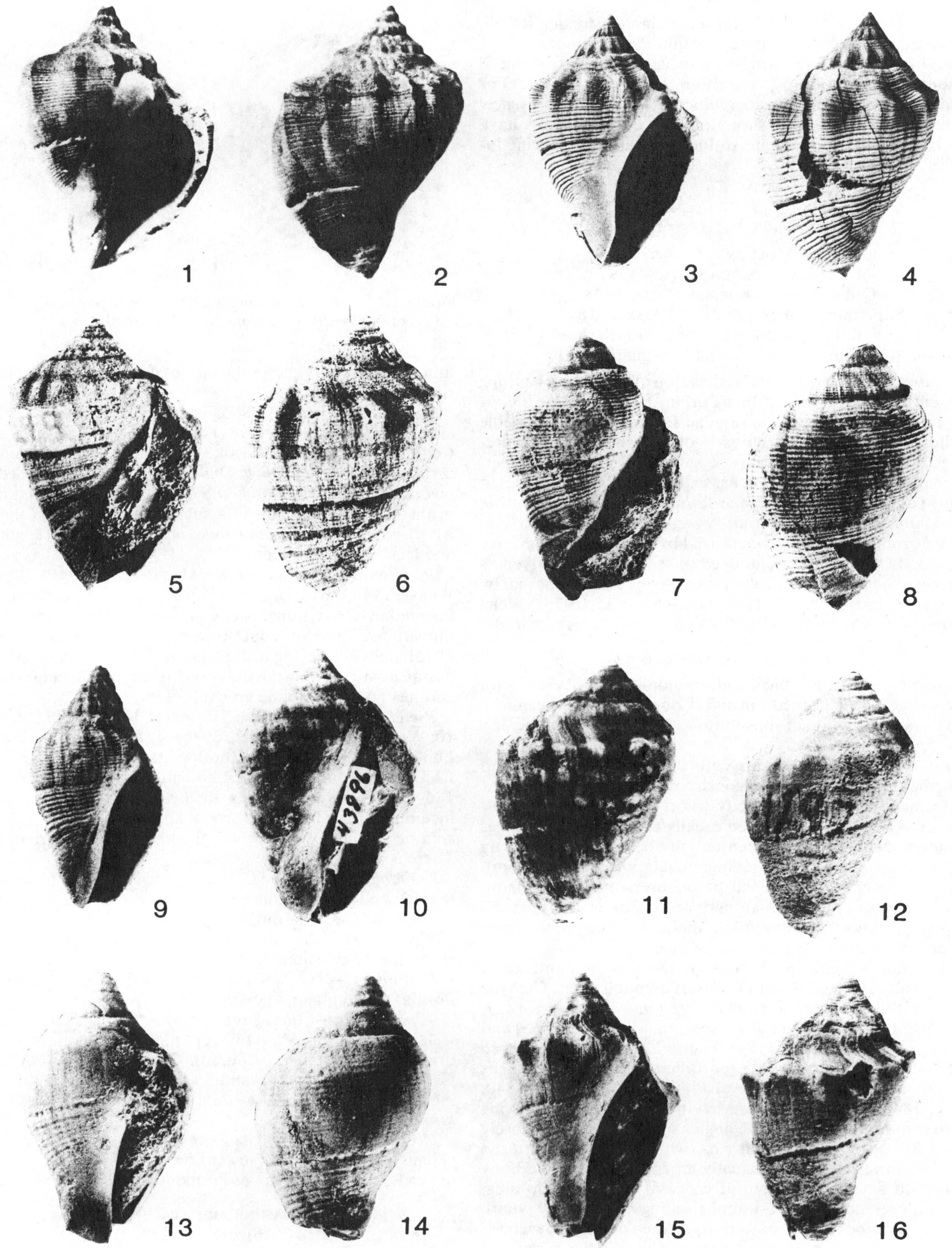

FIGURE 2—*1, 2, Calorebama unicarinata* (Aldrich), Toulmin's collection, hypotype 86, Toulmin's (1977) locality AWi-14, apertural and abapertural views, ×2.5. *3, 4, Calorebama tuberculifera* (Conrad), hypotype, LACMIP 7865, locality LACMIP 10894, apertural and abapertural views, ×1.7. *5, 6, Calorebama dilleri dilleri* (Dickerson), paratype, CAS 249, locality CAS 25, apertural and abapertural views, ×1.9. *7–9, Calorebama*

wavy and moderately impressed; protoconch smooth, low-domal shape; spire about 30 percent of shell height; spire whorls with numerous collabral costae that extend from suture to suture; body whorl shoulder with a slight subsutural swelling; body whorl shoulder angulate with 11 nodes that can be tuberculate; collabral costae extend from the nodes to the suture and anteriorly nearly to the pseudolivine groove; teleoconch covered with fine spiral ribs; growth lines faint, prosocline in body whorl ramp area, slightly orthocline in pseudolivine-groove region; aperture wide, inner lip with a thick callus, anterior notch narrow; moderately strong to strong siphonal fasciole, bordered by a low ridge.

Dimensions.—Toulmin's (1977, Pl. 7, fig. 5) collection, hypotype 86, height 19.4 mm, width 14.4 mm, h/w = 1.35.

Discussion.—*Calorebama unicarinata* is most similar to *C. tuberculifera* but differs in the following features: less fusiform; whorls more tabulate; slightly finer spiral ribs; and collabral costae extend nearly to the pseudolivine groove.

Material.—Four specimens (two from Toulmin's 1977 collection) showing excellent preservation. Holotype missing from Paleontological Research Institution, Ithaca, New York.

Toulmin's (1977, Pl. 7, fig. 5) figured specimen is illustrated in Figure 2.1, 2.2. Toulmin's type specimens, used in his 1977 article, were recently moved from the Florida State Museum, University of Florida, Gainesville, to the Alabama Geological Survey, Tuscaloosa.

Occurrence.—Gulf Coast Midwayan Stage, equivalent to lower Paleocene (Danian Stage). Matthew's Landing Marl Member of Porters Creek Formation, Wilcox County, western Alabama (Aldrich, 1886; Harris, 1896; Toulmin, 1977).

CALOREBAMA TUBERCULIFERA (Conrad, 1860)
Figure 2.3, 2.4

Pseudoliva tuberculifera CONRAD, 1860, p. 294, Pl. 47, fig. 27; GREGORIO, 1890, p. 110, Pl. 8, fig. 43; HARRIS, 1899, p. 32, Pl. 3, fig. 17; TOULMIN, 1977, p. 224, Pl. 28, fig. 3.
Sulcobuccinum (Buccinorbis) tuberculifera (Conrad). CONRAD, 1865, p. 22.
Pseudoliva (Buccinorbis) tuberculifera Conrad. CONRAD, 1866, p. 17.
Sulcobuccinum tuberculifera (Conrad). PALMER, 1927, p. 316.
Not *Pseudoliva tuberculifera* Conrad. COSSMANN, 1893, p. 33, Pl. 2, fig. 13 (=*P. vetusta* (Conrad, 1833), fide Harris, 1899, p. 32).

Supplementary description.—Medium-sized, shell height up to 35 mm; subfusiform to inflated biconical shape; 5–6 convex whorls; suture wavy and moderately impressed; protoconch smooth, moderately low-domal shape; spire about 30 percent of shell height; spire whorls with numerous collabral costae that extend from suture to suture; body whorl with a strong subsutural swelling (except in specimens less than 20 mm height); body whorl shoulder angulate with 11 nodes that can be tuberculate; whorl ramp strongly concave; collabral costae extend from nodes onto the subsutural swelling; teleoconch covered with moderately fine spiral ribs; from midpoint between shoulder and the median pseudolivine groove, spiral ribs increase to medium strength with minute spiral furrows bisecting individual ribs and/or secondary spiral threads between the primary spiral ribs; anterior to the pseudolivine groove, medium-strength spirals persist; growth lines very faint (except in siphonal fasciole area), prosocline in body whorl ramp area, orthocline in pseudolivine-groove region; aperture moderately narrow; inner lip with a thin to fairly thick callus; anterior notch narrow; moderately strong to strong siphonal fasciole, bordered by a low ridge.

Dimensions.—Holotype height 25.4 mm, width 15.9 mm, h/w = 1.59.

Discussion.—*Sulcobuccinum* Orbigny (1850) was used as a pseudolivine genus by Conrad (1865) and Palmer (1927). Wenz (1938–1944), however, considered *Sulcobuccinum* to be a junior synonym of *Pseudoliva.*

Calorebama tuberculifera is most similar to *C. unicarinata* but differs in the following features: more fusiform; less tabulate body whorl shoulder; more anteriorly located body whorl-shoulder nodes; slightly coarser spiral ribs; and body whorl collabral costae mainly confined to shoulder area.

Calorebama tuberculifera is similar to *C. dilleri dilleri* from the West Coast but differs in the following features: coarser spiral ribs; presence of secondary threads in the interspaces between most of the fine spiral ribs on the body whorl; more tuberculate nodes on the body whorl; more concave ramp area; lack of sunken spiral bands on the body whorl; and no subsutural swelling on body whorl of early adults (about 19 mm height).

Material.—Four specimens showing excellent preservation were examined. Three are adults.

Holotype missing from ANSP (Moore, 1962, p. 105). Type locality mislabelled; not from Claiborne as the label reads (Harris, 1899, p. 32).

Occurrence.—Gulf Coast lower Sabinian Stage, equivalent to upper Paleocene (Thanetian Stage). Gregg's Landing Marl Member of Tuscahoma Sand, Monroe and Wilcox Counties, western Alabama (Toulmin, 1977); Bell's Landing Marl Member of Tuscahoma Sand, Monroe County, western Alabama (Toulmin, 1977); Nanjemoy Formation(?), Charles County, southwestern Maryland (Toulmin, 1977; Harris, 1899).

CALOREBAMA DILLERI DILLERI (Dickerson, 1914)
Figure 2.5, 2.6

Pseudoliva dilleri DICKERSON, 1914, p. 122–123, Pl. 12, fig. 1a–d; MERRIAM AND TURNER, 1937, table 2; TURNER, 1938, p. 37, 77–78, Pl. 18, figs. 7, 8; WEAVER, 1943, p. 458–459, Pl. 89, figs. 5, 6, 10–12.
Pseudoliva cf. *dilleri* CLARK AND WOODFORD, 1927, p. 84, 115, Pl. 20, fig. 5; CLARK, 1929, Pl. 4, fig. 15; KEEN AND BENTSON, 1944, p. 188.
Not *Pseudoliva dilleri* Dickerson. SQUIRES, 1987, p. 42, fig. 58 (=*C. dilleri lineata* (Gabb, 1864)).

Supplementary description.—Small to medium-sized, shell height 8–35.3 mm (holotype largest specimen); fusiform (height less than 15 mm) to inflated biconical shape; 5–6 convex whorls; suture wavy and moderately impressed to indistinct; spire about 30 percent of shell height; penultimate whorl with numerous small nodes or smooth; body whorl with a strong subsutural swelling; body whorl shoulder angulate with 8–14 nodes, usually strong but rarely feeble; ramp slightly concave, nodes on body whorl shoulder can extend into this area, as well as onto the subsutural swelling; body whorl and usually penultimate whorl covered with very fine spiral ribs; body whorl posterior to the

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dilleri lineata (Gabb). *7, 8,* holotype, CAS 4200, locality northeast of Martinez, northern California, apertural and abapertural views, ×1.4; *9,* juvenile, hypotype, CAS 364.01, locality CAS 364, apertural view, ×4.5. *10–12, Calorebama dilleri kirbyi* (Clark). *10, 11,* hypotype, LACMIP 7866, locality UCLA 2340, apertural and abapertural views, ×1.6; *12,* hypotype, UCMP 38211, locality UCMP A-1297, abapertural view, ×2.8. *13, 14, Calorebama inornata* (Dickerson), hypotype, UCMP 38212, locality UCMP A-971, apertural and abapertural views, ×1.4. *15, 16, Calorebama volutaeformis* (Gabb), holotype, CAS 4201, locality Grapevine Canyon area, south-central California, apertural and abapertural views, ×1.6.

median pseudolivine groove usually with one or two smooth or nearly smooth, slightly sunken spiral bands; body whorl anterior to the pseudolivine groove with up to three of these smooth, sunken spiral bands; growth lines faint, prosocline in body whorl-ramp area, orthocline in pseudolivine-groove region; aperture moderately narrow; inner lip with a fairly thick callus; anterior notch narrow; strong siphonal fasciole, bordered by a low ridge.

Dimensions.—Holotype height 35.3 mm, width 24 mm, h/w = 1.46.

Discussion.—The subsutural swelling and smooth, sunken spiral bands are well developed in specimens with shell height greater than 20 mm. These two features are not present in the smallest specimens and are variably present in specimens with shell height between 9 and 20 mm. Nodosity is always present.

Calorebama dilleri dilleri intergrades in morphology with *C. dilleri lineata. Calorebama dilleri dilleri* differs from *C. dilleri lineata* in the following features: smooth, sunken spiral bands; discrete strong nodes on the body whorl; and finer spiral ribs.

Calorebama dilleri dilleri is similar to *C. tuberculifera* from the Gulf Coast but differs from it in the following features: smooth, sunken spiral bands on the body whorl; finer spiral ribs with no secondary ribs; and weaker body whorl nodes.

Pseudoliva cf. *P. dilleri* reported by Clark and Woodford (1927, hypotype, UCMP 31259) from Division D of the Meganos Formation ("Meganos Stage"), northern California, has smooth, sunken spiral bands on the posterior portion of the body whorl. Three additional Meganos Formation specimens from locality UCMP A-1435, which is only a few kilometers southeast of where hypotype UCMP 31259 was found, also show all the morphologic features distinctive of *C. dilleri dilleri.* Almgren et al. (1988) correlated, on the basis of calcareous nannofossils, Division D of the Meganos Formation to the lower Eocene.

Material.—Fifty-nine specimens showing fair to good preservation were examined. There are about equal numbers of juveniles and adults.

Holotype, CAS 248, and paratype, CAS 249, locality CAS 25, Lookingglass Formation, southwestern Oregon.

Occurrence.—West Coast "Meganos Stage," "Capay Stage," and "Domengine Stage," equivalent to lower Eocene to lower middle Eocene (Ypresian to lower Lutetian Stages). "Meganos Stage": Division D of Meganos Formation, Contra Costa County, northern California (Clark and Woodford, 1927; Clark, 1929) and new locality UCMP A-1435; "Capay Stage": Capay Formation, Yolo County, northern California (Merriam and Turner, 1937); Lookingglass Formation (=upper Umpqua Formation fide Miles, 1981, p. 98), Douglas County, southwestern Oregon (Dickerson, 1914; Turner, 1938; Weaver, 1943); "Domengine Stage": Domengine Formation, Contra Costa County, northern California (new stratigraphic occurrence, locality UCMP A-3174).

CALOREBAMA DILLERI LINEATA (Gabb, 1864)
Figure 2.7–2.9

Pseudoliva lineata GABB, 1864, p. 99, 223, Pl. 18, fig. 52; 1869, p. 219; DICKERSON, 1916, p. 379; STEWART, 1927, p. 400, Pl. 28, fig. 14a; VOKES, 1939, p. 139, Pl. 18, fig. 23; KEEN AND BENTSON, 1944, p. 188; SQUIRES, 1984, p. 33.

Pseudoliva dilleri Dickerson. SQUIRES, 1987, p. 42, fig. 58. Not of Dickerson, 1914.

Supplementary description.—Small to medium-sized, shell height 6–34.6 mm (holotype largest specimen); subfusiform to inflated biconical shape; 5–6 convex whorls; suture wavy and moderately impressed to indistinct; spire about 30 percent of shell height; spire whorls with numerous collabral ribs that extend from suture to suture; body whorl with a strong to moderately strong subsutural swelling (except on some, but not all, small specimens less than about 13 mm height); body whorl shoulder angulate with irregularly spaced swollen growth-line disturbances grading into about eight feeble nodes on part of whorl nearer aperture; on specimens less than about 16 mm height (Figure 2.9), swollen growth-line nodes better developed and more elongate; area between the subsutural swelling and body whorl shoulder slightly concave and swollen; teleoconch covered with fine spiral ribs; body whorl posterior to the median pseudolivine groove can have finer spiral ribs than body whorl anterior to this groove; growth lines faint (except in body whorl ramp and siphonal fasciole areas), prosocline in body whorl ramp area, orthocline in pseudolivine-groove region; aperture narrow; posterior sinus approximately as wide as it is long; inner lip with a thin to moderately thick callus; anterior notch narrow and slightly twisted; strong siphonal fasciole, bordered by a low ridge.

Dimensions.—Holotype height 34.6 mm, width 23.2 mm, h/w = 1.49.

Discussion.—Rare specimens show a single band of closely spaced fine spiral ribs posterior to the pseudolivine groove.

Calorebama dilleri lineata intergrades in morphology with both *C. dilleri dilleri* and *C. inornata. Calorebama dilleri lineata* differs from *C. dilleri dilleri* in the following features: coarser spiral ribs, especially on anterior half of body whorl; much weaker ornamentation on the body whorl shoulder with only feeble growth-line disturbances or weak small nodes; and an absence of smooth sunken spiral bands on the body whorl. Small specimens (less than 20 mm height) of *C. dilleri lineata* are also less tabulate than those of the same size *C. dilleri dilleri.*

Calorebama dilleri lineata differs from *C. inornata* in the following features: smaller size; less streamlined in shape; subsutural swelling on the body whorl; coarser spiral ribs; swollen growth-line disturbances and/or feeble nodes on the body whorl-shoulder angulation; and weaker growth lines.

Gabb (1864, p. 99) mentioned only one specimen in the discussion of his species, and this specimen was designated as a lectotype by Stewart (1927). In the lectotype ANSP 4200 box, there are 10 specimens. The largest one is the lectotype, and it along with eight other specimens constitute a growth-stage series of *C. dilleri lineata* with the juvenile specimens showing more of a tendency for development of feeble nodes on the body whorl shoulder. The tenth specimen is a naticid.

Material.—Thirty-eight specimens showing fair to good preservation were examined. There are about equal numbers of juveniles and adults.

Lectotype, ANSP 4200, designated by Stewart (1927, p. 400); exact location of type locality unknown, northeast of Martinez, northern California.

Occurrence.—West Coast "Capay Stage" and "Domengine Stage," equivalent to middle lower to lower middle Eocene (Ypresian and lower Lutetian Stages). "Capay Stage": Juncal Formation, *Turritella uvasana infera* fauna, Whitaker Peak area, Los Angeles County, southern California (Squires, 1987); upper Maniobra Formation, northeastern Orocopia Mountains, Riverside County, southern California (new stratigraphic occurrence, locality CSUN 674); lower Llajas Formation, interfingering coastal alluvial-fan facies and shallow-marine (transgressive) facies, Simi Valley, Ventura County, southern California (new stratigraphic occurrence, locality CSUN 452); "Domengine Stage": middle Llajas Formation, shallow-marine (transgressive) facies, Simi Valley, Ventura County, southern California (Squires, 1984) and new localities UCLA 2312 and UCMP 3304; Avenal Formation, Big Tar Canyon area, Kings County, central California; Domengine Formation, Big Blue

Hills area, Fresno County, central California (Vokes, 1939), and new locality UCMP 672; Black Hills area, south of Mt. Diablo, northern California (Dickerson, 1916), and new locality UCMP 725; northeast of Martinez, northern California (Gabb, 1864; Stewart, 1927).

CALOREBAMA DILLERI KIRBYI (Clark, 1938)
Figure 2.10–2.12

Pseudoliva volutaeformis Gabb. DICKERSON, 1915, p. 44 (in part), Pl. 7, fig. 3a; HANNA, 1927, p. 265, 315; GIVENS, 1974, p. 86, Pl. 9, fig. 14. Not of GABB, 1864.
Pseudoliva kirbyi CLARK, 1938, p. 709–710, Pl. 4, figs. 3, 4; KEEN AND BENTSON, 1944, p. 188.
Pseudoliva markleyensis CLARK, 1938, p. 710–711, Pl. 4, figs. 20, 21, 27, 28, 34, 35, 40, 44; KEEN AND BENTSON, 1944, p. 188.
Not *Pseudoliva kirbyi* Clark. WEAVER, 1943, Pl. 89, fig. 7 (=*C. inornata* (Dickerson, 1915)).

Supplementary description.—Small to medium-sized, shell height 11–33 m; sub-volutiform to inflated biconical shape; 4–5 convex whorls; suture wavy and moderately impressed to indistinct; protoconch low-domal shape; spire about 25 percent of shell height; spire whorls smooth, rarely with small nodes adjacent to each suture; body whorl with subsutural swelling, most common in specimens larger than about 20 mm in height; this subsutural swelling can have nodes; body whorl shoulder angulate with 11–15 nodes, stronger in larger specimens; area between these two angulations slightly concave to swollen depending upon variable thickness of infilling callus; body whorl covered by extremely fine spiral ribs, not preserved in most specimens; body whorl posterior to median pseudolivine groove usually with one or two smooth, slightly sunken spiral bands; subadjacent raised spiral areas on worn specimens can have an incipient nodular appearance; body whorl anterior to pseudolivine groove rarely with one or two of these smooth, sunken spiral bands; growth lines faint to weak (strongest in body whorl ramp area), prosocline in body whorl ramp area, orthocline in pseudolivine-groove region; aperture moderately narrow; inner lip with a fairly thick callus; anterior notch narrow; strong siphonal fasciole, bordered by a low ridge.

Dimensions.—Holotype height 14.4 mm, width 9.2 mm, h/w = 1.57.

Discussion.—*Calorebama dilleri kirbyi* intergrades in morphology with both *C. dilleri dilleri* and *C. volutaeformis*. *Calorebama dilleri kirbyi* differs from *C. dilleri dilleri* in the following features: more streamlined shape; a callus infilling in the area between the subsutural swelling (if present); and body whorl-shoulder angulation.

Calorebama dilleri kirbyi differs from *C. volutaeformis* in the following features: callus infilling in the area between the subsutural swelling and body whorl-shoulder angulation; weaker nodes on the body whorl shoulder; much finer spiral ribs (if present) on the body whorl; and sunken smooth spiral band(s) on the body whorl.

The Scripps Formation specimen of this subspecies is from locality UCMP 694. This locality, based upon the description by Hanna (1927, p. 265), plots in the Scripps Formation on the map by Givens and Kennedy (1979, fig. 5). Hanna (1927, p. 265) noted that the collections from this locality were made by Dickerson and Kew, suggesting that Dickerson's (1916, p. 439) record of *Pseudoliva volutaeformis* (=*C. dilleri kirbyi*) may be from this locality.

Specimens of *C. dilleri kirbyi* and *C. inornata* were found together at localities LACMIP 7155, UCMP 7187, and UCMP A-971, Tejon Formation, Grapevine Canyon area, Kern County. Locality information for these localities (as well as for locality UCLA 2340) is too imprecise to determine exact stratigraphic position. They are probably from the Liveoak Shale Member of the Tejon Formation. Four days of field checking by the author revealed no new specimens in the area between Grapevine and Liveoak Canyons where cover is extensive and structural complexities are prevalent.

Dickerson (1915, Pl. 7) and Keen and Bentson (1944, p. 188) reported hypotype CAS 309 from locality CAS 244. This locality, which is in the Tejon Formation, Liveoak Canyon, is also the type locality for *Turritella uvasana sargeanti*, a taxon confined to near the top of the Tejon Formation (Merriam, 1941) in beds equivalent to the Metralla Sandstone Member (Nilsen, 1987). The rock matrix in the aperture of this specimen, however, is a reddish, medium sandstone that is very different from the olive, calcareous, very fine sandstone associated with all the other specimens from this locality. Because of this discrepancy, hypotype CAS 309 is not considered to have come from locality CAS 244.

Material.—Thirty-three specimens showing fair to good preservation were examined. There are about equal numbers of juveniles and adults. Nearly all the juvenile specimens are worn and are from the Markley Formation, Vacaville area, locality UCMP A-1297.

Pseudoliva kirbyi: holotype, UCMP 12476, and paratype, UCMP 12477, locality UCMP A-1297, Markley Formation, Vacaville area, northern California. *Pseudoliva markleyensis:* holotype, UCMP 12472, and paratypes, UCMP 12473–12475, locality UCMP A-1297, Markley Formation, Vacaville area, northern California.

Occurrence.—West Coast "Domengine Stage" and "Transition Stage," equivalent to upper lower to lower middle Eocene (upper Ypresian to lower Lutetian Stages). "Domengine Stage": Crescent Formation, Crescent Bay, Clallam County, northwestern Washington (new stratigraphic occurrence, locality UCMP A-3212); "Transition Stage": Scripps Formation, Tecolote Valley, San Diego County, southern California (Hanna, 1927); Juncal Formation, *Ectinochilus supraplicatus* fauna, Pine Mountain area, Ventura County, southern California (Givens, 1974); Uvas Conglomerate Member, Liveoak Canyon, Tejon Formation (new stratigraphic occurrence, locality CSUN 1204); possibly the Liveoak Shale Member, Grapevine Canyon area, Tejon Formation, Kern County, south-central California, new localities LACMIP 7155, UCLA 2340, UCMP 7187, UCMP A-971; Markley Formation, Vacaville area, Napa County, northern California (Clark, 1938).

CALOREBAMA INORNATA (Dickerson, 1915)
Figure 2.13, 2.14

Pseudoliva inornata DICKERSON, 1915, p. 62–63, Pl. 7, fig. 1a–c; ANDERSON AND HANNA, 1925, p. 52, Pl. 12, fig. 1; HANNA, 1927, p. 314, foldout on p. 398; CLARK, 1929, Pl. 13, fig. 13; KEEN AND BENTSON, 1944, p. 188; GIVENS, 1974, p. 86, Pl. 9, fig. 6; GIVENS AND KENNEDY, 1979, table 3.
Pseudoliva tejonensis DICKERSON, 1915, p. 63, Pl. 7, fig. 2.
Pseudoliva kirbyi Clark. WEAVER, 1943, Pl. 89, fig. 7. Not of Clark, 1938.

Supplementary description.—Small to moderately large sized, shell height 4.5–46.5 mm (hypotype CAS 849 is largest specimen); fusiform with largest specimens somewhat inflated fusiform; 5–6 convex whorls; suture shallowly impressed to indistinct; protoconch low-domal shape; spire about 25 percent of shell height; antepenultimate whorl with about 15 small nodes that grade into very faint collabral swellings on penultimate whorl; on very small specimens less than 8 mm shell height, these collabral ribs persist onto body whorl; body whorl slightly angulate to rounded; area between suture and body whorl shoulder flattened or slightly concave; teleoconch covered by fine to medium spiral ribs; rare specimens show spiral bands in which spiral ribs less prominent; body whorl posterior to median pseudolivine groove usually with finer spiral ribs than body whorl anterior to this groove; growth lines fairly prominent, prosocline in body whorl ramp area, orthocline in pseudolivine-groove region; aperture moderately wide; inner lip with thin callus; on specimens with height greater than 40 mm, callus thick; anterior notch narrow; strong siphonal fasciole, bordered by a low ridge.

Dimensions.—Holotype height 33 mm, width 19 mm, h/w = 1.73.

Discussion.—Many of the specimens are worn, and spiral ribbing may be very faint or lacking in some of the specimens from a single locality. Holotype, UCMP 11503, is badly worn.

Calorebama inornata intergrades in morphology with *C. dilleri lineata* and differs from it in the following features: more fusiform; more elongate; body whorl shoulder can be rounded; no subsutural swelling on body whorl; and no nodes on the body whorl shoulder.

Dickerson (1915, Pl. 7) erroneously cited figure 1c as being a view of the same specimen as figure 1a. As noted by Anderson and Hanna (1925, p. 52), figure 1c is actually a view of the same specimen (paratype, CAS 307) shown in figure 1b. Paratype CAS 307 was considered by Anderson and Hanna (1925, p. 52) not to be *P. inornata* but rather an undescribed new species. Clark (1938, p. 710) assigned paratype CAS 307 to his new species *P. kirbyi.* Weaver (1943, Pl. 89, fig. 7) illustrated paratype CAS 307 and called it *P. kirbyi.*

One specimen of *C. inornata* was found at locality CAS 244, Liveoak Canyon, Tejon Formation. As discussed under "Discussion" for *C. dilleri kirbyi,* this locality is in the Metralla Sandstone Member of the Tejon Formation. Locality information for other localities in which *C. inornata* is present in the Tejon Formation is too imprecise to determine exact stratigraphic position. *Calorebama inornata* and *C. dilleri kirbyi* were found together at three such localities from the Grapevine Canyon area, Tejon Formation.

Several specimens of *C. inornata* show boreholes in the posterior portion of the body whorl.

Material.—Seventy specimens showing poor to good preservation were examined. There are about equal numbers of juveniles and adults.

Pseudoliva inornata: holotype, UCMP 11053, locality UCMP 458, Tejon Formation, south-central California. Paratype, CAS 307, locality CAS 183, Cowlitz Formation, southwestern Washington.

Pseudoliva tejonensis: holotype, CAS 308, locality CAS 245, Tejon Formation, south-central California.

Occurrence.—West Coast "Domengine Stage," "Transition Stage," and "Tejon Stage," equivalent to upper lower to middle Eocene (upper Ypresian to basal Priabonian Stages). "Domengine Stage": Upper Llajas Formation, shallow-marine (regressive) facies, Simi Valley, Ventura County, southern California (new stratigraphic occurrence, localities LACMIP 7435, 7438, 7445, UCMP loc. 3303); Ardath Shale, Rose Canyon, San Diego County, southern California (Hanna, 1927), and new localities, SDMNH 1667 and SU 378; Avenal Formation, Reef Ridge area, Kings County, central California (new stratigraphic occurrence, locality SU 378). "Transition Stage": Juncal Formation, *Ectinochilus supraplicatus* fauna, Pine Mountain area, Ventura County, southern California (Givens, 1974); upper Scripps Formation, Tecolote Canyon, San Diego County, southern California (Givens and Kennedy, 1979). "Tejon Stage": Metralla Sandstone Member (and possibly the underlying "Transition Stage" Liveoak Shale Member), Tejon Formation, Grapevine Canyon area to Liveoak Canyon, Kern County, south-central California (Dickerson, 1915; Anderson and Hanna, 1925); Matilija Formation, *Ectinochilus canalifera* fauna, Pine Mountain area, Ventura County, southern California (Givens, 1974); Cowlitz Formation, Lewis County, southwestern Washington (Anderson and Hanna, 1925).

CALOREBAMA VOLUTAEFORMIS (Gabb, 1864)
Figure 2.15, 2.16

Pseudoliva volutaeformis GABB, 1864, p. 99, Pl. 28, fig. 212; 1869, p. 220; DICKERSON, 1915, p. 44 (in part), Pl. 7, fig. 3b; STEWART, 1927, p. 400, Pl. 29, fig. 7; SCHENCK AND KEEN, 1940, Pl. 26, fig. 6; KEEN AND BENTSON, 1944, p. 188; WEAVER, 1943, p. 459, Pl. 89, fig. 20; Pl. 103, fig. 5.

Not *Pseudoliva volutaeformis* Gabb. DICKERSON, 1915, p. 44 (in part), Pl. 7, fig. 3a; GIVENS, 1974, p. 86, Pl. 9, fig. 14 (=*C. dilleri kirbyi* (Clark, 1938)).

Supplementary description.—Small to medium-sized, shell height 19–30.5 mm (holotype is largest specimen); volutiform; 4–5 whorls; suture obscure, undulatory; protoconch smooth, low-domal shape; spire about 25 percent of shell height; spire whorls flat to slightly concave with increasing age; penultimate whorl with nodes extending between sutures; body whorl with slight or no subsutural swelling; body whorl shoulder angulate with 7–11 tubercles; ramp area strongly concave; body whorl anterior to angulate shoulder covered with fine spiral ribs, increasing in strength anterior to median pseudolivine groove; growth lines weak (strongest in body whorl ramp and siphonal fasciole areas), prosocline in body whorl ramp area, orthocline in pseudolivine-groove region; aperture narrow; inner lip with fairly thick callus, increasing in thickness posteriorly; anterior notch narrow; moderately strong siphonal fasciole, bordered by a low ridge.

Dimensions.—Lectotype height 30.5 mm, width 19 mm, h/w = 1.60.

Discussion.—*Calorebama volutaeformis* intergrades in morphology with *C. dilleri kirbyi* and differs from it in the following features: more volutiform; only a slight or no subsutural swelling on the body whorl; a much stronger concave ramp area with no callus infilling; tubercles rather than nodes on the body whorl shoulder; much coarser spiral ribs (that strengthen anteriorly) on the body whorl; and no smooth sunken spiral bands on the body whorl.

Dickerson (1915, Pl. 7) and Keen and Bentson (1944, p. 188) listed hypotypes CAS 309 and 310 for *Pseudoliva volutaeformis.* Only hypotype CAS 310 belongs to this species, and hypotype CAS 309 belongs to *Calorebama dilleri kirbyi,* as mentioned earlier.

Material.—Nine specimens showing good preservation were examined. These are mostly adults. Five specimens are from the Tejon Formation, Liveoak Canyon area, and these were found at or near locality CAS 244. As discussed under "Discussion" for *C. dilleri kirbyi,* this locality is in the Metralla Sandstone Member of the Tejon Formation.

Lectotype ANSP 4201 designated by Stewart (1927, p. 400). Exact location of type locality unknown, type Tejon Formation area, Grapevine Canyon area, south-central California.

Occurrence.—West Coast "Tejon Stage," equivalent to middle middle to upper middle Eocene (middle Lutetian to basal Priabonian Stages). Metralla Sandstone Member, Tejon Formation, Grapevine Canyon area to Liveoak Canyon, Kern County, south-central California (Gabb 1864, 1869; Dickerson, 1915; Stewart, 1927; Schenck and Keen, 1940; Weaver, 1943); Matilija Formation, Nojoqui Creek, Santa Ynez Mountains, Santa Barbara County, southern California (new stratigraphic occurrence, locality SU 30275); Cowlitz Formation, Lewis

County, southwestern Washington (Weaver, 1943), and new locality UCMP B-5842.

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APPENDIX

LOCALITIES

Pseudolivine gastropods from 89 localities were studied. Only primary type-specimen localities, new hypotype (herein illustrated) localities, specifically mentioned localities, and pseudolivine-bearing localities that have not been previously mentioned in the literature are cited in this paper and listed here. Unless otherwise specified, all the quadrangle maps listed below are 7.5-minute.

CAS 25. On east bank of Little River at its confluence with Umpqua River, near center of sec. 19, T26S, R3W, Glide 15-minute quadrangle, Douglas County, Oregon.

CAS 183. In the west bank of the Cowlitz River, about 2.8 km SE of Vader, Lewis County, Washington.

CAS 244. In east bank of Liveoak Canyon, about 1.2 km from its mouth, Pastoria Creek quadrangle, California.

CAS 245. Along east bank of a small gulch about 0.4 km east of the pumping plant at the mouth of Grapevine Canyon, Grapevine quadrangle, Kern County, California.

CAS 364. In Devil Canyon below ranch house, sec. 25, T3N, R17W, Oat Mountain quadrangle, Los Angeles County, California.

CSUN 452. At elevation of 1,285 ft on west side of a small canyon branching north near mouth of Las Llajas Canyon, 503 m south and 168 m east of NW corner of sec. 32, T3N, R17W, Santa Susana quadrangle, Ventura County, California. = LACMIP loc. 16364

CSUN 674. On east side of canyon at elevation of 1,940 ft, 610 m south and 518 m west of NE corner of sec. 6, T7S, R13E, Canyon Spring SW quadrangle, Riverside County, California. = LACMIP loc. 16082

CSUN 1204. In saddle on ridge east of Liveoak Canyon at elevation of 2,025 ft, 1,274 m north and 76 m east of 34°55′ latitude and 118°52′30″ longitude, Pastoria Creek quadrangle, photorevised 1974, Kern County, California.

LACMIP 7155. First little canyon on east side above last loop of pre-1929 highway going up Grapevine Canyon, prospect pit exposing shell bed about 200 m east of highway, Grapevine quadrangle, Kern County, California.

LACMIP 7435. Cliff face on west side of McCray Canyon, near mouth, north side of Simi Valley; 67 m stratigraphically below Sespe Formation contact. B.M. in Santa Susana is 1.4 km south. Santa Susana quadrangle, Ventura County, California.

LACMIP 7438. West side of McCray Canyon, near mouth, north side of Simi Valley; 69 m stratigraphically below Sespe Formation contact. B.M. in Santa Susana is 1.4 km south. Santa Susana quadrangle, Ventura County, California.

LACMIP 7445. Second ridge east of McCray Canyon, north side of Simi Valley, 4 km N 7° E from B.M. in Santa Susana; 74 m stratigraphically below Sespe Formation contact. Santa Susana quadrangle, Ventura County, California.

LACMIP 10894. Tuscahoma Formation, Bells Landing, east bank of Alabama River, 3.2 km west of Tinela, sec. 36, T10N, R6E, Monroe County, Alabama.

SDMNH 1667. Rose Canyon Shale, Rose Canyon, La Jolla quadrangle, San Diego County, California.

SU 378. Southwest corner of sec. 17, T23S, R17E, Garza Peak quadrangle, Kings County, California.

SU 30275. On point of hill just west of Nojoqui Creek, 4 km north of Gaviota Pass, Solvang quadrangle, Santa Barbara County, California.

Toulmin's (1977) AWi-14. Alabama River, right bank, at mouth of Dixons Creek, in S½, sec. 2, T12N, R6E, Wilcox County, Alabama.

UCLA 2312. At elevation of 1,700 ft on a small cliff on south side of a side canyon to Las Llajas Canyon, 594 m north and 556 m east of SE corner of sec. 29, T3N, R17W, Santa Susana quadrangle, Ventura County, California. Locality is in the "Stewart bed" and is equivalent to CSUN locality 374.

UCLA 2340. East side of Grapevine Canyon about 0.8 km south of its north end, about 0.4 km east of and 30 m above the abandoned highway roadbed on east side of canyon (at about 2,100 ft contour), Grapevine quadrangle, Kern County, California.

UCMP 458. West side of Grapevine Canyon, elevation 2,050 ft, San Emigdio Mountains, Grapevine quadrangle, Kern County, California.

UCMP 672. South portion of crest of Parson's Peak, SE¼, NW¼, sec. 24, T18S, R14E, Joaquin Rocks quadrangle, Fresno County, California.

UCMP 694. Just east of Morena in Tecolote Canyon, latitude 32°47′30″, longitude 117°11′, La Jolla quadrangle, San Diego County, California.

UCMP 725. At elevation of 1,250 ft, Riggs Canyon, west of road north of Oyster Point Ridge, SE¼, SE¼, sec. 21, T1S, R1E, Tassajara quadrangle, Contra Costa County, California.

UCMP 3303. Devil Canyon near point where anticline crosses. On bank west of creek, SW¼, sec. 23, T3N, R17W, Santa Susana quadrangle, Ventura County, California.

UCMP 3304. Devil Canyon, sec. 36, T3N, R17W, Oat Mountain quadrangle, Ventura County, California.

UCMP 7187. On 3,000-ft terrace of the second draw east of mouth of Tecuya Canyon in center of SW¼, NE¼, T10N, R19W, Grapevine quadrangle, Kern County, California.

UCMP A-971. Grapevine Canyon on east side above road and near the level of the terrace, S 55° W and 22 m above the Violet Ray pumping station, Grapevine quadrangle, Kern County, California.

UCMP A-1297. From sandstone cliff on northeast bank of Pleasants Creek, opposite Brink Ranchhouse, about 1.2 km east of B.M. 257, and 3.2 km south of Putah Creek, Mt. Vaca quadrangle, Solano County, California.

UCMP A-1313. Gritty mudstone in Smith Canyon, about 90 m upstream from old well, SW¼, SE¼, sec. 28, T11N, R3W, Guinda quadrangle, Yolo County, California.

UCMP A-1314. Sandstone and conglomerate, 3 m stratigraphically above UCMP A-1313, east bank of Smith Canyon, SW¼, SE¼, sec. 28, T11R, R3W, Guinda quadrangle, Yolo County, California.

UCMP A-1435. In thin fossiliferous hard sandstone, at elevation of 260 ft, SE¼, SW¼, SW¼, sec. 6, T1S, R3E, Byron Hot Springs quadrangle, Contra Costa County, California.

UCMP A-3174. In gray sandstone on northeast side of road a little north of center of SE¼, sec. 8, T1S, R3E, Byron Hot Springs quadrangle, Contra Costa County, California.

UCMP A-3212. West side of west point of Port Crescent Bay, about in center of sec. 20, R8W, T31N, Joyce quadrangle, Clallam County, Washington.

UCMP B-5842. Castle Rock 15-minute quadrangle, Washington.