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REVIEW OF THE BIVALVE GENUS *PLICATULA* FROM CRETACEOUS AND LOWER CENOZOIC STRATA OF CALIFORNIA AND BAJA CALIFORNIA

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ABSTRACT—The Cretaceous and early Cenozoic species of the shallow-marine, warm-water bivalve *Plicatula* from California (United States) and Baja California (Mexico) are reviewed, and three new species are named. All of these species are representatives of *Plicatula* and not of the closely related taxon *Harpax,* which is associated with high-latitude and cool-water regions. The earliest-known Cretaceous species of *Plicatula* from the study area is *P. variata* Gabb, 1864, from Lower Cretaceous (Hauterivian Stage) strata in northern California, and our studies show it to be conspecific with *Plicatula onoensis* Anderson, 1958.

Plicatula allisoni new species is from Lower Cretaceous (Albian Stage) strata in Baja California, Mexico. *Plicatula modjeskaensis* new species is from Upper Cretaceous (Turonian Stage) strata in the Santa Ana Mountains, southern California. A possible new species from the same strata is also mentioned. A poorly preserved specimen of *Plicatula*? sp. is known from Upper Cretaceous (upper Campanian to lower Maastrichtian) strata in northern California.

The only Paleocene species of *Plicatula* from the study area is *P. ostreiformis* Stanton, 1896, from lower Paleocene strata of Lake County, northern California, and our studies show it to be conspecific with *Ostrea buwaldana* Dickerson, 1914. The only previously described Eocene species of *Plicatula* from the study area is *P. juncalensis* Squires, 1987, from lower middle Eocene ("Capay Stage") strata of Los Angeles County, southern California. *Plicatula surensis* new species is from middle lower Eocene ("Capay Stage") strata in Baja California Sur, Mexico. In addition, there is a *Plicatula*? sp. from Eocene strata of Baja California Sur, Mexico.

Although *Plicatula* is of uncommon occurrence north of Baja California, its thermophilic trait makes it useful in recognizing periods of warm climate.

INTRODUCTION

THE MARINE bivalve family Plicatulidae ranges from the Middle Triassic (Ladinian Stage) to Recent (Cox and Hertlein, 1969). Today, it is represented by only the genus *Plicatula* Lamarck, 1801, whose exact earliest appearance in the fossil record is not known. Cox and Hertlein (1969) reported its earliest record to be Middle Triassic (Ladinian), but their concept of genus *Plicatula* included *Harpax* Parkinson, 1811, as a junior synoynm. Most modern workers now believe that *Harpax* is a valid taxon and is either a distinct genus, or possibly a subgenus of *Plicatula* (e.g., Poulton, 1991; Damborenea, 1993). *Harpax* has been reported from Upper Triassic strata in high-latitude areas in both the Northern and Southern Hemispheres, and its bipolar distribution is suggestive of climatic control (Damborenea, 1993). Much work is needed to fully establish the relationship between *Harpax* and *Plicatula,* to document the place and time of origin of each taxon, and to reconstruct the paleobiogeographic distribution of each one.

The earliest record of *Plicatula* from the Pacific coast of North America is *P. perimbricata* Gabb, 1870, from the uppermost Triassic Modin Formation (Devils Canyon Member) of Shasta County, northern California (Sanborn, 1960, p. 25, pl. 2, figs. 26, 27) and from the uppermost Triassic Gabbs Formation, western Nevada (Laws, 1982). It is possible that this species might belong to *Harpax* because its peculiar oval shape, subdued sculpture, and projecting hinge area are similar to *Harpax* but are quite unlike the Cretaceous and Cenozoic *Plicatula* species reported on in this present study.

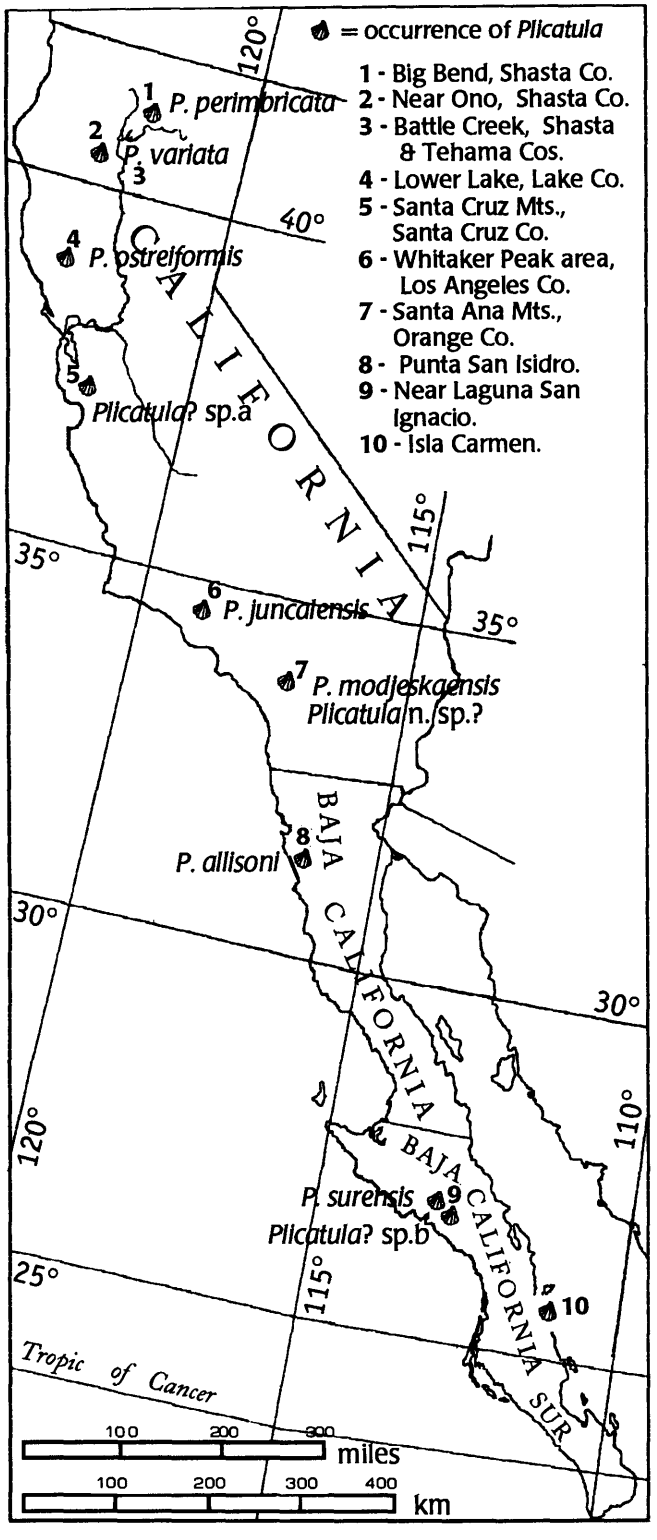


FIGURE 1—Index map for occurrences of *Plicatula* between northern California and southern Baja California Sur. *Plicatula* spp. near Isla Carmen (10) are *P. penicellata, P. spondylopsis,* and *P. inezana.* Geologic ages of the *Plicatula* are plotted on Figure 2.

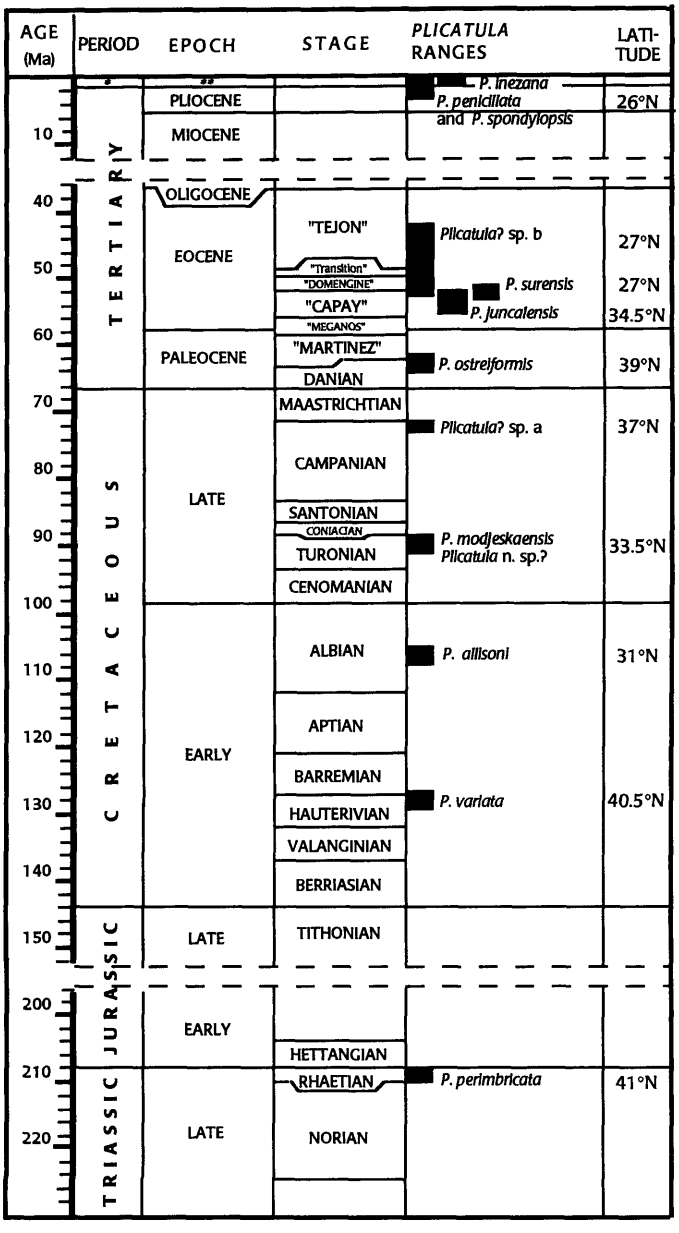


FIGURE 2—Time ranges of *Plicatula* in California and Baja California Sur. * = Quaternary; ** = Pleistocene. *Plicatula penicillata* and *P. spondylopsis* range from Pliocene to Recent; *P. inezana* from Pleistocene to Recent. Latitudes given are approximate northernmost occurrences of each species.

Even though *Plicatula* was widespread during the Jurassic (Hallam, 1977), we know of no Jurassic occurrences of this bivalve in California and Baja California. Hallam (1977) reported, in a generalized checklist fashion, that Early Jurassic and Middle Jurassic *Plicatula* are present in his so-called "western margins of North America." He defined this area as including Alaska, British Columbia, Oregon, Nevada, and California, but he did not list any specifics regarding taxa or localities. *Plicatula* spp. have been reported, also in a checklist fashion, as present in Jurassic strata of the Artic slope of northern Alaska (Imlay, 1955). It is likely that some of these species belong to genus *Harpax,* and a thorough study is needed.

During the Cretaceous, *Plicatula* was a widespread, warm-water bivalve (Kauffman, 1973). The earliest Cretaceous species

from the Pacific coast of North America is *P. variata* Gabb, 1864, from Lower Cretaceous strata (Hauterivian) of Shasta County, northern California (Figure 1). Occurrences of additional Cretaceous and Tertiary species of *Plicatula* from the Pacific coast of North America are plotted on Figure 1 and their age indicated on Figure 2. Three of these are new species, and one is a questionable new species. Two of the occurrences are questionable occurrences of genus *Plicatula.* None of these Cretaceous and Tertiary species included on Figure 2 is considered by us to represent the taxon *Harpax.*

The fossil record of *Plicatula* in California and Baja California is not continuous (Figure 2). The presence of confirmed *Plicatula* in this area includes the late Hauterivian, middle Albian, and Turonian. These times coincided with sea-level rises and the associated influx of warm-water, shallow-marine mollusks that show mainly a cosmopolitan and/or Tethyan aspect (Saul, 1986). Notable corresponding absences of species in the Cretaceous include the Berriasian through Valanginian, Barremian through early Albian, and Coniacian through early Campanian and Maastrichtian. These times in California and Baja California, as well as in the entire northeast Pacific region, coincided with lower sea levels, cooler water, and lower diversity of mollusks relative to the warm-water faunas (Saul, 1986).

The discontinuous aspect of the Cretaceous fossil record of *Plicatula* in California and Baja California also holds true for the Cenozoic record. The presence of *Plicatula* in this area includes the late Danian-"Martinez," "Capay," and most of the rest of the Eocene. The late Danian-"Martinez" coincided with a sea-level rise and the associated influx of warm-water, shallow-marine mollusks (Zinsmeister, 1983; Zinsmeister and Paredes-Mejia, 1988; Saul, 1986). The same is true for the "Capay," which was possibly the warmest time of the Cenozoic. During "Capay" time, the California and Baja California fossil record shows a very strong Tethyan aspect in the shallow-marine molluscan faunas (Squires, 1987; Squires and Demetrion, 1992). Another pulse of warm-water mollusk immigration took place during the "Domengine Stage," but it was not as extensive as the earlier two of the early Cenozoic (Squires, 1984). From late Eocene through Miocene (Figure 2), there was a notable absence of any *Plicatula* in California and Baja California. This interval of time coincides to a worldwide deterioration of the greenhouse climate of earlier times and the beginning of a transition into an icehouse climate (Kennett, 1982).

Although there are no Pliocene and Pleistocene occurrences of *Plicatula* in California, there are species of this age in warm-water deposits of the Baja California region. The same is essentially true for the extant species. Today, four species of *Plicatula* live in the southern Gulf of California, two of which range into Ecuador (Keen, 1971). Two of these living species, *P. penicillafa* Carpenter, 1857, and *P. spondylopsis* Rochebrune, 1895, have a fossil record back to the Pliocene in Baja California Sur, Mexico (Moore, 1987), and *P. inezana* Durham, 1950, has a fossil record back to the Pleistocene (Durham, 1950; Keen, 1971). From early Paleocene to modern times, the northern limit of *Plicatula* from the Pacific slope of North America has been steadily shifting southward.

The noncontinuous distribution of *Plicatula* during the Cretaceous and Cenozoic in California and Baja California parallels that observed (Saul and Squires, in press) for thermophilic shallow-marine, neritid gastropds in this region.

Today, *Plicatula* comprises just a small number of living species, which are confined to tropical waters (Watson, 1930; Cox and Hertlein, 1969). They are oyster-like, with attachment to the substrate by means of the right valve. The gills of *Plicatula,* however, are more primitive than those in oysters, and this difference in gills may account, in part, for why *Plicatula* has not been as successful as oysters during the Cenozoic (Watson, 1930).

Abbreviations used for catalog and/or locality numbers are: ANSP, Academy of Natural Sciences of Philadelphia; CASG, California Academy of Sciences, Geology Section, San Francisco; CIT, California Institute of Technology [collections now stored at LACMIP]; CSUN, California State University, Northridge; IGM, Instituto de Geología, Universidad Nacional Autónoma de México, Mexico City; LACMIP, Natural History Museum of Los Angeles County, Invertebrate Paleontology Section; UCMP, University of California, Museum of Paleontology, Berkeley; USGS, United States Geological Survey, Menlo Park, California; USNM, National Museum of Natural History, Washington, D. C.

SYSTEMATIC PALEONTOLOGY

Class BIVALVIA Linné, 1758
Family PLICATULIDAE Watson, 1930
Genus PLICATULA Lamarck, 1801

Discussion.—*Plicatula* is considered by most modern workers to be distinct from *Harpax* Parkinson, 1811. According to Poulton (1991), *Harpax* is an independent genus from *Plicatula* based on the fact that *Harpax* does not have a significant ligament pit and the teeth can be striate. Damborenea (1993) regarded *Harpax* as a subgenus of *Plicatula* based on the peculiar hinge and the peculiar scaly ornamentation of *Harpax.*

The species discussed below are considered by us to be representatives of *Plicatula* but not *Harpax,* based on the presence of a ligamental pit, absence of striae on the teeth, and/or the usual presence of well-developed radial ribbing.

Type species.—*Spondylus plicatus* Linné, 1758, by subsequent designation (Schmidt, 1818).

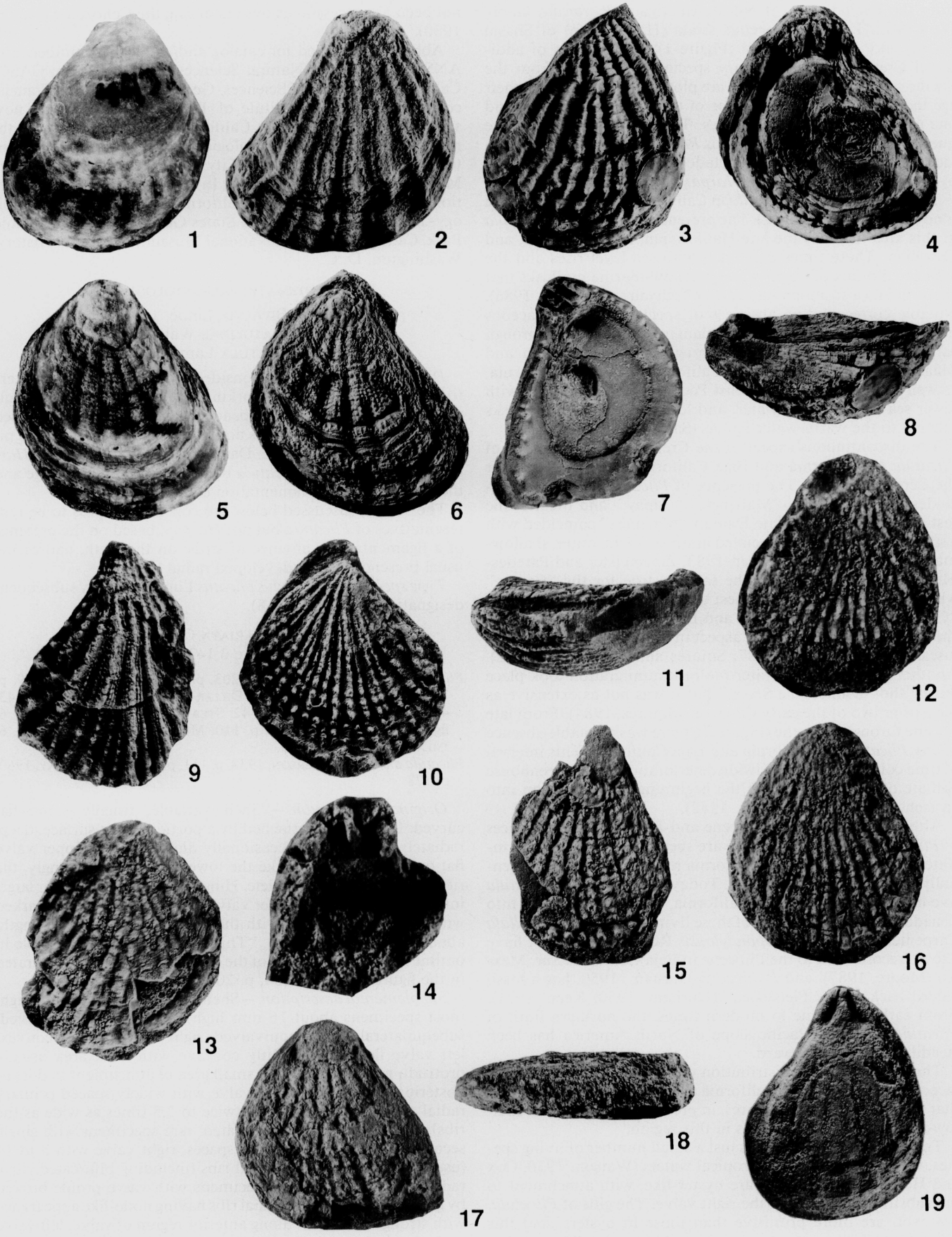
PLICATULA VARIATA Gabb, 1864
Figure 3.1–3.8

Plicatula variata GABB, 1864, p. 203, pl. 26, fig. 190; GABB, 1869, p. 252; STANTON, 1893, p. 251; DILLER AND STANTON, 1894, p. 443, 446; ANDERSON, 1902, p. 41–42; STEWART, 1930, p. 114–115, pl. 6, figs. 3–5; ANDERSON, 1938, p. 110; MURPHY, 1956, p. 2113, fig. 6; IMLAY, 1960, p. 179–180.

Plicatula onoensis ANDERSON, 1938, p. 111, pl. 4, figs. 1–3; IMLAY, 1960, p. 178.

Original description.—"Shell variable, usually somewhat curved. Lower valve attached by a portion of the surface, deep, radiately costate, ribs occasionally dichotomous. Upper valve flat or concave, plicate like the lower, but not so strongly, the ribs being sometimes obsolete. Hinge robust; muscular scar large; internal margin of the upper valve crenate; lower valve marked with pits corresponding with the teeth above. Average length, about .7 inch." [17.5 mm]. "This shell is extremely variable in outline and convexity; one of the commonest forms is illustrated in the figure" (Gabb, 1864, p. 203).

Supplemental description.—Shell medium (up to 27 mm high, most specimens about 16 mm high), semi-triangular, curved, subequilateral, very inequivalved, right valve strongly convex, left valve flattish to slightly concave with beak area usually protruding; right valve with small area of attachment in dorsal-posterior beak region; right valve with widely spaced primary radial ribs (interspaces about twice to 2.5 times as wide as the ribs), ribs in some cases bifurcated; rare specimens with single secondary radial riblet in interspaces, right valve with 8 to 14 (usually 8 to 9) primary radial ribs (including bifurcated ribs); radial ribs on unabraded specimens with valve profile broken by growth interruptions, radial ribs having node-like appearance with strongest "nodes" along anterior region of valve; left valve with closely spaced, wide primary radial ribs, bifurcation com-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mon especially toward venter, 6 to 13 (usually 8) radial ribs (including bifurcated ones), ribs in some cases scaly; hinge short, right valve with two long teeth on each side of a narrow resilifer, inner margin of right valve with numerous pits; left valve with two long sockets on each side of a moderately wide resilifer, inner margin of left valve with numerous tubercles; muscle scar monomyarian, elliptical, and posterior of center of each valve.

Type specimens.—Lectotype of *Plicatula variata* ANSP 4432, here designated; lectoparatypes ANSP 4432a, 4432b. Holotype of *P. onoensis* CASG 66509.01; paratype CASG 66510.01; hypotype [=voucher] CASG 66511.01.

Type localities.—Of *P. variata:* North Fork Cottonwood Creek, Shasta County, California (Ogo Member of the Budden Canyon Formation, Early Cretaceous). Of *P. onoensis:* holotype from CASG loc. 66509; paratype from CASG loc. 66510; Anderson's (1938) hypotype CASG loc. 66511 [=CASG loc. 113, see "Discussion"]; all from North Fork Cottonwood Creek, Shasta County, California (Ogo Member of the Budden Canyon Formation, Early Cretaceous).

Dimensions.—ANSP 4432, right valve, height 16.7 mm, length 15.1 mm, thickness 7.7 mm. ANSP 4432a, left valve, height 14.5 mm, length 12.9 mm, thickness 2.7 mm. ANSP 4432b, articulated specimen, height 12.5 mm, length 11.2 mm, thickness of double valves 5.4 mm. CASG, 66509.01, articulated specimen, height 16.9 mm, length 16.2 mm, thickness of double valves 7.8 mm. CASG 66510.01, articulated specimen, height 15.2 mm, length 13.8 mm, thickness of double valves 7.2 mm. CASG 66511.01, articulated specimen, height 16.4 mm, length 14.1 mm, thickness of double valves 8.9 mm.

Discussion.—Gabb did not publish type specimen designations in 1864 or 1869 and only infrequently noted them on labels. Stewart (1927, 1930) commonly indicated that the specimen figured by Gabb was the holotype, but where Gabb said he had several specimens, these should be considered syntypes, and Stewart's "holotype" a lectotype. Obviously, for those species of which Gabb indicated he had only a single specimen, that specimen would be the holotype, as would those specimens for which he wrote "type" on the label. In the absence of the specimen of *P. variata* figured by Gabb, Stewart (1930) illustrated specimens from a box labeled, in Gabb's hand, "(dupl. type), Shasta Group, Cottonwood Creek." Stewart (1930) suggested that if the original material from Battle Creek, Shasta County, could not be found, a neotype should be designated from specimens collected from that locality, but "Battle Creek, Shasta County," is an unsatisfactory type locality because it is ill-defined and unlikely to produce specimens.

Gabb (1864; 1869) listed only two species from Battle Creek: *Plicatula variata* Gabb, 1864 and *Ammonites subtricarinatus* Gabb, 1864 = [*A. tehamaensis* Gabb, 1869 = *Peroniceras tehamaensis* (Gabb, 1869) = *P. rousseauxi* Grossouvre, 1894] (Matsumoto, 1960). *Peroniceras tehamensis* is the basis of the Coniacian age for Battle Creek beds, Tehama County (Matsumoto, 1960). There is, however, no indication in Gabb, 1864 or 1869, that the two species came from the same locality. The ammonite was "presented to the Geological Survey of California by a gentleman at Battle Creek, Tehama County and said to have come from the vicinity" (Gabb, 1864, p. 61), but Gabb recorded the bivalve as from Battle Creek, Shasta County in 1864 and from the Shasta Group in 1869. In Bear Creek to the north of the North Fork of Battle Creek, Shasta County, the lower beds of the Redding Formation yield a Coniacian age fauna, and in canyons to the south of the South Fork of Battle Creek, Tehama County, the oldest beds of the Chico Formation have yielded a late Coniacian age fauna. No outcrops of the "Shasta Series" (=Lower Cretaceous) are known from the east side of the Great Valley. Lydon and O'Brien (1974, pl. 1) showed no outcrops of the "Chico" Formation along the North Fork of Battle Creek, Shasta County, although considering the scale of the map and its reconnaissance nature, small outcrops of the Redding Formation might none-the-less be present. Helley et al. (1981) also showed no outcrops of Cretaceous strata along Battle Creek or its forks in Shasta and Tehama Counties, California.

Although Gabb (1864; 1869) did not list *P. variata* from the "Shasta Series" on North Fork Cottonwood Creek, Shasta County, he had, in addition to the box at the Academy of Natural Sciences of Philadelphia, specimens from North Fork Cottonwood Creek that are at the University of California Museum of Paleontology. Gabb's abundance of specimens of *P. variata* from the "Shasta Series" on North Fork Cottonwood Creek suggests that the Battle Creek location is an error.

Designating ANSP 4432 (from North Fork Cottonwood Creek) as the lectotype provides *P. variata* with a specimen considered by Gabb to belong to this species and to be a type specimen. Additionally, the *Hertleinites aguila* zone on North Fork of Cottonwood Creek, Shasta County, has produced well-preserved specimens of *Plicatula* that have been identified as *P. variata* over the past century.

Plicatula onoensis Anderson (1938) was described from its type locality and a few other localities, all in the vicinity of Ono, California. Strata in the vicinity of the type locality have been studied by Murphy (1956) and Murphy et al. (1964, 1969) and are considered to be in the upper part of the Ogo Member of the Budden Canyon Formation, from the *Hertleinites aguila* zone, and thus of late Hauterivian age.

Imlay (1960) discussed hypotype locality CASG loc. 113 and suggested that Anderson had included, under this number, collections along Mitchell Creek from 137 to 183 m (450 to 600 ft) below the base of the Roaring River Member in the Ogo Member of the Budden Canyon Formation. Murphy (*in* Imlay,

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FIGURE 3—Cretaceous *Plicatula* from the Pacific coast of North America. Unless otherwise noted, specimens coated with ammonium chloride. *1–8, Plicatula variata* Gabb, 1864; *1,* lectotype ANSP 4432, Cottonwood Creek, California, right valve (uncoated), height 16.7 mm, ×2.7; *2,* hypotype CASG 67779.01, CASG loc. 62591, right valve, height 16.8 mm, ×2.7; *3,* hypotype LACMIP 8052, LACMIP loc. 22970, right valve, height 26.7 mm, ×1.8; *4,* hypotype LACMIP 8053, LACMIP loc. 22896, right-valve interior, height 15.7 mm, ×2.9; *5,* lectoparatype ANSP 4432A, Cottonwood Creek, California, left valve (uncoated), height 14.5 mm, ×3.1; *6,* hypotype LACMIP 8054, LACMIP loc. 22896, left valve, height 17 mm, ×2.7; *7,* hypotype LACMIP 8055, LACMIP loc. 22897, left-valve interior, height 14.1 mm, ×3; *8,* hypotype LACMIP 8052, LACMIP loc. 22970, anterior view, thickness of both valves 11.8 mm, ×1.7; *9–11, Plicatula allisoni* new species; *9,* paratype UCMP 39884, UCMP loc. A-6284, right valve, height 17.4 mm, ×2.6; *10–11,* holotype UCMP 39883, UCMP loc. B-5688; *10,* left valve, height 33.2 mm, ×1.3; *11,* anterior view, thickness of both valves 15 mm, ×1.2. *12–18, Plicatula modjeskaensis* new species, LACMIP loc. 10888; *12,* holotype LACMIP 8056, right valve, height 12.8 mm, ×3.5; *13,* paratype LACMIP 8057, right valve, height 13.6 mm, ×3.3; *14,* paratype LACMIP 8058, right-valve interior, height 8 mm, ×4.6; *15,* paratype LACMIP 8059, left valve, height 15 mm, ×3; *16,* holotype LACMIP 8056, left valve, height 12.8 mm, ×3.5; *17,* paratype LACMIP 8060, left valve, height 11.3 mm, ×3.6; *18,* holotype LACMIP 8056, anterior view, thickness of both valves 3.7 mm, ×3.5; *19, Plicatula* cf. *P. modjeskaensis* new species, hypotype LACMIP 8061, LACMIP loc. 10883, right-valve interior, height 14.2 mm, ×3.

1960) stated that there are two fossil zones at the head of Mitchell Creek west of the road, and Imlay (1960) considered the lower of these to be the Hamlin-Broad zone and of early late Hauterivian age. Murphy et al. (1969), however, rejected Hamlin-Broad as a zone because the fossils of CASG loc. 113 were collected in a general area at the head of Mitchell Creek, and at least four horizons are represented by the fossils, most of which were donated to the California Academy of Sciences by two amateur collectors; namely, Mr. Hamlin and E. J. Broad. Possibly the *P. onoensis* reported by Anderson from 137 to 183 m (450 to 600 ft) below the Roaring River Member are of early late Hauterivian age.

Other mollusks recorded by Murphy (1956, fig. 6) as occurring with *P. onoensis* are suggestive of a moderate-depth habitat. One of the most common ammonites, *Lytoceras auleum,* reflects quiet, deeper marine waters (Dailey, 1973). Perhaps, there was either downslope transport of shallow species, or there was flotation of the ammonites. Specimens of *Plicatula* from strata crossing the North Fork Cottonwood Creek are commonly in aggregations, suggesting a reflection of communal living, although to what substrate the *Plicatula* were attached is not clear.

Plicatula variata resembles *Plicatula torreonensis* Imlay (1940, p. 144, pl. 2, figs. 41, 42) from Lower Cretaceous (Berriasian-Valangianian) strata of eastern Durango, Mexico, but *P. variata* differs by having fewer radial ribs on both valves, much rarer radial riblets in the interspaces, and non-spinate radial riblets in the interspaces.

Among Early Cretaceous (Neocomian) *Plicatula* of France figured by Orbigny (1843), *Plicatula radiola* Lamarck, 1819, is most similar to *P. variata* in having prominent and widely spaced radial ribbing, as well as a flat to concave upper (left) valve. *Plicatula variata* differs in having bifurcated ribs or scaly ribs but no spinose ribs.

Plicatula variata differs from *P. modjeskaensis* new species in having a more convex right valve and ribs that are not spinose. The number of ribs varies in both species, and a considerable overlap in rib count exists. Specimens with the fewest ribs are *P. variata,* and those with the greatest number of ribs are *P. modjeskaensis.* Those specimens falling in the overlap in rib count are assigned to species based on other characters.

Plicatula variata differs from *P. allisoni* new species by having smooth interspaces between the primary radial ribs and by having much weaker nodes on the primary ribs.

Material examined.—Lectotype, and two lectoparatypes of *P. variata.* Holotype, paratype, and hypotype [=voucher] of *P. ononensis.* Approximately 100 specimens of *P. variata* from the North Fork Cottonwood Creek area, northern California (LACMIP locs. 22788, 22896, 22897, 22914, 22970, and CASG locs. 62591 and 67779). About one-third of these 100 specimens are articulated.

Distribution.—Ogo Member of the Budden Canyon Formation, Ono area, west of Redding, Shasta County, northern California.

Age.—Early Cretaceous (late Hauterivian).

PLICATULA ALLISONI new species
Figure 3.9–3.11

Plicatula radiola Lamarck. Allison, 1974:table 5. Not *Plicatula radiola* Lamarck, 1819.

Diagnosis.—A large *Plicatula* with a convex right valve and a concave left valve; primary radial ribs (13–16) on both valves narrow, noded to spinose and interspaces (especially on right valve) with finely beaded radial sculpture.

Description.—Valves large (up to 33.2 mm high), semi-triangular, strongly curved, subequilateral, very inequivalved, right valve strongly convex, left valve concave with beak area flattish; right valve with about 13 narrow and unnoded, primary radial ribs, becoming spinose posteriorly; interspaces (including sides of primary radial ribs) covered with up to seven closely spaced, finely beaded radial threads, one to two becoming spinose and of secondary-rib or nearly primary-rib strength on posterior half of valve; left valve with narrow and noded primary radial ribs, becoming spinose posteriorly, bifurcation common, about 16 primary ribs (including bifurcated ones), interspaces with very weak, finely noded and radial ribs. Valve interiors and hinge not seen.

Holotype.—UCMP 39883.

Paratype.—UCMP 39884.

Type locality.—UCMP loc. B-5688, Punta San Isidro, Baja California, Mexico (Alisitos Formation, Late Early Cretaceous).

Dimensions.—UCMP 39883, articulated specimen, height 33.2 mm, length 30.3 mm, thickness of double valves 15 mm. UCMP 39884, height 17.4 mm, length 12.4 mm.

Discussion.—Weathering has obscured much of the fine radial sculpture in the interspaces between the primary radial ribs on the available specimens of the new species, especially those that show the left valve.

Allison (1974) referred to the specimens of the new species as *Plicatula radiola* Lamarck (1819:185; Orbigny, 1843:683–685, pl. 463, figs. 1–7), which is known from rocks of Early Cretaceous age (Albian) of France. Comparisons between the Alisitos Formation specimens and two LACMIP collection specimens of *P. radiola* from Cotes Noires, Moeslains (Haute Marne), France, as well as comparisons with published illustrations, reveals that the new species is not *P. radiola.* The new species differs from this European species in the following features: right valve more convex and with narrower primary radial ribs, interspaces with closely spaced beaded to spinose radial sculpture rather than smooth; left valve primary rib interspaces with fine radial sculpture.

The new species is very similar to *Plicatula placunea* Lamarck (1819:186; Orbigny, 1843:682–683, pl. 462, figs. 11–18) from strata of Early Cretaceous age (Neocomian and Aptian) of France. The new species differs from *P. placunea* in the following features: right valve with narrower interspaces between the primary ribs, left valve with more radial ribs and nodes, and radial ribs and nodes on left valve more projecting rather than flattened out.

The strata at the type locality of the new species are part of the upper member of the Alisitos Formation, and Allison (1955, 1974) assigned these rocks to the middle Albian Stage.

Etymology.—The new species is named for the late Edwin C. Allison, who found the specimens of the new species.

Material examined.—One specimen from the type locality, and five others from the immediate vicinity of the type locality (two from UCMP loc. A-6278, and one from UCMP loc. A-9763).

Distribution.—Upper member of the Alisitos Formation at Punta San Isidro, Baja California, Mexico (UCMP locs. A-6278, A-6284, A-9763, B-5688).

Age.—Late Early Cretaceous (middle Albian).

PLICATULA MODJESKAENSIS new species
Figure 3.12–3.18

Diagnosis.—A small *Plicatula* with nearly equally convex valves sculpted by 9 to 13 fold-like, noded or spinose, radial ribs.

Description.—Valves small (up to 17.5 mm high), ostreiform, slightly curved, equivalved, slightly inequilateral, usually with same degree of low convexity; right valve showing small area of attachment in dorsal-posterior beak region; right valve com-

monly thickened in early stages of growth and slightly more convex than flattened left valve; shell sculpture of closely spaced primary, fold-like radial ribs (a few ribs bifurcated on some specimens), right valve with 9 to 13, rarely as many as 19, primary radial ribs (includes bifurcated ribs), left valve with 10 to 14 primary radial ribs (includes bifurcated ribs); primary ribs noded or spinose, strength increasing ventrally and posteriorly on some specimens; interior of left valve with closely spaced, small tubercles along anterior-ventral margin; hinge short, right valve with two stout teeth on each side of shallow resilifer.

Holotype.—LACMIP 8056.

Paratypes.—LACMIP 8057–8060.

Type locality.—LACMIP loc. 10888, Santa Ana Mountains, Orange County, southern California (Baker Canyon Member of the Ladd Formation, Early Late Cretaceous).

Dimensions.—LACMIP 8056, articulated specimen, height 12.8 mm, length 10.8 mm, thickness of double valves 3.7 mm. LACMIP 8057, right valve, height 13.6 mm, length 10.6 mm, thickness 4.3 mm. LACMIP 8058, partial right valve, height 11.8 mm, length (incomplete) 9.4 mm, thickness 3.2 mm. LACMIP 8059, partial right valve, height 15.0 mm, length (incomplete) 10.2 mm, thickness 3.7 mm. LACMIP 8060, left valve, articulated specimen, height 11.3 mm, length 10.6 mm, thickness of double valves 3.8 mm.

Discussion.—Ten of the available eleven specimens of *Plicatula modjeskaensis* are articulated. The specimens range in height from 6 to 17.5 mm. Preservation is moderately good to poor.

Plicatula modjeskaensis was found in the lower part of the Baker Canyon Member of the Ladd Formation at LACMIP loc. 10888 (=CIT loc. 981), in the northern part of the Santa Ana Mountains, Orange County, southern California (Figure 1). This locality is plotted (as CIT loc. 981) on a topographic base map in Saul and Bottjer (1982). The strata at CIT loc. 981 were deposited along a shoreline in warm, very shallow sublittoral water (Saul, 1982). The sedimentological details of the Baker Canyon Member indicate a fluctuating, moderate to high-energy, lower to upper shoreface paleoenvironment associated with a fan-delta setting (Cooper et al., 1982). A late Turonian age for the Baker Canyon Member is indicated by the ammonites *Subprionocyclus normalis* (Anderson, 1958) and *S.* cf. *Subprionocyclus neptuni* (Geinitz, 1849) (Saul, 1982).

Packard (1916, table 1) listed a *Plicatula* n. sp. from the Cretaceous of the Santa Ana Mountains but never described, named, or illustrated the species, and it cannot be equated with *Plicatula modjeskaensis.* Willis P. Popenoe collected and labelled, as *Plicatula* sp., specimens of *Plicatula modjeskaensis* but did not include them among the new species he described from the Santa Ana Mountains (Popenoe, 1937). He also did not include them on his check list of the Cretaceous fauna from the Santa Ana Mountains (Popenoe, 1942). Saul (1982, fig. 2) augmented this check list with additional localities, but, although mollusks from CIT loc. 981 are listed on both Popenoe's and Saul's check lists, no species of *Plicatula* are recorded from the Santa Ana Mountains.

The radial ribbing of *P. modjeskaensis* is of the type found in *Plicatula instabilis* Stoliczka, (1871, p. 445, pl. 34, figs. 3–14, not 19) from the Upper Cretaceous Arrialoor Group of India, in that the ribs appear fold-like.

Plicatula modjeskaensis is most similar to *Plicatula juncalensis* Squires (1987, p. 57–58, figs. 95–96) (Figure 4.11–4.13) from the middle lower Eocene ("Capay Stage") part of the Juncal Formation, Whitaker Peak area, Los Angeles County, southern California. The new species differs in having thinner and fewer radial ribs that are noded and/or spinose and in lacking secondary ribs.

The new species differs from *Plicatula variata* in having valves more nearly equally convex with spinose ribs. The number of ribs varies in both species, and a considerable overlap in rib count exits. Specimens with the greatest number of ribs are *P. modjeskaensis* and those with the lowest number of ribs are *P. variata.*

Two poorly preserved specimens of *Plicatula* cf. *P. modjeskaensis* were found in the Baker Canyon Member at LACMIP loc. 10883, which is 214 m (700 ft) south of the type locality of *P. modjeskaensis.* One of these specimens (hypotype LACMIP 8061) shows the hinge teeth of the right valve and is illustrated in Figure 3.19.

Etymology.—The new species is named for the hamlet of Modjeska just south of the type locality of the species.

Material examined.—Eleven specimens, all from the type locality, and two specimens, questionably included, from LACMIP loc. 10883.

Distribution.—The species is known only with certainty from its type locality in the lower part of the Baker Canyon Member of the Ladd Formation, Santa Ana Mountains, Orange County, southern California.

Age.—Early Late Cretaceous (late Turonian).

PLICATULA OSTREIFORMIS Stanton, 1896
Figure 4.5–4.10

Plicatula ostreiformis STANTON, 1896, p. 1038, pl. 63, figs. 5, 6; KEEN AND BENTSON, 1944, p. 103; MOORE, 1987, p. C5, pl. 1, figs. 1–3.

Plicatula ostreaformis Stanton. DICKERSON, 1914: 151, pl. 9, fig. 12; ZINSMEISTER AND PAREDES-MEJIA, 1988, table 1 on p. 15; [error for *ostreiformis*].

Ostrea buwaldana DICKERSON, 1914, p. 127, pl. 9, fig. 4; KEEN AND BENTSON, 1944, p. 74.

Acutostrea idriaensis fettkei (Weaver). MOORE, 1987, p. 30 (in part), fig. 5 (only).

Original description.—"Shell large, irregularly ovate in outline, but varying considerably in this respect; valves subequal, the right one being usually slightly convex and the left flattened or a little concave in the middle; test unusually thick; surface with obscure radiating plications and irregular pits. An average specimen measures 52 mm in length, 39 mm in breadth, and 19 mm in greatest convexity of the two valves united. Internal casts show impression of the characteristic hinge of *Plicatula*" (Stanton, 1896, p. 1038).

Type specimens.—Syntypes of *Plicatula ostreiformis* USNM 157838. Holotype of *Ostrea buwaldana* UCMP 11719.

Type locality.—Of *P. ostreiformis:* 1.5 km (1 mi.) southeast of Lower Lake, NE ¼, T12N, R7W, Lake County, California (Martinez Formation, early Paleocene). Of *O. buwaldana:* UCMP loc. 790, Lower Lake, Lake County, California (Martinez Formation, early Paleocene).

Discussion.—This unusual species has a maximum size of 52 mm in height and represents the largest known *Plicatula* in the fossil record of California and Baja California. Most available specimens, including the syntypes figured in Moore (1987, pl. 1, figs. 1–3) are partially exfoliated and show virtually no sculpture. Partially exfoliated specimens in the LACMIP collection from LACMIP loc. 7047 show about six broad, low, dichotomous radial ribs, which are commonly most obvious near the ventral margin of the valves. Where not exfoliated, the broad ribs bear narrow radiating cords. The radial ribs, and in some specimens both valves, are thrown into broad concentric undulations by apparent growth checks. Both valves are convex, that of the attached right valve being the more variable, ranging from scarcely more than that of the upper valve to at least twice as deep. Unlike the Cretaceous species, *P. variata* and *P. mod-*

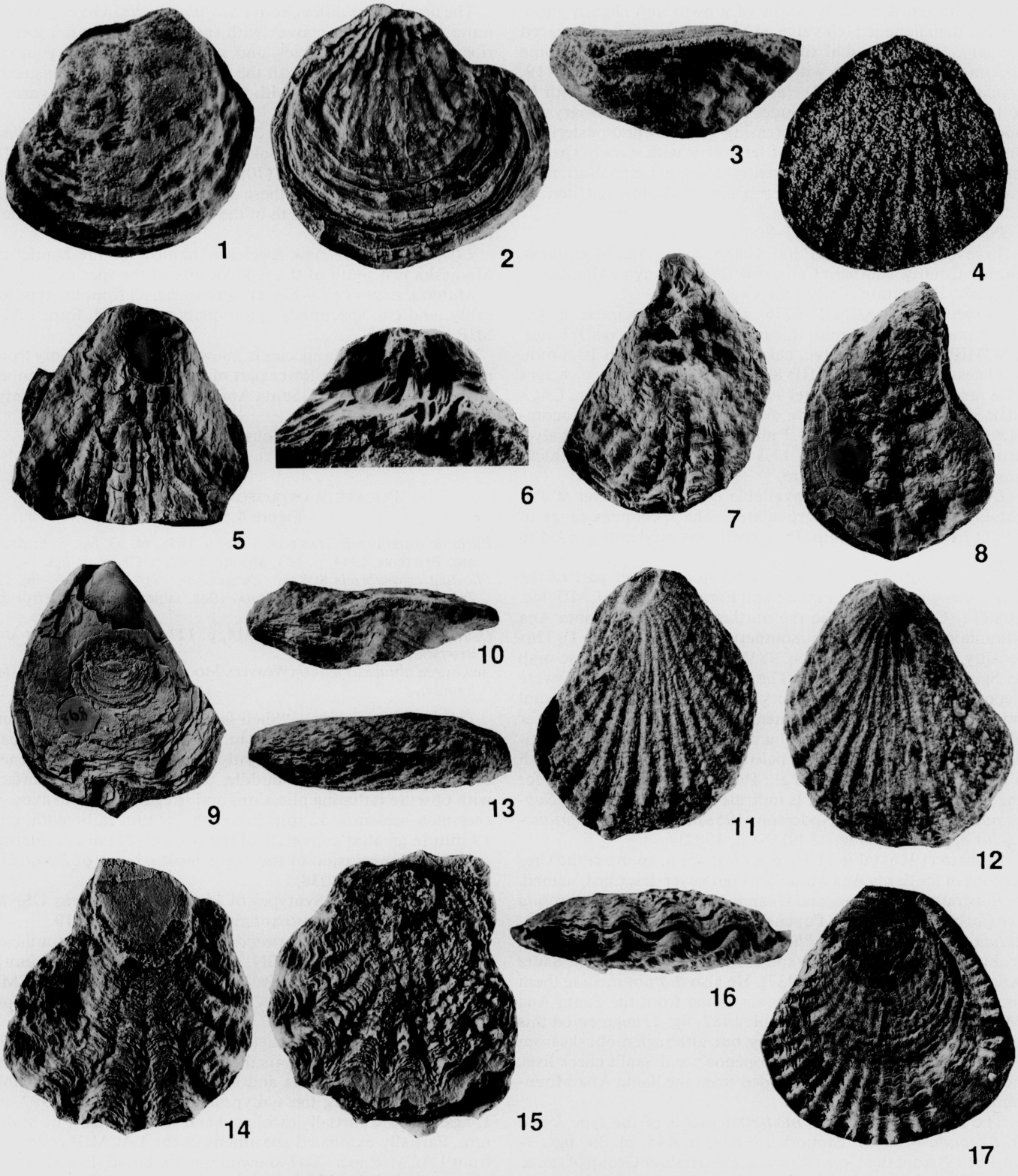

FIGURE 4—Cretaceous, Paleocene, and Eocene *Plicatula* from the Pacific coast of North America. All specimens coated with ammonium chloride. *1–3, Plicatula* n. sp.?, hypotype LACMIP 8062, LACMIP loc. 10883; *1,* right valve, height 10.6 mm, ×3.8; *2,* left valve, latex cast, height 11.6 mm, ×4.1; *3,* anterior view, thickness of both valves 4.7 mm, ×4.3; *4, Plicatula*? sp. a Elder, 1991, hypotype USNM 487992, USGS loc. M8576, latex cast of right? valve, height 11.8 mm, ×3.5; *5–10, Plicatula ostreiformis* Stanton, 1896, LACMIP loc. 7047; *5–6,* hypotype LACMIP 8063, right valve, height 33.4 mm (incomplete); *5,* exterior, ×1.2; *6,* interior, ×1.9; *7, Ostrea buwaldana* Dickerson, 1914, holotype UCMP 11719, UCMP loc. 790, right valve, height 49.3 mm, ×0.9; *8,* hypotype LACMIP 8064, left valve, height 40.3 mm, ×1.2; *9,* hypotype LACMIP 8065, left-valve interior, height 40.1 mm, ×1.1; *10,* hypotype LACMIP 8064, anterior view, thickness of both valves 13.2 mm, ×1.1; *11–13, Plicatula juncalensis* Squires, 1987, holotype LACMIP 7513, CSUN loc. 362; *11,* right valve, height 18.5 mm, ×2.6; *12,* left valve, height 18.5,

jeskaensis, the left valve does not appear to be thickened and denticulated marginally.

Plicatula ostreiformis closely resembles *Ostrea buwaldana* in sculpture and in shape, and we consider *Ostrea buwaldana* to be a junior synonym of *Plicatula ostreiformis.* Both nominal species have their type localities just southeast of Lower Lake. The holotype of *O. buwaldana* is illustrated in Figure 4.7. Moore (1987) placed *O. buwaldana* under *Acutostrea idriaensis fettkei* (Weaver, 1912), a late middle Eocene oyster known from the Cowlitz Formation near Vader in southwestern Washington. Specimens of *P. ostreiformis* are much thicker shelled than those of *A. idriaensis fettkei. Plicatula ostreiformis* is attached by the right valve and tends to be slightly arched counterclockwise whereas the oyster is attached by the left valve and tends to be arched clockwise. The upper valve of *P. ostreiformis* is slightly inflated to nearly flat, but that of the oyster is flat to concave and lacks radials. The muscle scar of *P. ostreiformis* is relatively large, oval, and more centrally placed than the reniform scar of *A. idriaensis fettkei.* Although Dickerson (1914) described the muscle scar of *Ostrea buwaldana* as reniform, the muscle scar is not visible on the holotype.

The beds that include the type locality of *P. ostreiformis* were mapped as part of the Martinez Formation by Dickerson (1914) and Brice (1953). Both workers reported the presence of *Turritella pacheocensis* Stanton, 1896, in these strata, but a specimen of *Turritella* from LACMIP loc. 7047 has a wide pleural angle and sculpture more suggestive of *Turritella peninsularis quaylei* Saul, 1983, and indicative of an early Paleocene (possibly late Danian) age.

Distribution.—Martinez Formation, Lower Lake area, Lake County, northern California and, according to Dickerson (1914), also at San Pedro Point, San Mateo County, California.

Age.—Early Paleocene (late? Danian).

PLICATULA JUNCALENSIS Squires, 1987
Figure 4.11–4.13

Plicatula juncalensis SQUIRES, 1987, p. 57–58, figs. 95–96.

Holotype.—LACMIP 7513.

Type locality.—CSUN loc. 362, Whitaker Peak area, southern California (Juncal Formation).

Original description.—"Shell small, ostreiform, slightly oblique, inequilateral, and equivalved with same degree of convexity. Valve margins plicate, no byssal sinus. Right valve shows small area of attachment in dorsal-posterior beak region. Left valve has an inflated beak with prominent callosity. Shell sculpture of closely spaced primary radial ribs (some bifurcate) with up to five intervening secondary ribs. Right valve with up to 24 primary radial ribs (includes bifurcating ribs). Left valve with up to 17 primary radial ribs (includes bifurcating ribs). Primary ribs commarginally lamellose, and secondary radial ribs commarginally scaly and/or noded (i.e., beaded appearance). Hinge short, valves with two small teeth on each side of a shallow resilium pit. Widely spaced turbercles along valve margin interiors near hinge. Length of holotype (complete) 15 mm, height (complete) 18.5 mm" (Squires, 1987, p. 57–58).

Distribution.—Lower part of the Juncal Formation, Canton Canyon, Whitaker Peak area, Los Angeles County, southern California.

Age.—Middle early Eocene ("Capay Stage").

PLICATULA SURENSIS new species
Figure 4.14–4.16

Plicatula sp., aff. *P. filamentosa* Conrad, 1833. SQUIRES AND DEMETRION, 1992, p. 37–38, figs. 106–107.

Diagnosis.—A *Plicatula* with very broad, fold-like primary radial ribs (especially along venter) and without secondary ribs in interspaces.

Description.—Valves small, ostreiform, slightly curved, equivalved, slightly inequilateral, with same degree of low convexity; right valve showing relatively large area of attachment in dorsal-posterior beak region; shell sculpture of very broad fold-like radial ribs with only the faintest hint of any secondary radial ribs; right valve with 16 primary radial ribs, those along venter the broadest, interspaces correspond to ribs on the left valve; left valve with 14 to 15 moderately broad primary radial ribs, slightly spinose on posterior margin; interspaces correspond to ribs on the right valve; valve interiors and hinge not seen.

Holotype.—IGM 5195.

Type locality.—CSUN loc. 1220b, south of Laguna San Ignacio, Baja Sur California, Mexico (Bateque Formation, middle early Eocene).

Dimensions.—IGM 5195, height 16 mm, length 14.4 mm, thickness of double valves 4.4 mm.

Discussion.—Only two specimens were found. Squires and Demetrion (1992) reported that this species has affinity with weathered specimens of *Plicatula filamentosa* Conrad, 1833, a species known from middle Eocene strata in the southeastern United States. Gardner (1945) reported that the Eocene species, *Plicatula lalajensis* Gardner (1945, p. 70–71, pl. 5, fig. 4) and *Plicatula euplecta* Gardner (1945, p. 71, pl. 1, figs. 13–14) are very closely related to *P. filamentosa.* These two species, both of which are from northeastern Mexico, therefore, also resemble *Plicatula surensis.* With new study, we conclude that the specimens found by Squires and Demetrion (1992) of *P.* sp., aff. *P. filamentosa* represent a new species. The new species differs from *P. filamentosa, P. lalajensis,* and *P. euplecta* by not having secondary ribs in the interspaces of the primary radial ribs.

Etymology.—The new species is named for Baja California Sur, Mexico.

Material Examined.—Two specimens, both from the type locality.

Distribution.—Bateque Formation, Baja California Sur, Mexico.

Age.—Middle early Eocene ("Capay Stage").

PLICATULA new species?
Figure 4.1–4.3

Discussion.—A single specimen of a possible new species of *Plicatula* was found in Turonian strata at LACMIP loc. 10883 in the Baker Canyon Member of the Ladd Formation of the Santa Ana Mountains, Orange County, southern California. Although found at the same locality where specimens of *P.* cf. *P. modjeskaensis* were found, this single specimen differs by having a concavo-convex shell. The right valve of this shell, which is strongly convex, is nearly smooth (worn?). The left valve is flat to concave with several radial ribs in the dorsal area, but the ventral area only has concentric ribs. The specimen resembles *P. variata* in having a convex right valve and a flat to concave left valve, upon which the radial ribs might be obsolete.

←

×2.6; *13,* anterior view, thickness of both valves 5.3 mm, ×2.5; *14–16, Plicatula surensis* new species, holotype IGM 5195, CSUN loc. 1220b; *14,* right valve, height 16 mm, ×3.1; *15,* left valve, height 16 mm, ×3.1; *16,* anterior view, thickness of both valves 4.4, ×3.4; *17, Plicatula*? sp. b Squires and Demetrion, 1992, hypotype IGM 5196, CSUN loc. 1293, left? valve, height 20 mm, ×2.3.

PLICATULA? sp. a Elder, 1991
Figure 4.4

Plicatula? sp. ELDER, 1991, table 1 on p. E7.

Discussion.—Elder (1991) listed a questionable occurrence of *Plicatula* sp. from unnamed upper Campanian to lower Maastrichtian rocks at USGS Mesozoic locality M8576, near Loma Prieta, Santa Cruz Mountains, northern California. He did not discuss or illustrate the species. The specimen, a partial external mold of a single valve, has sculpture suggestive of *Plicatula,* but no hinge is available. Elder (personal commun., 1996) has opined that it might be a brachiopod.

PLICATULA? sp. b
Figure 4.17

Plicatula sp. SQUIRES AND DEMETRION, 1992, p. 38, fig. 108.

Hypotype.—IGM 5196, CSUN loc. 1293, Arroyo El Mezquital, Baja California Sur, Mexico (Bateque Formation, middle early Eocene to late Eocene).

Discussion.—This species has about 30 narrow, closely spaced, and somewhat spinose primary radial ribs. Although several specimens were found at various localities (CSUN 1291a, 1293, and 1471?), none of the specimens shows the hinge and, therefore, none can be positively assigned to genus *Plicatula.* The sculpture on the specimens closely resembles the oyster *Cubitostrea.*

Distribution.—Bateque Formation, Baja California Sur, Mexico.

Age.—Middle early Eocene ("Capay Stage") through late Eocene ("Tejon Stage").

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ACCEPTED 1 AUGUST 1996

APPENDIX

LOCALITIES CITED

CASG 113 [=CASG 66511]. At top of Paskenta beds, head of north branch of Mitchell Creek, approximately 6.4 km (4 mi) southwest of Ono, U. S. Geological Survey, 15-minute, Ono Quadrangle, 1952, Shasta County, northern California. Budden Canyon Formation, Ogo Member. Age: Early Cretaceous (late Hauterivian). Collector: F. M. Anderson (but apparently added to over a period of time and, in part, collected by others).

CASG 1353. On the highway grade near bridge south of Ono about 0.4 km (0.25 mi), North Fork Cottonwood Creek, U. S. Geological Survey, 15-minute, Ono Quadrangle, 1952, Shasta County, northern California. Budden Canyon Formation, Ogo Member. Age: Early Cretaceous (late Hauterivian). Collector: F. M. Anderson and G. D. Hanna, April, 1928.

CASG 62591. From first bluff downstream from the Ono Bridge, from north side of North Fork Cottonwood Creek, U. S. Geological Survey, 15-minute, Ono Quadrangle, 1952, Shasta County, northern California. Budden Canyon Formation, Ogo Member. Age: Late Cretaceous (late Hauterivian). Collector: M. A. Murphy.

CASG 66509. 183 m (600 ft) above bridge at Ono, North Fork Cottonwood Creek, U. S. Geological Survey, 15-minute, Ono Quadrangle, 1952, Shasta County, northern California. Budden Canyon Formation, Ogo Member. Age: Early Cretaceous (late Hauterivian).

CASG 66510. North Fork Cottonwood Creek, U. S. Geological Survey, 15-minute, Ono Quadrangle, 1952, Shasta County, northern Cal-

ifornia. Budden Canyon Formation, Ogo Member. Age: Early Cretaceous (late Hauterivian).

CASG 66511. [=CASG 113, in part].

CASG 67779. Just south of Ono, North Fork Cottonwood Creek, U. S. Geological Survey, 15-minute, Ono Quadrangle, 1952, Shasta County, northern California. Budden Canyon Formation, Ogo Member. Age: Late Cretaceous (late Hauterivian). Collector: M. A. Murphy.

CSUN 362. Nearshore-marine deposits at elevation of 520 m (1,690 ft) on west side of Canton Canyon, 663 m (2,175 ft) north and 625 m (2,050 ft) west of southeast corner of section 1, T5N, R18W, U. S. Geological Survey, 7.5-minute, Whitaker Peak Quadrangle, 1958, Whitaker Peak area, northern Los Angeles County, southern California. Lower Juncal Formation. Age: Middle early Eocene ("Capay Stage"). Collector: R. L. Squires, circa 1980.

CSUN 1220b. Along a prominent ridge, north side of a minor canyon on the west side of Mesa La Salina, 84 to 130 m above the bottom of the exposures of the Bateque Formation in this area, approximately 1.25 km SE of the intersection of 113°00'W and 26°45'N, Mexican government topographic quadrangle map (scale 1:50,000) of Laguna San Ignacio (number C12A53), Baja California Sur, Mexico, 1982. Bateque Formation. Age: Middle early Eocene ("Capay Stage"). Collectors: R. L. Squires and R. A. Demetrion, March 28, 1988.

CSUN 1293. West-facing, 40 m-high bluff on east side of Arroyo El Mezquital, 0.5 km east of the northeast-trending part of the prominent loop in the dirt road leading to San Juanico (13.5 km to the north), Mexican government topographic quadrangle map (scale 1:50,000) of Punta Pequeña (number G12A85), Baja California Sur, Mexico, 1983. Bateque Formation. Age: Middle Eocene ("Tejon"). Collectors: R. L. Squires and R. A. Demetrion, March 20, 1989.

CSUN 1471. Near middle of canyon wall along west side of Arroyo San Juan de Abajo, about 40 m elevation, about 0.75 km west of dirt road from San José de Gracia to El Datilon, at 112°44'W and 26°29.5'N, Mexican government topographic quadrangle map (scale 1:50,000) of Punta Santo Domingo (number G12A74), Baja California Sur, Mexico, 1982. Bateque Formation. Age: Middle early Eocene ("Capay"). Collectors: R. L. Squires and R. A. Demetrion, April 8, 1990.

LACMIP 7047 [=CIT 868 =UCMP 790]. Small gully about 46 m (150 ft) west of Herndon Creek and 0.4 km (0.25 mi) south of the Monticello-Lower Lake Road bridge over Herndon Creek at Lower Lake, U. S. Geological Survey, 7.5-minute, Lower Lake Quadrangle, 1975, Lake County, northern California. Martinez Formation. Age: Early Paleocene (late? Danian). Collectors: D. W. Scharf and W. P. Popenoe, August 26, 1930.

LACMIP 10883 [=CIT loc. 1067 =CIT loc. 986]. At elevation of 591 m (1,940 ft) immediately above base of gray sandstone overlying basal conglomerate, 549 m (1,800 ft) north and 183 m (600 ft.) east of southwest corner of section 21, T5S, R7W, U. S. Geological Survey, 7.5-minute, Santiago Peak Quadrangle, 1954 (photorevised 1982), northern Santa Ana Mountains, Orange County, southern California, Ladd Formation, Baker Canyon Member. Age: Late Cretaceous (Turonian). Collector: W. P. Popenoe, April 21, 1932.

LACMIP 10888 [=CIT loc. 981]. At elevation of 549 m (1,800 ft) in fossiliferous sandstone overlying the gray basal conglomerate, latitude 33°43'18"N, longitude 117°37'30"W, 7,474 m (2,450 ft) north and 122 m (400 ft.) east of southwest corner of section 21, T5S, R7W, U. S. Geological Survey, 7.5-minute, Santiago Peak Quadrangle, 1954 (photorevised 1982), northern Santa Ana Mountains, Orange County, southern California. Ladd Formation, Baker Canyon Member. Age: Late Cretaceous (Turonian). Collector: W. P. Popenoe, March, 1932.

LACMIP 10949. Holz Ranch, north side of Silverado Canyon, east side of first canyon west of Ladd Canyon at approximate elevation 392 m (1,285 ft), about 59 m (193 ft) above base of upper Baker Canyon Sandstone, approximately 919 m (3,015 ft) north and 76 m (250 ft) of southeast corner of section 7, T5S, R7W, U. S. Geological Survey, 7.5-minute, Black Star Canyon Quadrangle, 1982, Santa Ana Mountains, Orange County, southern California. Ladd Formation, upper Baker Canyon Member. Age: Late Cretaceous (late Turonian). Collector: Robert G. Cassi, Spring, 1958.

LACMIP 22788. Massive sandstone ledge at bend in stream on south bank of North Fork Cottonwood Creek, 354 m (1,160 ft) N74°W of Platina-Ono highway bridge over North Fork Cottonwood Creek. U. S. Geological Survey, 15-minute, Ono Quadrangle, 1952, Shasta County, northern California. Budden Canyon Formation, Ogo Member. Age: Early Cretaceous (late Hauterivian). Collector: M. A. Murphy, summers 1951–1953.

LACMIP 22896. 286 m (940 ft) S51.5°E of Platina-Ono highway bridge over North Fork Cottonwood Creek, on east bank of North Fork Cottonwood Creek in *Plicatula* mudstone beds, U. S. Geological Survey, 15-minute, Ono Quadrangle, 1952, Shasta County, northern California. Budden Canyon Formation, Ogo Member. Age: Early Cretaceous (late Hauterivian). Collector: M. A. Murphy, summers 1951–1953.

LACMIP 22897. 317 m (1,040 ft) S42.5°E of Platina-Ono highway bridge over North Fork Cottonwood Creek, in same *Plicatula* bed as LACMIP 22896, U. S. Geological Survey, 15-minute, Ono Quadrangle, 1952, Shasta County, northern California. Budden Canyon Formation, Ogo Member. Age: Early Cretaceous (late Hauterivian). Collector: M. A. Murphy, summers 1951–1953.

LACMIP 22914. In dark mudstone in county road metal pit on Ono-Igo County road across from George Shelton's residence, U. S. Geological Survey, 15-minute, Ono Quadrangle, 1952, Shasta County, northern California. Budden Canyon Formation, Ogo Member. Age: Early Cretaceous (late Hauterivian). Collector: M. A. Murphy, summers 1951–1953.

LACMIP 22970. Fossils occur free in yellow-orange weathering, thin limestone beds in black mudstone, 341 m (1,120 ft) S43°E of Bland Ranch Road bridge over north fork of Roaring River, on Roaring River, U. S. Geological Survey, 15-minute, Ono Quadrangle, 1952, Shasta County, northern California. Budden Canyon Formation, Ogo Member. Age: Early Cretaceous (late Hauterivian). Collector: M. A. Murphy, summers 1951–1953.

UCMP 781. Vicinity of Lower Lake, SE ¼, NE ¼ of section 11, T12N, R7W, U. S. Geological Survey, 7.5-minute, Lower Lake Quadrangle, 1975, Lake County, northern California. Martinez Formation. Age: Early Paleocene.

UCMP 790 [=LACMIP 7047]. 0.9 km (0.75 mi) east of Lower Lake, 366 m (1,200 ft) south from bridge over Copsey Creek, in gully on west side of creek, SE/4 of NE/4 of section 11, T12N, R7W, U. S. Geological Survey, 7.5-minute, Lower Lake Quadrangle, 1975, Lake County, northern California. Martinez Formation. Age: Early Paleocene (late? Danian).

UCMP A-6278, A-6284, A-9763, B-5688. Localities are all in the same general area approximately 2 km north of Punta San Isidro, latitude 31°17'30"N and longitude 116°25'W, coordinates 55.5 (east-west axis) and 62.5 (north-south axis) on Mexican government, scale 1:50,000, Puerto San Isidro Quadrangle (number H11B32), Baja California (northern part), Mexico. Alisitos Formation, upper member. Collector: E. C. Allison.

USGS Mesozoic M8576. Elevation of 427 m (1,400 ft) on south side of Williams Reservoir, 37°07'17"N, 121°54'22"W, U. S. Geological Survey, 7.5-minute, Laurel Quadrangle, 1968, Santa Cruz Mountains, Santa Clara County, northern California. Unnamed Upper Cretaceous rocks. Age: Late Cretaceous (Campanian to lower Maastrichtian). Collector: W. P. Elder.