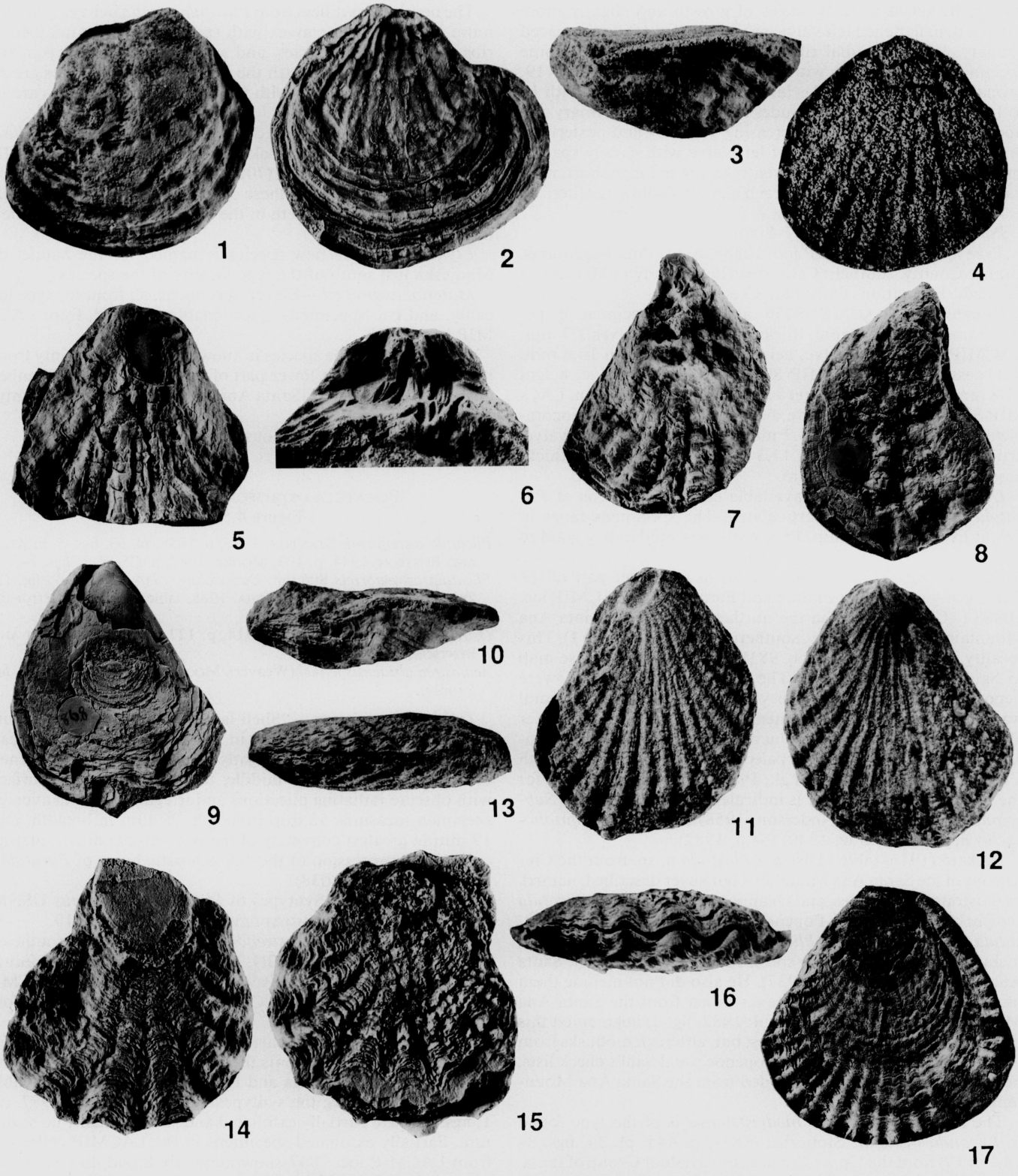

FIGURE 4—Cretaceous, Paleocene, and Eocene *Plicatula* from the Pacific coast of North America. All specimens coated with ammonium chloride. *1–3, Plicatula* n. sp.?, hypotype LACMIP 8062, LACMIP loc. 10883; *1,* right valve, height 10.6 mm, ×3.8; *2,* left valve, latex cast, height 11.6 mm, ×4.1; *3,* 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").

ACKNOWLEDGMENTS

W. P. Elder shared his knowledge of Cretaceous *Plicatula* and loaned a specimen. P. U. Rodda and J. DeMouthe (CAS) loaned comparative specimens of *Plicatula variata,* and E. Benamy (ANSP) loaned Gabb's "duplicate types" of this species. K. Wetmore (UCMP) loaned the holotypes of *Ostrea buwaldana* and *O. weaveri,* as well as specimens used in describing *Plicatula allisoni.* L. T. Groves (LACMIP) allowed access to the collections and provided catalog numbers. M. S. Florence (USNM) provided a catalog number. J. Treiman and especially G. Saucedo, California Division of Mines and Geology, assisted in acquiring geologic maps of Battle Creek, Shasta and Tehama counties, California. G. L. Kennedy, San Diego State University, provided a hard-to-find reference. T. Summers (CASG) helped in obtaining information about early collectors. The manuscript benefited from reviews by S. Damborenea and E. J. Moore.

REFERENCES

ALLISON, E. C. 1955. Middle Cretaceous Gastropoda from Punta China, Baja California, Mexico. Journal of Paleontology, 29:400–432.

——. 1974. The type Alisitos Formation (Cretaceous, Aptian-Albian) of Baja California and its bivalve fauna, p. 20–59. *In* G. Gastil and J. Lillegraven (eds.), The Geology of Peninsular California. American Association of Petroleum Geologists, Society of Economic Paleontologists and Mineralogists, Society of Engineering Geologists, Pacific Sections Guidebook. Los Angeles.

ANDERSON F. M. 1902. Cretaceous deposits of the Pacific coast. Proceedings of the California Academy of Sciences, Series 3, 2, 126 p.

——. 1938. Lower Cretaceous deposits in California and Oregon. Geological Society of America Special Papers, 16, 339 p.

——. 1958. Upper Cretaceous of the Pacific coast. Geological Society of America Memoir, 71, 378 p.

BRICE, J. C. 1953. Geology of Lower Lake Quadrangle, California. California Division of Mines Bulletin, 166, 72 p.

CARPENTER, P. P. 1857. Catalogue of the Collection of Mazatlan shells in the British Museum: Collected by Frederick Reigen. Oberlin Press, Washington, England, 552 p.

CONRAD, T. A. 1833. On some new fossil and Recent shells of the United States. American Journal of Science and Arts, 23:339–346.

COOPER, J. D., I. P. COLBURN, AND F. A. SUNDBERG. 1982. Upper Cretaceous environmental stratigraphy and field trip stops, Silverado Canyon area, p. 11–23. *In* D. J. Bottjer, I. P. Colburn, and J. D. Cooper (eds.), Late Cretaceous Depositional Environments and Paleogeography, Santa Ana Mountains, Southern California. Pacific Section Society of Economic Paleontologists and Mineralogists, Annual Convention Field Guidebook, Volume 24, Los Angeles.

COX, L. R., AND L. G. HERTLEIN. 1969. Family Plicatulidae Watson, 1930, p. N377–N378. *In* R. C. Moore and C. Teichert (eds.), Treatise on Invertebrate Paleontology, Part N, Vol. 1 (of 3), Mollusca 6, Bivalvia. Geological Society of America and University of Kansas Press, Lawrence.

DAILEY, D. H. 1973. Early Cretaceous Foraminifera from the Budden Canyon Formation, northwest Sacramento Valley, California. University of California Publications in Geological Sciences, 106, 111 p.

DAMBORENEA, S. E. 1993. Early Jurassic South American pectinaceans and circum-Pacific paleobiogeography. Palaeogeography, Palaeoclimatology, Palaeoecology, 100:109–123.

DICKERSON, R. E. 1914. Fauna of the Martinez Eocene of California. University of California Publications Bulletin of the Department of Geology, 8:61–180.

DILLER, J. S., AND T. W. STANTON. 1894. The Shasta-Chico Series. Geological Society of America Bulletin, 5:435–464.

DURHAM, J. W. 1950. E. W. Scripps cruise to the Gulf of California. Part 2. Megascopic paleontology and marine stratigraphy. Geological Society of America Memoir, 43, 216 p.

ELDER, W. P. 1991. An unusual Late Cretaceous fauna from an oyster-rich interval in the Santa Cruz Mountains of California. U. S. Geological Survey Bulletin, 1934:E1–E18.

GABB, W. M. 1864. Description of the Cretaceous fossils. California Geological Survey, Palaeontology Volume 1: 57–243.

——. 1869. Cretaceous and Tertiary fossils. California Geological Survey, Palaeontology, Volume 2, 299 p.

——. 1870. Descriptions of some secondary fossils from the Pacific states. American Journal of Conchology, 5:5–18.

GARDNER, J. 1945. Mollusca of the Tertiary formations of northeastern Mexico. Geological Society of America Memoir, 11, 332 p.

GEINITZ, H. B. 1849. Das Quadersandstein oder Kreidegebirge in Deutschland. Freiburg, 293 p.

GROSSOUVRE, A. DE. 1894. Recherches sur la craie supérieure. 2. Paléontologie. Les ammonites de la craie supérieure. Mémoires du Service de la Carte Géologique Détaillée de la France, (1894), 264 p. [misdated 1893].

HALLAM, A. 1977. Jurassic bivalve biogeography. Paleobiology, 3:58–73.

HELLEY, E. J., D. S. HARWOOD, J. A. BARKER, AND E. A. GRIFFEN. 1981. Geologic map of the Battle Creek fault zone, northern Sacramento Valley, California. U. S. Geological Survey Miscellaneous Field Investigations Map, MF-1298.

IMLAY, R. W. 1940. Neocomian faunas of northern Mexico. Geological Society of America Bulletin, 51:117–190.

——. 1955. Characteristic Jurassic mollusks from northern Alaska. U. S. Geological Survey Professional Paper, 274-D:69–96.

——. 1960. Ammonites of Early Cretaceous age (Valangianian and Hauterivian) from the Pacific coast states. U. S. Geological Survey Professional Paper, 334-F:167–228.

KAUFFMAN, E. G. 1973. Cretaceous Bivalvia, p. 353–383. *In* A. Hallam (ed.), Atlas of Palaeobiogeography. Elsevier Scientific Publishing Company, Amsterdam.

KEEN, A. M. 1971. Sea Shells of Tropical West America. Marine Mollusks from Baja California to Peru (second edition). Stanford University Press, Stanford, California, 1064 p.

——, AND H. BENTSON. 1944. Check list of California Tertiary marine Mollusca. Geological Society of America Special Papers, 56, 280 p.

KENNETT, J. P. 1982. Marine Geology, Prentice Hall, Englewood Cliffs, New Jersey, 813 p.

LAMARCK, J.-B., P. A. DE M. DE. 1801. Systême des animaux san vertèbres, ou tableau général des classes, des ordres et des genres de ces animaux. Paris, 432 p.