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NEW EOCENE MARINE BIVALVES FROM BAJA CALIFORNIA SUR, MEXICO

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ABSTRACT—A new genus, a new subgenus, and five new species of pteroid bivalves are described from shallow-marine faunas in the middle lower to middle Eocene Bateque Formation in the vicinity of Laguna San Ignacio to about 105 km southward, Pacific coast of Baja California Sur, Mexico. *Batequeus* n. gen. is a medium-sized pectinid with equally convex valves, a short byssal notch, anterior auricles smaller than the posterior ones, the left valve with numerous very closely spaced radial riblets that show the imbricated growth lines very well, the right valve with about 30 low, flat-topped radial ribs that can be grooved, and intercalary ribs on both valves. It is only known from its type species, *Batequeus mezquitalensis* n. sp., which is from the middle Eocene part of the Bateque Formation. *Spondylus batequensis* n. sp., a very spinose species, is from the middle lower Eocene part of the Bateque Formation and is only the second reported *Spondylus* from the lower Eocene of the west coast of North America. *Pycnodonte (Phygraea) pacifica* n. sp., a species characterized by a radial sulcus that originates in the umbo area, occurs in both the middle lower and middle Eocene parts of the Bateque Formation. *Phygraea* has not been reported previously from the west coast of North America. *Pycnodonte (Pegma)* n. subgen. has a plicate left valve with a large attachment area (that can cover the entire valve) and a right valve that usually has an inflated smooth central area surrounded by plicate margins. It is only known from its type species, *Pycnodonte (Pegma) bajaensis* n. sp., which occurs in both the middle lower and middle Eocene parts of the Bateque Formation. *Cubitostrea mezquitalensis* n. sp., a strongly ornamented species, is from the middle Eocene part of the Bateque Formation and is the first occurrence of this genus from the west coast of North America.

INTRODUCTION

THE BIVALVES discussed in this paper were collected from three localities in the Bateque Formation on the Pacific coast of Baja California Sur, Mexico, between Laguna San Ignacio and Bahia San Juanico about 105 km to the south (Figure 1). Two of the localities, California State University, Northridge (CSUN) localities 1220b and 1220c, are along the same measured section in a canyon in Mesa La Salina, just south of Laguna San Ignacio. Details of the geology of locality 1220b have been previously described in Squires and Demetron (1990). *Spondylus batequensis* n. sp. and *Pycnodonte (Pegma) pacifica* n. subgen. and sp. were found at this locality.

Locality 1220c is 160–170 m above the base of the measured section. *Spondylus batequensis* n. sp. and *Pycnodonte (Phygraea) pacifica* n. sp. were also found at this locality. The lithology and stratigraphy at locality 1220c are nearly the same as for locality 1220b. Very fine-grained sandstone is interbedded with fossiliferous lenses containing a slightly transported shallow-marine fauna. Associated planktonic foraminifers indicate the early Eocene *Globorotalia aragonensis* or *G. pentacamerata* Zone of Stainforth et al. (1975), which is equivalent to the P8 or P9 Zone as used by Berggren et al. (1985). Locality 1220c differs

from locality 1220b in that the fossiliferous lenses are taxonomically less diverse. They lack colonial scleractinian corals, stromatolites, and the gastropod *Velates perversus* that are all common at locality 1220b. Immediately overlying the stratigraphic interval of locality 1220c are beds that contain *Turritella andersoni*, a species not present lower in the Bateque Formation. This gastropod is indicative of the middle lower Eocene provincial molluscan "Capay Stage" in California and southwest Oregon (Squires, 1988).

The third locality, CSUN 1293, is about 90 km south of the other two localities. It is on the south side of Arroyo Mezquital about 13.5 km south of the village of San Juanico. Only a 30-m-thick portion of the Bateque Formation is exposed here, and the formation is unconformably overlain by the Miocene Isidro Formation. (For a generalized geologic map of the area, see McLean et al., 1985.) Locality 1293 is near the base of the Bateque exposures in a 9-m-thick, very weathered, reddish-gray mudstone that contains extremely abundant discocyclinid foraminifers, abundant *Cubitostrea mezquitalensis* n. sp., and commonly occurring *Batequeus mezquitalensis* n. gen. and sp. Other mollusks occur in the mudstone but only as molds. A few single valves of *Pycnodonte (Phygraea) pacifica* n. sp. and only a single

left valve of *Pycnodonte (Pegma) bajaensis* n. subgen. and sp. were found in float at locality 1293. Possibly, they are from overlying, poorly exposed, very fine-grained sandstone beds higher in the Bateque Formation.

The delicate discocyclinids at locality 1293 are mostly complete, up to 22 mm in diameter, and show a growth series. Many of the *Cubitostrea* and a few of the *Batequeus* are articulated, and specimens of both show growth series. Absence of any indications of pre-burial transport indicates that the fossils found in the mudstone are in situ. According to Vaughan (1945), discocyclinids are indicative of warm waters no deeper than 100 m. The fossils at locality 1293 are interpreted to have been associated with a protected environment, or one that was below normal-storm wave base. In either case, mud could accumulate and the shells would remain in situ. The low-energy environment at locality 1293 contrasts with the higher energy environment associated with the mollusks found at localities 1220b and 1220c.

Calcareous nannofossils are common at locality 1293 and indicate the middle Eocene *Discoaster bifax* (CP14a) Zone of Okada and Bukry (1980), which correlates with the middle Eocene part of the provincial molluscan "Tejon Stage" at the CP13/CP14 boundary (Squires, 1987). Preservation and diversity are better than for age-equivalent assemblages in California, which suggests warmer (tropical?) paleotemperatures (M. V. Filewicz, personal commun.).

Abbreviations are as follows: CAS, California Academy of Sciences; CSUN, California State University, Northridge; IGM, Instituto de Geología, Universidad Nacional Autónoma de México; LACMIP, Natural History Museum of Los Angeles County, Invertebrate Paleontology Section.

SYSTEMATIC PALEONTOLOGY

Order PTERIOIDA Newell, 1965

Family PECTINIDAE Rafinesque, 1815

Genus BATEQUEUS n. gen.

Type species.—*Batequeus mezquitalensis* n. sp., the sole included species.

Diagnosis.—A medium-sized pectinid, slightly longer than high, with equally low-convex valves, short byssal notch, anterior auricles smaller than the posterior ones, left valve with numerous very closely spaced radial riblets that show the imbricated growth lines very well, right valve with about 30 low flat-topped radial ribs that can be grooved, and intercalary ribs (usually single ones) on both valves.

Remarks.—Of the groups of family Pectinidae Rafinesque, 1815, listed by Hertlein (1969), *Batequeus* n. gen. has more in common with the *Chlamys* Group than any other. *Batequeus* is interpreted to be only distantly related to the *Chlamys* Group because true *Chlamys* Röding, 1798, and related genera have a convex left valve and a less convex right valve. Superficially, the new genus resembles the *Pecten* Group of Hertlein (1969), but true *Pecten* Müller, 1776, and related forms have broad, flat, relatively unornamented ribs (not like *Batequeus*) and their byssal notch is very shallow (not like the right valve of *Batequeus*).

Etymology.—The new genus is named for the Bateque Formation.

BATEQUEUS MEZQUITALENSIS n. sp.

Figure 2.1–2.5

Diagnosis.—Same as for genus.

Description.—Medium sized; shell height up to 41 mm, slightly shorter than long; subcircular disk and moderately convex thin valves, equally low-convex valves; tendency for oblique

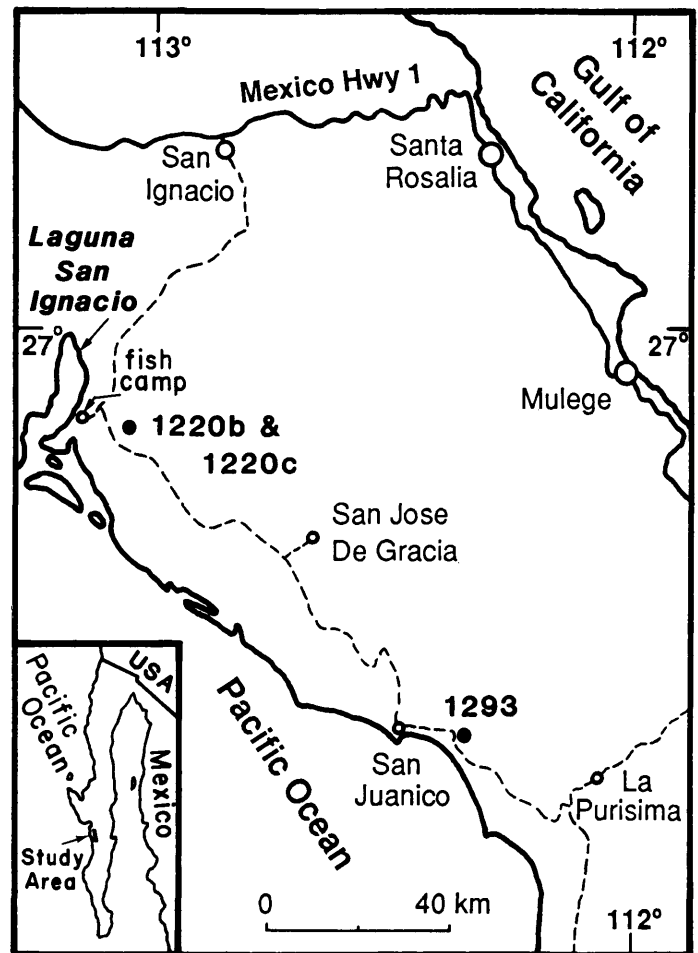
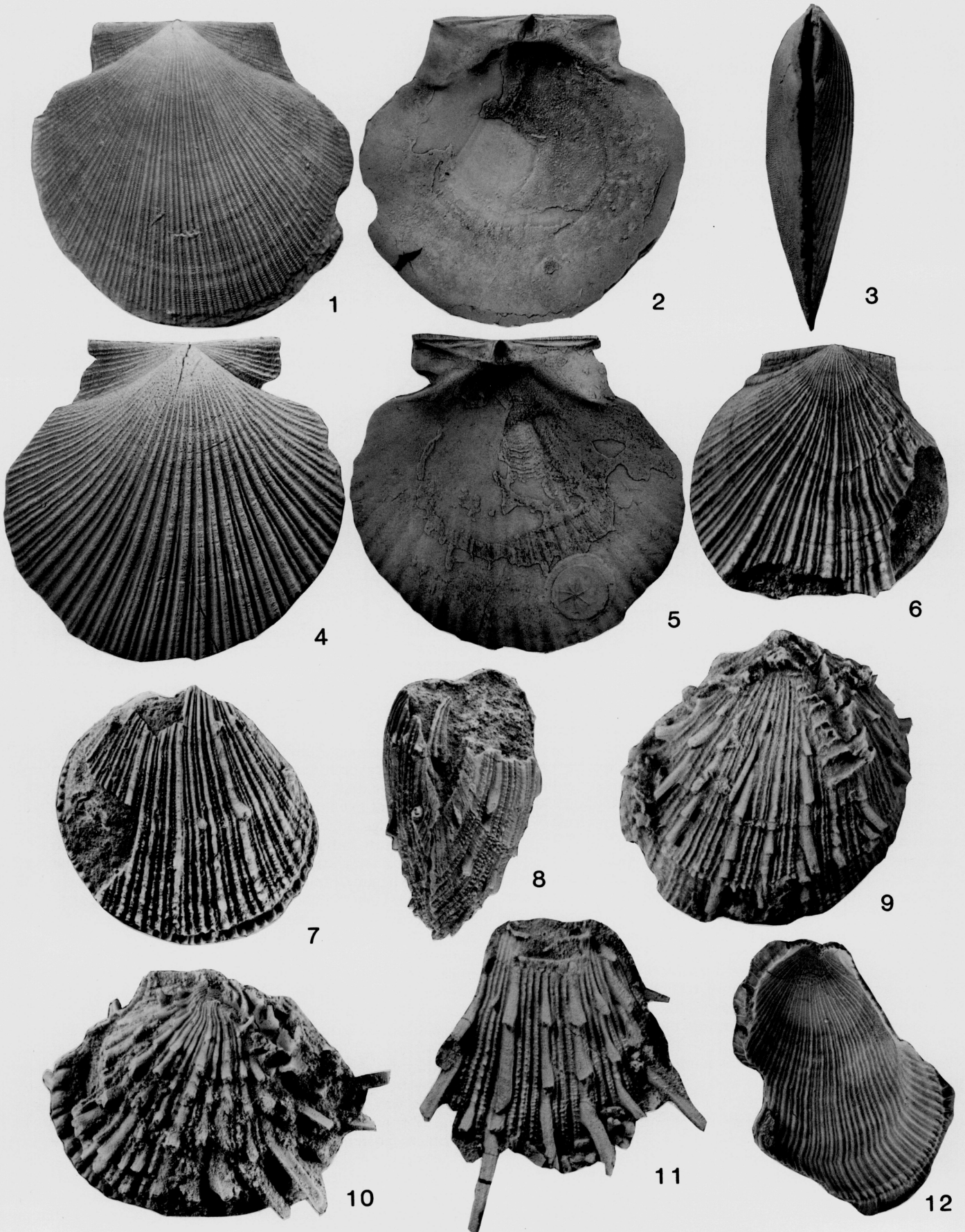


FIGURE 1—Index map to California State University, Northridge (CSUN) collecting localities, Bateque Formation, Baja California Sur, Mexico.

growth in ornamentation in posterior region of each valve; anterior auricles shorter than posterior ones; hinge line about three-fifths length of disk; hinge plate raised and lens shaped; resilifer triangular and extending to hinge line, bordered on each side by a low ridge adjacent to a flattened area. Left valve with numerous scaly radial ribs, interspaces about same width with one or two intercalaries in later growth stage (beyond about 20 mm valve height), radial ribs tend to be more closely spaced on anterior and posterior regions of valve; anterior auricle with about six scaly riblets; posterior auricle with about eight scaly riblets; dorsal margin of hinge line smooth and bordered ventrally by low ridge, fairly deep groove separating this low ridge from cardinal crus (rarely two or more) on both sides of resilifer; interior of valve with numerous wide and flat, weak radial ribs that can be fluted at valve margin. Right valve with about 30 low, flat-topped radial ribs that may become grooved and may have a single rib in flat-bottomed interspaces in later growth stage (beyond about 20 mm valve height); radial ribs wider than interspaces; commarginal growth lines extremely fine; primary ribs give way posteriorly to cluster of 8–12 scaly, secondary radial ribs; anterior auricle with short byssal notch and about six riblets; posterior auricle with about eight scaly riblets; exterior surface of each auricle bent backwards into hinge-line area (except in resilifer area), causing interior dorsal margin of each auricle to be swollen and accentuated by vertical, scale-like growth lines; hinge line with two cardinal crura radiating



from each side of apex of resilifer, uppermost one extending nearly entire length of hinge line, lowermost one much shorter and less prominent, fairly deep groove separating uppermost cardinal crus from swollen dorsal margin; interior of valve with about 23 wide, flat, weak radial ribs with fairly wide interspaces.

Remarks.—The left valve of *Batequeus mezquitalensis* n. sp. is very similar in ornamentation to some specimens of "*Chlamys*" *decemnaria* (Conrad, 1834, p. 151; 1840, p. 49, Pl. 24, fig. 2) from the upper Pliocene Yorktown Formation, Virginia and North Carolina. As shown in Gibson (1987, p. 65–69, Pl. 15, figs. 2, 3, 5–7, Pl. 16, figs. 3–5, Pls. 19, 20), there is a great deal of variation in "*C.*" *decemnaria*. Some specimens (Gibson, 1987, Pl. 20, fig. 3) are remarkably similar to *B. mezquitalensis*, except that in the new species the anterior auricle is smaller than the posterior. *Batequeus mezquitalensis* is the earliest documentable Cenozoic pectinid from the west coast of North America. *Chlamys proavus* (Arnold, 1906, p. 52–53, Pl. 2, figs. 6–8; Moore, 1984, p. B19, Pl. 3, fig. 15) may be from the Paleocene Locatelli Formation, San Mateo County, middle California, but its stratigraphic position is uncertain (Moore, 1984). *Cyclopecten? martinezensis* (Gabb, 1869, p. 198, Pl. 33, fig. 96; Moore, 1984, p. B8–B9, Pl. 1, figs. 9, 10) from the Martinez Formation, Contra Costa County, middle California (Moore, 1984) is earlier in age than *Batequeus mezquitalensis*, but *C. martinezensis* is a propeamussiid rather than a pectinid.

Etymology.—The specific name is for Arroyo Mezquital, along which the type locality of the new species is located.

Material.—About 100 specimens with nearly equal number of left and right valves, all of which show the interior. A few specimens are articulated.

Occurrence.—Middle Eocene CP14a Zone of Okada and Bukry (1980), which correlates within the middle Eocene part of the "Tejon Stage" (Lutetian Stage). Bateque Formation, Baja California Sur, Mexico, locality CSUN 1293.

Repository.—Holotype, IGM 5058 (=plasto-holotype), LACMIP 8061; paratypes, IGM 5059, 5060 (=plasto-paratypes), LACMIP 8062, 8063; locality CSUN 1293.

Family SPONDYLIDAE Gray, 1826
Genus SPONDYLUS Linné, 1758

Type species.—By subsequent designation (Schmidt, 1818), *Spondylus gaederopus* Linné, 1758.

SPONDYLUS BATEQUENSIS n. sp.
Figure 2.6–2.12

Diagnosis.—*Spondylus* with left valve having about 12 radial ribs that may be spinose with interspaces containing usually three ribs with or without single intervening radial riblets; right valve (attached) with 10–12 usually fairly evenly spaced, strong, flattish radial ribs bearing upturned elongate spines with interspaces containing usually three spinose radial riblets.

Description.—Medium sized; shell up to 32 mm high (incomplete), subcircular; beaks central; shell thin, moderately inflated; left valve less convex than right valve. Left valve with about 12 primary radial ribs that may have short spines more common posteriorly; bottoms of short spines with longitudinal groove; interspaces between ribs with 1–3 smooth to spinose secondary

radial ribs alternating with smooth to spinose tertiary radial riblets; secondary ribs may approach primary rib strength, especially in beak region; anterior auricle sloping (preservation?), with three ribs; small posterior auricle with two faint ribs; both auricles separated from rest of valve by somewhat swollen radial rib; hinge area poorly preserved with triangular ligamental pit elongate. Right (attached) valve with 10–12 usually fairly evenly wide-spaced, strong radial ribs with imbricated spines; spines flattish to spikelike with longitudinal groove on bottom; spines along anterior margin commonly strongest and commonly upturned; spiny nature of right valve produces "thorny" appearance; interspaces between strong radial ribs with 1–7 (commonly three) spinose imbricated riblets; anterodorsal part of right valve may have lamellose overgrowths (which represent the attachment area); small posterior auricle with two riblets, anterior auricle obscured by matrix; interior of valve showing numerous primary radial ribs separated by secondary ribs, all ribs extend from beak to ventral margin with ribs stronger, more flat-topped, and more uniform in size ventrally; hinge area not seen.

Remarks.—*Spondylus batequensis* n. sp. is most closely allied to *Spondylus dumosus* (Morton, 1834, p. 59, Pl. 16, fig. 8, text-fig. p. 60; Dockery, 1982, p. 49, 50, Pl. 14, figs. 1–9, text-figs. 33, 34.1) known from the lower Oligocene Red Bluff Formation, Mississippi and southwestern Alabama (Glawe, 1967; Dockery, 1982).

Spondylus batequensis n. sp. differs from *S. dumosus* in the following features: 10–12 rather than 9–10 radial ribs, weaker radial ribs on the left valve, right valve interior with radial ribs throughout, and spinose secondary and tertiary riblets over entire shell exterior rather than only on beak area. These differences become harder to discern on juvenile specimens (less than 30 mm shell height) and juvenile portions of adult specimens of *S. dumosus*. The evidence suggests that *S. batequensis* is the ancestral species and some of its morphological traits are retained in the juvenile portion of *S. dumosus*. Their close relationship is further strengthened by the presence of a longitudinal groove along the bottoms of the flattish radial ribs on both valves.

The new species shows more affinity to Gulf Coast lower Oligocene species than to Cretaceous or Eocene species from the west coast of North America. *Spondylus striatus* Packard (1922, p. 422, Pl. 29) and *S. rugosus* Packard (1922, p. 422, Pl. 27, fig. 3, Pl. 30, fig. 3, Pl. 31, fig. 3) were present in southern California during the Late Cretaceous. These species lack spines. *Spondylus* cf. *S. striatus* in Sundberg and Riney (1984, figs. 2–13) from the Upper Cretaceous Lusardi Formation and Point Loma Formation in the San Diego area, southern California, resembles the new species somewhat but is much larger (up to 80 mm height), much less spiny, and the interribs are not spinose.

Spondylus batequensis n. sp. is only the second reported *Spondylus* from the "Capay Stage" of the west coast of North America. *Spondylus carlosensis* Anderson (1905, p. 194, Pl. 13, fig. 1) has been previously reported (Baldwin, 1964, p. 11) from rocks in northwestern Oregon equivalent to the middle lower Eocene "Capay Stage." This species, however, has been reported (Vokes, 1939; Squires, 1984, 1989; Moore, 1987) most com-

FIGURE 2—1–5, *Batequeus mezquitalensis* n. gen. and sp., locality CSUN 1293. 1, 2, holotype, IGM 5058, left-valve exterior and interior, $\times 1.6$; 3, paratype, IGM 5059, posterior view of both valves, $\times 1.8$; 4, 5, paratype, IGM 5060, right-valve exterior and interior, $\times 1.6$. 6–12, *Spondylus batequensis* n. sp., locality CSUN 1220b. 6, paratype, IGM 5062, left valve, $\times 2.4$; 7, 8, paratype, IGM 5063; 7, left valve, $\times 1.6$; 8, posterior view of both valves, $\times 1.6$; 9, holotype, IGM 5061, right valve, $\times 2.8$; 10, paratype, IGM 5064, right valve, $\times 2.4$; 11, paratype, IGM 5065, right valve, $\times 2.5$; 12, paratype, IGM 5066, interior of right valve, $\times 1.9$.

monly from strata in California equivalent to the mostly middle Eocene "Domengine Stage" and "Transition Stage." *Spondylus carlosensis* is only very obscurely spinose.

Spondylus cliffensis Hanna (1927, p. 278, Pl. 32, figs. 2, 7) is the only other *Spondylus* known from the Eocene of the west coast of North America. This species, known only from "Domengine Stage" strata in southern California (Hanna, 1927), lacks spines. Similarly, *Spondylus perrini* Wiedey (1928, p. 138, Pl. 17, figs. 6, 7) is the only Oligocene species of *Spondylus* from the west coast of North America, and it lacks spines.

Etymology.—The specific name is for the Bateque Formation.

Material.—Twenty-one right valves (with nine showing the interior) and 21 left valves. Four of the 42 valves are articulated.

Occurrence.—Middle lower Eocene "Capay Stage" (Ypresian Stage). Bateque Formation, Baja California Sur, Mexico, localities CSUN 1220b and 1220c.

Repository.—Holotype, IGM 5061 (=plasto-holotype), LAC-MIP 8064; paratypes, IGM 5062–5066 (=plasto-paratypes), LACMIP 8065–8069; locality CSUN 1220b.

Family GRYPHAEDAE Vyalov, 1936

Subfamily PYCNODONTEINAE

Stenzel, 1959

Genus PYCNODONTE

Fischer de Waldheim, 1835

Type species.—By original designation, *Pycnodonte radiata* Fischer de Waldheim, 1835.

Subgenus PHYGRAEA Vyalov, 1936

Type species.—By original designation, *Gryphaea (Gryphaea) sec. Phygraea frauscheri* Vyalov, 1936 (= *Gryphaea pseudovesicularis* Gümbel, 1861).

PYCNODONTE (PHYGRAEA) PACIFICA n. sp.

Figure 3.1–3.4

Diagnosis.—A *Phygraea* with radial sulcus originating in umbo area.

Description.—Medium to large sized; shell up to 100 mm high, ovate to quadrate, strongly inequivalved, opisthogyrate; both valves smooth or with low irregular growth-line welts; ligamental pit in both valves large and well defined to small and poorly defined; margin of commissural shelf prominent in both valves extending subparallel to shell margin from each side of ligamental pit, with posterior ridge stronger and more oblique. Left valve (rarely attached) moderately to very convex; umbo central, may serve as attachment area to substrate; posterodorsal margin commonly concave and geniculate; posterior radial sulcus originating in umbo area, weakly developed on specimens less than 60 mm high, more prominent with increasing size of specimen; vermiculate catachomata not very extensive and commonly not evident; band of junction of two valves on interior of left valve fairly wide in anteroposterior area with ventral extent marked by prominent margin of commissural shelf. Right valve concave to flat, rarely convex, can be smaller than corresponding left valve; ventrally posterior margin deflected upward to accommodate radial sulcus of left valve; vermiculate

anachomata not very extensive but evident; adductor-muscle scar circular, situated just posterior and dorsal of center of right valve; band of junction of two valves on interior of right valve very wide in posterior area, becoming very narrow in anterior area; inner margin of band of junction marked by circular-shaped prominent ridge.

Remarks.—Specimens of the new species are most common at locality CSUN 1220c. The few specimens at locality CSUN 1293 are smaller.

According to Stenzel (1971, p. N1107), *Pycnodonte (Phygraea)* ranges from Cretaceous to Miocene and is worldwide. *Pycnodonte (Phygraea) pacifica* n. sp. is the first record of the subgenus on the west coast of North America.

Pycnodonte (Phygraea) pacifica n. sp. shows close affinity to both *Pycnodonte (Phygraea) wratheri* (Stephenson, 1936, p. 2–4, Pl. 1, figs. 1–4) from Upper Cretaceous (Santonian) strata in Texas and Alabama and to *Pycnodonte (Phygraea) pseudovesicularis* (Gümbel, 1861; Stenzel, 1971, figs. J83 1a–e) from upper Paleocene strata at Haunsberg, north of Salzburg, Austria. The new species differs from both in that it has a better defined radial sulcus, which originates in the umbo region rather than near the posterodorsal margin.

Pycnodonte (Phygraea) pacifica n. sp. superficially resembles *Ostrea haleyi* Hertlein (1933, p. 277–281, Pl. 18, figs. 5, 6; Givens, 1974, p. 45, Pl. 1, figs. 11–13; Squires, 1987, p. 58, fig. 97) from middle lower Eocene ("Capay Stage") strata, southern California. The new species differs from *O. haleyi* in the following features: larger, broader shell; beaks not as in-turned, umbonal ridge not as angulate, radial sulcus much better defined and originating in umbo area rather than in the posterodorsal region. Comparison between valve interiors cannot be made because such features are not known for *O. haleyi*.

Material.—Twenty-three left valves (with 12 showing the interior) and 10 right valves (with two showing the interior). Eight of the 33 valves are articulated.

Occurrence.—Middle lower Eocene "Capay Stage" (Ypresian Stage) to middle Eocene CP14a Zone of Okada and Bukry (1980), which plots within the middle Eocene part of the "Tejon Stage" (Lutetian Stage). "Capay Stage": Bateque Formation, Baja California Sur, Mexico, locality CSUN 1220c. "Tejon Stage": Bateque Formation, Baja California Sur, Mexico, locality CSUN 1293.

Repository.—Holotype, IGM 5067 (=plasto-holotype), LAC-MIP 8070; paratype, ICM 5068 (=plasto-paratype), LACMIP 8071; locality CSUN 1220c.

PEGMA n. subgen.

Type species.—*Pycnodonte (Pegma) bajaensis* n. sp., the sole included species.

Diagnosis.—*Pycnodonte* with left valve plicate and large attachment area that can cover entire valve; right valve usually with inflated, smooth central area surrounded by plicate margins.

Remarks.—The systematics of Gryphaeidae follow that of Harry and Dockery (1983) and Harry (1985). Of the four subgenera of *Pycnodonte* that Stenzel (1971) recognized, *Pegma* is

FIGURE 3—1–4, *Pycnodonte (Phygraea) pacifica* n. sp., locality CSUN 1220c. 1, holotype, IGM 5067, left valve, $\times 0.8$; 2–4, paratype, IGM 5068; 2, left-valve interior, $\times 0.9$; 3, right valve, $\times 0.9$; 4, right-valve interior, $\times 1.1$. 5–12, *Pycnodonte (Pegma) bajaensis* n. subgen. and sp. 5–7, paratype, IGM 5070, locality CSUN 1293, left valve; 5, exterior, $\times 1.4$; 6, interior $\times 1.4$; 7, enlargement of vesicular structure in lower left-hand part of specimen shown in Figure 3.6, $\times 7.3$; 8, 9, holotype, IGM 5069, locality CSUN 1220b, right-valve exterior and interior, $\times 2.8$; 10, paratype, IGM 5071, right-valve interior, $\times 1.1$; 11, 12, paratype, IGM 5072, right-valve interior; 11, $\times 0.95$; 12, enlargement of vesicular structure in lower left of specimen shown in Figure 3.9, $\times 4.4$.