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NEW MOLLUSKS FROM THE LOWER MIDDLE EOCENE LLAJAS FORMATION, SOUTHERN CALIFORNIA

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ABSTRACT—Five new mollusks are described from shallow-marine deposits of the lower middle Eocene Llajas Formation, northeastern Simi Valley, southern California. Most of the mollusks are confined to a 1-m-thick bed informally known as the "Stewart bed" and are part of an *Eocernina-Turritella-Crassatella* community.

Cymatium (Septa) janetae n. sp. is at present the earliest species worldwide referable to *Septa*. *Ranella katherineae* n. sp. is one of the earliest West Coast species of *Ranella* s.s. A new species of *Clavilithes* occurs with *C. tabulatus* (Dickerson); *C. tabulatus* was previously regarded as being of early Eocene age only. *Pinna llajasensis* n. sp. is conspecific with *Pinna* n. sp. Vokes from the middle Eocene Domengine Formation of central California. A partial phragmocone of a spirulimorph sepiid, family indeterminate, is the first record of a sepiid in the Eocene of western North America.

INTRODUCTION

THE new mollusks reported in this study were collected from the lower middle Eocene Llajas Formation, southwestern Santa Susana Mountains, northeastern corner of Simi Valley, southern California (Figure 1). They are predominantly confined to a 1-m-thick sandstone bed that occurs near the middle of the 545-m-thick Llajas Formation. This bed, which crops out between Chivo and Devil Canyons (Squires, 1981), has been informally called the "Stewart bed" since the 1930's in honor of Ralph Stewart, who collected there and described some new species of mollusks (Stewart, 1927, 1930).

Other workers who named new molluscan taxa from the Llajas Formation are Waring (1914, 1917), Schenck (1926), Clark (1934, 1942), Merriam and Turner (1937), Vokes (1937, 1939), Bentson (1940), Merriam (1941), and Sutherland (1966).

The Llajas Formation represents a transitional coastal alluvial fan to marine sequence (Squires, 1981). The new mollusks occur within a transgressive shallow-marine facies that makes up most of the middle part of the formation. The "Stewart bed" occurs where this shallow-marine facies grades into bioturbated and finer-grained deposits of the outer shelf to slope facies. Fossils in the "Stewart bed" include articulated valves and nearly complete growth series; delicate morphologic features are well preserved (Squires, 1981). Such fossils constitute a residual (or winnowed) community as defined by Fagerstrom (1964).

Including the new mollusks, the "Stewart bed" megafaunal species consist of 29 gastropods, 15 bivalves, and 1 species each of nautiloid, scaphopod, discocylinid, brachiopod, solitary scleractinian coral, shark tooth, and spatangoid. In addition there are bryozoan, brachyuran, sepiid, and terrestrial plant remains. Common to abundant taxa are the gastropods *Eocernina hannibali, Turritella andersoni lawsoni, Pachycrommium clarki,* the bivalves *Crassatella uvasana, Venericardia (Pacificor) calafia,* and the solitary scleractinian *?Trochocyathus striatus* (in part, Squires, 1979).

New mollusk species described here include 2 cymatiid gastropods, a fasciolarid gastropod, a pinnid bivalve, and a spiruliomorph sepiid. All are from the middle portion of the Llajas Formation. The middle and upper portions of the formation are equivalent to the Pacific Coast megainvertebrate provincial "Domengine Stage" of early middle Eocene age (Squires, 1981). Such an age asignment is supported by studies of the calcareous nannofossil assemblages, currently being undertaken by M. V. Filewicz and M. E. Hill, III, of Union Oil, California. The lower portion of the formation is either latest

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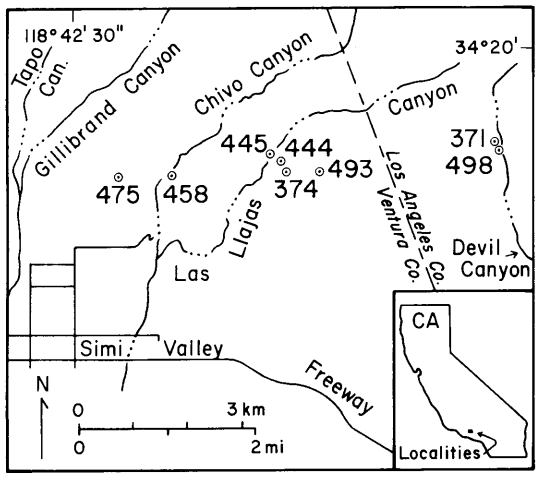


FIGURE 1—Index map to California State University, Northridge (CSUN) collecting localities, Llajas Formation, southwestern Santa Susana Mountains, California.

early Eocene or earliest middle Eocene in age (Squires, 1981; Filewicz and Hill, personal commun.).

The type specimens are deposited in the University of California, Los Angeles (UCLA) Department of Earth and Space Sciences paleontology collections.

SYSTEMATIC PALEONTOLOGY

Class GASTROPODA Cuvier, 1797
Subclass PROSOBRANCHIA
Milne Edwards, 1848
Order MESOGASTROPODA Thiele, 1925
Family CYMATIIDAE Iredale, 1913
Genus CYMATIUM Röding, 1798

Type species.—By subsequent designation (Dall, 1904) *Murex femorale* Linné, 1758.

Subgenus SEPTA Perry, 1810

Type species.—By monotypy, *Septa scarlatina* Perry, 1810 (=*Murex rubecula* Linné, 1758).

Diagnosis.—Ovate-fusiform shell of moderate size with impressed sutures, tall, conical, smooth protoconch, and prominent, widely spaced, discontinuous varices. Whorls sculptured by numerous beaded spiral cords and collabral costae; spiral cords at least of two sizes. Outer lip thickened and denticulate. Inner lip calloused and plicate. Anal canal obsolete. Siphonal canal moderately short, recurved.

CYMATIUM (SEPTA) JANETAE n. sp.
Figure 2A–D

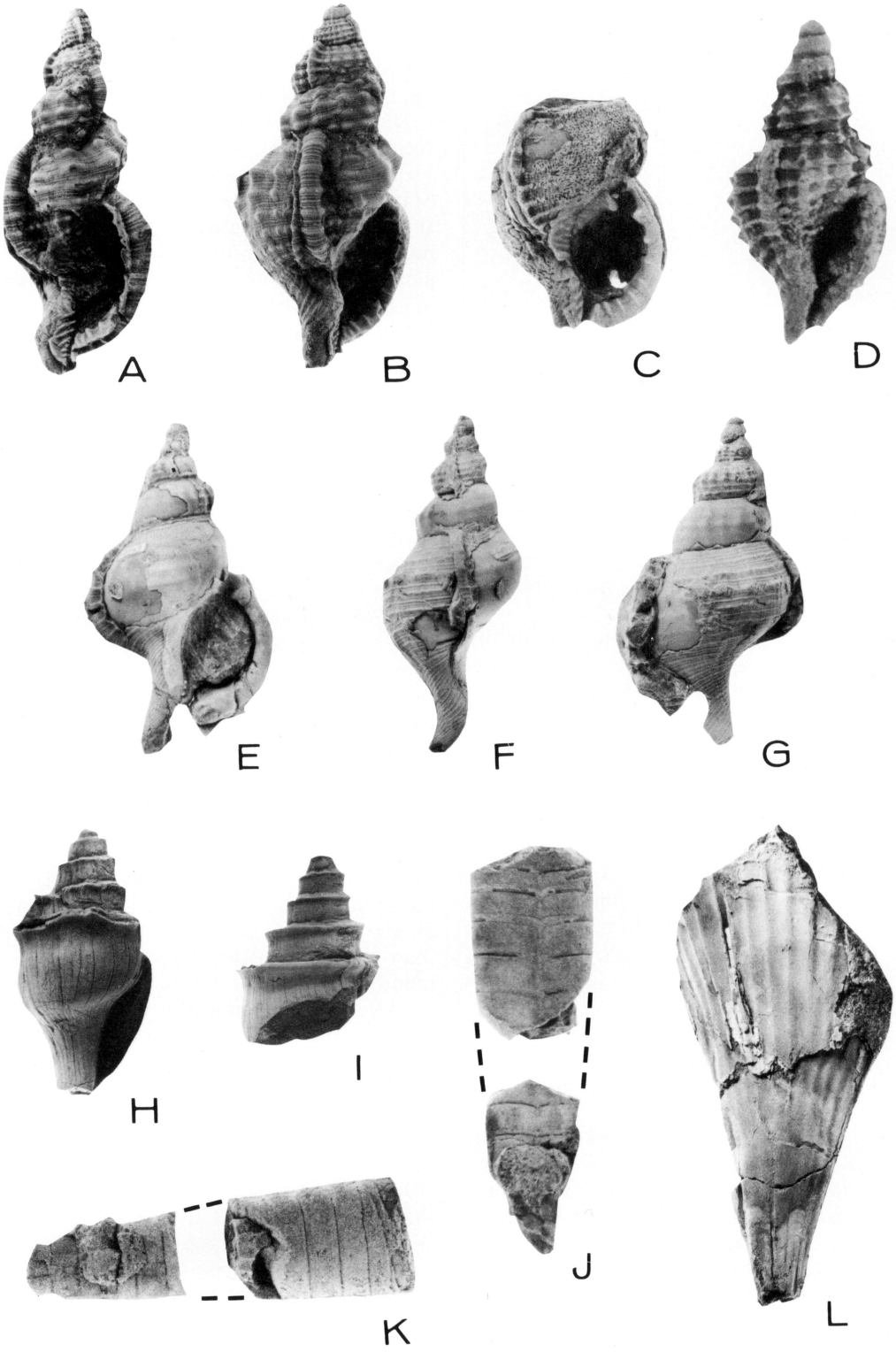
Diagnosis.—A *Septa* with fine cancellate interstitial sculpture.

Description.—Medium shell with spire about 30 percent of the height. Suture moderately impressed and undulating. Basal part of protoconch smooth, with rounded whorls and fairly shallow sutures. Upper spire whorls rounded, body whorl angulate. Varices regularly spaced about ⅔ of a whorl apart, aligned in alternate whorls.

Pre-antepenultimate whorl with 20 collabral costae and 4 to 5 primary spiral cords, 2 to 3 secondary spiral cords in interspaces. Primary spiral cords noded where they intersect collabral costae, producing a regularly beaded sculpture; earlier whorls also beaded. Antepenultimate and penultimate whorls with 12 collabral costae and 4 to 6 primary spiral cords. Body whorl with 9 collabral costae and 8 primary spiral cords. Adult whorls noded where primary cords intersect collabral costae; nodes swollen, pointed, and separated by wide interspaces. On adult whorls, interspaces between primary spiral cords with 4 to 6 secondary cords alternating with tertiary cords. Body and penultimate whorls with 7 collabral costae between each varix. Neck area with 5 primary spiral cords, 2 to 3 secondary cords in interspaces. Shell surface covered by fine growth lines and secondary spiral cords, producing intricate cancellate pattern.

Aperture ovate with outer lip varicose. Outer face of outer lip flattened with 8 teeth on the interior; posterior-most tooth larger than the others. Inner lip calloused, ornamented with 11 to 12 narrow, well raised, weakly anastomosing plicae. Parietal callus extends onto body whorl; a parietal tooth opposite the enlarged posterior-most tooth of outer lip. Short anterior canal incomplete, slightly twisted.

Comparison.—The new species is most similar to *Cymatium etheringtoni* Weaver (1943, p. 413–414, Pl. 82, figs. 2, 3, 10) from the upper Eocene Cowlitz Formation of Washington and Oregon. *C. (S.) janetae* differs from the holotype of *C. etheringtoni* in the following features: a more elongate shape, a more elongate aperture, one less tooth inside the outer lip, a thicker and more extensive parietal callus with actual plicae rather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than just extensions of the primary spiral cords, lower primary spiral cords, flatter sides on the body whorl, and one more collabral costa between each varix on the body and penultimate whorls. *C. (S.) janetae* has also a beaded upper spire, 3 more collabral costae and 1 more primary spiral cord on the antepenultimate and penultimate whorls, and a parietal tooth rather than an extension of a primary spiral cord. It has finer and more numerous, more intricately cancellate interstitial sculpture than that of *C. etheringtoni.*

Vokes (1939, p. 146) identified a few fragmentary and poorly preserved shells from various middle Eocene formations in California as *Cymatium (Lampusia)* n. sp. Some of this material reportedly was from the Llajas Formation (at a locality equivalent to CSUN 374) but has since been lost. The type specimen of *C. (L.)* n. sp. of Vokes consists of only the upper spire. *C. (S.) janetae* differs from it in having only half the number of noded collabral costae between equivalent varices, more swollen and more elongate nodes, less rounded and more flat-sided whorls, and intricate cancellate interstitial sculpture, which is lacking in *C. (L.)* n. sp. of Vokes.

Discussion.—The protoconch is missing on adult specimens of *C. (S.) janetae* due to abrasion. It is incomplete on juveniles, and only the basal part is present.

The basis of modern taxonomic work on the Cymatiidae is the monograph by Clench and Turner (1957). Most workers now regard *Septa* as a subgenus of *Cymatium* and *Lampusia* as a synonym of *Septa.* Prior to these Llajas specimens, authors gave the geologic range of *Septa* and/or *Lampusia* as Miocene to Recent (Suter, 1913; Wenz, 1941; Beu, 1970; Davies, 1971). *C. (S.) janetae* n. sp. extends the earliest occurrence to early middle Eocene and is the oldest known species referrable to the subgenus *Septa* (Beu, personal commun.).

Material.—One nearly complete adult specimen (holotype), 5 partial adult specimens, 2 internal molds of partial adult specimens, 1 external mold of a partial adult specimen, and 32 juvenile specimens.

Types.—Holotype, UCLA 59191, CSUN locality 444, height 45 mm, specimen somewhat laterally compressed. Paratype, UCLA 59192, CSUN locality 445, height 30 mm. Paratype, UCLA 59193, CSUN locality 371, height 9 mm.

Occurrence.—All the adult specimens were obtained from the Llajas Formation from the 1-m-thick "Stewart bed" approximately 340 m above its base, at or near CSUN localities 374, 444, and 445. Three of the specimens (UCLA 59173, UCLA locality 2312 = CSUN locality 374) were borrowed from UCLA.

Most of the juveniles came from the Llajas Formation, CSUN locality 371. Additional juveniles were collected from CSUN locality 498, 60 m stratigraphically below CSUN locality 371 and in the same general area. CSUN locality 371 is 3.6 km east of CSUN locality 444 and correlates to approximately 40 m below the "Stewart bed." Specimens at localities 371 and 498 occur in channel-fill deposits. The amount of transport of the specimens was short, to judge from the presence of delicate morphologic features.

Etymology.—The species is named after Janet Squires, who found the holotype.

Genus RANELLA Lamarck, 1816

Type species.—By subsequent designation (Children, 1823) *Ranella gigantea* Lamarck, 1816 (=*Murex olearium* Linné, 1758).

Diagnosis.—Ovate-fusiform shell of moderately large size, with impressed sutures and

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FIGURE 2—*A–D, Cymatium (Septa) janetae* Squires n. sp. *A,* holotype, UCLA 59191, ×1.2, apertural view; *B,* holotype, ×1.2, side view; *C,* paratype, UCLA 59192, ×1.2, apertural view; *D,* paratype, UCLA 59193, ×5.2, apertural view of a juvenile specimen. *E–G, Ranella katherineae* Squires n. sp. *E,* holotype, UCLA 45969, ×0.5, apertural view; *F,* holotype, ×0.5, side view; *G,* holotype, ×0.5, back view. *H, I, Clavilithes* n. sp. *H,* UCLA 59194, ×0.4, apertural view; *I,* UCLA 59195, ×0.5, spire. *J, K,* unidentifiable spirulimorph sepiid. *J,* UCLA 59197, ×2.6, ventral view of partial phragmocone; *K,* UCLA 59197, ×2.6, lateral view of partial phragmocone. *L, Pinna llajasensis* Squires n. sp. Holotype, UCLA 59196, ×0.58, internal mold of right valve. Note posterior adductor scar and medial sulcus in anterior region.

varices approximately every 200°. Whorls well rounded, with fine spiral cords that intersect fairly well developed collabral costae, producing a cancellated ornament. Aperture rounded-oval. Outer lip with flattened outer face, toothed on inner margin. Inner lip calloused, wrinkled with a few nodules near base of columella; posterior parietal region with a low tubercle opposite an outer lip tooth, thereby forming a constriction. Siphonal canal fairly long, slightly recurved.

RANELLA KATHERINEAE n. sp.
Figure 2E–G

"*Ranella*" sp. SMITH, 1970, p. 523.

Diagnosis.—A *Ranella* with a distinct anal groove and no collabral costae on body whorl.

Description.—Large shell with spire about 30 percent of the height. Suture moderately impressed and undulating. Protoconch missing. Upper spire whorls rounded, antepenultimate and penultimate whorls somewhat angulate, and body whorl strongly angulate. Varices regularly spaced about ½ of a whorl apart, aligned vertically.

Antepenultimate whorl with about 14 collabral costae and 5 primary spiral cords, with 3 to 4 secondary spiral cords in interspaces. Except for posterior-most cord, primary spiral cords noded where they intersect collabral costae. Two cords on the shoulder have the most pronounced nodes, of similar width and with a beaded microsculpture. Pre-antepenultimate and penultimate whorls partially preserved with similar sculpture. Body whorl lacks collabral costae, has numerous, irregularly spaced primary spiral cords with 1 to 5 secondary cords in the interspaces. Spiral cord at shoulder has widely spaced, elongate low nodules. Every third primary spiral cord adapically from shoulder has numerous small closely spaced swellings. Near upper suture of body whorl, fine growth lines interrupt secondary spiral cords of the spiral ornamentation, producing an intricate cancellate pattern.

Neck area sculpture with about 9 widely spaced primary spiral cords, generally with smooth interspaces. Aperture rounded-ovate. Outer lip with a distinctly flattened outer face, varicose, with 8 weak, low teeth along inner margin; posterior-most tooth larger than the others. Posterior groove distinct. Inner lip calloused, ornamented with 5 unequal teeth at base of columella; parietal region with a low node. Spiral ornamentation of neck area shows through the callus above the basal columellar teeth. Anterior canal moderately long, twisted, and recurved.

Comparison.—The new species is most similar to *Ranella washingtoniana* Weaver (1912, p. 41, Pl. 2, fig. 14) (=*Gyrineum uvasalis* Anderson and Hanna, 1925, p. 57–58, Pl. 6, fig. 1, Pl. 10, fig. 5, Pl. 13, fig. 13).

R. washingtoniana has been reported from the upper Eocene Cowlitz Formation, Washington and Oregon (Weaver, 1912, 1943). Based on my identification of a specimen loaned to me by C. Givens, it occurs also from the middle part of the lower middle Eocene Ardath Shale, San Diego County. The specimen is from University of California, Riverside locality 4847 (see Givens and Kennedy, 1979), and it has been deposited in the University of California, Riverside, Department of Earth Sciences invertebrate paleontology collection. *G. uvasalis* has been reported from the upper Eocene portion of the Tejon Formation, California (Anderson and Hanna, 1925).

R. katherineae n. sp. differs from a hypotype of *R. washingtoniana,* as well as from the holotype and paratypes of *G. uvasalis,* in having varices with a more flattened outer face, weak teeth all along the outer lip, a distinct posterior groove in the aperture, and in lacking a pronounced angle on the whorls and collabral costae on the body whorl. In addition, the antepenultimate and penultimate whorls of *R. katherineae* have 4 rather than 2 primary spiral cords. The varices of *R. katherineae* are aligned vertically, whereas those of *R. washingtoniana* are lower and slightly offset.

Due to preservation problems, a complete comparison between *R. katherineae* and the Ardath Shale specimen of *R. washingtoniana* is not possible as the anterior portion of the outer lip is missing and the interior of the outer lip is obscured in the Ardath Shale specimen. *R. katherineae* differs from the Ardath Shale specimen, however, in all the other ways listed above for the *R. washingtoniana* and *G. uvasalis* specimens.

Discussion.—Earlier authors regarded the geologic range of *Ranella* as Paleocene to Recent (Wenz, 1941; Davies, 1971), some pre-

sumably using the name for a broader generic concept and including in it *Bursa* Röding, 1798, which was formerly known as *Ranella*. *Ranella katherinae* n. sp. and *R. washingtoniana* from the Ardath Shale represent the earliest typical species of *Ranella* on the West Coast of the United States.

Material.—A single nearly complete adult specimen.

Type.—Holotype, UCLA 45959, UCLA locality 2312 (which is equivalent to CSUN locality 374), height 98 mm. Shell material is missing from parts of the whorls.

Occurrence.—Llajas Formation from the 1-m-thick "Stewart bed" approximately 340 m above its base.

Etymology.—The species is named after Katherine Squires.

Order NEOGASTROPODA Wenz, 1938
Family FASCIOLARIIDAE Gray, 1853
Genus CLAVILITHES Swainson, 1840

Type species.—By subsequent designation (Grabau, 1904) *Fusus parisiensis* Mayer-Eymar, 1877 (=*Fusus longaevus* Lamarck, 1803, *non* Solander).

CLAVILITHES n. sp.
Figure 2H, I

Discussion.—The figured specimens of *Clavilithes* n. sp. show the strong carina on the shoulder that distinguishes this species from the more round-shouldered *C. tabulatus* (Dickerson) (1913, p. 283–284, Pl. 12, fig. 7).

Clavilithes n. sp. was found in the Llajas Formation only in the "Stewart bed" at CSUN localities 374, 444, and 445. At locality 374, it occurs with *C. tabulatus,* which can also be found slightly lower in the section at CSUN locality 371. *C. tabulatus* previously has been regarded as restricted to the early Eocene (Givens, 1974).

Clavilithes n. sp. is not named at this time, pending further taxonomic research by Jack Mount, presently at Rutgers University. *Clavilithes* n. sp. figured here is not the *Clavilithes* n. sp. of Clark and Vokes (1936, p. 862, 874, Pl. 1, fig. 1) from the uppermost portion of the Llajas Formation. The "Stewart bed" specimens differ from the specimen illustrated by Clark and Vokes in having a more prominent carina on the whorls and a slightly depressed sutural ramp area between the carina and the suture; the specimen of Clark and Vokes has a strongly convex sutural ramp.

Clavilithes n. sp. figured here differs also from *Clavilithes* n. sp. of Givens and Kennedy (1976) from strata of probable middle Eocene age in San Diego County, California. The San Diego specimen has collabral costae on the spire whereas the Llajas specimens do not.

Material.—Two nearly complete large specimens. Only one (UCLA 59194) is free of matrix (Figure 2H). A third adult specimen (UCLA 59195) is only a spire (Figure 2I).

Types.—Hypotype, UCLA 59194, CSUN locality 445, height 97 mm. Hypotype, UCLA 59195, CSUN locality 444, height 62 mm.

Occurrence.—Llajas Formation from the 1-m-thick "Stewart bed" approximately 340 m above its base.

Class BIVALVIA Linné, 1758
Order MYTILOIDA Férussac, 1822
Family PINNIDAE Leach, 1819
Genus PINNA Linné, 1758

Type species.—By subsequent designation (Children, 1823) *Pinna rudis* Linné, 1758.

Diagnosis.—Equivalved shell, elongate-triangular to wedge shaped. Umbones at narrowed anterior end. No teeth on hinge. Ventral margin straight to concave. Inner nacreous layer divided into dorsal and ventral lobes by a medial sulcus. Anterior external portion of valves with a longitudinal keel. Sculpture consists of radiating ribs which may bear spines or scales, some forms with growth undulations on ventral region.

PINNA LLAJASENSIS n. sp.
Figure 2L

Pinna n. sp. VOKES, 1939, p. 50, Pl. 2, fig. 14.

Diagnosis.—A *Pinna* with 12 equally spaced radial ribs on each valve and no comarginal ribs.

Description.—Shell elongate-triangular and moderately inflated. Anterior portion of valves with a medial longitudinal sulcus; lobate-shaped posterior adductor scar of right valve apparently limited to the dorsal nacreous lobe region. Strong radial sculpture on each valve consisting of 12 equally spaced ribs whose interspaces are twice their width.

Comparison.—A specimen of *Pinna* n. sp. Vokes from the middle Eocene Domengine

Formation of central California is conspecific with *Pinna llajasensis* n. sp. Vokes's specimen also has 12 equally spaced radial ribs whose interspaces are twice their width and comarginal sculpture is not present.

Pinna lewisi Waring (1917, p. 94, Pl. 15, fig. 24) is known also from the Llajas Formation. The new species differs from the holotype of *P. lewisi* in that it has fewer and more widely spaced radiating ribs and no comarginal ribs. *P. lewisi* has about 16 to 18 closely-spaced radial ribs and about 9 comarginal ribs on each valve.

Superficially, *P. llajasensis* resembles *P. barrowsi* Dickerson (1914, p. 125–126, Pl. 8, fig. 3) from the early Tertiary of central California, but the "Stewart bed" taxon has fewer radiating ribs and no comarginal ribs.

Discussion.—The exact geographic and stratigraphic positions of the type locality of *Pinna lewisi* are unknown. The matrix surrounding *P. lewisi* differs lithologically from that of *P. llajasensis*. Specimens of *P. lewisi* have been found at CSUN locality 475, 155 m above the "Stewart bed," in a lithology similar to the matrix of its holotype. *P. lewisi* occurs within a prograding shallow-marine facies in the upper portion of the Llajas Formation (see Squires, 1981).

Material.—Two articulated, incomplete specimens; one with posterior portion slightly crushed and only remnants of shell present (holotype); the other uncrushed with more shell present.

Type.—Holotype, UCLA 59196, CSUN locality 458, height 12.8 cm, length 5.5 cm.

Occurrence.—Llajas Formation from the 1-m-thick "Stewart bed" approximately 340 m above its base. The holotype is from CSUN locality 458, and the other specimen is from CSUN locality 374.

Etymology.—The species is named for the Llajas Formation.

Class CEPHALOPODA Cuvier, 1794
Subclass COLEOIDEA Bather, 1888
Order SEPIIDA Zittel, 1895,
emend. Naef, 1916
Family INDETERMINATE
SPIRULIMORPH SEPIID
Figure 2J, K

Description.—Orthoconic phragmocone as two fragments. Larger adoral fragment (10 mm in length) with 5 tubular, straight camerae having lengths 0.22 to 0.30 times width; holochoanitic septal necks and ventral lobe of the suture line clearly visible, septa simple.

Smaller, more apical fragment (9 mm in length) crushed at adapical end, with 5½ straight camerae having lengths about 0.35 to 0.38 times width; holochoanitic septal necks exposed on the more adoral camerae. External mold (32 mm in length) shows 18 camerae, dorsal side only; mold tapers in adapical direction.

Discussion.—J. A. Jeletzky examined photographs of the specimen and mold and concluded that they are unidentifiable in the absence of the rostrum and the apical part of the phragmocone. The families Groenlandibelidae, Belopteridae, and Spirulirostridae have phragmocones with slender oral and middle parts just as in the Llajas specimen. Lacking more diagnostic features, this specimen is identified as a spirulimorph form of the Sepiida, as opposed to the sepiamorph form. This is the first record of a sepiid in the Eocene of western North America. They have been reported, however, from the Eocene of the Gulf Coast of North America (Palmer, 1937; Piveteau, 1952; Jeletzky, 1966, 1969).

Material.—A single partial phragmocone and associated external mold.

Type.—Hypotype, UCLA 59197, CSUN locality 493.

Occurrence.—Llajas Formation from the 1-m-thick "Stewart bed" approximately 340 m above its base.

COLLECTING LOCALITIES

All are California State University, Northridge (CSUN) localities, southwestern Santa Susana Mountains, Ventura and Los Angeles Counties (Figure 1). All are in T3N, R17W, Santa Susana, California quadrangle, 7.5′ series, 1951, photorevised 1969.

371—2,000 ft elevation along south side of a side canyon to Devil Canyon, 892 m (2,925 ft) S64° E of NW corner sec. 26. = LACMIP 16115

374—1,700 ft elevation along a cliff on south side of a side canyon to Las Llajas Canyon, 823 m (2,700 ft) N43° E of SE corner sec. 29. This locality is equivalent to University of California, Berkeley localities 7003 and 7004, California Institute of Technology locality 206, and University of California, Los Angeles locality 2312.

444—1,600 ft elevation along north side of = LACMIP 16203

a side canyon to Las Llajas Canyon, 876 m (2,875 ft) N29° E of SE corner sec. 29.

445—1,475 ft elevation along west side of Las Llajas Canyon, 907 m (2,975 ft) N17° E of SE corner of sec. 29. This locality is equivalent to California Institute of Technology locality 215. = LACMIP 16176

458—1,300 ft elevation along south side of Chivo Canyon, 488 m (1,600 ft) N13° E of SW corner sec. 29. = LACMIP 16280

475—1,625 ft elevation near a ridge top, west side of Chivo Canyon, 785 m (2,575 ft) N59° E of SW corner sec. 30. = LACMIP 16337

493—2,225 ft elevation along a ridge top, east side of Las Llajas Canyon, 1,189 m (3,900 ft) N62° E of SE corner sec. 29. = LACMIP 16198

498—1,850 ft elevation along west side of Devil Canyon, 1,082 m (3,550 ft) S63° E of NW corner sec. 26. = LACMIP 16189

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