

## NEW EARLY EOCENE MOLLUSKS FROM THE OROCOPIA MOUNTAINS, SOUTHERN CALIFORNIA

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**ABSTRACT**—Five new species of mollusks are described from the early Eocene Maniobra Formation, northeastern Orocopia Mountains, southern California. The new species are from the basal part of the formation, and the fauna is indicative of the West Coast provincial molluscan early Eocene "Capay Stage." The mollusks are shallow-marine forms that were transported a short distance into slope/upper submarine-canyon deposits.

*Chedevillia saltonensis* n. sp. and *Eocypraea? maniobraensis* n. sp. resemble Eocene species from Paris Basin, France. *Phalium (Semicassis) louella* n. sp. is the earliest North American species of *Semicassis*. *Volutilithes orocopiaensis* n. sp. is the earliest North American species of this genus and resembles *V. muricinus* from Paris Basin. *Glossus (Meiocardia) susukii* n. sp. is the earliest reported species of *Meiocardia* on the West Coast of North and South America.

*Galeodea gallica*, a species previously only known from lower Eocene strata in the Anglo-Paris Basin, is tentatively identified from the Maniobra Formation. *Campanilopa dilloni*, previously only known from south-central California, is present in the formation. Supplementary descriptions and illustrations are given for these two species.

The Maniobra species described have a close relationship to species characteristic of the Eurasian Tethyan paleobiogeographic province. The age of the Maniobra mollusks permits greater resolution of the timing of the westward migration of the Eurasian species, indicating that much of it occurred during early Eocene and/or late Paleocene time.

## INTRODUCTION

THE new mollusks reported in this study were collected from the early Eocene Maniobra Formation, northeastern Orocopia Mountains, Riverside County, California (Figure 1). This formation was discovered in 1955 (Crowell and Susuki, 1959) and dated as being of early and middle Eocene age. This dating can now be refined and the Maniobra is early early Eocene through late early Eocene in age. It is the only known marine Eocene exposure south of the Tehachapi Mountains and east of the San Andreas fault in southern California.

The Maniobra Formation has a maximum thickness of 1,460 m and consists of siliciclastics that locally contain some macrofossils and microfossils. These deposits represent a transitional marginal marine to deep-water submarine-fan sequence deposited in subtropical waters (Advocate, 1983).

Most of the new mollusks are from California State University, Northridge (CSUN) locality 662 (Figure 1), which is 57 m above the base of the formation. This locality is the same as University of California, Los Angeles locality 3779, which Crowell and Susuki (1959) assigned to the West Coast macroin-

vertebrate provincial "Capay Stage" of early Eocene age. Their assignment was based on the presence of *Clavilithes* cf. *C. tabulatus*, *Galeodea* cf. *G. sutterensis*, *Chedevillia* cf. *C. stewarti*, and on benthic foraminifers. *Clavilithes tabulatus* recently has been shown by Squires (1983, 1984) to occur in both the "Capay Stage" (restricted sense of Givens, 1974) and the overlying "Domengine Stage." *Galeodea* cf. *G. sutterensis* and *Chedevillia* cf. *C. stewarti* are reidentified in this present paper as *Galeodea* cf. *gallica* and *Chedevillia saltonensis* n. sp., respectively. A "Capay" age for CSUN locality 662, nevertheless, is still maintained. It is based, in part, on the presence of the bivalve *Odontogryphaea? haleyi*, which is confined to the "Capay Stage" (Givens, 1974). Foraminifera indicative of P7 to P9 Zones and calcareous nannofossils indicative of CP9 to CP11 Zones also have been found 58 m upsection from CSUN locality 662 (Advocate, 1983). These zones are of earliest Eocene through late early Eocene age (Berggren et al., in press) and correspond mostly to the restricted "Capay Stage" (Saul, 1983). In addition, about 740 m upsection from CSUN locality 662, there is an occurrence of *Turritella meganosensis protumes-*

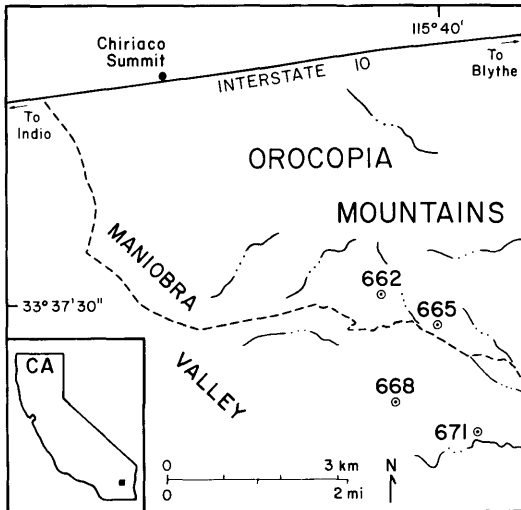


FIGURE 1—Index map to California State University, Northridge (CSUN) collecting localities, Maniobra Formation, northeastern Orocoopia Mountains, southern California.

*ens* at CSUN locality 671. This taxon is confined to the “Capay Stage” and is especially diagnostic of the uppermost “Capay Stage” (Saul, 1983; Squires, 1984).

Upsection from CSUN locality 671, the Maniobra Formation contains species that have been reported (Givens, 1974; Givens and Kennedy, 1979; Saul, 1983; Kappeler et al., 1984; Squires, 1984) elsewhere on the West Coast as confined to the “Domengine Stage”; namely, *Lyriscapa lajollaensis*, *Turritella uvasana applinae*, *Turritella andersoni lawsoni*, *Lyria andersoni*, and *Venericardia (Pacifcor) hornii calafia*. Based on calcareous nannofossils and mollusks in the Lajas Formation, Simi Valley, southern California, Saul (1983) and Squires (1984) reported the “Domengine Stage” to be of late early through early middle Eocene age. With the exception of *T. u. applinae*, all the above-listed taxa which are indicative of the “Domengine Stage” in the Maniobra Formation are confined to the early Eocene portion of the “Domengine Stage” of the Lajas Formation; namely, the shallow-marine (transgressive) facies (Squires, 1984). Based on this, it is concluded that the upper portion of the Maniobra Formation is of late early Eocene age.

At CSUN locality 662, the macrofossils are in a few discontinuous, thin sandy mudstone beds interpreted to have formed in a slope

environment because of the presence of bathyal foraminifers (Advocate, 1983). The shallow-marine macrofossils retain delicate spiral ribbing and must have been transported in a medium in which abrasion was minimal. *Odontogryphaea? haleyi* specimens are common, but all are disarticulated left valves. Small specimens of *Glyptoactis mcmasteri* are mostly articulated, as are fairly common small specimens of the brachiopods *Eogryphus* cf. *E. tolmani ynezensis* and *Kingenia simiensis*.

Locality 662 contains the most diverse fauna of any locality in the Maniobra Formation. Macrofauna present, including four new species of mollusks, comprises 21 gastropods, six bivalves, two brachiopods, and one species each of scaphopod, calcareous annelid tube, discocyclinid, and spatangoid. In addition, there are terrestrial plant fragments. A new species of cassid gastropod is from CSUN locality 665, a lateral equivalent of the fossil-bearing bed at CSUN locality 662. A specimen of *Velates perversus*, a gastropod that is indicative of the Eurasian Tethyan paleobiogeographic province (Vokes, 1935; Clark and Vokes, 1936; Palmer, 1967), was also found at this locality.

At locality 668, about 200 m above the base of the formation and within the “Capay Stage” portion of the Maniobra, are sparse macrofossils in sandy conglomerate beds interpreted to have formed in the upper part (landward) of a submarine-canyon channel complex (Advocate, 1983). A large, incomplete specimen of the cerithiid gastropod *Campanilopa dilloni* Hanna and Hertlein occurred as a conglomerate clast and had obviously undergone postmortem transport although the amount of abrasion was not great.

The species described in this report, as well as the Maniobra specimen of *Velates perversus*, help to further document Clark and Vokes’ (1936) conclusion that an important trans-Atlantic migration route existed between western Europe and western North America during the Eocene. According to Zinsmeister (1983), the first indication of this influx of large numbers of mollusks was in the late Paleocene and continued into the early Eocene. Squires (1984) showed that this influx of mollusks into western North America continued into early middle Eocene time.

Letter abbreviations used for catalog and

locality numbers are: CAS = California Academy of Sciences; CSUN = California State University, Northridge; LACMIP = Los Angeles County Museum, Invertebrate Paleontology Section; UCLA = University of California, Los Angeles; and UCMP = University of California Museum of Paleontology (Berkeley).

#### SYSTEMATIC PALEONTOLOGY

- Phylum MOLLUSCA Cuvier, 1797  
 Class GASTROPODA Cuvier, 1797  
 Subclass PROSOBRANCHIA  
 Milne Edwards, 1848  
 Order MESOGASTROPODA Thiele, 1925  
 Superfamily CERITHIACEA  
 Fleming, 1822  
 Family CERITHIIDAE Fleming, 1828  
 Genus CAMPANILOPA Iredale, 1917

*Type species.*—By original designation, *Cerithium giganteum* Lamarck, 1804, middle Eocene (Lutetian Stage), Paris Basin, France.

#### CAMPANILOPA DILLONI

Hanna and Hertlein, 1949

Figure 2.1

*Campanilopa dilloni* HANNA AND HERTLEIN, 1949, p. 392–394, Pl. 77, figs. 1–4; GIVENS, 1974, p. 69, Pl. 7, fig. 10.

*Supplementary description.*—Turreted-elongate shell of very large size; protoconch and upper spire missing; whorls slightly concave, becoming flat sided in later whorls; posterior portion of each whorl with a very projecting, greatly thickened carina with eight to ten pointed nodes, sides of whorls with three to four swollen spiral cords; groove along inside of carina in later whorls; outer lip missing and aperture obscured by matrix.

*Comparison.*—As mentioned by Hanna and Hertlein (1949), *Campanilopa dilloni* closely resembles *Campanile incomptum* Dixon (1850, p. 101, Pl. 6, fig. 18; Cossmann and Pissarro, 1910–1913, Pl. 25, fig. 137–46; not Deshayes, 1866, p. 116, Pl. 77, fig. 1 = *Campanile giganteum* (Lamarck) *vide* Delpy, 1941, p. 15) from the Lutetian Stage, Paris Basin, France, except that in *C. dilloni* the nodes are confined to the much more projected carina.

*Campanilopa dilloni* also resembles *Campanile morgani* Douvillé (1904, p. 312–313, Pl. 43, figs. 1–11) from early Paleocene? strata

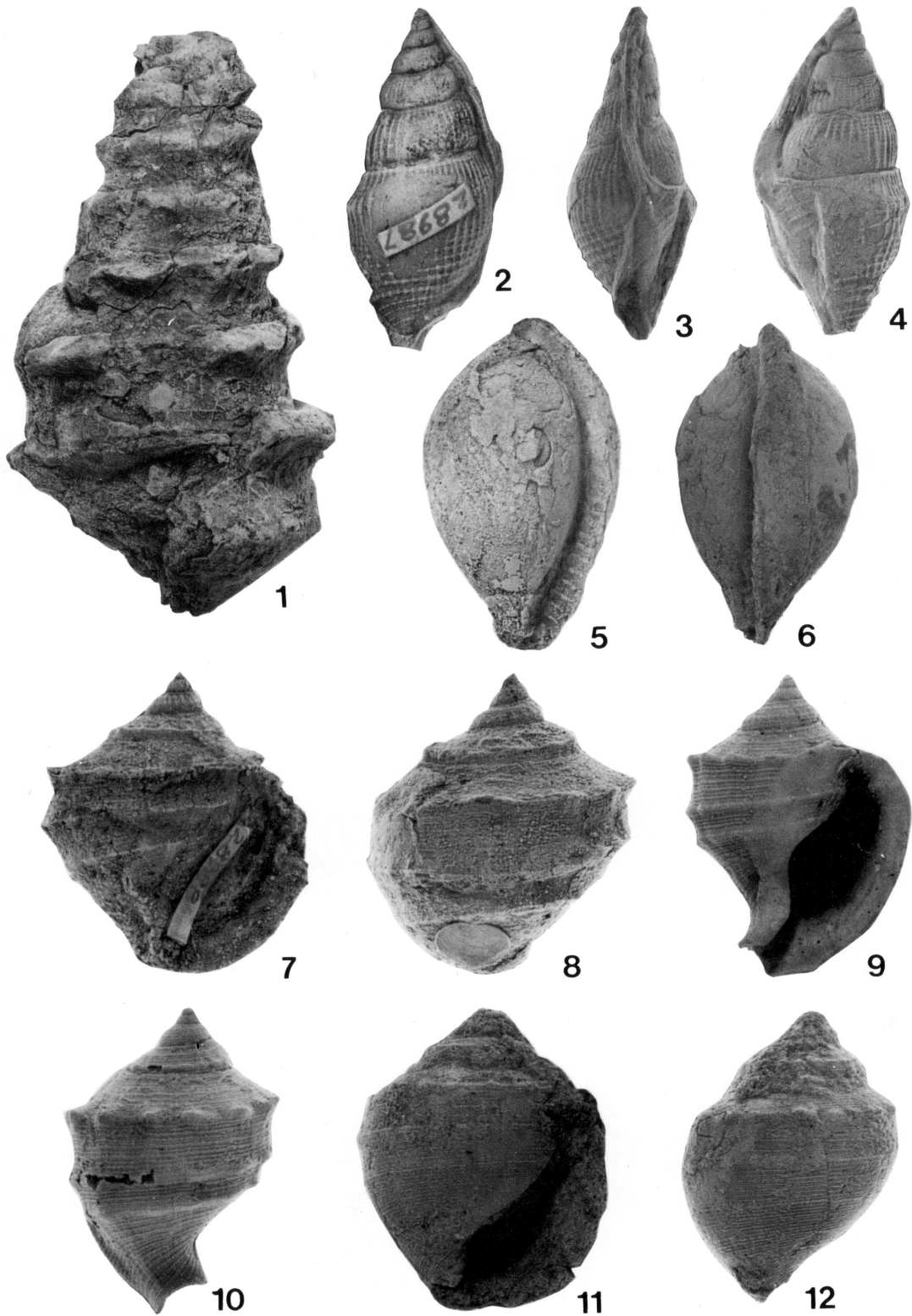
of western Iran, except that *C. dilloni* has fewer nodes and a much more projecting carina. *Campanile morgani* is more strongly sculptured than *Campanile symbolicum* Iredale, the type species of *Campanile* (*vide* Iredale, 1917), and may belong to *Campanilopa*. Douvillé (1904) reported his new species *C. morgani* to be from Maastrichtian strata. Davies (1975, p. 84), however, referred these strata to the Danian, but considered the Danian to be Cretaceous. More stratigraphic work is needed.

*Discussion.*—As noted by Wrigley (1940) and discussed by Iredale (1917) and Hanna and Hertlein (1949), there has been considerable confusion regarding whether or not *Cerithium giganteum* Lamarck, 1804, should be the type species of *Campanile*. According to Iredale (1917), *Campanile* already had a type species; namely, *Cerithium laeve* Quoy and Gaimard, 1834. Because *C. laeve* is a junior homonym, Iredale (1917) replaced *C. laeve* Quoy and Gaimard with *Campanile symbolicum* Iredale, 1917, and provided the supraspecific taxon *Campanilopa* for the separate and distinct group of *Cerithium giganteum* Lamarck. Douvillé (1904) compared his new species *Campanile morgani* to *Cerithium laeve* = *Campanile symbolicum* and did not mention *Cerithium giganteum*, although all of his forms have well developed sculpture.

*Campanilopa*, as a subgenus of *Campanile*, has been reported with certainty from strata of early Paleocene (Danian) through late Eocene age in Europe (Delpy, 1941).

*Campanilopa dilloni* is the earliest species of this genus on the West Coast of the United States. Its molluscan stage range is from the "Capay" through probably lower "Domenigine" (Hanna and Hertlein, 1949; Givens, 1974). Its geographic distribution is now from the Orocochia Mountains through south-central California.

A supplementary description of *C. dilloni* is given for two reasons. Firstly, the anterior half of the Maniobra specimen represents older growth-stage material than the specimens used by Hanna and Hertlein (1949) in their original description of the species. Secondly, although they figured an early stage of growth (holotype, CAS 9425; Pl. 77, fig. 4) and a middle stage of growth (paratype, CAS 9428; Pl. 77, fig. 2), they only described the





early stage of growth. The posterior half of the *Maniobra* specimen corresponds in growth stage and in morphologic detail to paratype, CAS 9428. The morphology of the *Maniobra* specimen does not change significantly from posterior to anterior portions. The specimen does not have, however, the flat-sided appearance, the 14 to 16 carina nodes, or the six spiral ribs that the early growth-stage holotype, CAS 9425, possesses.

*Material.*—Later whorls of a large, incomplete adult specimen.

*Repository.*—Hypotype, LACMIP 7165.

*Occurrence.*—Hypotype, LACMIP 7165 was obtained from the early Eocene "Capay Stage" portion of the *Maniobra* Formation from a coarse sandstone approximately 200 m above the base of the formation, at CSUN locality 668.

#### Superfamily STROMBACEA

Rafinesque, 1815

Family STROMBIDAE Rafinesque, 1815

Genus CHEDEVILLIA Cossmann, 1906a

*Type species.*—By original designation, *Rimella muniere* Chédeville, 1904a, middle Eocene (Lutetian Stage), Paris Basin, France.

*Diagnosis.*—Inflated-fusiform shell of medium size; whorls convex, with narrow collabral costae and spiral ribs; aperture narrow, outer lip thin, bent, drawn out into a solid flange (rostrum) that extends to shell apex, no posterior canal or notch on flange; inner lip smooth and calloused, callus merges with flange.

CHEDEVILLIA SALTONENSIS n. sp.

Figure 2.2–2.4

*Chedevillia* sp. cf. *C. stewarti* Clark. CROWELL AND SUSUKI, 1959, Pl. 2, figs. 2, 3.

*Diagnosis.*—A *Chedevillia* with an intricate cancellate sculpture pattern.

*Description.*—Inflated-fusiform shell of medium size; spire about 50% of height and curved toward back of shell; teleoconch of at

least seven rounded whorls; sculpture not preserved in posteriormost spire whorls; preantepenultimate whorl covered only by closely spaced spiral ribs; other spire whorls and body whorl covered by numerous evenly spaced and equal-weight, collabral and primary spiral ribs that produce an intricate cancellate pattern; angulate shoulder on apertural half of body whorl with small nodes on collabral ribs; suture impressed with a fairly strong sutural cord on lower spire whorls and body whorl; outer lip missing; inner lip covered by callus that passes into an irregular solid flange that extends from siphonal canal region to shell apex along right margin of shell; anterior canal missing.

*Comparison.*—*Chedevillia saltonensis* n. sp. resembles the California species, *C. stewarti*, as well as the Paris Basin species *C. mirabilis* and *C. muniere*. It differs from *C. stewarti* Clark (1942, p. 116–117, Pl. 19, figs. 7–11), a species from upper Paleocene strata in the Simi Valley area, southern California (Squires, 1984), in the following features: finer and more numerous collabral costae, coarser primary spiral ribs, nodes on body whorl shoulder only on apertural half of whorl and not elongate, and collabral costae do not noticeably decrease in number per whorl in the later stages of growth. In addition, in the interspaces between the primary spiral ribs of *C. saltonensis*, there are two or three very fine spiral threads, whereas in *C. stewarti* there are none. The evenly spaced, equal-weight collabral and primary spiral ornamentation in *C. saltonensis* produces an intricate cancellate pattern, but in *C. stewarti* no such condition is present. It also is not present in *C. mirabilis* (Deshayes, 1866, p. 457, Pl. 89, figs. 7–9; Chédeville, 1904b, p. 380; Cossmann, 1904, Pl. 3, fig. 20; Cossmann and Pissarro, 1910–1913, Pl. 31, fig. 157–15), a species from Ypresian and Cuisian strata of the Paris Basin. These strata are late early Eocene in age and in the upper Ypresian Stage = Cuisian Substage (Pomerol, 1982). *Chedevillia sal-*

←  
FIGURE 2—1, *Campanilopa dilloni* Hanna and Hertlein, hypotype, LACMIP 7165, CSUN loc. 668, ×0.5. 2–4, *Chedevillia saltonensis* n. sp., holotype, UCLA 28987, CSUN loc. 662, ×2. 2, apertural view; 3, side view; 4, abapertural view. 5, 6, *Eocypraea? maniobraensis* n. sp., holotype, UCLA 48431, CSUN loc. 662, ×1.25. 7, 8, *Galeodea* cf. *G. gallica* Wrigley, hypotype, UCLA 28988, CSUN loc. 662, ×1.7. 9, 10, *Galeodea gallica* Wrigley, hypotype, UCMP B-5415, Paris Fontaine, Paris Basin, France, ×1.9. 11, 12, *Phalium (Semicassis) louella* n. sp., holotype, LACMIP 7166, CSUN loc. 665, ×1.7.

*tonensis*, furthermore, differs from *C. mirabilis* in having finer collabral costae and coarser primary spiral ribs.

*Chedevillia saltonensis* differs from *C. muniari* (Chédeville, 1904a, p. 101–102, fig. 1 (two views); 1904b, p. 380; Cossmann, 1906a, Pl. 14, fig. 8; 1906b, Pl. 5, fig. 157–14, Pl. 6, fig. 157–14; Cossmann and Pissarro, 1910–1913, Pl. 31, fig. 157–14; Wenz, 1940, fig. 2735; Clark, 1942, Pl. 19, figs. 13, 14), a species from middle Eocene strata (Lutetian Stage) of Paris Basin, in the following features: finer collabral costae; presence of collabral costae on the antepenultimate whorl; and, no bifurcation of the collabral costae on the body whorl.

*Discussion.*—Crowell and Susuki's (1959, Pl. 2, figs. 2, 3) figured specimen is the same one (holotype, UCLA 28987) figured in this report.

Cossmann (1906a) and Wenz (1940) reported *Chedevillia* only from the Eocene in Europe. Clark (1942) recognized this genus in North America, and named *Chedvillia stewarti* but misspelled the generic name. He placed the type locality (UCMP locality 7015) of this species in the Lajas Formation, Simi Valley, southern California; but, as discussed in Squires (1984), this locality actually plots within the lower part of the Santa Susana Formation and is of late Paleocene age.

*Material.*—One nearly complete adult specimen and the upper spire of an adult specimen.

*Repository.*—Holotype, UCLA 28987; paratype, UCLA 59725.

*Occurrence.*—Both specimens were obtained from the early Eocene "Capay Stage" portion of the Maniobra Formation from a 30 cm thick bed approximately 57 m above the base of the formation, at CSUN locality 662 (which is equivalent to UCLA locality 3779).

*Etymology.*—This species is named for the Salton Sea, which is immediately southwest of the Orocopia Mountains.

Superfamily CYPRAEACEA Gray, 1824

Family OVULIDAE Fleming, 1828

Subfamily EOCYPRAEINAE

Schilder, 1924

Genus EOCYPRAEA Cossmann, 1903

*Type species.*—By original designation, *Cypraea inflata* Lamarck, 1802, middle

Eocene (Lutetian-Bartonian Stages), Paris Basin, France.

*Diagnosis.*—Inflated-pyriform shell of small to medium size; spire involute; body whorl smooth with long, very narrow aperture elongated anteriorly, curved posteriorly; inner lip with numerous weak teeth, terminal columellar tooth of one or two ridges; outer lip moderately flat with uniformly spaced numerous teeth; fossula broad, its inner edge smooth with no columellar furrow.

EOCYPRAEA? MANIOBRAENSIS n. sp.

Figure 2.5, 2.6

*Diagnosis.*—An *Eocypraea*-like, very inflated shell.

*Description.*—Very inflated, ovate-pyriform shell of medium size; maximum diameter in middle of shell; spire involute; narrow aperture near right margin of shell, elongate anteriorly and curved posteriorly; extreme anterior end missing; inner lip with numerous small teeth; thickened outer lip narrow, with numerous teeth that become stronger in the anterior direction.

*Comparison.*—The new species is most similar to *Eocypraea inflata* (Lamarck, 1802, p. 389; 1805, Pl. 2, fig. 1a, 1b) from the middle Eocene (Lutetian-Bartonian Stages) of Paris Basin, France. Other workers who have described and/or illustrated the type species of *Eocypraea* include Deshayes (1824, p. 724, Pl. 97, figs. 7, 8), Cossmann (1903, p. 162–163, Pl. 9, figs. 18, 19), Cossmann and Pissarro (1910–1913, Pl. 32, fig. 162–7), Wenz (1941, p. 1004, fig. 2882), and Palmer (1977, Pl. 2, fig. 6a, 6b).

*Eocypraea? maniobraensis* differs from UCLA collection specimen 32794 of *E. inflata* from Chaumont en Vexin (Oise), France, in the following features: a narrower and more elongate shell, a much more inflated apertural side of the body whorl, and a much narrower outer lip.

*Discussion.*—As a result of crushing, the interior of the aperture of the Maniobra specimen cannot be observed, and the nature of the fossula cannot be determined. Positive generic assignment, therefore, cannot be made.

The classification of *Eocypraea* follows that of Schilder (1966, 1967). This genus is known from strata of Late Cretaceous (Cenomanian)

through late Miocene age in Europe, West Africa, West Pakistan, Indonesia, North America (Atlantic and Pacific Coasts), Caribbean region, South America (Pacific Coast), and possibly New Zealand (Schilder, 1932; Wenz, 1941; Davies, 1971).

Prior to *Eocypraea? maniobraensis* n. sp., workers (Schilder, 1932; Vokes, 1939; Zinsmeister, 1974) had assigned four species from the West Coast of the United States to *Eocypraea*: *Ovula martini* Dickerson, 1914, *O. novasumma* Nelson, 1925, *Cypraea? bayerquei* Gabb, 1864, and *Cypraea castacensis* Stewart, 1927. None of these four species has the characteristics of *Eocypraea*. *Ovula martini* is from late Paleocene strata in central California (Dickerson, 1914; Keen and Bentson, 1944). The flattened ventral surface and very thick outer lip suggest that this species belongs in *Cypraea*. *Ovula novasumma* is from late Paleocene strata in southern California (Nelson, 1925; Keen and Bentson, 1944). It has smooth inner and outer lips and does not belong in *Eocypraea*. *Cypraea? bayerquei* is from late Paleocene through late Eocene strata in California (Gabb, 1864; Keen and Bentson, 1944). Its flattened ventral surface and broad outer lip suggest that this species belongs in *Cypraea* as indicated by Ingram (1942). *Cypraea castacensis* is found in late early through early middle Eocene strata (i.e., "Domengine Stage") in southern and central California (Squires, 1984). The flattened ventral surface, broad outer lip, position of the aperture just right of the midline of the shell, and deep notches at both ends suggest that this species also belongs in *Cypraea*. Ingram (1942), Stewart (1927), and Squires (1984) assigned this species to *Cypraea*.

If *Eocypraea? maniobraensis* n. sp. does belong in *Eocypraea*, it represents the earliest typical species of *Eocypraea* on the West Coast of the United States.

**Material.**—One nearly complete adult specimen with shell material partly missing, and slightly crushed.

**Repository.**—Holotype, UCLA 48431.

**Occurrence.**—Specimen was obtained from the early Eocene "Capay Stage" portion of the Maniobra Formation from a 30 cm thick bed approximately 57 m above the base of the formation, at CSUN locality 662 (which is equivalent to UCLA locality 3779).

**Etymology.**—The species is named for the Maniobra Formation.

Superfamily TONNACEA Suter, 1913

Family CASSIDAE Swainson, 1832

Genus GALEODEAE Link, 1807

**Type species.**—By monotypy, *Buccinum echinophorum* Linné, 1758, Recent, Mediterranean.

GALEODEA cf. *G. GALLICA* Wrigley, 1934  
Figure 2.7, 2.8

*Galeodea* sp. cf. *G. sutterensis* Dickerson. CROWELL AND SUSUKI, 1959, p. 588, Pl. 2, figs. 1, 4

**Supplementary description.**—Subglobose shell of medium size with moderately elevated spire and large body whorl; protoconch conical, multispiral, smooth; uppermost spire whorls rounded with spiral lirae; antepenultimate whorl convex with spiral lirae and faint collabral riblets, middle to lower portion of whorl angulate due to presence of a strong spiral rib; penultimate whorl flat-sided and covered by spiral lirae, noded carina just above suture; body whorl flat-sided to slightly concave, covered by numerous fine, spiral lirae; shoulder carina with 12 to 13 nodes, two well developed carinae on middle portion of body whorl less noded; middlemost carina on body whorl closer to anteriormost carina than to carina on shoulder.

Aperture oval, outer lip thickened and reflected, inner lip with a smooth, thin parietal callus; anterior canal region missing.

**Comparison.**—The Maniobra specimens of this gastropod are very much like specimens of *Galeodea gallica* from Paris Fontaine, Paris Basin, France. Comparison of the preserved parts of the Maniobra specimens to an actual specimen (hypotype, UCMP B-5415) (Figure 2.9, 2.10) and published descriptions/illustrations of *G. gallica* (Deshayes, 1835, p. 633–634, Pl. 85, figs. 1, 2; 1866, p. 476, 477; Cossmann and Pissarro, 1910–1913, Pl. 34, fig. 166-2) from the Paris Basin revealed no significant morphologic differences.

The Maniobra specimens are less like specimens of *G. gallica* (Wrigley, 1934, p. 123–125, Pl. 16, figs. 24, 25; British Museum Natural History, 1975, p. 11, Pl. 21, fig. 4) from the London, England, area. The English specimens, which show more variety than the typ-

cial forms from the Paris Basin, have up to 15 nodes on the shoulder of the body whorl, a tendency toward collabral ribs, a possible varix at 180° or 360° from the aperture, and a possible slightly developed fourth carina on the body whorl (Wrigley, 1934).

The *Maniobra* specimens are incomplete and badly pitted and corroded from weathering. The nodes on the carinae, for example, probably have been diminished in size due to the weathering, as have the spiral ribs. Such preservation problems, therefore, do not allow positive specific identification, and the *Maniobra* specimens are tentatively assigned to *G. cf. G. gallica*.

The most characteristic feature of *G. gallica* and *G. cf. G. gallica* is the presence of three nodose carinae on the body whorl. Because there are three carinae rather than two, they differ from West Coast species of *Galeodea*, except for *G. sutterensis* Dickerson (1916, p. 492, Pl. 40, figs. 1, 2) from early Eocene strata of California and southwestern Oregon. See Vokes (1939) for a refined description of *G. sutterensis*.

*Galeodea gallica* and *G. cf. G. gallica* differ from *G. sutterensis* in the following features: 12 to 15 nodes on the shoulder of the body whorl rather than 8 or 9, small nodes to tubercles rather than spinose tubercles, much less angulated spire whorls, and slightly coarser spiral threads that cover the shell.

*Discussion*.—Crowell and Susuki's (1959, Pl. 2, figs. 1, 4) figured specimen is the same one (hypotype, UCLA 28988) figured in this report (Figure 2.7, 2.8).

For a synonymy of *G. gallica*, see Wrigley (1934). Prior to his work, the preoccupied name *Galeodea diadema* was used for the Paris Basin specimens of *G. gallica*.

Previously, *G. gallica* has been reported only from the upper Cuis sands in the Paris Basin (Deshayes, 1835, 1866; Chédeville, 1904b; Lhomme, 1904; Cossmann and Pissarro, 1910–1913; Glibert, 1963) and the Pyrenees (Wrigley, 1934), as well as from the London Clay in southern England (Wrigley, 1934). The Cuis sands are late early Eocene in age and correspond to the upper Ypresian Stage = Cuisian Substage (Pomerol, 1982). The London Clay is primarily early Eocene in age (Curry et al., 1978). If *G. gallica* actually does occur in the *Maniobra* Formation,

it would be the first occurrence of this species in the Western Hemisphere.

*Material*.—Five nearly complete adult specimens and eight partial adult specimens.

*Repository*.—Hypotypes, UCLA 28988, 48435, 59726.

*Occurrence*.—Specimens were obtained from the early Eocene "Capay Stage" portion of the *Maniobra* Formation from a 30 cm thick bed approximately 57 m above the base of the formation, at CSUN locality 662 (which is equivalent to UCLA locality 3779).

#### Genus PHALIUM Link, 1807

*Type species*.—By subsequent designation (Dall, 1909), *Buccinum glaucum* Linné, 1758, Recent, Indo-Pacific.

#### Subgenus SEMICASSIS Mörch, 1852

*Type species*.—By subsequent designation (G. F. Harris, 1897), *Cassis japonica* Reeve (= *Phalium bisulcatum* Schubert and Wagner, 1829), Recent, Indo-Pacific.

*Diagnosis*.—Ovate shell of medium size with moderately low acuminate spire; protoconch whorls conical, smooth; teleoconch whorls convex, body whorl well-rounded, usually only an outer lip varix; whorls sculptured by numerous spiral threads; outer lip thickened and finely denticulate, base of outer lip lacks terminal spines; inner lip with wrinkled columellar shield; short anterior canal with a longitudinally threaded siphonal fasciole.

#### PHALIUM (SEMICASSIS) LOUELLA n. sp. Figure 2.11, 2.12

*Diagnosis*.—A *Semicassis* with three evenly spaced carinae, no varices (other than a possible one on outer lip), and covered by fine spiral threads.

*Description*.—Ovate-globular shell of medium size; spire about 20% of the height; protoconch missing; teleoconch of at least four whorls; whorls angulate, covered by closely-spaced fine spiral threads; shoulder of penultimate whorl marked by a carina with numerous nodes; body whorl with three evenly spaced carinae: carina along shoulder of body whorl with about 16 spinose nodes, carina along middle portion of body whorl less nodose, and anteriormost carina less pronounced and not nodose; outer lip mostly

absent with faint suggestion of a varix; inner lip with only a faint trace of a very thin parietal callus; anterior canal mostly absent with a faint trace of a siphonal fasciole.

*Comparison.*—The new species is similar in overall shape, size, and sculpturing to *Phalium (Semicassis) tuberculiformis* (Hanna, 1924). A synonymy for this species is given in Squires (1984). The best descriptions of *P. (S.) tuberculiformis* are given in Schenck (1926, p. 83–84, Pl. 14, figs. 12–16) and in Vokes (1939, p. 149–150, Pl. 19, figs. 19, 21, 23–27).

*Phalium (S.) louella* differs from *P. (S.) tuberculiformis* in the following features: no varix on the body whorl (other than on the lip), smaller nodes on the carinae, finer spiral threads, and the spiral threads do not have a fine cancellate-sculpture pattern caused by growth lines intersecting with the spiral threads.

*Discussion.*—The basis of modern taxonomic work on *Phalium*, *Semicassis*, and closely related genera and subgenera are the articles by Abbott (1968) and Kanno (1973). Abbott (1968) included *Semicassis* as a subgenus of *Phalium*, but he did so hesitantly because the soft parts, radulae, and opercula do not appear to differ significantly. He stated that *Phalium* probably had its origin during the late Eocene in south Asia. Wenz (1941) and Davies (1971) also reported that *Phalium* originated during the Eocene, and they both reported that *Semicassis* originated during the Late Cretaceous (Maastrichtian).

Prior to *P. (S.) louella* n. sp., the undoubted earliest reported species of *Phalium (Semicassis)* in North America was *P. (S.) tuberculiformis* from late early through early middle Eocene strata ("Domengine Stage") of California (Squires, 1984). The occurrence of *P. (S.) louella* from the Maniobra Formation constitutes the earliest record of this genus/subgenus in North America.

*Material.*—Two nearly complete specimens.

*Repository.*—Holotype, LACMIP 7166, LACMIP 7167.

*Occurrence.*—Both specimens were obtained from the early Eocene "Capay Stage" portion of the Maniobra Formation from a thin bed approximately 57 m above the base of the formation, at CSUN locality 665.

*Etymology.*—This species is named in honor of Louella R. Saul for her many important contributions to the study of Late Cretaceous and early Tertiary mollusks of the West Coast.

Order NEOGASTROPODA Wenz, 1938  
Superfamily VOLUTACEA Rafinesque, 1815  
Family VOLUTIDAE Rafinesque, 1815  
Subfamily VOLUTILITHINAE  
Pilsbry and Olsson, 1954  
Genus VOLUTILITHES Swainson, 1829

*Type species.*—By subsequent designation (Dall, 1906), *Voluta muricina* Lamarck, 1802, middle Eocene (Lutetian Stage), Paris Basin, France.

*Diagnosis.*—Fusiform shell of medium to slightly large size, shouldered, with elevated spire nearly equal to length of the aperture; protoconch whorls smooth, cylindrical, with apical end pointed; teleoconch whorls convex with sculpture of strong, collabral costae which are spiniform or nodose on shoulder, surface otherwise smooth or marked with fine spirals.

Columella with prominent anterior fold and with none or up to three or four weaker folds posterior to it; outer lip almost straight; anterior canal notch deep, bent backwards and forming a strong, siphonal fasciole.

VOLUTILITHES OROCOPIAENSIS n. sp.  
Figure 3.1, 3.2

*Diagnosis.*—A narrow *Volutilithes* with strong collabral costae and one prominent columellar fold with two weaker folds posterior to it.

*Description.*—Fusiform and elongate shell of medium size; spire about 40% of the height; protoconch missing; teleoconch of at least seven whorls; whorls angulate with strong, narrow, collabral costae that are equally spaced and extend from suture to suture; sutural ramp narrow, gently sloping; eight collabral costae on each spire whorl, eight or nine on body whorl; shoulder angle more prominent on later whorls; on penultimate whorl, collabral costae are nodose at shoulder whereas on body whorl they are spiniform; on body whorl, collabral costae extend prominently to neck area; some very faint spiral riblets on basal portion of body whorl; columella with one prominent fold and one to

two weaker folds posterior to it; aperture narrow; outer lip broken or obscured; siphonal fasciole fairly strong; anterior canal missing.

*Comparison.*—The new species is most similar to *Volutilithes muricinus* (Lamarck, 1802, p. 477) from the middle Eocene (Lutetian Stage), Paris Basin, France. *Volutilithes muricinus* has been further described and/or illustrated by Deshayes (1835, p. 697, Pl. 91, figs. 18, 19; Pl. 93, figs. 3, 4; Pl. 94, figs. 3, 4), Cossmann (1899, Pl. 6, fig. 1), Cossmann and Pissarro (1910–1913, Pl. 43, fig. 204-1), Wenz (1943, fig. 3773), and Pomerol (1982, fig. 3.16–3.19).

*Volutilithes orocopiaensis* n. sp. differs from UCLA specimen 29199 of *V. muricinus* from Chaumont-en-Vexin (Oise), France, and UCMP specimen B-5440 of *V. muricinus* from Damery, Marne, France, in the following features: a narrower shell; a less inflated body whorl; and, more strongly protruding collabral costae on the spire whorls. *Volutilithes orocopiaensis* also has a narrow, gently sloping sutural ramp whereas *V. muricinus* has a broad, fairly steep sloping, sutural ramp.

*Volutilithes torreyensis* Givens, 1978, is the only other reliably reported species of this genus from the Western Hemisphere, and it is from the early middle Eocene Ardath Shale near San Diego, California. *Volutilithes orocopiaensis* n. sp. differs from *V. torreyensis* in the following features: much more prominent nodes on the shoulder of the body whorl; spiral ribs only on basal portion of the body whorl rather than over the entire surface of the shell; and, only two to three columellar folds rather than five. In addition, *V. orocopiaensis* has no folds anterior to the most prominent columellar fold, whereas *V. torreyensis* does have a single fold there.

*Discussion.*—The basis of modern taxonomic work on the Volutilithinae is the article by Pilsbry and Olsson (1954). Most workers now assign *Volutilithes* to the subfamily Volutilithinae rather than Volutilithinae.

As mentioned by Givens (1978), *Volutilithes* is typical of the Old World Tethyan paleobiogeographic province, where it occurs in strata of Late Cretaceous through late Eocene age. The occurrence of *Volutilithes orocopiaensis* n. sp. from the Maniobra Formation constitutes the earliest record of this genus in North America.

*Material.*—One nearly complete adult specimen and one partial adult specimen.

*Repository.*—Holotype, LACMIP 7168; paratype, UCLA 48438.

*Occurrence.*—Both specimens were obtained from the early Eocene “Capay Stage” portion of the Maniobra Formation from a 30 cm thick bed approximately 57 m above the base of the formation, at CSUN locality 662 (which is equivalent to UCLA locality 3779).

*Etymology.*—This species is named for the Orocochia Mountains in which the Maniobra Formation crops out.

Class BIVALVIA Linné, 1758

Subclass HETERODONTA Neumayr, 1884

Order VENEROIDA H. and A. Adams, 1856

Superfamily GLOSSACEA Gray, 1847

Family GLOSSIDAE Gray, 1847

Genus GLOSSUS Poli, 1795

*Type species.*—By monotypy, *Glossus rubicundus* Poli, 1795 (= *Cardium humanum* Linné, 1758), Recent, Western Europe and Mediterranean.

Subgenus MEIOCARDIA

H. and A. Adams, 1857

*Type species.*—By subsequent designation (Stoliczka, 1870), *Meiocardia moltkiana* “Spengler” (= *Chama moltkiana* Gmelin, 1791), Recent, East Indies.

*Diagnosis.*—Equivalved shell, inflated, subtrigonal shape; prosogyrate beaks in anterior half, spirogyrate umbones, lunular area depressed, no escutcheon, nymph prominent and long; ligament external, attached in deep groove; hinge teeth thin, elongate, horizontal instead of vertical, with two lamellar cardinals in each valve, variable in form, parallel, separated by a lateral groove; ridge-like posterior lateral tooth near posterior margin in both valves; adductor scars equal, valve margins internally smooth; integripalliate pallial line; posterior margin of shell bounded by a sharp carina; ornament of commarginal ribs.

GLOSSUS (MEIOCARDIA) SUSUKII n. sp.

Figure 3.3–3.5

*Diagnosis.*—Small *Meiocardia* with a wide concave, posterior carina; entire shell exterior finely ribbed.

*Description.*—Equivalved shell subtrigo-

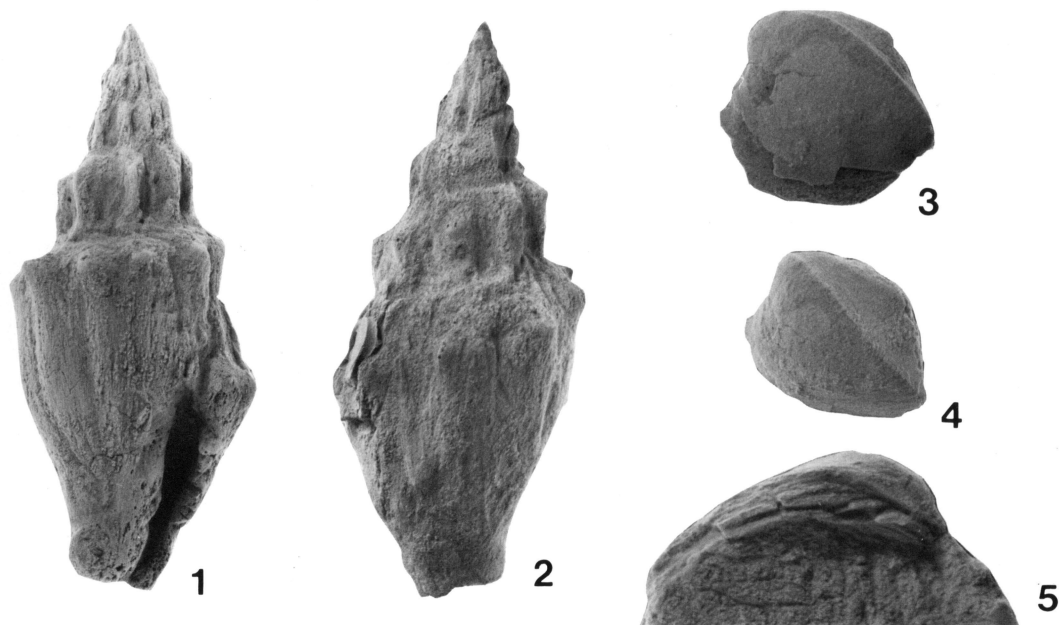


FIGURE 3—1, 2, *Volutilithes orocopiaensis* n. sp., holotype, LACMIP 7168, CSUN loc. 662,  $\times 1.2$ . 3–5, *Glossus (Meiocardia) susukii* n. sp., holotype, UCLA 48427, CSUN loc. 662. 3, left valve,  $\times 2$ ; 4, oblique posterior view of left valve,  $\times 1.8$ ; 5, left valve hinge line,  $\times 4$ .

nal, moderately inflated, and of small size; prosogyrate beaks in anterior half; beak in left valve incipiently coiled; right valve beak and umbo area obscured; nymph long; two parallel, horizontal, lamellar cardinals in left valve separated by a lateral groove; posterior lateral tooth area missing; right valve dentition features obscured; posterior margin of shell, from beak to the ventral region, bounded by a sharp, wide, concave carina; ornament of very fine, very closely spaced, commarginal costellae, including carina surface.

*Comparison.*—The new species is most similar to *Glossus mediavia* (Harris, 1896, p. 66–67, Pl. 6, fig. 5) from the Paleocene (lower Midway Group) of Alabama (Palmer and Brann, 1965). It differs from *G. mediavia* in having commarginal sculpture over the entire surface of the shell and less inflated valves. *Glossus mediavia* has a well developed posterior carina and is considered to belong to *Glossus (Meiocardia)*.

*Glossus (M.) susukii* does not have the strongly spirogyrate umbones, the heavy rounded undulations on the shell exterior, or the lack of sculpture on the carina that *Meiocardia colombiana* Clark and Durham (1946,

p. 72, Pl. 13, figs. 19–22) possesses. *Meiocardia colombiana* is the only other reported species of *Glossus (Meiocardia)* in the western Americas.

*Discussion.*—*Meiocardia* has been reported from strata of Paleocene through Recent age in Europe, Middle East, India, and Indo-Pacific (Keen and Casey, 1969; Davies, 1971). It also occurs in strata as old as Paleocene age in Alabama (Palmer and Brann, 1965) and in strata as old as late Eocene/early Oligocene in Colombia, South America (Clark and Durham, 1946).

*Glossus (M.) susukii* n. sp. is the earliest reported species of this subgenus on the West Coast of North and South America. It should be noted, however, that according to Saul (personal commun.), there is an unreported species of *Meiocardia* from the Point Loma Formation of Late Cretaceous age in the San Diego, California area.

*Material.*—A left valve, nearly complete, with the hinge details exposed, shell surface weathered, and sculptured layer missing. Also, a crushed complete specimen.

*Repository.*—Holotype, UCLA 48427a; paratype, UCLA 48427b.

*Occurrence.*—Both specimens were obtained from the early Eocene "Capay Stage" portion of the Maniobra Formation from a 30 cm thick bed approximately 57 m above the base of the formation, at CSUN locality 662 (which is equivalent to UCLA locality 3779).

*Etymology.*—This species is named for Takeo Susuki who found the type specimens, identified them as belonging to *Meiocardia* (= *Miocardia*), and reported the earliest occurrence of this taxon from the West Coast of North America (Crowell and Susuki, 1959).

#### LOCALITIES

All localities are California State University, Northridge (CSUN), northeastern Orocochia Mountains, Riverside County, California (Figure 1).

662—2,190 ft elevation along crest of small hill, 137 m (450 ft) south and 31 m (100 ft) west of the northeast corner of sec. 25, T6S, R12E, Canyon Spring NW 7.5' Quadrangle, 1963. This locality is equivalent to University of California, Los Angeles locality 3779, which is equivalent to locality F of Crowell and Susuki (1959).

665—2,120 ft elevation along east side of small canyon, 861 m (2,825 ft) north and 709 m (2,325 ft) west of the southeast corner of sec. 30, T6S, R13E, Canyon Spring SW 7.5' Quadrangle, 1963. =LACMIP 16336

668—2,000 ft elevation in stream bed, 421 m (1,380 ft) south and 198 m (650 ft) east of the northwest corner of sec. 31, T6S, R13E, Canyon Spring SW 7.5' Quadrangle, 1963. =LACMIP 16155

671—2,040 ft elevation in stream bed, 579 m (1,900 ft) north and 26 m (85 ft) west of the southeast corner of sec. 31, T6S, R13E, Canyon Spring SW 7.5' Quadrangle, 1963. =LACMIP 16076

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