THE VELIGER
© CMS, Inc., 2000

The Veliger 43(2):118–125 (April 3, 2000)

The Buccinid Gastropod *Deussenia* From Upper Cretaceous Strata of California

RICHARD L. SQUIRES

Department of Geological Sciences, California State University, Northridge 91330-8266, USA

AND

LOUELLA R. SAUL

Invertebrate Paleontology Section, Natural History Museum of Los Angeles County, 900 Exposition Boulevard, Los Angeles, California 90007, USA

Abstract. Rare specimens of three new species of the Late Cretaceous buccinid gastropod *Deussenia* Stephenson, 1941, are reported from California. *Deussenia **sierrana*** sp. nov. is from lower Campanian strata in the Chico Formation in the Pentz area, Butte County, northern California. *Deussenia **californiana*** sp. nov. is from upper middle to lower upper Campanian strata in the Tuna Canyon Formation in the Garapito Creek area, eastern Santa Monica Mounains, Los Angeles County, southern California. *Deussenia **pacificana*** sp. nov. is from uppermost Maastrichtian or possibly lowermost Paleocene strata in the Dip Creek area, northern San Luis Obispo County, central California. These three new species are the only known occurrences of this genus from the Pacific coast of North America. *Deussenia* has been reported before only from upper Santonian to lower Campanian strata at the mouth of the Mzamba River (Pondoland, Transkei) in South Africa and from Campanian to Maastrichtian strata in Texas and the Gulf Coast of the United States.

INTRODUCTION

Late Cretaceous buccinid gastropods are relatively uncommon on the Pacific coast of North America. Recent inspection of previously collected material resulted in the detection of three new species of genus *Deussenia* from widely separated locales in California (Figures 1, 2). It is the purpose of this paper to describe and name these species. They significantly extend the biogeographic range of *Deussenia,* which was previously known only from Upper Cretaceous rocks in South Africa and southeastern United States.

Abbreviations used are: CASG, California Academy of Sciences, Geology Section, San Francisco; CSUC, Department of Geology & Physical Science, California State University, Chico; CSUN, Department of Geological Sciences, California State University, Northridge; LACMIP, Natural History Museum of Los Angeles County, Invertebrate Paleontology Section.

SYSTEMATIC PALEONTOLOGY

Superorder CAENOGASTROPODA Cox, 1959

Order NEOGASTROPODA Thiele, 1929

Family BUCCINIDAE Rafinesque, 1815

Subfamily MELONGENINAE Gill, 1871

Discussion: Stephenson (1941) questionably assigned his genus *Deussenia* to family Buccinidae, but he gave no discussion as to why he chose this family. Sohl (1964) assigned *Deussenia* to family Melongenidae, and he also gave no discussion for the basis of this assignment. Melongenids have pyriform to fusiform shells, usually shouldered whorls, a long anterior canal, and a smooth columella (Wenz, 1943; Davies & Eames, 1971; Rosenberg, 1992). These morphologic features are present on all species of *Deussenia* Stephenson, 1941, including the new species described here. Ponder & Warén (1988) regarded melongenids to be a subfamily of Buccinidae. Akers & Akers (1997) did likewise and, furthermore, placed genus *Deussenia* in subfamily Melongeninae.

Genus *Deussenia* Stephenson, 1941

Type species: *Deussenia cibolensis* Stephenson, 1941, by original designation; Upper Cretaceous (upper Maastrichtian) Kemp Formation of the Navarro Group, eastern Texas.

Discussion: *Deussenia* resembles the Upper Cretaceous bucciniform *Aliofusus* Stephenson, 1941, but *Deussenia* differs from *Aliofusus* by having a stronger subsutural collar, less inclined growth lines on the collar, and straighter axial ribs. *Aliofusus* has axial ribs that are curved and follow the outline of the outer lip.

Deussenia superficially resembles the Upper Cretaceous volutid genus *Volutomorpha* Gabb, 1877, but *Deussenia* lacks volutid characteristics in that it has no

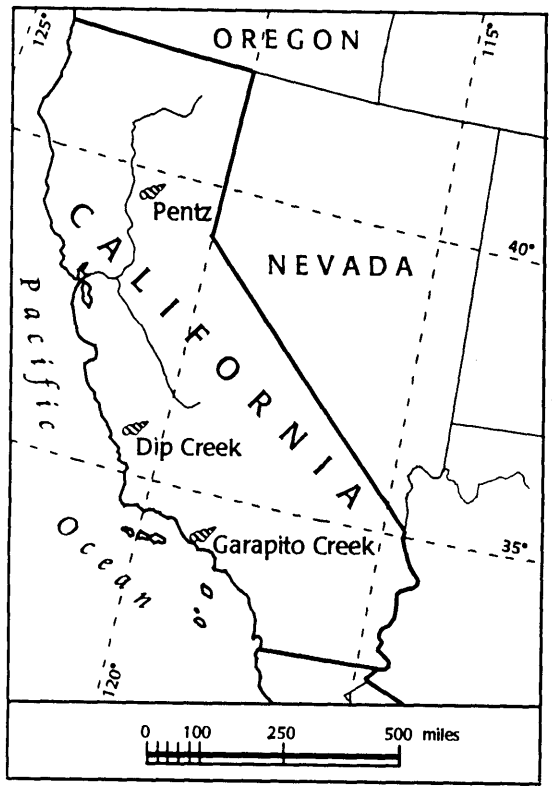


Figure 1

Index map to type locality areas of the three new species of *Deussenia*.

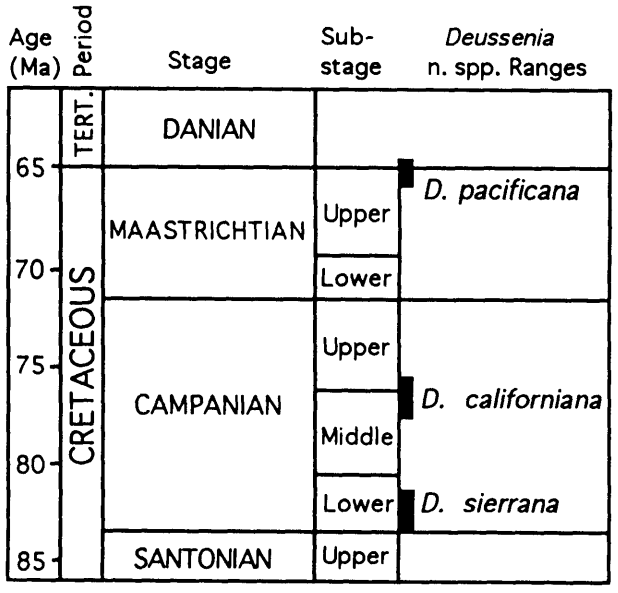


Figure 2

Age and stratigraphic positions of the three new species of *Deussenia*. Geochronologic time scale from Gradstein et al. (1995).

fold(s) on the columella, no posterior notch, and no sigmoidal deflection of growth lines near the suture. Furthermore, *Deussenia* differs from *Volutomorpha* by having a higher spire, a shorter body whorl, a twisted anterior end, and more dense ornamentation.

Prior to this present study, only 10 other species have been placed in genus *Deussenia*, and Sohl (1964:200) listed them. All are of Late Cretaceous age. Four of the species are from upper Maastrichtian strata in eastern Texas, but Sohl (1964) believed that some of these names might be synonyms because they are (1) distinguished on minor differences in shape and ornament, (2) all are from the same stratigraphic horizon in a limited geographic area, and (3) the number of available specimens of these four species are so few that it is not possible to determine whether or not the minor differences are significant.

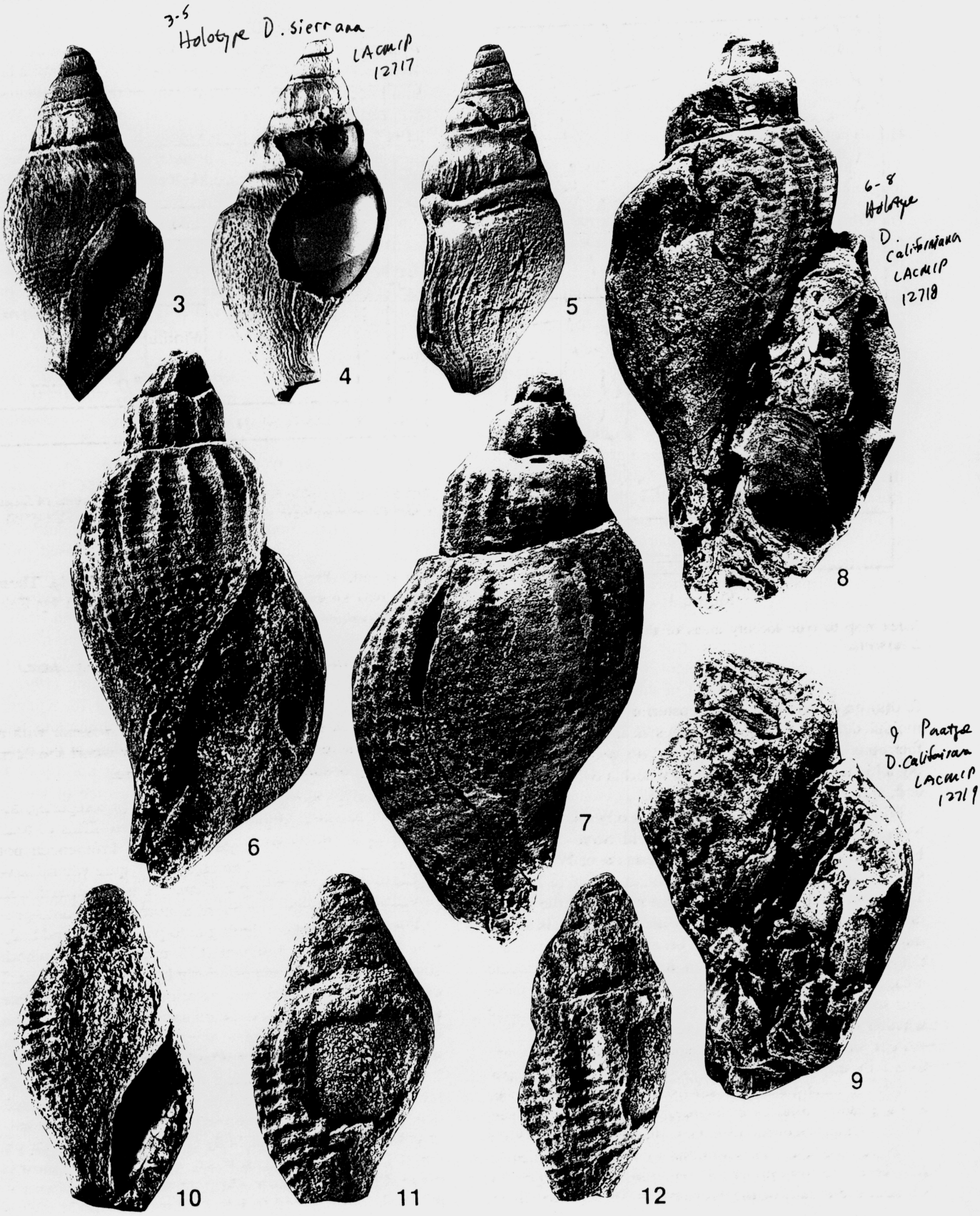
Four of the other known species of *Deussenia* are found in upper Campanian to Maastrichtian or upper Maastrichtian strata in Texas, Mississippi, and Tennessee, and are found, to a lesser degree, in similar age strata in Alabama and Georgia (Stephenson, 1941; Sohl, 1964; Akers & Akers, 1997). The other two known species of *Deussenia* are from upper Santonian to lower Campanian strata at the mouth of the Mzamba (= Umzamba) River, Pondoland, Transkei, South Africa (Sohl, 1964). These latter two species were questionably assigned by Sohl (1964) to genus *Deussenia*.

Deussenia sierrana Squires & Saul, sp. nov.

(Figures 3–5)

Diagnosis: A small-shelled species of *Deussenia* with a prominent sutural cord, subtabulate body whorl shoulder, and nearly obsolete body whorl sculpture.

Description: Shell small, 25 mm high (incomplete); fusiform; spire of medium height, about two-fifths of total height of shell; spiral angle about 45°. Protoconch not preserved. Whorls 6 (estimated). Upper spire whorls lowly convex, smooth. Ramp concave, constricted, and well differentiated starting on more mature half of ante-penultimate whorl and continuing onto penultimate and body whorls; ramp widest (about 0.75 mm) on body whorl. Ramp always bordered posteriorly by a prominent sutural cord and always bordered anteriorly by a subtabulate shoulder. Prominent sutural cord somewhat undulatory on body whorl. On penultimate whorl, subtabulate shoulder with low axial ribs. Body whorl sculpture mostly obsolete, with faint spiral ribbing near neck area on ventral face. Growth lines prosocline on ramp; sharply flexed (sinused) and opisthocine on subtabulate shoulder; broadly prosocline on most of body whorl; nearly straight on whorl base; and strongest near outer lip where growth rugae develop. Aperture elongate, anterior end (incomplete) slightly twisted to left. Columella smooth, with a


3-5
Holotype D. sierrana
LACMIP
12717
3
4
5
6-8
Holotype
D.
californiana
LACMIP
12718
8
6
7
9 Paratype
D. californiana
LACMIP
12719
9
10
11
12
Holotype D. pacificana
CAS 61598.01

light callus. Outer lip sinuous, notched slightly opposite subtabulate shoulder.

Dimensions of holotype: Height 25 mm (incomplete at both extremities), width 11.2 mm.

Holotype: LACMIP 12717.

Type locality: CSUC loc. PN32, latitude 39°39′08″N, longitude 121°35′50″W.

Distribution: Chico Formation, informal Pentz Road member of Russell et al. (1986), Pentz area, Butte County, northern California.

Geologic age: Late Cretaceous (early Campanian).

Discussion: Only three specimens were found. Two are from CSUC locs. PN31 and PN32, and the third is from LACMIP loc. 10833. Except for the holotype, the specimens are internal molds. It is likely that the holotype has been slightly worn or weathered, but the shell does not appear to ever have been strongly sculptured.

Specimens of *Duessenia* ***sierrana*** are known only from the Chico Formation in the informal Pentz Road member. Russell et al. (1986) inferred that the member was deposited under estuarine conditions and contains mixed shallow-marine and brackish-marine faunal assemblages. Many faunal elements of the Pentz assemblages, however, suggest normal-marine conditions (Squires & Saul, 1997; Haggart et al., 1997), and the localities yielding *D.* ***sierrana*** were considered by Watkins & Göhre (unpublished MS) to represent a fully marine, shoreface deposit.

In the Pentz area, the Chico Formation probably does not exceed 150 m (450 ft.) in thickness (Russell et al., 1986), and based on the presence of the ammonites *Baculites chicoensis* (Trask, 1856) and *Submortoniceras chicoense* (Trask, 1856), the rocks are early Campanian in age (Matsumoto, 1960; Russell et al., 1986). The early Campanian magnetic anomaly 33R is included within the ranges of both of these ammonites (Ward et al., 1983). The gastropod *Anchura callosa* Whiteaves, 1903, is also present in these rocks, and suggests an early Campanian age (Elder & Saul, 1996).

Deussenia ***sierrana*** somewhat resembles the so-called *Cryptorhytis pseudorigida* Rennie (1930:227–228; Woods, 1906:321–322, pl. 39, figs. 2a–c; pl. 40, fig. 1) from the Upper Cretaceous Mzamba Formation in South Africa. The genus *Cryptorhytis* Meek, 1876, is not a buccinid because it has one weak fold on the inner lip and a weaker fold in the interior of the aperture, and Wenz (1943) believed it to be a volute. Sohl (1964) was the first to suggest that "*C.*" *pseudorigida* might belong to *Deussenia.* We also consider Rennie's species to be a *Deussenia* because it has a fusiform shape, a long anterior canal, a smooth columella, and a concave ramp with a cord bordering the suture; all of which characterize *Deussenia.* The new species differs from *D. pseudorigida* by being narrower just anterior to the ramp, by having only a hint of spiral sculpture rather than strong spiral sculpture, and by having no axial nodes on the shoulder of the body whorl.

Rennie (1930) provided the name *Cryptorhytis pseudorigida* for specimens misidentified by Woods (1906) as the closely allied, so-called "*Cryptorhytis*" *rigida* (Baily, 1855:459, pl. 12, fig. 14; Rennie, 1930:225–227, pl. 27, figs. 9–12; [*non* Woods, 1906:321, pl. 39, fig. 2a–c, pl. 40, fig. 1 = "*C.*" *pseudorigida* Rennie]). "*Cryptorhytis*" *rigida* differs from "*C.*" *pseudorigida* by having a higher spire, a much more tabulate body whorl shoulder, and narrower and more numerous axial ribs. Based on the very close morphological similarities between these two species, we also consider "*C.*" *rigida* to be a *Deussenia.* Both species are based on specimens collected from the type section of the Mzamba Formation at the mouth of the Mzamba River. Rennie (1930) reported "*C.*" *pseudorigida* from Beds 3 and 16, and Greyling (1992) recorded "*C.*" *rigida* from Beds 9, 11, and 16. Klinger & Kennedy (1980), on the basis of the ammonite fauna, placed the Santonian-Campanian boundary at the base of Bed 8, but Greyling (1992) placed it at the top of Bed 12. In spite of this debate, both species are of late Santonian to early Campanian age and are about the same age as *D.* ***sierrana.***

Etymology: The new species is named for the Sierra Nevada range, which rises immediately east of Pentz, northern California.

←

Explanation of Figures 3 to 12

All specimens coated with ammonium chloride.

Figures 3–5. *Deussenia* ***sierrana*** Squires & Saul, sp. nov., holotype LACMIP 12717, CSUC locality PN32, Pentz area, height 25 mm, ×2.6. Figure 3. Apertural view. Figure 4. Abapertural view. Figure 5. Right-lateral view showing outline of outer lip.

Figures 6–9. *Deussenia* ***californiana*** Squires & Saul, sp. nov., CSUN loc. 153, Garapito Creek area. Figures 6–8. Holotype LACMIP 12718, height 11 cm, ×1. Figure 6. Apertural view. Figure 7. Abapertural view. Figure 8. Apertural view with a portion of body whorl removed to better show the columella. Figure 9. Paratype LACMIP 12719, apertural view, height 10.75 cm, ×0.8.

Figures 10–12. *Deussenia* ***pacificana*** Squires & Saul, sp. nov., holotype CASG 61598.01, CASG loc. 61598, Dip Creek area, ×1.9. Figure 10. Apertural view. Figure 11. Abapertural view. Figure 12. Right-lateral view.

*Deussenia **californiana*** Squires & Saul, sp. nov.

(Figures 6–9)

Diagnosis: A large-shelled species of *Deussenia* with a rounded body whorl shoulder bearing about 20 low and narrow axial ribs, and with numerous spiral ribs over the entire body whorl.

Description: Shell large, up to 13 cm high (estimated); fusiform; spire of medium height, about two-fifths of total height of shell; spiral angle about 50°. Protoconch not preserved. Whorls 6 1/2 (estimated). Spire whorls tabulate, steep-sided with axial ribs stronger than spiral ribs. Posterior part of body whorl constricted to a moderately broad and lowly concave ramp, with spiral ribs weaker on ramp than on area of greatest inflation of whorl. Body whorl elongate, with greatest inflation from rounded shoulder to medial part of whorl. Body whorl sculptured by about 20, narrow and widely spaced axial ribs, becoming obsolete toward medial part of whorl, and numerous and closely spaced spiral ribs over entire body whorl, persisting onto the ventral surface of the neck. Axial ribs more prominent than spiral ribs on posterior half of body whorl. Aperture elongate-lenticular, anterior end twisted to left. Columella smooth.

Dimensions of holotype: Height 11 cm (tip of spire and extreme anterior end both missing); width 5.8 cm.

Holotype: LACMIP 12718.

Type locality: CSUN loc. 153, latitude 34°07'N, longitude 118°34'W.

Paratype: LACMIP 12719.

Distribution: Tuna Canyon Formation, south fork of Garapito Creek, eastern Santa Monica Mountains, Los Angeles County, southern California.

Geologic age: Late Cretaceous (late middle to early late Campanian) = *Metaplacenticeras pacificum* ammonite zone.

Discussion: Only two specimens have been found, and both are internal molds. The paratype is larger (estimated total height 13 cm, width 6.5 cm), but most of its spire is missing. The paratype shows spiral ribbing on the neck of the body whorl (Figure 9), whereas on the holotype the spiral ribbing in this area is not preserved.

*Deussenia **californiana*** is similar to *Deussenia ciboloensis* Stephenson (1941:332–333, pl. 64, figs. 13, 14; Akers & Akers, 1997:figs. 183–184) from the Upper Cretaceous Kemp Clay [also referred to as the Kemp Formation] in eastern Texas. Modern workers (e.g., Sohl, 1964:fig. 12; Elder, 1996) correlated the Kemp Clay to the upper Maastrichtian Stage. The new species differs from *D. ciboloensis* by having a much less tabulate body whorl shoulder, no tubercules on the body whorl shoulder, and narrower spiral ribs on the body whorl.

*Deussenia **californiana*** is also similar to *Deussenia pseudorigida* (Rennie, 1930:227–228; Woods, 1906:321–322, pl. 39, figs. 2a–2c; pl. 40, fig. 1) from upper Santonian to lower Campanian rocks in the Mzamba Formation in South Africa (See "Discussion" under *D. **sierrana*** sp. nov.). The new species differs from *D. pseudorigida* by being narrower just anterior to the concave ramp, by having narrower and more numerous narrower axial ribs, and by having weaker spiral ribs on the anterior half of the body whorl.

The type locality of *Deussenia **californiana*** in the Garapito Creek area in the eastern Santa Monica Mountains, Los Angeles County, southern California, plots in cartographic unit "Kss" (unnamed Upper Cretaceous strata) of Dibblee's (1992) map, which is the most recently published geologic map of the region. Rocks belonging to unit "Kss" in the Temescal Canyon-Santa Ynez Canyon just southeast of Garapito Creek were assigned by Colburn (1996) to the Upper Cretaceous Tuna Canyon Formation of Yerkes & Campbell (1979). This formation was deposited by turbidity currents on submarine fans (Yerkes & Campbell, 1979, 1980; Dibblee, 1992), and unit "Kss" represents a dominantly sandy facies. Unit "Kss" in the region of Garapito Creek corresponds to "member D" mentioned by Popenoe (1973) and to the so-called "upper Chico" Formation utilized by Carey & Colburn (1978). Popenoe (1973:26–27) reported that "member D" rocks were probably deposited as turbidities and that the mollusk fossils are shallow-marine forms that might have been transported from their regular habitat into somewhat deeper water. Carey & Colburn (1978) reported that these same rocks represent middle-fan channelized turbidites containing lenses of concentrated shallow-marine molluscan shells that appear to have been transported.

The paleoenvironment of the Tuna Canyon Formation closely resembles that of the Chatsworth Formation of Colburn et al. (1981) in the Simi Hills just to the north of the Santa Monica Mountains. According to Dibblee (1992), the Tuna Canyon Formation is probably equivalent to the Chatsworth Formation in the Simi Hills.

Based on the presence of the ammonite *Metaplacenticeras pacificum sensu stricto* (Smith, 1900), Popenoe (1973) assigned a late Campanian age to the rocks at CSUN loc. 153. Subsequent detailed collecting at this type locality of *D. **californiana*** yielded this ammonite, as well as the gastropods *Anchura phaba* Elder & Saul, 1996, *Volutoderma magna* Packard, 1922, and *Zinsitys kingi* (Gabb, 1864); the bivalves *Crassatella elongata* Anderson, 1958, *Indogrammatodon* sp., *Cucullaea* sp., *Pinna* sp., (closed valved), *Pterotrigonia evansana* (Meek, 1858), *Inoceramus* sp., *Clisocolus dubius* (Gabb, 1864), an isognomid, and a venerid. The presence of *Metaplacenticeras pacificum sensu stricto* is very age diagnostic because this species constitutes the *Metaplacenticeras pacificum* ammonite zone (after Matsomoto, 1960), which is of middle to early late Campanian age (Elder &

Saul, 1996). The geologic ranges of both *Zinsitys kingii* and *Anchura phaba* are correlative to the *M. pacificum* zone (Saul, 1988; Elder & Saul, 1996).

At LACMIP loc. 27002, which is in the general area of CSUN loc. 153, the bivalves *Glycymeris (Glycymerita) veatchii* (Gabb, 1864), *Pterotrigonia evansana* (Meek, 1858), *Cymbophora triangulata* (Waring, 1917), *Calva* sp., and *Yaadia* sp. were also found. The exact location of LACMIP loc. 27002 is not known, but is undoubtedly in the immediate area of CSUN loc. 153.

The mollusks at CSUN loc. 153 must have undergone post-mortem transport from shallow-water sites into deep-water, submarine-fan paleoenvironments of the Tunca Canyon Formation. Several of the species found at CSUN loc. 153 or in the immediate vicinity (e.g., *Anchura phaba, Volutoderma magna, Crassatella elongata, Cymbophora triangulata, Glycymeris (Glycymerita) veatchii, Pterotrigonia evansana,* and *Pinna* sp.) were normal-marine, shallow-depth dwellers (10 to 50 m) that also have been reported as transported remains in bathyal submarine-fan deposits of Campanian age in the Chatsworth Formation in the Simi Hills (Saul & Alderson, 1981).

Etymology: The species is named for the state of California.

Deussenia ***pacificana*** Squires & Saul, sp. nov.

(Figures 10–12)

Deussenia? n. sp. Saul, 1986:figs. 54–55.

Diagnosis: A medium-shelled species of *Deussenia* with a subtabulate body whorl shoulder, bearing about 11 moderately strong axial ribs, and with prominent, closely spaced spiral ribs on body whorl.

Description: Shell medium in size, 31 mm high (incomplete); fusiform; spire of medium height, about two-fifths of total height of shell; spiral angle about 55°. Protoconch not preserved, and spire sculpture not preserved. Whorls about 4 1/2 (estimated). Upper part of body whorl constricted somewhat to broad, slightly concave ramp. Body whorl with about 11 (estimated) moderately strong and widely spaced axial ribs; strongest on shoulder and becoming obsolete toward base of whorl. Body whorl with prominent, closely spaced spiral ribs persisting onto neck area. Aperture elongate-lenticular. Columella smooth.

Dimensions of holotype: Height 31.5 mm, width 16 mm (incomplete at both extremities, especially the anterior end).

Holotype: CASG 61598.01 [*ex* Stanford University 30031].

Type locality: CASG loc. 61598, latitude 120°55′40″N, longitude 35°43′45″W.

Distribution: Unnamed formation at Dip Creek, south shore of Lake Nacimiento, San Luis Obispo County, central California.

Geologic age: Late Cretaceous (latest Maastrichtian) or possibly earliest Paleocene.

Discussion: Only a single specimen has been found. It is small in size and could be a juvenile form.

Taliaferro (1944) referred the Dip Creek strata to his "Dip Creek Formation," but Durham (1968) referred to them as unnamed Upper Cretaceous and lower Tertiary rocks. At Dip Creek, the mollusks are shallow-marine forms that have undergone post-mortem transport and are within deep-water turbidites in beds of coarse-grained grit or conglomerate (Grove, 1986). More detailed geologic mapping is needed in the area before the Dip Creek section can be assigned to a formation. The outcrops along Dip Creek are usually covered by waters behind the Lake Nacimiento dam but are exposed during drought years (Squires & Saul, 1993). One can collect fossils along the nearby ridge top, but these specimens are harder to find and are more poorly preserved than those along the lake shore.

The Dip Creek fauna contains some mollusks that resemble genera or species usually considered to indicate a Cretaceous age, as well as some indicative of a Paleocene age. Taliaferro (1944) reported an unidentified ammonite from the fauna, and Saul (1983) reported a fragment of another ammonite, probably a *Neophylloceras.* Kirby & Saul (1995) reported a fragment of the bivalve *Roudaria.* These fossil remains suggest that at least the lower part of the section is of very Late Cretaceous age and that the upper half of the section, where the new species was collected, is no younger than earliest Paleocene. Based on specimens of *Turritella peninsularis adelaidana* (Merriam, 1941) and *T. webbi* (Saul, 1983), Saul (1983) assigned the Dip Creek mollusks to a latest Maastrichtian and possibly an earliest Paleocene age. This age assignment was followed by Saul (1986) and Squires & Saul (1993).

Etymology: The new species is named for the Pacific Ocean.

Acknowlegments. Richard A. Flory (CSUC) donated two specimens of *D. **sierrana*** to the LACMIP collection. James W. Haggart (Geological Survey of Canada, Vancouver, British Columbia) facilitated our obtaining of specimens from the Pentz area. Lindsey T. Groves (LACMIP) provided access to the collections and loaned specimens. Jean DeMouthe (CAS) loaned specimens. Anton Oleinik (Department of Geology, Purdue University, Indiana) kindly shared his knowledge of buccinid gastropods. Michael R. Cooper (Department of Geology, University of Durban-Westville, Durban, South Africa) graciously provided information on the type section of the Mzamba Formation, Pondoland, Transkei, South Africa. The manuscript benefited by reviews from David T. Dockery III (Mississippi Office of Geology) and an anonymous reviewer.

LITERATURE CITED

AKERS, R. E. & T. J. AKERS. 1997. Texas Cretaceous Gastropods. Paleontology Section, Houston Gem and Mineral Society, Texas Paleontology Series Publication Number 6: Houston, Texas. 340 pp., 294 figs.

BAILY, W. H. 1855. Description of some Cretaceous fossils from South Africa; collected by Captain Garden, of the 45th Regiment. Quarterly Journal of the Geological Society 11:454–465, pls. 11–13.

CAREY, S. M. & I. P. COLBURN. 1978. Late Cretaceous sedimentation in the Santa Monica Mountains, California. Pp. 547–558 in D. G. Howell & K. A. McDougall (eds.), Mesozoic Paleogeography of the Western United States. Pacific Section, Society of Economic Paleontologists and Mineralogists, Pacific Coast Paleogeography Symposium 2: Los Angeles, California.

COLBURN, I. P. 1996. Stratigraphic and sedimentary structures of the Paleogene successions in the west central Santa Monica Mountains, Los Angeles County, California. Pp. 93–116 in P. L. Abbott & J. D. Cooper (eds.), Field Conference Guide 1996. Pacific Section, American Association of Petroleum Geologists Guidebook 73: Los Angeles, California.

COLBURN, I. P., L. R. SAUL & A. A. ALMGREN. 1981. The Chatsworth Formation: a new formation name for the Upper Cretaceous strata of the Simi Hills, California. Pp. 9–16 in M. H. Link, R. L. Squires & I. P. Colburn (eds.), Simi Hills Cretaceous Turbidites, Southern California. Pacific Section, Society of Economic Paleontologists and Mineralogists, Volume and Guidebook: Los Angeles, California.

DAVIES, A. M. (revised by F. E. EAMES). 1971. Tertiary Faunas—A Text-Book for Oilfield Palaeontologists and Students of Geology. Vol. 1. The Composition of Tertiary Faunas. George Allen & Unwin Ltd.: London. 571 pp.

DIBBLEE, T. W., JR. 1992. Geologic map of the Topanga and Canoga Park (south 1/2) quadrangles, Los Angeles County, California. Dibblee Geological Foundation Map DF-35.

DURHAM, D. L. 1968. Geology of the Tierra Redonda Mountain and Bradley quadrangles, Monterey and San Luis Obispo counties, California. U.S. Geological Survey Bulletin 1255: 60 pp., pls. 1–4.

ELDER, W. P. 1996. Bivalves and gastropods from the middle Campanian Anacacho Limestone, south central Texas. Journal of Paleontology 70(2):247–271, figs. 1–8.

ELDER, W. P. & L. R. SAUL. 1996. Taxonomy and biostratigraphy of Coniacian through Maastrichtian *Anchura* (Gastropoda: Aporrhaiidae) of the North American Pacific slope. Journal of Paleontology 70(3):381–399, figs. 1–6.

FRITSCHE, A. E. 1973. Map of Cretaceous sedimentary exposures in the eastern Santa Monica Mountains. Map (in pocket) in I. P. Colburn & A. E. Fritsche (eds.), Pacific Section, Society of Economic Paleontologists and Mineralogists Fall Field Guidebook: Los Angeles, California.

GRADSTEIN, F. M., F. P. AGTEBERG, J. G. OGG, J. HARDENBOL, P. V. VEEN, J. THIERRY & Z. HUANG. 1995. A Triassic, Jurassic and Cretaceous time scale. Pp. 95–121 in W. A. Berggren, D. V. Kent, M. -P. Aubry & J. Hardenbol (eds.), Geochronology Time Scales and Global Stratigraphic Correlation. SEPM (Society for Sedimentary Geology) Special Publication 54: Tulsa, Oklahoma.

GREYLING, E. H. 1992. The Mzamba Formation (Cretaceous) of the Transkei—stratigraphy, sedimentology and palaeontology. Master of Science Thesis, University of Durban-Westville. Durban, South Africa.

GROVE, K. 1986. Field trip boatlog: depositional environments of Upper Cretaceous and lower Tertiary strata around Lake Nacimiento, central California Coast Ranges. Pp. 43–59 in K. Grove & S. Graham (eds.), Geology of Upper Cretaceous and Lower Tertiary Rocks Near Lake Nacimiento, California. Pacific Section, Society of Economic Paleontologists and Mineralogists, Book Number 49: Los Angeles, California.

HAGGART, J. W., L. R. SAUL, R. WATKINS & E. S. GÖHRE. 1997. Cretaceous shallow marine strata at Pentz, California. Pp. 1–6 in M. Erskine & D. Lawler (eds.), Northern Sierra Nevada Region. Northern California Geological Society Field Trip Guidebook.

KIRBY, M. X. & L. R. SAUL. 1995. The Tethyan bivalve *Roudairia* from the Upper Cretaceous of California. Palaeontology 38(pt. 1):23–38, pls. 1–2.

KLINGER, H. C. & W. J. KENNEDY. 1980. The Umzamba Formation at its type section, Umzamba Estuary (Pondoland, Transkei), the ammonite content and palaeogeographical distribution. Annals of the South African Museum 81(pt. 6): 207–222, figs. 1–5.

MATSUMOTO, T. 1960. Upper Cretaceous ammonites of California. Part III. Kyushu University. Memoirs of the Faculty of Science, Series D, Geology, Special Volume 2:1–204, pls. 1–2.

PONDER, W. F. & A. WARÉN. 1988. Classification of the Caenogastropoda and Heterostropha—a list of the family-group names and higher taxa. Malacological Review, supplement 4:288–326.

POPENOE, W. P. 1973. Southern California Cretaceous formations and faunas with especial reference to the Simi Hills and Santa Monica Mountains. Pp. 15–29, pls. 1–3 in I. P. Colburn & A. E. Fritsche (eds.), Pacific Section, Society of Economic Paleontologists and Mineralogists Fall Field Guidebook: Los Angeles, California.

RENNIE, J. V. L. 1930. New Lamellibranchia and Gastropoda from the Upper Cretaceous of Pondoland (with an appendix on some species from the Cretaceous of Zululand). Annals of the South African Museum 28(pt. 12122):159–260, pls. 16–31.

ROSENBERG, G. 1992. The Encyclopedia of Seashells. Dorset Press: New York. 224 pp.

RUSSELL, J. S., S. L. BAUM & R. WATKINS. 1986. Late Coniacian to early Campanian clastic shelf deposits and molluscan assemblages of the northeastern Sacramento Valley, California. Pp. 179–196 in P. L. Abbott (ed.), Cretaceous Stratigraphy Western North America. Pacific Section, Society of Economic Paleontologists and Mineralogists, Book 46: Los Angeles, California.

SAUL, L. R. 1983. *Turritella* zonation across the Cretaceous-Tertiary boundary, California. University of California Publications in Geological Sciences 125:1–164, pls. 1–7.

SAUL, L. R. 1986. Mollusks of latest Cretaceous and Paleocene age, Lake Nacimiento, California. Pp. 25–31, figs. 1–60 in K. Grove & S. Graham (eds.), Geology of Upper Cretaceous and Lower Tertiary Rocks Near Lake Nacimiento, California. Pacific Section, Society of Economic Paleontologists and Mineralogists, Volume 49: Los Angeles, California.

SAUL, L. R. 1988. New Late Cretaceous and Early Tertiary Perissityidae (Gastropoda) from the Pacific slope of North America. Natural History Museum of Los Angeles County, Contributions in Science 400:1–25, figs. 1–128.

SAUL, L. R. & J. M. ALDERSON. 1981. Late Cretaceous Mollusca of the Simi Hills: an introduction. Pp. 29–42, pls. 1–3 in M. H. Link, R. L. Squires & I. P. Colburn (eds.), Simi Hills

Cretaceous Turbidites, Southern California. Pacific Section, Society of Economic Paleontologists and Mineralogists, Volume and Guidebook: Los Angeles, California.

SOHL, N. F. 1964. Neogastropoda, Opisthobranchia and Basommatopohora from the Ripley, Owl Creek, and Prairie Bluff Formations. U.S. Geological Survey Professional Paper 331-B:1–344, pls. 19–52.

SQUIRES, R. L. & L. R. SAUL. 1993. A new species of *Otostoma* (Gastropoda: Neritidae) from near the Cretaceous/Tertiary boundary at Dip Creep, Lake Nacimiento, California. The Veliger 36(3):259–264, figs. 1–4.

SQUIRES, R. L. & L. R. SAUL. 1997. Late Cretaceous occurrences on the Pacific slope of North America of the melanopsid gastropod genus *Boggsia* Olsson, 1929. The Veliger 40(3): 193–202, figs. 1–17.

STEPHENSON, L. W. 1941. The larger invertebrate fossils of the Navarro Group of Texas (exclusive of corals and crustaceans and exclusive of the fauna of the Escondido Formation). The University of Texas Publication 4101:1–641, pls. 1–95.

TALIAFERRO, N. L. 1944. Cretaceous and Paleocene of Santa Lucia Range, California. Bulletin of the American Association of Petroleum Geologists 28(4):449–521.

WARD, P. D., K. L. VEROSUB & J. W. HAGGART. 1983. Marine magnetic anomaly 33–34 identified in the Upper Cretaceous of the Great Valley Sequence of California. Geology 11:90–93.

WENZ, W. 1943. Familia Galeodidae. Pp. 1211–1224, figs. 3452–3479 in O. H. Schindewolf (ed.), Handbuch der Paläzoologie, Band 6, Prosobranchia, Teil 4. Gebrüder Borntrager: Berlin. [reprinted 1960–1961]

WOODS, H. 1906. The Cretaceous fauna of Pondoland. Annals of the South African Museum 4(7):245–350, pls. 33–44.

YERKES, R. F. & R. H. CAMPBELL. 1979. Stratigraphic nomenclature of the central Santa Monica Mountains, Los Angeles County, California. U.S. Geological Survey Bulletin 1457E: E1–E31.

YERKES, R. F. & R. H. CAMPBELL. 1980. Geologic map of east-central Santa Monica Mountains, Los Angeles County, California. U.S. Geological Survey Map I-1146.

APPENDIX

LOCALITIES CITED

CASG 61598. Dip Creek, NE 1/4 of section 30, T. 25 S, R. 10 E, U.S. Geological Survey Lime Mountain quadrangle (7.5 minute, 1948, photorevised 1979), San Luis Obispo County, central California. Unnamed formation. Age: Late Cretaceous (latest Maastrichtian) or possibly earliest Paleocene. Collector: N. L. Taliaferro.

CSUC PN31. At elevation of 530 ft., in a small canyon east of Highway 70, 716 m (2350 ft.) S and 69 m (225 ft.) E of NW corner of section 31, T. 21 N, R. 4 E, U.S. Geological Survey Cherokee quadrangle (7.5 minute, 1970), Butte County, northern California. Chico Formation, Pentz Road member (informal) of Russell et al. (1986). Age: Early Campanian. Collector: R. Watkins. = LACMIP loc. 17205.

CSUC PN32. At elevation of 530 ft., in a small canyon east of Highway 70, 754 m (2475 ft.) N and 107 m (350 ft.) W of SE corner of section 36, T. 21 N, R. 3 E, U.S. Geological Survey Cherokee quadrangle (7.5 minute, 1970), Butte County, northern California. Chico Formation, Pentz Road member (informal) of Russell et al. (1986). Age: Early Campanian. Collector: R. Watkins. = LACMIP loc. 17206.

CSUN 153. [= LACMIP 11975.] At elevation of 1450 ft., in bottom of south fork of Garapito Creek, 533 m (1750 ft.) S and 521 m (1710 ft.) E of the intersection of the San Bernardino base line and Los Angeles City boundary, U.S. Geological Survey Topanga quadrangle (7.5 minute, 1952, photorevised, 1967), Santa Monica Mountains, Los Angeles County, southern California. Unnamed strata. Age: Late middle Campanian. Collector: John Alderson, 1974–1987. [See Fritsche's (1973) map for a plot of this locality on a detailed topographic base.]

LACMIP 10833. Fossiliferous layers cropping out in beds of small gullies in field along Pentz Road [formerly Durham-Pentz Road], approximately 290 m (950 ft.) S and 107 m (350 ft.) E of NW corner of section 25, T. 1 N, R. 3 E, U.S. Geological Survey Cherokee quadrangle (7.5 minute, 1970), Butte County, northern California. Chico Formation, Pentz Road member (informal) of Russell et al. (1986). Age: Early Campanian. Collector: W. P. Popenoe, 1931.

LACMIP 27002. South fork of Garapito Creek, U.S. Geological Survey Topanga quadrangle (7.5 minute, 1952, photorevised, 1967), Santa Monica Mountains, Los Angeles County, southern California. Unnamed strata. Age: Late middle Campanian. Collector: Mike Hamilton, circa middle 1970s.