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New Late Cretaceous Epitoniid and Zygopleurid Gastropods from the Pacific Slope of North America

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Abstract. Seventeen species of epitoniid gastropods are discussed from Upper Cretaceous shallow-marine rocks in British Columbia, California, and northern Baja California. Eleven of the species are new: *Opalia* ***atra***, *Opalia* ***cavea***, *Amaea* ***trifolia***, *Amaea* ***cerva***, *Amaea* ***pentzia***, *Belliscala* ***petra***, *Belliscala* ***meta***, *Acirsa* ***alpha***, *Acirsa* ***beta***, *Acirsa* ***delta***, and *Acirsa* ***epsilon***. The genera *Amaea*, *Belliscala*, and *Acirsa* have not been previously reported from Cretaceous rocks in this region. Generic assignment, age, and distribution of *Opalia*? *mathewsonii* (Gabb, 1864), *Belliscala suciense* (Whiteaves, 1879), *Acirsa obtusa* (White, 1889), *Acirsa nexilia* (White, 1889), and *Confusiscala newcombii* (Whiteaves, 1903) are discussed. *Claviscala* sp. is recognized, and it represents the first confirmed Late Cretaceous occurrence of this genus in this region.

The very rare and large ***Zebalia*** n. gen. *suciensis* (Packard, 1922), from Upper Cretaceous rocks in Washington and southern California, is an epitoniid-like zygopleurid gastropod and the first Late Cretaceous record of zygopleurids.

INTRODUCTION

As far as we know, this is the first paleontologic study anywhere in the world that has focused on Late Cretaceous epitoniid gastropods. It is certainly the first detailed study of Late Cretaceous epitoniid gastropods from shallow-marine rocks in a region extending from Vancouver Island, British Columbia, Canada, to northern Baja California, Mexico (Figure 1). The only other study devoted entirely to epitoniids from this region is Durham's (1937) study of Mesozoic and Cenozoic species, with an emphasis on the latter. He listed only five Mesozoic epitoniid taxa, two of Early Cretaceous age and three of Late Cretaceous age. Studies by Saul & Popenoe (1993) and by us indicate that of these five, only two are unequivocal epitoniids: *Opalia* (*Confusiscala*) *mathewsonii* (Gabb, 1864) and *Opalia* (*Confusiscala*) *mathewsonii* (Gabb)?. The former is herein identified as *Opalia*? *mathewsonii*, and the latter is the same as *Confusiscala*? *sulfurea* Saul & Popenoe, 1993.

Over the last few years, while examining the collections of Late Cretaceous fossils at the Natural History Museum of Los Angeles County, we detected 11 new species of epitoniids and a new genus of an epitoniid-like zygopleurid gastropod, formerly known as "*Cerithium*" *suciaensis* Packard, 1922. Also included in this paper is a restudy of the poorly known *Opalia*? *mathewsonii* Gabb, 1864, as well as the description augmentation, generic reassignment, and biostratigraphic analyses of the following four other previously named species of Late Cretaceous epitoniids from the study area: *Cerithium lallierianum*, var. *suciense* Whiteaves, 1879; *Mesalia obtusa* White, 1889; *Ceratia nexilia* White, 1889; and *Mesostoma newcombii* Whiteaves, 1903. *Cirsotrema tenuisculptum* Whiteaves, 1879, is not an epitoniid. The chronostratigraphic positions of the new and restudied taxa are shown in Figure 2. Most of these taxa occur between the Santonian and late Campanian, and this peak in epitoniid diversity is coincident with a cooling of the waters in this region when warm-temperate seas were the norm, relative to the warmer seas of the Turonian and the Maastrichtian (Saul, 1986).

Much of this present study stems from collections made by Saul (1959) in the Chico Formation of northern California. Her detailed stratigraphic locality data have made it possible to sort out and arrange chronologically, similar faunas of different ages. In addition, collections of epitoniids made by various collectors from the Chatsworth Formation of southern California are also very valuable.

The family Epitoniidae Berry, 1910, is a group of marine gastropods popularly referred to as "wentletraps." It is a relatively large family with more than 600 Recent species and an additional 300 or 400 fossil species. Epitoniids can be found worldwide, from the intertidal zone

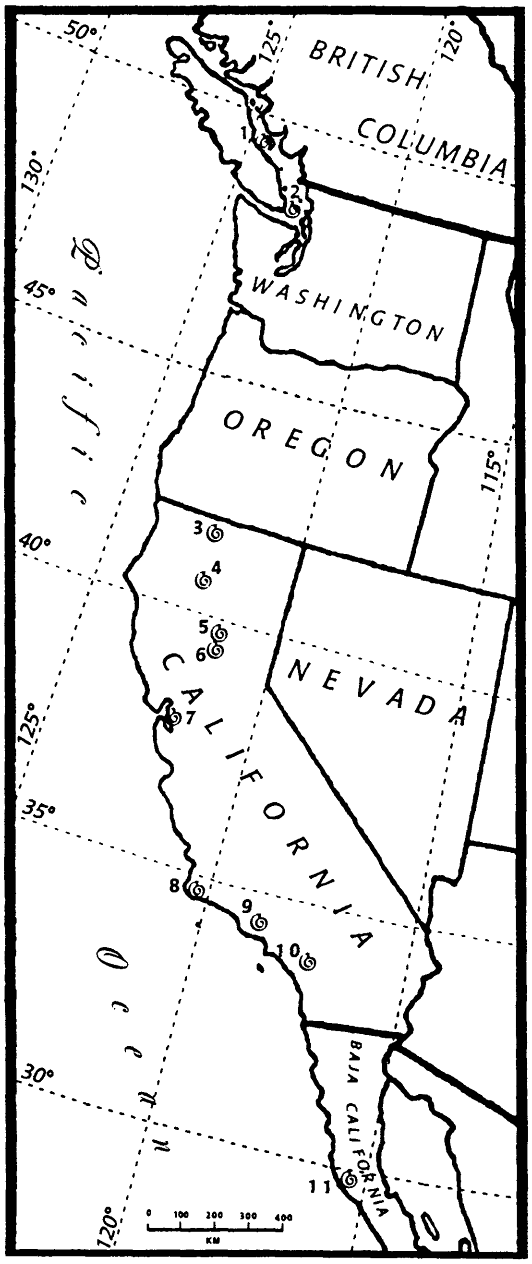


Figure 1. Index map of the study area's geographic place names mentioned in text. 1 = Hornby Island. 2 = Sucia Island. 3 = Yreka area. 4 = East of Redding. 5 = Chico Creek. 6 = Pentz. 7 = Martinez. 8 = Jalama Creek. 9. = Simi Hills. 10. = Santa Ana Mountains. 11. = Arroyo Santa Catarina.

to deep water but are rare in the abyssal zone (> 6000 m depth). They are particularly common in shallow, warm waters of the continental shelf. Some epitoniids have planktotrophic larval stages (Bouchet & Warén, 1986), hence wide dispersal. Members of the family are predators or parasites on sea anemones or corals (Bouchet & Waren, 1986; Weil et al., 1999), and most epitoniid species seem to be loosely associated with their prey or host species (Bouchet & Warén, 1986).

According to Cossmann (1912), the earliest known epitoniid is the Middle Jurassic (Bathonian) *Proacirsa inornata* (Terquem & Jourdy, 1869; Wenz, 1940:fig. 2290) from Lorraine, France. According to Clench & Turner (1950), the greatest generic/subgeneric diversities of epitoniids took place during the Eocene and Miocene. On the Pacific slope of North America, however, the greatest generic/subgeneric diversities were during the Oligocene (Durham, 1937:481–483) and Pliocene (DuShane, 1979: 95), with seven genera/subgenera during both times. In comparison, during the Eocene and Miocene in this region, there were three and six genera/subgenera, respectively (Durham, 1937:481–483). The greatest generic diversity of Cretaceous epitoniids from the Pacific slope of North America was during the early to middle Campanian, with six genera present (Figure 2). On a worldwide scale, it is very difficult to assess Cretaceous epitoniid generic diversity because many of the specimens illustrated in the literature do not show the critical views of the aperture and basal part of the last whorl. In addition, diversity studies are difficult because early workers used very broadly defined generic names (e.g., *Scala* Bruguière, 1792; *Scalaria* Lamarck, 1801) that have been replaced by a multitude of other generic names. Very few modern workers have attempted to do additional collecting and restudy of these faunas.

The higher classification system used here follows that of Bandel (1991). Abbreviations used for catalog and locality numbers are: ANSP, Academy of Natural Sciences, Philadelphia; GSC, Geological Survey of Canada, Ottawa, Ontario; CIT, California Institute of Technology, Pasadena [collections now housed at LACMIP]; LACMIP, Natural History Museum of Los Angeles County, Invertebrate Paleontology Section; UCMP, University of California, Museum of Paleontology, Berkeley; USGS, United States Geological Survey, Menlo Park [collections now housed at UCMP]; USNM, United States National Museum, Washington, D. C.

STRATIGRAPHY

The geologic ages of most of the formations/members cited in this paper have been summarized by Saul (1982), Haggart & Ward (1984), and Squires & Saul (2001, 2003). Cited literature in these papers includes relevant information on lithostratigraphy and depositional environments. Stratigraphic information mentioned below concerns either those rock units not discussed in recent literature or additional pertinent biostratigraphic details.

Osburger Gulch Sandstone Member of Hornbrook Formation

This Cenomanian to lower Coniacian member crops out in northern California and southwestern Oregon and

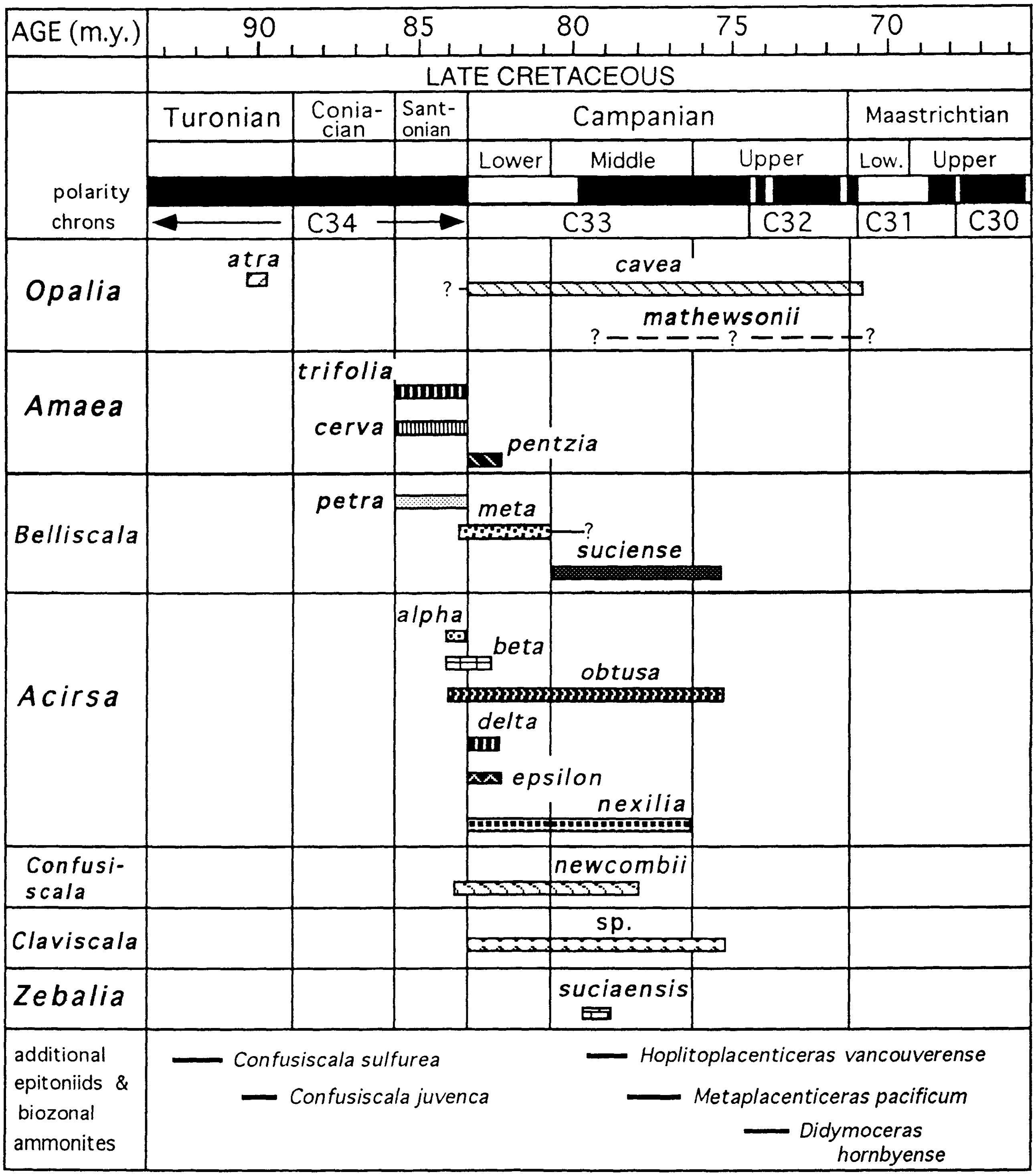


Figure 2. Chronostratigraphic positions of the new and restudied Late Cretaceous epitoniid and zygopleurid gastropods from the Pacific slope of North America. Geologic ages, polarities, and chrons after Gradstein et al. (1994). Ammonite biozones after Matsumoto (1959, 1960) and Elder & Saul (1996).

is primarily a high-energy nearshore deposit containing abundant molluscan fossils (Nilsen, 1984). The type locality of *Opalia* ***atra*** is in this member in the Yreka area (Figure 1), and this locality has also yielded the gastropods *Carota dilleri* (White, 1889) and *Turritella hearni* Merriam, 1941. The former is indicative of the early to late Turonian (Saul & Popenoe, 1993), and the latter is indicative of the late Turonian to possibly early Coniacian (Saul, 1982). Based on the overlapping geologic ranges of these two species, the age of the type locality beds of *O.* ***atra*** is late Turonian.

Redding Formation

This formation crops out east of Redding, Shasta County, northern California (Figure 1) and consists of several shallow-marine members deposited during the Turonian to Santonian stages. The members that concern this paper are Members V and VI of Popenoe (1943). These members were also utilized by Murphy et al. (1957), Matsumoto (1959, 1960), and Trujillo (1960), with some modification of outcrop distribution of members V and VI by Murphy et al. (1957:pl. 3) and Matsumoto (1960:fig. 2). Haggart (1986) named Members IV to V, but his units do not directly correspond to those of Popenoe. Haggart included in his Hooten Gulch Mudstone Member the mudstones of Members IV and VI. The thick conglomerate at the base of Member V along Oak Run, Haggart referred to his Oak Run Conglomerate Member, but he did not discuss his concept of the stratigraphic equivalency of the remaining part of Member V. Conversion of Popenoe's (1943) version of the Redding Formation stratigraphy to Haggart's version would require a more detailed map than available in Haggart (1986: fig. 4) and a detailed integration of previous workers' biostratigraphic data.

All the specimens of *Amaea* ***trifolia*** sp. nov. and *Belliscala* ***petra*** sp. nov., as well as those specimens of *Amaea* ***cerva*** sp. nov. from east of Redding, were collected by Popenoe, and the recorded locality descriptions reflect his view of the stratigraphy. The first two of these species are both present in Members V and VI, and the localities (LACMIP 10794 and 24217 for both, as well as 24246 for *B.* ***petra***) they were found at correspond to the Santonian (Popenoe et al., 1987; Popenoe & Saul, 1987; Saul, 1988; Saul & Popenoe, 1992). Most of the specimens of *Amaea* ***cerva*** are of late Santonian age and from the upper part of the Musty Buck Member of the Chico Formation, but a few specimens are from LACMIP loc. 10786 in Member V (lower part), and the rocks at this locality are of early Santonian age (Saul, 1988).

"Trent River Formation"

This broad stratigraphic unit is equivalent to several formations that crop out along the eastern side of Vancouver Island from Hornby Island, British Columbia, on the north, to Sucia Island, Washington, on the south (Mustard, 1994). These formations, which include the Haslam, Extension, Pender, Protection, and Cedar District, range in age from Santonian to middle Campanian (Haggart, 1991).

Ten Mile Member of Chico Formation

The stratigraphically highest strata of the Chico Formation exposed along Big Chico and Butte creeks, Butte County, northern California (Figure 1) constitute the Ten Mile Member of Saul (1959, 1961), which was formalized by Haggart & Ward (1984). This silty sandstone member ranges in age from Santonian to early Campanian, and epitoniids are from the part recognized by Saul (1959) to be of early Campanian age. The member is quite fossiliferous, and on the basis of mollusks, the maximum-water depth of the member was 90 m (Saul, 1961).

Spray Formation

This formation, which was named by Usher (1952) for thin-bedded shale and sandstone outcrops on Hornby Island, east coast of Vancouver Island, British Columbia, is a sparsely fossiliferous, outer shelf to upper slope deposit (Haggart, 1991). Muller & Jeletzky (1970) subdivided the formation into a lower part, correlative to the ammonite *Metaplacenticeras pacificum* biozone, and an upper part, correlative to the ammonite *Didymoceras hornbyense* biozone. In modern usage, the *M. pacificum* biozone is equivalent to the upper middle Campanian to lower upper Campanian, and the *D. hornbyense* biozone is equivalent to the middle upper Campanian (Figure 2).

SYSTEMATIC PALEONTOLOGY

Class GASTROPODA Cuvier, 1797

Superorder CAENOGASTROPODA Cox, 1959

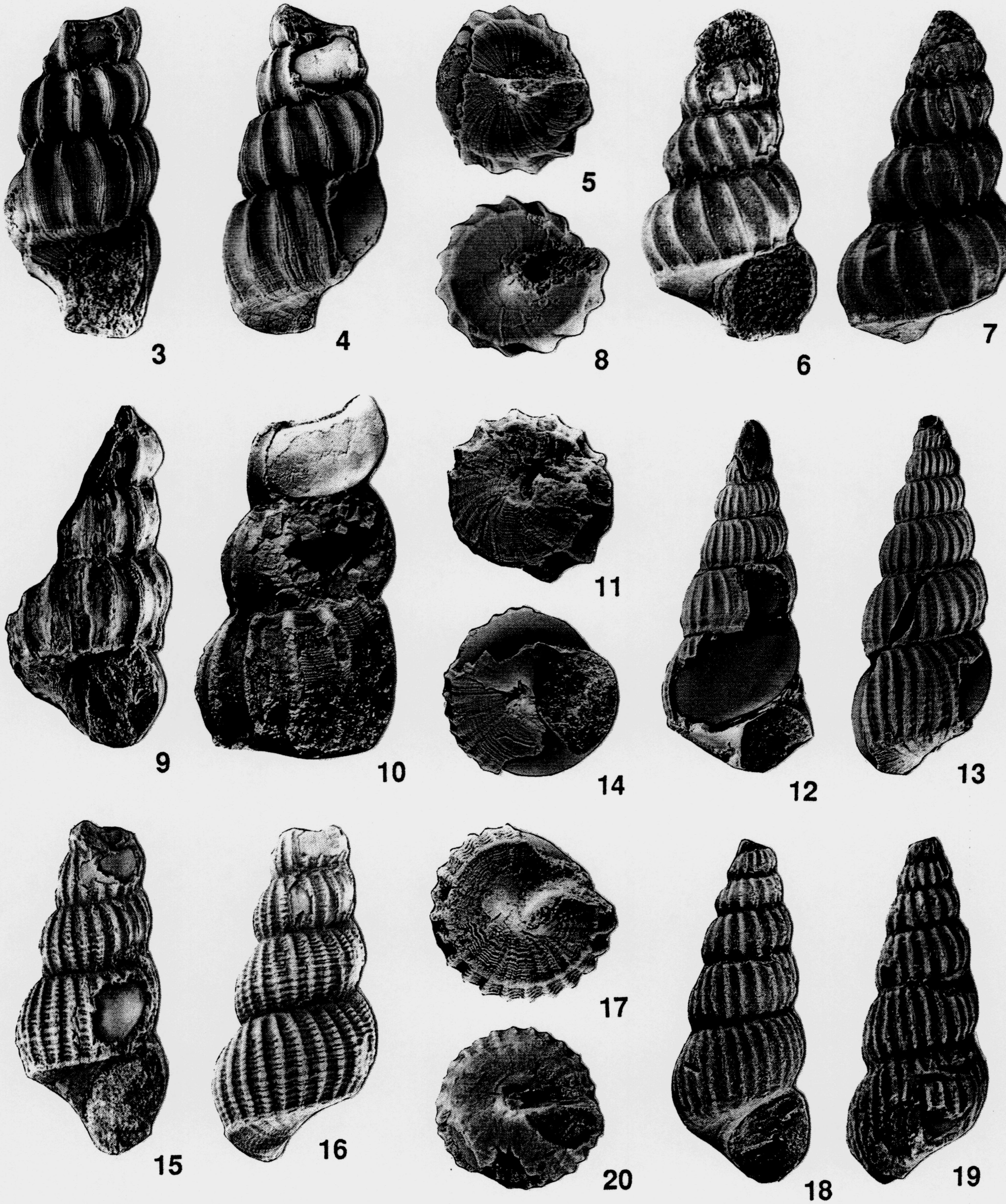
Order PTENOGLOSSA Gray, 1853

Superfamily Janthinoidea Lamarck, 1812

Family Epitoniidae Berry, 1910

Discussion: We follow the convention of most modern workers in using Berry (1910) as the author of family Epitoniidae. According to Garvie (1996:64), however, the first author to actually use the family name Epitoniidae seems to have been Suter (1913). This discrepancy needs to be officially resolved.

All the current classifications of this family are still based on shell characters, and the present state of knowledge of epitoniids allows for only a provisional classification scheme because the nomenclatural history of this family is chaotic, particularly above the species level (Weil et al., 1999). Much of this confusion is the result of the early French worker de Boury, who named many genera and subgenera but who provided, in many cases, no more than just type designations for the names. Some



of these type species are obscure European ones. Even when the type species can be examined, it is not always possible to differentiate the genera or subgenera. It must be realized that many of his names are probably superfluous or questionable, and that a rather broad interpretation of the better known taxa is the most practical approach until such time as the family can be thoroughly revised (Clench & Turner, 1950; Maxwell, 1992).

Kilburn (1985) reported that in scanning the Epitoniidae for synapomorphies that might be useful in formulating a classification, he received the impression that most lineages have arisen through the genetic "reshuffling" of a limited number of characters and that convergence is rampant. He also reported that radula studies have yielded little of value, and one must, at present, rely on shell characters. Bouchet & Warén (1986), however, reported that there are radular differences among the family, as well as some differences in the operculum. At present, only two major shell characters appear to be of "taxonomic value"; namely, the presence of a pitted intritacalx (or chalky layer external to the primary shell) and, especially, the protoconch form of those species with planktotrophic type of larval shell (Kilburn, 1985; Bouchet & Warén, 1986). Unfortunately, the intritacalx and protoconchs are rarely preserved in fossil epitoniids, especially those from the Cretaceous of the Pacific slope of North America.

Genus *Opalia* H. Adams & A. Adams, 1853

Type species: *Scalaria australis* Lamarck, 1822, by subsequent designation (de Boury, 1886); Recent, New South Wales to Western Australia.

Diagnosis: Shell solid, whorls joined, and not umbilicate. Axial ribs usually strong, broad, and occasionally angulated or nodulose. Spiral sculpture usually consisting of exceedingly fine incised threads, finely pitted or not. Intritacalx pitted and present on unworn specimens. Basal keel usually present and strong. Basal disk present or absent; transverse ribs absent on base. Operculum thin, corneous, paucispiral, and littorinoid in shape (Clench & Turner, 1950; Neville, 2001).

Discussion: One of the most diagnostic characters of *Opalia* is the pitted intritacalx, which consists of microscopic sculpture in a very thin and soft outer layer of calcium carbonate that is quickly lost in worn specimens. This feature is easily eroded and rarely preserved in fossil specimens (Bouchet & Warén, 1986). Although *Opalia* generally has axial ribs, all transitions seem to exist between species with strong axial sculpture and species with no axial sculpture at all.

Wenz's (1940:fig. 2297) illustration of the type species of *Opalia* shows transverse ribs on the base. Clench & Turner (1950), as well as other authors, have maintained that *Opalia* is distinctive for its lack of transverse ribs on the base. We have examined specimens of *O. australis* stored in the Natural History Museum of Los Angeles County, Malacology Section, and found them to be lacking transverse ribs on the base, just like the specimen of this species illustrated by Wells & Bryce (1985:fig. 148).

Opalia is morphologically very similar to *Confusiscala* de Boury, 1909, and future work may show them to be the same. The two new species of *Opalia* described below have narrow axial ribs, as well as very weak to nearly obsolete spiral ribbing, and are more similar to the type species of *Opalia,* than they are to the type species of *Confusiscala,* which has swollen axial ribs and relatively strong spiral ribbing. *Opalia*? *mathewsonii* (Gabb, 1864), which is also included in this present report, generally resembles *Opalia* but cannot be positively placed in this genus because of poor preservation of the available material.

According to Bouchet & Warén (1986), *Opalia* is morphologically indistinguishable from *Gregorioiscala* Cossmann, 1912, and *Punctiscala* de Boury, 1890, both of which are found today only in bathyal and abyssal habitats. Bouchet & Warén (1986), however, preferred to treat *Opalia* as distinct from these two genera because *Gregorioiscala* and *Punctiscala* are bathymetrically distinct.

As will be discussed below, the two new species of *Opalia* described here, and especially *Opalia* ***cavea,*** are very similar to an array of other Cretaceous *Opalia* found throughout the world. These Cretaceous species are, in

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Figures 3–20. Specimens coated with ammonium chloride, unless otherwise stated. Figures 3–5. *Opalia* ***atra*** Squires & Saul, sp. nov., holotype LACMIP 12898, LACMIP loc. 25401, Yreka area, ×3.6. Figure 3. Apertural view. Figure 4. Abapertural view. Figure 5. Basal view. Figures 6–8. *Opalia* ***cavea*** Squires & Saul, sp. nov., holotype LACMIP 12990, LACMIP loc. 2853, Arroyo Santa Catarina, ×3.3 Figure 6. Apertural view. Figure 7. Abapertural view. Figure 8. Basal view. Figures 9–11. *Opalia*? *mathewsonii* (Gabb, 1864), holotype ANSP 4220, Martinez area, specimen uncoated. Figure 9. Apertural view, ×2.7. Figure 10. Right-lateral view, ×3.7. Figure 11. Basal view, ×3.4. Figures 12–14. *Amaea* ***trifolia*** Squires & Saul, sp. nov., holotype LACMIP 12991, LACMIP loc. 24217, east of Redding. Figure 12. Apertural view, ×2.9. Figure 13. Left-lateral view, ×2.9. Figure 14. Basal view, ×3.5. Figures 15–17. *Amaea* ***cerva*** Squires & Saul, sp. nov., holotype LACMIP 12992, LACMIP loc. 10849, Chico Creek. Figure 15. Apertural view, ×2.7. Figure 16. Abapertural view, ×2.7. Figure 17. Basal view, ×3.3. Figures 18–20. *Amaea* ***pentzia*** Squires & Saul, sp. nov., holotype LACMIP 12993, LACMIP loc. 24340, Pentz area, ×2. Figure 18. Apertural view. Figure 19. Abapertural view. Figure 20. Basal view.

turn, very similar to the *Opalia australis*, the living type species of *Opalia*.

The geologic range of *Opalia* sensu lato is Late Jurassic to Recent (Durham, 1937).

Opalia ***atra*** Squires & Saul, sp. nov.

(Figures 3–5)

Diagnosis: An *Opalia* with slightly sinuous and slightly prosocline axial ribs, approximately 11 to 12 of them on middle-spire whorls. Spiral striae very fine. Basal keel strong.

Description: Shell medium small (up to 14.7 mm high), turriculate, with high spire. Pleural angle approximately 23° (estimated). Protoconch and upper spire unknown. Teleoconch whorls approximately six (estimated), rounded, suture moderately impressed. Axial ribs stronger than spiral sculpture. Axial ribs narrow to moderately broad, moderately spaced, extending from suture to suture, not aligned from whorl to whorl, slightly prosocline, occasionally sinuous posteriorly, usually reflexed leftward near posterior suture, approximately 13 on last whorl, 12 on penultimate whorl, and approximately 11 on ante-penultimate whorl. Spiral sculpture consisting of numerous, very closely spaced spiral striae crossing axial ribs. Basal keel prominent, slightly swollen where axial ribs meet it. Basal disk with microscopic spiral ribs and some raised growth lines; axial ribs obsolete. Aperture ovate, anterior end twisted slightly to left.

Dimensions of holotype: Incomplete specimen of three whorls, height 14.7, diameter 7 mm.

Holotype: LACMIP 12989.

Type locality: LACMIP loc. 25401, 41°51′30″N, 122°30′W.

Geologic age: Late Cretaceous (late Turonian).

Distribution: Hornbrook Formation, Osburger Gulch Sandstone Member, Siskiyou County, northern California.

Discussion: Only two specimens are known. Both are partial specimens, with one of them consisting of only the last whorl, without its base. The new species is very similar to *Opalia* ***cavea*** sp. nov. but differs from it by having a slightly narrower pleural angle; broader and fewer axial ribs that are more sinuous; and spiral striae that are more prominent. *Opalia* ***atra*** is somewhat similar to *Confusiscala*? *juvenca* Saul & Popenoe (1993:359–360, figs. 25, 26) from the Turonian Frazier Siltstone Member of the Redding Formation, Redding area, Shasta County, northern California. *Opalia* ***atra*** differs from *C.*? *juvenca* by having much narrower and more numerous axial ribs, much weaker spiral striae, and probably a narrower pleural angle.

Etymology: The specific name *atra* is Latin, meaning black, and refers to Black Mountain in the type-locality area.

Opalia ***cavea*** Squires & Saul, sp. nov.

(Figures 6–8)

Diagnosis: An *Opalia* with a 28° pleural angle. Axial ribs prosocline, approximately 14 to 15 on middle-spire whorls. Spiral striae nearly obsolete. Basal keel strong.

Description: Shell medium small (up to 19.2 mm high), turriculate, with high spire. Protoconch and upper spire unknown. Pleural angle approximately 28°. Teleoconch whorls approximately six (estimated), rounded, suture moderately impressed and with or without a subsutural cord. Axial ribs stronger than spiral sculpture. Axial ribs narrow, moderately spaced, extending from suture to suture, generally aligned from whorl to whorl on upper spire but becoming less so on more mature whorls, prosocline, occasionally reflexed leftward near posterior suture, 14 on last whorl, and 15 on penultimate and antepenultimate whorls. Spiral striae between axial ribs nearly obsolete, except for very faint striae (especially near anterior suture) on some whorls. Basal keel prominent, noded where axial ribs meet it. Basal disk with very faint, closely spaced spiral striae and some raised growth lines. Aperture subcircular, inner lip with thin callus.

Dimensions of holotype: Incomplete specimen of 3.5 whorls, height 16.2 mm, diameter 8.6 mm.

Holotype: LACMIP 12990.

Type locality: LACMIP loc. 2853, 29°36′N, 115°15′W.

Geologic age: Late Cretaceous (latest Santonian?, Campanian to early Maastrichtian).

Distribution: UPPERMOST SANTONIAN: Tentatively in the Chico Formation, Musty Buck Member, Chico Creek, Butte County, northern California; LOWER CAMPANIAN: Chico Formation, Ten Mile Member, Chico Creek, Butte County, northern California. MIDDLE CAMPANIAN: Tentatively in the Cedar District Formation, Sucia Island, San Juan County, Washington. LOWER UPPER CAMPANIAN: Jalama Formation, Santa Barbara County, southern California. UPPER CAMPANIAN TO LOWER MAASTRICHTIAN: Upper part of Chatsworth Formation, Lang Ranch area, western Simi Hills, Ventura County, southern California; Rosario Formation, "Ammonite Ravine," Arroyo Santa Catarina, northern Baja California, Mexico.

Discussion: The new species is known from approximately 20 specimens. Preservation is mostly poor, but a few specimens have moderately good preservation.

The new species is very similar to *Opalia* ***atra*** sp. nov. but differs from *O.* ***atra*** by having a slightly wider pleural angle; narrower, more numerous axial ribs that are more prosocline; and nearly obsolete spiral striae between axial ribs.

The new species is very similar to *Opalia*? *mathewsonii* (Gabb, 1864), discussed below. The new species differs from *O.*? *mathewsonii* by having axial ribs that are unnoded, more prosocline and more uniform in width; nearly obsolete spiral striae between axial ribs; finer spiral sculpture; and obsolete axial ribs on basal disk.

The new species is very similar to *Opalia* (*Opalia*?) *fistulosa* Sohl (1964:320–321, pl. 52, figs.1, 2) from Maastrichtian strata in Mississippi. The new species differs from Sohl's species by having an absence of fine punctae on the spiral lines covering the whorl sides and having weaker spiral sculpture on the basal disk.

Opalia ***cavea*** is also very similar to *Opalia* (*Opalia*) sp. A Perrilliat et al. (2000:16, fig. 6.15) and *Opalia* (*Opalia*) sp. B Perrilliat et al. (2000:16, fig. 6.17), both from lower Maastrichtian strata of southern Mexico. *Opalia* ***cavea*** differs from these two species by having spiral striae that are nearly obsolete. *Opalia* (*O.*) sp. A and *O.* (*O.*) sp. B both have spiral ribs covering the whorl sides and crossing the axial ribs. In the former species, the spiral ribs are fine in strength, whereas in the latter species, they are medium in strength.

Opalia ***cavea*** is also very similar to *Epitonium faearium* Dockery (1993:84, pl. 26, fig. 13; pl. 27, figs. 10, 11; pl. 41, figs. 4, 5) from Campanian strata of Mississippi. Perrilliat et al. (2000) reported *Epitonium* cf. *faearium* from Maastrichtian strata of southern Mexico. *Opalia* ***cavea*** differs from *E. faearium* by having a wider pleural angle and axial ribs that are more prosocline.

Opalia ***cavea*** sp. nov. is similar to *Confusiscala uchauxensis* Roman & Mazeran (1920:39, pl. 4, fig. 21) from Turonian strata of the Uchaux basin in southwestern France. Comparison is difficult because Roman & Mazeran only figured the dorsal view of their species. The new species differs from *C. uchauxensis* by having a more rounded last whorl and possibly one more axial rib per whorl on the more mature whorls.

Webster (1983) provided a detailed index map of the type locality area of the new species.

Etymology: The specific name *cavea* is Latin, meaning a cage for animals, and refers to the resemblance of the shell to an elongate cage for birds.

Opalia? *mathewsonii* (Gabb, 1864)

(Figures 9–11)

Scalaria (*Opalia*) *mathewsonii* Gabb, 1864:212, pl. 32, fig. 278; 1869, p. 223.

Epitonium (*Confusiscala*) *mathewsonii* (Gabb). Stewart, 1927:321–322, pl. 24, fig. 20.

Opalia (*Confusiscala*) *mathewsonii* (Gabb). Durham, 1937: 504, unfig.

Not *Opalia* (*Confusiscala*) *mathewsonii* (Gabb)?. Durham, 1937:504, pl. 56, fig. 23 (= holotype of *Confusiscala*? *sulfurea* Saul & Popenoe, 1993).

Supplementary description: Shell medium (up to 27.8 mm high), turriculate. Pleural angle approximately 22° (estimated). Protoconch and upper spire unknown. Teleoconch whorls approximately seven to eight (estimated), rounded, suture slightly impressed and undulatory. Axial ribs stronger than spiral sculpture; axial ribs narrow, minutely noded, moderately spaced, extending from suture to suture, not aligned from whorl to whorl, slightly prosocline to orthocline, occasionally reflexed leftward near posterior suture, and approximately 15 (estimated) on last whorl. Spiral ribs very fine, very closely spaced, and crossing axial ribs. Basal keel prominent. Basal disk with very fine spiral ribs and irregularly spaced, weak and narrow axial ribs. Aperture subcircular.

Dimensions of holotype: Incomplete specimen of five whorls, height 22.1 mm, diameter 9.2 mm.

Holotype: ANSP 4220.

Type locality: Great Valley Series near Martinez, Contra Costa County, northern California (see "Discussion" below).

Geologic age: Late Cretaceous (probably Campanian to early Maastrichtian).

Distribution: MIDDLE CAMPANIAN: Tentatively in the Chatsworth Formation, Bell Canyon, eastern Simi Hills, Ventura County, southern California. EARLY TO LATE CRETACEOUS GREAT VALLEY SERIES: Cretaceous rocks near Martinez, Contra Costa County, northern California.

Discussion: The location of the type locality of *O.*? *mathewsonii* is uncertain, as it was given as "near" Martinez, Contra Costa County, northern California. Cretaceous rocks in the vicinity of Martinez are in fault slivers and range in age from Albian to Maastrichtian. A partial specimen of a medium-large, poorly preserved individual from LACMIP loc. 26020 in the middle Campanian part of the Chatsworth Formation at Bell Canyon, eastern Simi Hills, southern California, is tentatively identified as *O.*? *mathewsonii*. Only two and one-half whorls are present, and they show 16 axial ribs, of variable width, crossed by fine spirals, and there appears to be remnants of axial nodes. This specimen lends support to the type locality of *O.*? *mathewsonii* being in Upper Cretaceous rocks rather than in Lower Cretaceous rocks. Saul & Popenoe (1993) surmised that the holotype of *O.*? *mathewsonii* is probably of Maastrichtian age.

Opalia? *mathewsonii* is included in this present paper because it is similar to the two new species of *Opalia* illustrated and discussed here. The right-lateral and basal views (Figures 10, 11) of the holotype (ANSP 4220) are illustrated here for the first time.

Genus *Amaea* H. & A. Adams, 1853, *sensu lato*

Type species: *Scalaria magnifica* Sowerby, 1844, by subsequent designation (Boury, 1909); Recent, Pacific coast of Japan.

Diagnosis: Shell acuminate, whorls joined, and not umbilicate. Protoconch smooth, conical, and polygrate. Suture impressed. Sculpture consisting of both axial and spiral ribs, usually cancellate (occasionally a few irregular varices). Basal keel prominent or weak (only a line and visible, or not, next to suture). Basal-disk sculpture similar to or unlike that on rest of teleoconch, axial ribs occasionally passing onto basal disk. Aperture ovate to quadrate (Clench & Turner, 1950; DuShane, 1974, 1979; Kilburn, 1985; Garvie, 1996; Neville, 2001).

Discussion: Sixteen subgenera of *Amaea* were recognized by Wenz (1940), and eight subgenera of this genus were recognized by Weil et al. (1999). Attempts by us to place the following three new species into subgenera proved to be tenuous at best and overall most unsatisfactory. It seems that many of these subgenera were based on descriptions of single species. Some of them, especially extinct genera like *Coniscala* de Boury, 1887 and *Unidiscala* de Boury, 1909, are rare, poorly preserved, not fully described, and poorly illustrated. Their definitions are very narrowly construed and impractical to use for intermediate forms, like those encountered in this study. Pending a thorough revision of the definitions of these subgenera, so that they include the concepts of variation and of incorporating similar species into one genus, we believe it to be prudent to heed the advice of Clench & Turner (1950) and use a rather broad interpretation of the better known taxa. In this paper, therefore, we use *Amaea* sensu lato. Its geologic range is late Early Cretaceous (Albian) to Recent (Wenz, 1940).

Amaea ***trifolia*** Squires & Saul, sp. nov.

(Figures 12–14)

Diagnosis: An *Amaea* with axial ribs strong, closely spaced, and reflected leftward near posterior suture. Spiral ribs weak, moderately widely spaced, not crossing axial ribs. Subsutural rib and sulcus posterior to subsutural rib. Basal keel weak, and weak axial ribs crossing onto basal disk.

Description: Shell medium small (up to 28.3 mm high), turriculate, with high spire. Pleural angle approximately 25°. Protoconch unknown. Teleoconch whorls approximately nine (estimated), rounded, suture moderately impressed and usually containing a subsutural rib, with a sulcus posterior to subsutural rib. Axial ribs stronger than spiral sculpture; axial ribs moderately strong, closely spaced, half as broad as interspaces, occasionally irregularly spaced, extending from suture to suture, somewhat aligned on early whorls but much less so on later whorls, opisthocyrt, reflexed leftward near posterior suture, and approximately 22 on last whorl, penultimate, and antepenultimate whorls. Spiral ribs weak and closely spaced, approximately as broad as interspaces; spiral ribs much weaker and more closely spaced than axial ribs; spiral ribs faint to obsolete? on upper spire whorls, with a tendency to become stronger on later whorls; and spiral ribs extending onto sides of axial ribs but not across them. Basal keel weak, same width as axial ribs and noded where crossed by them. Basal disk with axial ribs much thinner than on last whorl with some becoming obsolete toward axis of shell; spiral ribs on basal disk crenulated, very fine, thinner, and more closely spaced than elsewhere on shell. Aperture ovate; inner lip with a smooth callus (at least in parietal region).

Dimensions of holotype: Incomplete specimen of 6.5 whorls; height 19.4 mm, diameter 8.13 mm.

Holotype: LACMIP 12991.

Type locality: LACMIP loc. 24217, 40°36′40″N, 122°4′20″W.

Geologic age: Late Cretaceous (Santonian).

Distribution: Redding Formation, Members V and VI of Popenoe (1943), east of Redding, Shasta County, northern California.

Discussion: The above description is based on six specimens. Although much of the shell is missing on the last whorl and penultimate whorl of the holotype, the preservation of the remaining shell is very good and much better than the other specimens, which are incomplete and more weathered. The pleural angle is somewhat difficult to measure on the holotype because the penultimate whorl is crushed. Spiral ribs were not observed on the uppermost spire whorls of this species, but this might be a result of preservation.

The new species is most similar to *Amaea* ***pentzia*** sp. nov. and differs from it by having opisthocyrt axial ribs (rather than nearly straight ones), narrower axial ribs, subsutural rib and associated sulcus, basal keel, and no microscopic spiral striae and associated banding.

The new species is similar to *Amaea* ***cerva*** sp. nov. and differs from it by having a subsutural rib and associated sulcus, a weaker basal keel, less prominent spiral ribs, and, therefore, an absence of subcancellate ornamentation. In addition, the new species differs from *A.* ***cerva*** by having spiral ribs that are narrower, more uniform in width, not crossing the axial ribs, and without interribs.

Etymology: The specific name *trilofia* is Latin, meaning clover, and refers to the type locality in Clover Creek.

Amaea ***cerva*** Squires & Saul, sp. nov.

(Figures 15–17)

Diagnosis: An *Amaea* with subcancellate sculpture (axial ribs stronger than spiral ribs); narrow interspaces with occasional spiral interrib. Basal keel prominent.

Description: Shell medium (up to 31.5 mm high), turriculate, with high-acuminate spire. Pleural angle approximately 23°. Protoconch unknown. Teleoconch whorls approximately nine to 10 (estimated), rounded, suture moderately impressed. Sculpture subcancellate, with axial ribs stronger than spiral ribs. Axial ribs moderately strong, moderately spaced, and half as broad as interspaces. Axial ribs extending from suture to suture, not usually aligned from whorl to whorl, mostly straight (orthocline), occasionally slightly reflexed leftward near posterior suture (especially on later whorls), and approximately 20 to 22 on last whorl, penultimate, and ante-penultimate whorls. Spiral ribs numerous, crossing axial ribs, flat, variable width, narrower and more closely spaced on posterior part of whorls near suture, wide and straplike especially on medial part of whorls, very closely spaced, and narrow interspaces with occasional interrib. Basal keel prominent. Axial ribs cross weakly onto basal disk, with some axial ribs becoming obsolete toward axis of shell; spiral ribs on basal disk crenulate, thinner and more closely spaced than elsewhere on shell. Aperture ovate; outer lip thin, without a thickened varix; inner lip thicker, reflected, and with thin callus wash extending onto basal disk.

Dimensions of holotype: Incomplete specimen of 3.5 whorls, height 20 mm, diameter 9.2 mm.

Holotype: LACMIP 12992.

Type locality: LACMIP loc. 10849, 39°52′35″N, 121°42′15″W.

Geologic age: Late Cretaceous (Santonian).

Distribution: Redding Formation, Member V (lower part) of Popenoe (1943), east of Redding, Shasta County, northern California; Chico Formation, Musty Buck Member, Chico Creek, Butte County, northern California.

Discussion: The above description is based on approximately 30 fragmental specimens. Preservation is moderately poor to poor, and no specimen has a complete, undamaged aperture.

The new species is most similar to *Acrilla* (*Unidiscala*) *lolakensis* Durham (1937:509–510, pl. 56, fig. 22) from the Paleocene Martinez Formation, stratigraphically situated near the lower-upper Paleocene boundary at Lower Lake, Lake County, northern California (see Squires, 1997). The new species differs from Durham's species by having much wider spiral ribs with much narrower interspaces, and a secondary spiral rib only rarely in these interspaces.

Amaea ***cerva***, sp. nov. is very similar to *Amaea reticulata* (Solander in Brander, 1766; Castell, 1975:pl. 17, fig. 6) from the upper middle to lower upper Eocene Bracklesham-Barton Beds, Hampshire basin, southern England. The new species differs by having larger size, wider and stronger axial and spiral ribs, fewer and much stronger spiral interribs, and spiral ribs that cross the axial ribs.

The new species resembles somewhat *Amaea* ***trilofia***, sp. nov. but differs from it by having subcancellate sculpture; stronger, more closely spaced, straighter, and flatter spiral ribs with an occasional interrib; no subsutural rib and associated sulcus; and a stronger basal keel.

Etymology: The specific name *cerva* is Latin, meaning deer or buck, and refers to the Musty Buck Member.

Amaea ***pentzia*** Squires & Saul, sp. nov.

(Figures 18–20)

Diagnosis: An *Amaea* with axial ribs strong, closely spaced, and nearly straight. Spiral sculpture consisting of microscopic spiral striae occurring in bands; spiral groove near change in sculpture on basal part of last whorl.

Description: Shell medium (up to 28.2 mm high), turriculate, with high spire. Pleural angle approximately 23°. Protoconch unknown. Teleoconch whorls approximately seven to eight (estimated), rounded, suture moderately impressed. Axial ribs narrow, prominent, relatively closely spaced, and approximately two-thirds as broad as interspaces. Axial ribs extending from suture to suture, somewhat aligned on later whorls but much less so on early whorls, nearly straight, slightly prosocline, occasionally slightly reflexed leftward near posterior suture, 28 on last whorl, 23 on penultimate whorl, and 17 on ante-penultimate whorl. Spiral striae microscopic, not crossing axial ribs, numerous, very closely spaced, occurring in white and yellow narrow bands, with both types becoming wider, and white bands becoming slightly elevated on penultimate and last whorls. Basal part of last whorl with narrow-spiral groove; axial ribs extending short distance beyond spiral groove and transitioning into faint axial ribs extending toward axis of shell but becoming obsolete before reaching axis; anterior end of base of last whorl with some fine, closely spaced spiral ribs. Aperture ovate; inner lip with smooth callus.

Dimensions of holotype: Incomplete specimen of 5.5 whorls, height 28.2 mm, diameter 11.3 mm.

Holotype: LACMIP 12993.

Type locality: LACMIP loc. 24340, 39°39′08″N, 121°35′50″W.

Geologic age: Late Cretaceous (early Campanian).

Distribution: Chico Formation, Pentz Road Member, Pentz area, Butte County, northern California.

Discussion: The above description is based on a single specimen, whose preservation is generally good. The last whorl has been subject to abrasion, resulting in the spiral striae not being discernible there, even when viewed by means of a microscope. The spiral bands, nevertheless, are evident on the last whorl.

The new species resembles *Amaea* ***trifolia***, sp. nov. but differs from it by having larger size, straighter and wider axial ribs, microscopic spiral striae and associated banding, no subsutural rib and associated sulcus, and a narrow-spiral groove rather than a basal keel.

Etymology: The specific name *pentzia* refers to the type locality near the hamlet of Pentz.

Genus *Belliscala* Stephenson, 1941

Type species: *Belliscala rockensis* Stephenson, 1941, by original designation; Upper Cretaceous (Campanian to Maastrichtian), Texas.

Diagnosis: Shell conical-turriculate, whorls joined, rounded, and not umbilicate. Suture impressed. Sculpture consisting of rounded axial ribs and weaker spiral threads. Base rounded without a well developed disk (Stephenson, 1941; Dockery, 1993).

Discussion: Sohl (1964) indicated that the lack of a distinct basal disk in *Belliscala* suggests placement close to *Acirsa* Mörch, 1857.

Prior to this study, *Belliscala* had only been reported from Upper Cretaceous (near the boundary of the lower/middle Campanian to Maastrichtian) rocks of the southern United States (east Texas and northeast Mississippi) (Stephenson, 1941; Sohl, 1964; Dockery, 1993). The new occurrences reported here extend the geologic range of this genus back to the Coniacian and extend its geographic range to the Pacific slope of North America, as far north as Sucia Island, Washington. Although at least one of the southern United States Campanian species of *Belliscala* closely resembles one of the Pacific coast species (see "Discussion" of *Belliscala* ***meta***, sp. nov. below), the southern United States Maastrichtian species of *Belliscala* differ from the Pacific slope ones by having very weak spiral ribs that do not cross the axials and an absence of nodes on the whorls.

Perrilliat et al. (2000) reported a *Belliscala* sp. from Maastrichtian strata of southern Mexico. Although the figured specimen of *Belliscala* sp. Perrilliat et al. (2000: fig. 6.16) is incomplete, its very convex whorls, non-rounded axial ribs, and very weak spiral threads strongly suggest that it is an *Opalia*.

Belliscala ***petra*** Squires & Saul, sp. nov.

(Figures 21–25)

Diagnosis: A *Belliscala* with approximately 18 axial ribs on last whorl, axial and spiral ribs moderately spaced and moderately swollen. Strong development of a finer inter-rib between spiral ribs on most of shell. Intersections of axial and spiral ribs with low nodes. Axial ribs weak to moderately weak on base of last whorl.

Description: Shell small (up to approximately 16.6 mm high), conical, with moderately high spire. Pleural angle approximately 34°. Protoconch unknown. Teleoconch whorls approximately eight (estimated), flatly rounded medially, with a slight subsutural ramp and glossy surface; suture moderately impressed. Whorls with subcancellate sculpture, axial ribs stronger than spiral sculpture, intersections of ribs with low nodes, usually elongate but occasionally swollen-beaded on shoulder of last whorl. Axial ribs broadly rounded, extending from suture to suture, not usually aligned from whorl to whorl, straight, prosocline, and becoming more irregular and numerous near outer lip. Axial ribs on immature specimens (less than 13 mm in height) approximately 16 on last whorl, and 13 to 14 on penultimate and ante-penultimate whorls. Axial ribs on mature specimens moderately spaced, approximately 18 on last whorl, and 13 to 14 on penultimate and ante-penultimate whorls. Spiral ribs on spire and posterior part of last whorl moderately spaced, crossing axial ribs, narrower than interspaces, and usually with one finer

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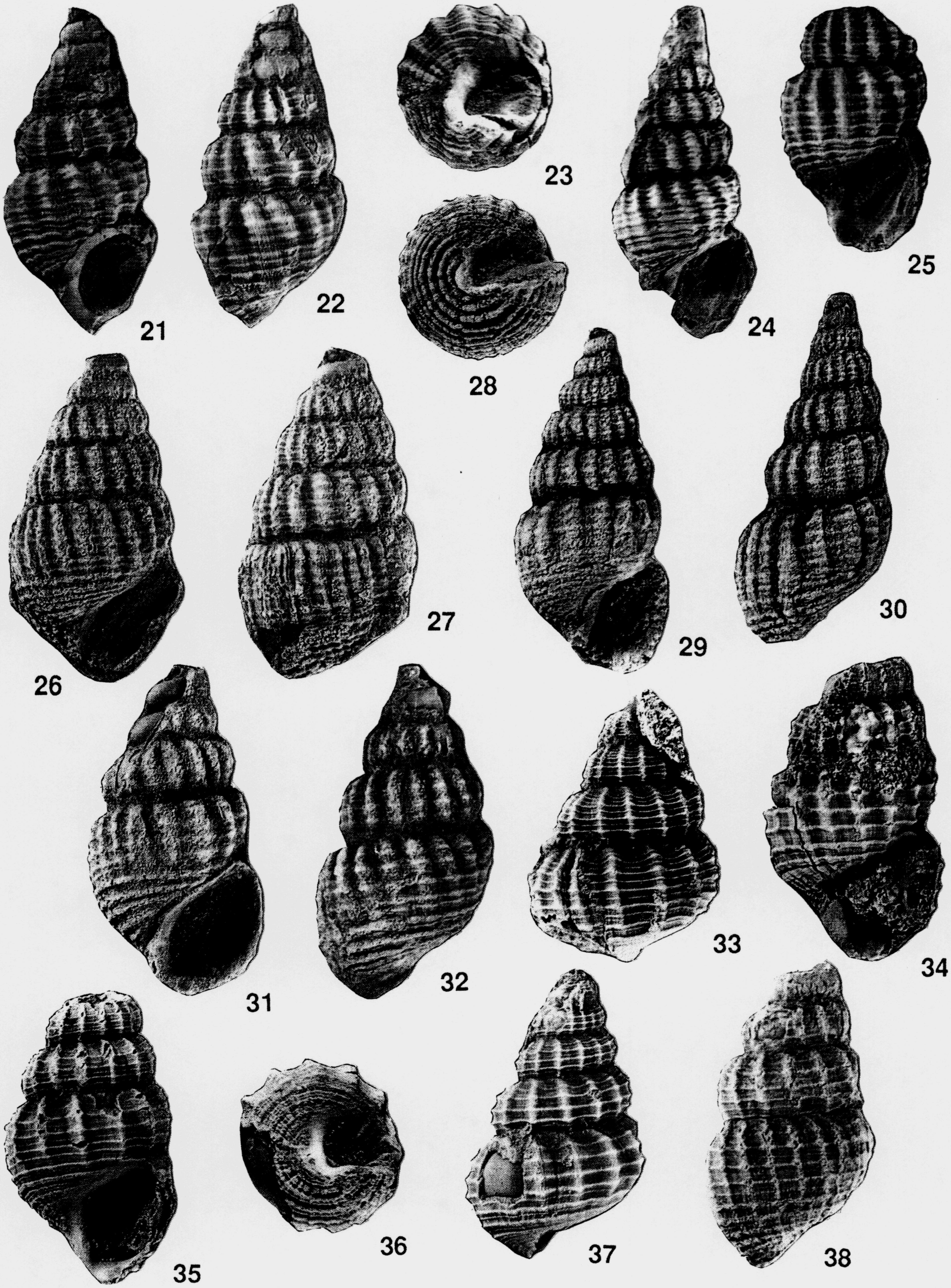
Figures 21–38. Specimens coated with ammonium chloride. Figures 21–25. *Belliscala* ***petra*** Squires & Saul, sp. nov., east of Redding. Figures 21–23. Holotype LACMIP 12994, LACMIP loc. 24246, ×4.2. Figure 21. Apertural view. Figure 22. Abapertural view. Figure 23. Basal view. Figure 24. Paratype LACMIP 12995, LACMIP loc. 24246, apertural view, ×3.3. Figure 25. Paratype LACMIP 12996, LACMIP loc. 10794, apertural view, ×4.2. Figures 26–33. *Belliscala* ***meta*** Squires & Saul, sp. nov. Figures 26–27. Holotype LACMIP 12997, LACMIP loc. 23635, Chico Creek, ×3.3. Figure 26. Apertural view. Figure 27. Abapertural view. Figure 28. Paratype LACMIP 12998, LACMIP loc. 23634, basal view, ×3.2. Figures 29–30. Paratype USNM 46851, USGS Mesozoic loc. M8610, Pigeon Point, slightly crushed, ×5.1. Figure 29. Apertural view. Figure 30. Abapertural view. Figures 31–32. Paratype LACMIP 12999, LACMIP loc. 23648, Chico Creek, ×4.4. Figure 31. Apertural view. Figure 32. Abapertural view. Figure 33–38. *Belliscala suciense* (Whiteaves, 1879). Figure 33. Lectotype GSC 5764b, Sucia Island, abapertural view, ×4.7. Figure 34. Hypotype GSC 5930, Sucia Island, apertural view, ×4.2. Figures 35–36. Hypotype LACMIP 13000, LACMIP loc. 10449, Sucia Island, ×3.9. Figure 35. Apertural view. Figure 36. Basal view. Figure 37. Hypotype LACMIP 13001, Sucia Island, abapertural view, ×4.8. Figure 38. Hypotype LACMIP 13002, LACMIP loc. 10715, Simi Hills, abapertural view, ×3.9.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intercalated rib; four spiral ribs on spire and five on posterior part of last whorl. Sculpture on basal part of last whorl consisting of weak axial ribs and closely spaced, five to six spiral ribs (three posterior ones strongest), commonly beaded or occasionally unbeaded, and broader than interspaces. Aperture oval; inner lip callused, smooth; anterior end of aperture thickened and slightly produced anteriorly.

Dimensions of holotype: Incomplete specimen of 5.5 whorls, height 12.8 mm, diameter 5.9 mm.

Holotype: LACMIP 12994.

Type locality: LACMIP loc. 24246, 40°37′45″N, 122°04′50″W.

Paratypes: LACMIP 12995 to 12996.

Geologic age: Late Cretaceous (Santonian).

Distribution: Redding Formation, Members V and VI of Popenoe (1943), east of Redding, Shasta County.

Discussion: The new species is based on 20 specimens. About half show good preservation, but the apices are usually broken off. The other specimens are mostly internal molds. The spiral ribs on the base of the last whorl of *Belliscala* ***petra*** are more closely spaced than elsewhere on the shell, and this close spacing, along with usually weaker axial ribs than elsewhere on the shell, imparts a weak, basal disklike appearance.

Belliscala ***petra*** is most similar to *Belliscala suciense* (Whiteaves, 1879) and differs from Whiteaves's species by having a narrower pleural angle; axial ribs that are more numerous, more swollen, more closely spaced, and not obsolete on the base of the last whorl; as well as by having swollen nodes rather than pointed nodes where the axial and spiral ribs intersect, and a stronger spiral interrib.

Belliscala ***petra*** differs from *Belliscala* ***meta***, sp. nov. by having a less variable pleural angle, a less stout shell, non-subtabulate whorls, fewer axial ribs that are more widely spaced and not obsolete on the base of the last whorl, stronger spiral ribs, more swollen nodes weaker at intersections of axial and spiral ribs, as well as having a good development of spiral ribs with an interrib.

Etymology: The specific name *petra* is Greek, meaning stone.

Belliscala ***meta*** Squires & Saul, sp. nov.

(Figures 26–32)

Bittiscala suciense (Whiteaves, 1879). Elder & Saul, 1993: pl. 2, fig. 9.

Not *Cerithium lallierianum*, var. *suciense* Whiteaves, 1879: 122–123, pl. 15, figs. 10, 10a.

Diagnosis: A *Belliscala* with stout shell, whorls subtabulate. Approximately 22 to 25 axial ribs on last whorl. Axial and spiral ribs closely spaced and swollen. Axial ribs on shoulder of whorls usually almost nodular. Approximately seven to eight closely spaced spiral ribs on most of shell, spiral interrib development uncommon. Axial ribs obsolete on base of last whorl.

Description: Shell small (up to 17.5 mm high), stout and conical, with moderately high spire. Pleural angle approximately 34°. Protoconch unknown. Teleoconch whorls approximately seven to eight (estimated), flatly rounded medially, and narrowly subtabulate posteriorly; suture moderately impressed. Upper spire whorls with cancellate sculpture, remaining whorls (except for base of last whorl) with subcancellate sculpture, axial ribs stronger than spiral sculpture, intersections of ribs almost nodular at shoulder, lowly noded elsewhere on shell. Axial ribs round-topped, closely spaced, extending from suture to suture, not usually aligned from whorl to whorl, straight, slightly prosocline, and slightly reflexed leftward near posterior suture. Axial ribs becoming less prominent, more irregular, and numerous near outer lip. Axial ribs on immature specimens (less than 13 mm in height) 17 to 20 on last whorl, and approximately 17 on penultimate and ante-penultimate whorls. Axial ribs on mature specimens 22 to 25 on last whorl, and 17 to 19 on penultimate and ante-penultimate whorls. Spiral ribs, moderately spaced, crossing axial ribs, on spire consisting of seven to eight, flat-topped spiral ribs narrower than interspaces; on some specimens (immature or mature) finer intercalated rib (usually on anterior medial portion of last whorl) occasionally present, and, on most specimens intercalated ribs approaching other spiral ribs in strength. Sculpture on basal part of last whorl consisting of approximately seven spiral ribs (three posterior ones strongest), beaded or unbeaded, and broader than interspaces; axial ribs obsolete. Aperture ear-shaped, pointed posteriorly with broad shallow anterior notch at base of columella; outer lip broadly arched apparently without varix, inner lip well defined, callused, smooth, and somewhat reflexed anteriorly.

Dimensions of holotype: Incomplete specimen of five whorls, height 16.3 mm, diameter 8.9 mm.

Holotype: LACMIP 12997.

Paratypes: LACMIP 12998 and 12999.

Type locality: LACMIP loc. 23635, 39°51′06″N, 121°42′40″W.

Geologic age: Late Cretaceous (latest Santonian to early Campanian, middle? Campanian).

Distribution: UPPERMOST SANTONIAN: Chico Formation, uppermost part of Musty Buck Member, Chico Creek, Butte County, northern California. LOWER CAMPANIAN: Chico Formation, Ten Mile Member, Chico Creek, Butte County, northern California; Ladd Formation, middle part of the Holz Shale Member, Santa Ana Mountains, Orange County, southern California. PROBABLE LOWER MIDDLE CAMPANIAN: Pigeon Point Formation, southern sequence, San Mateo County, northern California (Elder & Saul, 1993).

Discussion: Specimens are abundant at most localities, but they are usually somewhat weathered. The species is represented by approximately 100 variously preserved specimens, and nearly all are from the Chico Formation. The stratigraphic interval encompassed by these localities, all of which are in either the Musty Buck or the Ten Mile members of this formation, is approximately 600 m, and the age is near the Santonian/Campanian boundary.

Only a single specimen of the new species is known from the Pigeon Point Formation specimen (slightly crushed). This specimen was illustrated by Elder & Saul (1993) and is also illustrated here, as two new views (Figures 29, 30). The age of the southern sequence of this formation, from which the specimen of *B. meta* was obtained, is problematic because of limited exposures, faulting, and a paucity of age-diagnostic fossils. Elder & Saul (1993) concluded that the age is probably middle Campanian.

Belliscala ***meta*** is most similar to *Belliscala lirata* Dockery (1993:86, pl. 26, fig. 6) from the Chapelville fossiliferous horizon within the Tupelo Tongue of the Coffee Sand in northeast Mississippi. According to Dockery (1993), the geologic age of this fossiliferous horizon is near the early/middle Campanian boundary. *Belliscala* ***meta*** differs from *B. lirata* by being smaller and by having many more axial ribs on the last whorl (22 to 25 rather than 15).

Belliscala ***meta*** differs from *Belliscala* ***petra*** by having subtabulate whorls, more numerous axial and spiral ribs that are also more closely spaced, almost nodular axial ribs at shoulder, much narrower interspaces between spiral ribs, only rare development of intercalated spiral ribs, and obsolete axial ribs on base of last whorl.

Belliscala ***meta*** differs from *Belliscala suciense* (Whiteaves, 1879) by having a narrower pleural angle, whorls that are subtabulate posteriorly, more numerous axial and spiral ribs that are more closely spaced, more swollen axial ribs, much narrower interspaces between spiral ribs, only rare development of intercalated spiral ribs, intersections of axial and spiral ribs with low nodes rather than projecting nodes, and obsolete rather than occasionally weak axial ribs on base of last whorl.

Etymology: The specific name *meta* is Latin, meaning a conical column.

Belliscala suciense (Whiteaves, 1879)

(Figures 33–38)

Cerithium lallierianum, var. *suciense* Whiteaves, 1879:122–123, pl. 15, figs. 10, 10a.

Mesostoma suciense Whiteaves, 1903:359–360, pl. 44, fig. 7.

Bittiscala sp. Dailey & Popenoe, 1966:fig. 3 [= a faunal list].

? "*Potamides tenuis*" *nanaimoensis* (Whiteaves, 1879). Elder & Saul, 1996:392, figs. 5–28.

Diagnosis: A *Belliscala* with whorls bearing a weak ramp. Approximately 15 to 17 axial ribs on last whorl. Axial ribs and spiral ribs moderately spaced but narrow. Strong development of a finer interrib between spiral ribs on most of shell. Intersections of axial and spiral ribs with projecting nodes. Axial ribs weak to obsolete on base of last whorl.

Supplemental description: Shell small (up to 15.6 mm high), conical to turriculate, with moderately high spire. Pleural angle approximately 40°. Protoconch unknown. Teleoconch whorls approximately eight (estimated), rounded, with a weak subsutural ramp and glossy surface; suture slightly impressed. Upper spire whorls cancellate, remaining part of shell subcancellate, axial ribs stronger than spiral sculpture, intersections of ribs with projecting nodes. Axial ribs narrow, moderately to widely spaced, extending from suture to suture, not usually aligned from whorl to whorl, straight, orthocline on early whorls, prosocline on later whorls, and very slightly reflexed leftward near posterior suture. Axial ribs becoming less prominent, more irregular, and numerous near outer lip. Axial ribs on immature specimens (less than 13 mm in height) approximately 13 on last whorl, penultimate, and ante-penultimate whorls. Axial ribs on mature specimens approximately 15 to 17 on last whorl, and approximately 13 on penultimate and ante-penultimate whorls. Spiral ribs moderately widely spaced, crossing axial ribs. On spire, spiral sculpture of four, flat-topped spiral ribs much narrower than interspaces with occasionally one finer intercalated rib; anterior basal portion of last whorl with approximately six very fine spiral ribs (two posterior ones strongest), and narrower than interspaces. Sculpture on basal part of last whorl consisting of several widely spaced, weak to moderately strong, spiral ribs usually with one or more, finer intercalated spiral ribs; axial ribs weak or obsolete. Aperture ovate; inner lip smooth.

Dimensions of lectotype: Incomplete specimen of seven whorls, height 9.5 mm, diameter 5.2 mm.

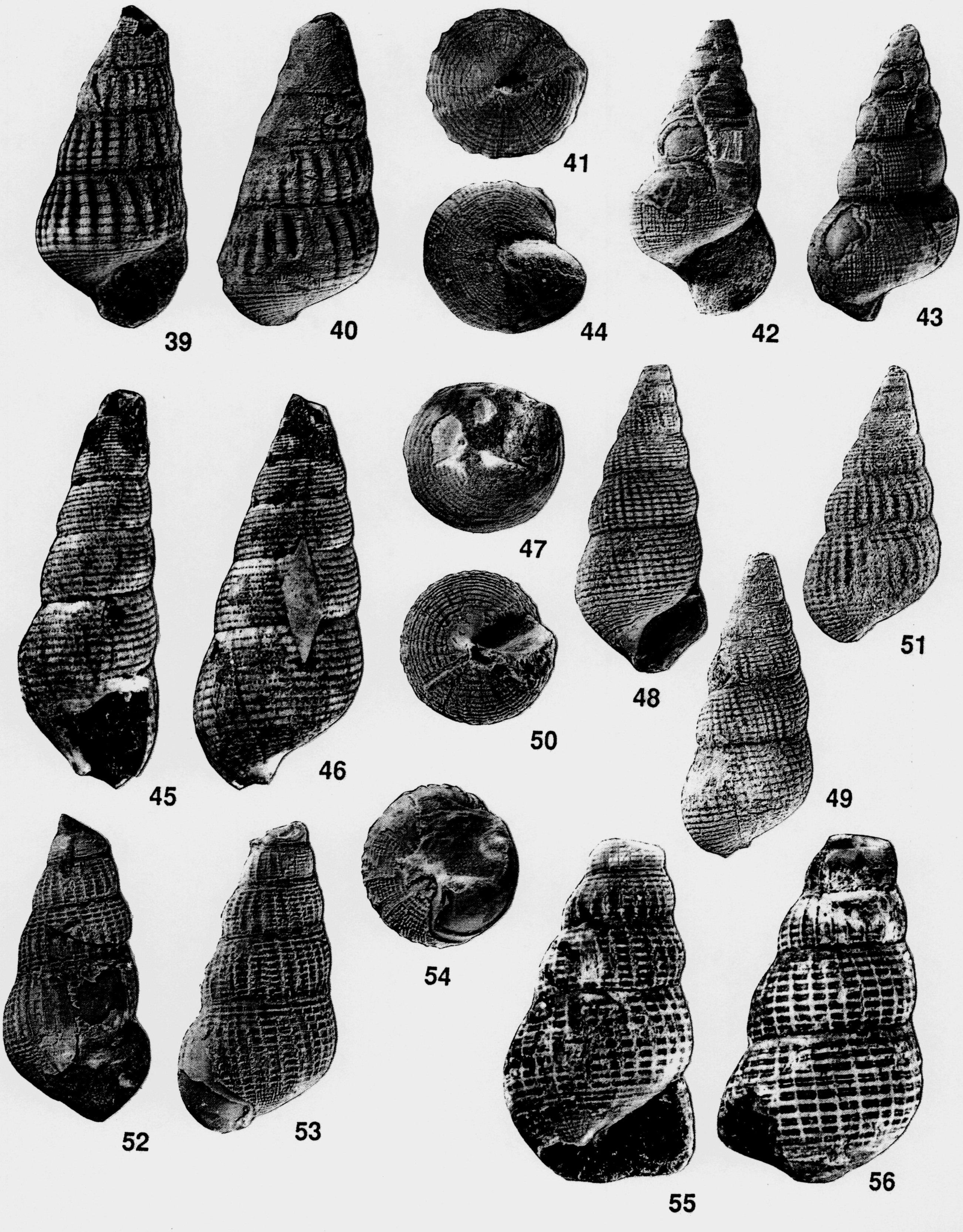
Lectotype: GSC 5764b, designated here.

Paralectotypes: GSC 5764, 5764a, 5764c–h, designated here.

Type locality: Sucia Island, San Juan County, Washington.

Geologic age: Late Cretaceous (Middle to early late Campanian).

Distribution: MIDDLE CAMPANIAN: Cedar District Formation, Sucia Island, San Juan County, Washington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(Whiteaves, 1879, 1903); Chatsworth Formation, eastern Simi Hills, Los Angeles and Ventura counties, southern California. UPPER MIDDLE CAMPANIAN: Williams Formation, Pleasants Sandstone Member, Orange County, southern California. LOWER UPPER CAMPANIAN: Jalama Formation, Santa Barbara County, southern California. UPPER MIDDLE CAMPANIAN TO UPPER CAMPANIAN UNDIFFERENTIATED: Spray Formation, northwest Hornby Island, Vancouver Island area, British Columbia (Elder & Saul, 1996:392).

Discussion: Specimens are abundant at many of the localities in the Cedar District Formation, but they are usually immature ones and missing much of their shell. Only a few specimens were found in the other formations, and these specimens are usually poorly preserved mature ones.

Whiteaves (1903) assigned the Late Cretaceous epitoniid species *suciense, intermedium,* and *newcombii* to genus *Mesostoma* Deshayes, 1861, but the latter name is preoccupied by *Mesostoma* Ehrenberg, 1837, a turbellarian flatworm (Sohl, 1960:92), and preoccupied by *Mesostoma* Heude, 1886, a gastropod. According to Palmer (1937) and Wenz (1940), *Mesostoma* Deshayes, 1861, is also the junior synonym of *Cerithioderma* Conrad, 1860.

It is generally inadvisable to include a faunal-list reference of a species in a synonymy because the exact specimens are seldom known for purposes of documentation. In the case of the Jalama Formation, however, all the specimens listed by locality in Dailey & Popenoe (1966: fig. 3) are in the LACMIP collection and were seen by us. All are *Belliscala suciense.*

Elder & Saul (1996:392) mentioned that one of the syntypes of "*Potamides tenuis*" *nanamimoensis* Whiteaves, 1879, GSC 5763b, resembles *Belliscala suciense.* Elder & Saul (1996:fig. 5–28) also figured this syntype. Much of the sculpture is obliterated, thus the specimen can be only questionably identified as *B. suciense.* This specimen is probably from the Spray Formation on the northwest side of Hornby Island, east coast of Vancouver Island, British Columbia. According to Elder & Saul (1996), depending on which part of this formation it is from, the specimen could be either late middle to early late Campanian or late Campanian in age.

Elder & Saul (1993) placed Whiteaves' species in genus *Bittiscala* Finlay & Marwick (1937), known from two species in lower Paleocene (Danian) rocks of New Zealand. Finlay & Marwick (1937) mentioned that their genus strongly resembles certain early members of the Epitoniidae, but they concluded that *Bittiscala* should be placed in family Cerithiidae. *Belliscala* differs from *Bittiscala* in having a conical rather than a cerithiform shape, a shorter spire, a wider pleural angle, and a sculpture where axial ribs rather than spiral ribs dominate.

Scalaria philippi Reuss (1846:114, pl. 44, figs. 14a, b; Pervinquière, 1912:61, pl. 3, figs. 19, 20) from Cenomanian strata of Tunisia strongly resembles *Belliscala suciense,* which differs from *S. philippi* by having secondary spiral ribs.

Genus *Acirsa* Mörch, 1857

Type species: *Scalaria eschrichti* Holböll in Möller, 1842, by subsequent designation (Bouchet & Warén, 1986); Recent, northwest Atlantic.

Diagnosis: Shell acuminate, whorls joined (with only a moderately impressed suture), and not umbilicate. Sculpture much reduced, may be spiral or axial or both; incised spiral grooves usually present. Basal keel absent. Basal disk indistinct but may be defined by a subperipheral ridge (Clench & Turner, 1950; DuShane, 1974, 1979; Kilburn, 1985; Bouchet & Warén, 1986; Dockery, 1993; Neville, 2001).

Discussion: Bouchet & Warén (1986) treated *Hemiacirsa* de Boury, 1890, *Pleisoacirsa* de Boury, 1909, and *Pseudoacirsa* Kobelt, 1903, as synonyms of *Acirsa.* The protoconch of *S. eschrichti* indicates direct development (Bouchet & Warén, 1986). Today, *Acirsa* is a cold-water genus (Kilburn, 1985).

According to Kase (1984), *Acirsa (Hemiacirsa) ofunatoensis* Kase (1984:165, pl. 28, fig. 15) from Barremian (Lower Cretaceous) strata in Japan is the earliest record of *Acirsa.* He also reported *Acirsa (Hemiacirsa) miyak-*

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Figures 39–56. Specimens coated with ammonium chloride, unless otherwise stated. Figures 39–41. *Acirsa* ***alpha*** Squires & Saul, sp. nov., holotype LACMIP 13003, LACMIP loc. 23628, Chico Creek, ×4. Figure 39. Apertural view. Figure 40. Abapertural view. Figure 41. Basal view. Figures 42–44. *Acirsa* ***beta*** Squires & Saul, sp. nov., holotype LACMIP 13004, LACMIP loc. 23634, Chico Creek. Figure 42. Apertural view, ×2.9. Figure 43. Abapertural view, ×2.9. Figure 44. Basal view, ×3.3. Figures 45–47. *Acirsa obtusa* (White, 1889). Figures 45, 46. Lectotype USNM 20116a, Pentz area, specimen uncoated, ×3.1. Figure 45, apertural view. Figure 46. Abapertural view. Figure 47. Hypotype LACMIP 13005, LACMIP loc. 24340, Pentz, basal view, ×3.5. Figures 48–51. *Acirsa* ***delta*** Squires & Saul, sp. nov. LACMIP loc. 23635, Chico Creek. Figures 48–50. Holotype LACMIP 13006, ×2.2. Figure 48. Apertural view. 49. Abapertural view. 50. Basal view. Figure 51. Paratype LACMIP 13007, abapertural view, ×3.3. Figures 52–54. *Acirsa* ***epsilon*** Squires & Saul, sp. nov., holotype LACMIP 13008, LACMIP loc. 23639, Chico Creek, ×3.5. Figure 52. Apertural view. Figure 53. Abapertural view. Figure 54. Basal view. Figures 55–56. *Acirsa nexilia* (White, 1889), USNM lectotype 20119a, Pentz area, ×4.6. Figure 55. Apertural view. Figure 56. Abapertural view.

oensis (Nagao, 1934:241–242, pl. 38, figs. 11, 12; Kase, 1984:164–165, pl. 28, figs. 13, 14) from Aptian/Albian (Lower Cretaeous) strata of Japan. Both of these species have a strong basal keel, strong axial ribs, and very fine spiral ribs, and they resemble *Confusiscala* and *Opalia* more than they do the *Acirsa* described in this present report. Dockery (1993) reported the geologic range of *Acirsa* to be Late Cretaceous (Campanian) to Recent.

Acirsa is well represented in Maastrichtian strata of Mississippi and Tennessee (Sohl, 1964; Dockery, 1993), but all of these species have narrower pleural angles than those of the new species described here.

Acirsa ***alpha*** Squires & Saul, sp. nov.

(Figures 39–41)

Diagnosis: An *Acirsa* with fine, subcancellate sculpture. Axial ribs predominant. Spiral ribs somewhat wavy, closely spaced, relatively broad, and with shallow interspaces containing a distinct interrib on anterior part of mature whorls.

Description: Shell small (up to 13.9 mm high), elongate conical, with high spire. Pleural angle approximately 25°. Protoconch unknown. Teleoconch whorls approximately seven to eight (estimated), lowly rounded, somewhat flattish; suture moderately impressed. Sculpture subcancellate, axial ribs stronger than spiral ribs. Axial ribs moderately high, relatively wide, approximately as broad as interspaces, prosocline, approximately 20 on last whorl, and 21 on penultimate whorl. Spiral ribs fine, wavy, approximately six on penultimate whorl, and nine on last whorl posterior to basal part of whorl. Interspaces between spiral ribs on penultimate and last whorls shallow, narrow, and with a single distinct, wavy, very narrow interrib on anterior halves of these two whorls. No basal keel. Sculpture on basal part of last whorl consisting of approximately nine, very fine to fine spiral ribs (no interrib) crossed by growth lines; axial ribs obsolete. Aperture subcircular; inner lip with a narrow callus.

Dimensions of holotype: Incomplete specimen of 4.5 whorls, height 13.9 mm, diameter 6.5 mm.

Holotype: LACMIP 13003.

Type locality: LACMIP loc. 23628, 39°51′15″N, 121°42′35″W.

Geologic age: Late Cretaceous (latest Santonian).

Distribution: Chico Formation, Musty Buck Member, Chico Creek, Butte County, northern California.

Discussion: The above description is based on a single specimen, which is well preserved.

Acirsa ***alpha*** is most similar to *Acirsa* ***delta***, sp. nov. and differs from it by having stronger and broader axial ribs with narrower interspaces, fewer axial ribs, wavy and broader spiral ribs, a spiral interrib, a non-beaded look, and slightly flatter whorl sides. *Acirsa* ***alpha*** is similar to *Acirsa nexilia* (White, 1889), discussed later, and differs from it by having broader axial ribs that are more closely spaced and with non-sunken interspaces.

Etymology: The specific name *alpha* is the first letter of the Greek alphabet.

Acirsa ***beta*** Squires & Saul, sp. nov.

(Figures 42–44)

Diagnosis: An *Acirsa* with extremely fine cancellate sculpture. Intersections minutely beaded. Basal part of last whorl with extremely fine, very faintly beaded spiral ribs.

Description: Shell medium small (up to approximately 17.7 mm high), conical, with moderately high spire. Pleural angle approximately 33°. Protoconch unknown. Teleoconch whorls approximately eight (estimated), lowly rounded, somewhat flattish; suture moderately impressed. Sculpture minutely cancellate, consisting of many very fine spiral ribs crossed by approximately equal-strength growth lines with intersections minutely beaded; approximately 17 spiral ribs on penultimate whorl and on posterior part of last whorl. No basal keel. Spiral ribs on basal part of last whorl finer than elsewhere and very faintly beaded. Aperture oval.

Dimensions of holotype: Nearly complete specimen of 5.5 whorls, height 17.7 mm, diameter 8.8 mm.

Holotype: LACMIP 13004.

Type locality: LACMIP loc. 23624, 39°52′25″N, 121°42′30″W.

Geologic age: Late Cretaceous (latest Santonian to early Campanian).

Distribution: UPPERMOST SANTONIAN: Chico Formation, Musty Buck Member, Chico Creek, Butte County, northern California. LOWER CAMPANIAN: Chico Formation, Ten Mile Member, Chico Creek, Butte County, northern California.

Discussion: The above description is based on nine specimens, all of which have generally good preservation. The new species is unlike the other *Acirsa* spp. nov. in having such minute cancellate sculpture and no axial ribs (only growth lines).

Etymology: The specific name *beta* is the second letter of the Greek alphabet.

Acirsa obtusa (White, 1889)

(Figures 45–47)

Mesalia obtusa White, 1889:20:pl. 4, figs. 6, 7.

Diagnosis: An *Acirsa* with spiral ribs only. Interspaces between ribs with prominent growth lines producing a "pitted appearance." Anteriormost part of last whorl with similar sculpture but thinner spiral ribs.

Description: Shell medium small (up to 22.5 mm high), elongate conical, with moderately high spire. Pleural angle approximately 30°. Protoconch unknown. Teleoconch whorls approximately seven to eight (estimated), very lowly rounded, flattish; suture slightly impressed. Teleoconch sculpture of fine, closely spaced, smooth spiral ribs, interspaces narrower than ribs and with prominent growth lines giving "pitted appearance" to shell; spiral ribs numerous, with approximately nine on penultimate and ante-penultimate whorls, and approximately 20 on last whorl; spiral ribs on base of last whorl thinner than elsewhere. Aperture oval; inner lip smooth on anterior part.

Dimensions of holotype: Mostly complete specimen of 5.5 whorls, height 18.4 mm, diameter 7.5 mm (slightly crushed).

Lectotype: USNM 20116a, designated here.

Type locality: Near Pentz, northern California, 39°39′08″N, 121°35′50″W.

Geologic age: Late Cretaceous (late Santonian to early late Campanian).

Distribution: UPPER SANTONIAN: Chico Formation, Musty Buck Member, Chico Creek, Butte County, northern California. LOWER CAMPANIAN: Chico Formation, Pentz Road member (informal), Pentz area, Butte County, northern California. LOWER UPPER CAMPANIAN: Jalama Formation, Santa Barbara County, southern California.

Discussion: The above description is based on nine specimens, all of which have generally good preservation. One specimen from the Jalama Formation at LACMIP loc. 24108 shows that the spiral ribs next to the posterior suture can be wider than the other spiral ribs.

Acirsa ***delta*** Squires & Saul, sp. nov.

(Figures 48–51)

Diagnosis: An *Acirsa* with fine, subcancellate sculpture. Axial ribs very slightly stronger than spiral ribs. Intersections producing a beaded-look. Spiral ribs closely spaced, relatively broad, and separated by much narrower linear grooves. Basal part of last whorl with fine, unbeaded spiral ribs.

Description: Shell medium (up to 24 mm high), elongate conical, with high spire. Pleural angle approximately 30°. Protoconch unknown. Teleoconch whorls approximately seven to eight (estimated), lowly rounded, somewhat flattish; suture slightly impressed. Sculpture subcancellate, slight beads at intersections of ribs, and axial ribs very slightly stronger than spiral ribs on whorls anterior to uppermost spire. Axial ribs narrow, low, closely spaced, approximately half as broad as interspaces, prosocline, approximately 36 to 39 on last whorl and penultimate whorls, and approximately 33 on ante-penultimate whorl. Spiral ribs, fine, closely spaced, and approximately 10 on penultimate whorl and on last whorl posterior to basal part. Interspaces between spiral ribs moderately deep, linear-grooved, and approximately one-half as broad as ribs. No basal keel. Sculpture on basal part of last whorl consisting of approximately 10 to 12 spiral ribs, closer spaced than elsewhere on teleoconch, and crossed by growth lines; axial ribs obsolete. Aperture oval; inner lip with smooth callus.

Dimensions of holotype: Nearly complete specimen of six whorls, height 24 mm, diameter 10.2 mm.

Holotype: LACMIP 13006.

Type locality: LACMIP loc. 23635, 39°51′06″N, 121°42′40″W.

Paratype: LACMIP 13007.

Geologic age: Late Cretaceous (earliest Campanian).

Distribution: Chico Formation, Ten Mile Member, Chico Creek, Butte County, northern California.

Discussion: The above description is based on seven specimens. Although some are fragments, they have mostly good preservation.

Acirsa ***delta*** is most similar to *Acirsa* ***epsilon***, sp. nov. but differs from it by having wider spirals, closer spaced spirals, less obvious axial ribs, and not having sunken rectangular interspaces between intersections of axial and spiral ribs. The new species is similar to *Acirsa obtusa* (White) but differs from it by having axial ribs, stronger spiral ribs, and a beaded rather than a pitted appearance.

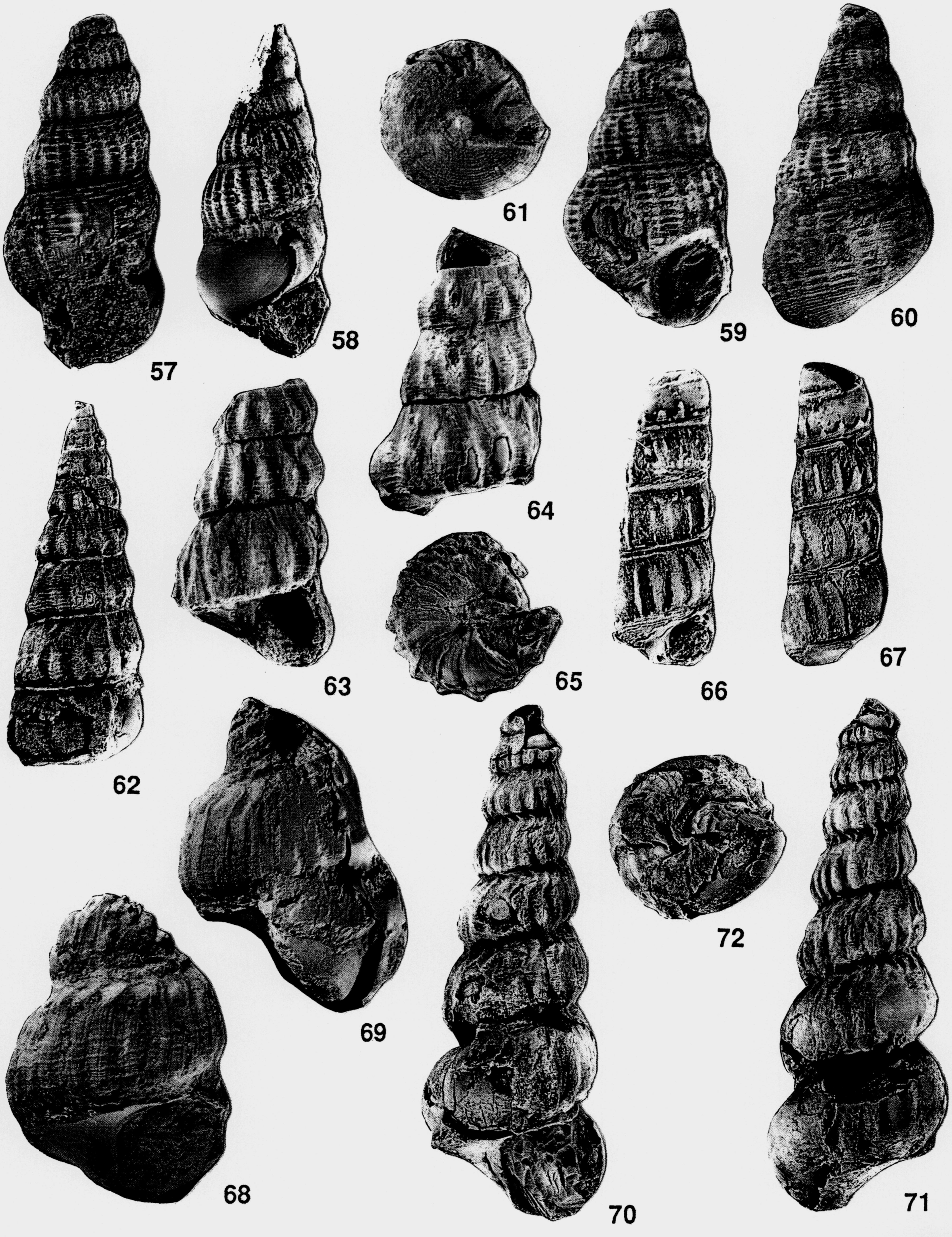
Etymology: The specific name *delta* is the fourth letter of the Greek alphabet.

Acirsa ***epsilon*** Squires & Saul, sp. nov.

(Figures 52–54)

Diagnosis: A small *Acirsa* with cancellate sculpture. Axial ribs slightly stronger than spiral ribs. Axial ribs narrow and closely spaced, approximately 27 on penultimate whorl. Sunken rectangular interspaces between intersections of axial and spiral ribs. Basal part of last whorl with very fine and minutely beaded cancellate sculpture.

Description: Shell small (up to 15.3 mm high), elongate conical, with moderately high spire. Pleural angle approximately 28°. Protoconch unknown. Teleoconch whorls approximately seven to eight (estimated), rounded; suture very slightly impressed. Sculpture cancellate, axial ribs slightly stronger than spiral ribs, intersections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minutely beaded, and sunken rectangular interspaces between intersections of axial and spiral ribs. Axial ribs narrow, closely spaced, approximately one-third as broad as interspaces, extending from suture to suture, aligned or not from whorl to whorl, straight, prosocline, numerous, approximately 32 on last whorl, approximately 27 on penultimate whorl, and approximately 26 on ante-penultimate whorl. Spiral ribs fine, narrow, closely spaced, approximately half as broad as interspaces, approximately 10 on penultimate whorl, and approximately 11 on last whorl posterior to basal part. No basal keel. Sculpture on base of last whorl consisting of approximately 12 spiral ribs, very fine but becoming stronger (fine) toward shell axis, very closely spaced, approximately as broad as interspaces, and very minutely beaded where crossed by growth lines (producing very fine cancellate pattern); axial ribs obsolete. Aperture ovate; inner lip smooth.

Holotype: LACMIP 13008.

Dimensions of holotype: Incomplete specimen of 4.5 whorls, height 15.3 mm, diameter 7.2 mm.

Type locality: LACMIP loc. 23639, 39°50′10″N, 121°42′55″W.

Geologic age: Early Campanian.

Distribution: Chico Formation, Ten Mile Member, Chico Creek, Butte County, northern California.

Discussion: The above description is based on 10 specimens, most of which are poorly preserved. *Acirsa* ***epsilon*** is most similar to *Acirsa nexilia* (White, 1889), discussed below, but differs from it by having smaller size; more numerous, more closely spaced, and weaker axial ribs; more closely spaced spiral ribs with no interrib; and stronger cancellate sculpture. *Acirsa* ***epsilon*** is similar to *Acirsa* ***delta***, sp. nov. but differs from it by having thinner axial and spiral ribs, more widely spaced cancellate sculpture, and sunken rectangular interspaces between intersections of axial and spiral ribs.

Etymology: The specific name *epsilon* is the fifth letter of the Greek alphabet.

Acirsa nexilia (White, 1889)

(Figures 55–61)

Ceratia nexilia White, 1889:21, pl. 3, figs. 13, 14.
Mesostoma (?) *intermedium* Whiteaves, 1903:360, pl. 43, fig. 4.

Diagnosis: A medium-sized *Acirsa* with subcancellate sculpture. Axial ribs stronger than spiral ribs. Approximately 24 axial ribs. Interspaces between spiral ribs with one secondary spiral interrib. Basal part of last whorl with very fine cancellate sculpture.

Supplementary description: Shell medium (up to 28 mm high), elongate conical, with high spire. Pleural angle approximately 31°. Protoconch unknown. Teleoconch whorls approximately 10 (estimated), rounded; suture slightly impressed and occasionally coincident with spiral rib. Sculpture cancellate on uppermost spire, subcancellate on more mature whorls, axial ribs stronger than spiral ribs, intersections with low nodes on mature whorls. Axial ribs moderately swollen, moderately spaced, and approximately half as broad as interspaces. Axial ribs extending from suture to suture, generally aligned from whorl to whorl on uppermost spire but becoming less so on more mature whorls, mostly straight, slightly prosocline, slightly reflexed leftward near posterior suture, approximately 24 on penultimate and last whorls, and 19 to 20 on penultimate and ante-penultimate whorls. Spiral ribs fine, narrow, and moderately closely spaced, approximately nine on last whorl, and seven to eight on penultimate whorl. Interspaces between spiral ribs accommodate finer but prominent spiral rib, except on uppermost spire whorls. No basal keel. Sculpture on basal part of last whorl consisting of many, very closely spaced, fine spiral ribs with narrow interspaces showing growth lines; axial ribs generally obsolete, rarely with few very weak axial ribs extending to shell axis. Aperture oval; inner lip smooth.

Dimensions of lectotype: Incomplete specimen of four whorls, height 13.5 mm, diameter 7.6 mm.

Lectotype: USNM 20119a, designated here.

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Figures 57–72. Specimens coated with ammonium chloride. Figures 57–61. *Acirsa nexilia* (White, 1889), Sucia Island. Figure 57. Syntype GSC 5956 of *Mesostoma* (?) *intermedium* Whiteaves, 1903, apertural view, ×2.1. Figure 58. Syntype GSC 5956c of *Mesostoma* (?) *intermedium* Whiteaves, 1903, apertural view, ×2.6. Figures 59–61. Hypotype LACMIP 13009, LACMIP loc. 6965, Simi Hills, ×3.2. Figure 59. Apertural view. Figure 60. Abapertural view. Figure 61. Basal view. Figures 62–65. *Confusiscala newcombii* (Whiteaves, 1903). Figure 62. Holotype GSC 5928, Sucia Island, abapertural view, ×1. Figures 63–65. LACMIP loc. 23635, Chico Creek. Figures 63, 64. Hypotype LACMIP 13010, ×1.5. Figure 63. Apertural view. Figure 64. Abapertural view. Figure 65. Hypotype LACMIP 13011, basal view, ×1. Figures 66, 67. *Claviscala* sp., hypotype LACMIP 13012, LACMIP loc. 23637, Chico Creek, ×2.9. Figure 66. Apertural view. Figure 67. Abapertural view. Figures 68–72. ***Zebalia*** Squires & Saul, gen. nov. *suciaensis* (Packard, 1922). Figures 68, 69. Plastoholotype UCMP 12303, UCMP loc. 2209, Sucia Island, ×1. Figure 68. Apertural view. Figure 69. Right-lateral view. Figures 70–72. Hypotype LACMIP 13013, LACMIP loc. 10716, Simi Hills, ×0.6. Figure 70. Apertural view. Figure 71. Abapertural view. Figure 72. Basal view.

Type locality: Pentz area, Butte County, northern California.

Paralectotype: USNM 20119b, designated here.

Geologic age: Late Cretaceous (lower to upper middle Campanian).

Distribution: LOWER CAMPANIAN: Chico Formation, Pentz Road member (informal), Butte County, northern California. MIDDLE CAMPANIAN: Cedar District Formation, Sucia Island, Washington; Chatsworth Formation, Dayton and Bell canyons, eastern Simi Hills, Los Angeles and Ventura counties, southern California. UPPER MIDDLE CAMPANIAN: Williams Formation, Pleasants Sandstone Member, Santa Ana Mountains, Orange County, southern California.

Discussion: The above description is based on 14 specimens, which are mostly poorly preserved. The syntypes (GSC 5956, 5956a–d) of *M.* (?) *intermedium* are weathered and either in rock matrix or missing shell material on the last whorl. Photographs of *Acirsa nexilia* are shown for the first time here.

White's (1889) species *Ceratia nexilia* has the medium-shell size and subcancellate sculpture of an *Acirsa* and does not belong in genus *Ceratia* H. & A. Adams, 1852, which is characterized by minute size, fine spiral striae, and an absence of axial sculpture. Although Wenz (1939) and Fretter & Graham (1978) placed *Ceratia* in Rissoidae, Ponder (1984, 1985) showed that it can be included in the Iravadiidae, which, like the rissoids, belongs (Ponder & Warén, 1988) to the Truncatelloidea.

Genus *Confusiscala* de Boury, 1909

Type species: *Scalaria dupiniana* d'Orbigny, 1842, by original designation and monotypy; Late Cretaceous (Albian), Aube, France.

Diagnosis: Whorls joined and not umbilicate. Basal keel visible on spire supradjacent to suture. Axial ribs not crossing basal keel. Spiral sculpture fine, covering whorl sides. Basal disk with fine spiral threads, crossed by radiating slightly sinuous growth lines (Saul & Popenoe, 1993).

Discussion: *Confusiscala* was originally considered to be a subgenus of *Amaea* by de Boury (1909), and Wenz (1940) agreed. It has continued to be treated as a subgenus by several workers, including Stewart (1927), who placed it as a subgenus of *Epitonium* Röding, 1798, and Gardner (1876) and Durham (1937) who placed it as a subgenus of *Opalia.* Saul & Popenoe (1993) considered *Confusiscala* to be a genus that is closely similar to *Opalia,* and they reported that *Confusiscala* ranges from Early Cretaceous (Neocomian) through Maastrichtian. Darragh & Kendrick (1994) reported that *Confusiscala* attained a widespread, near cosmopolitan distribution during the Cretaceous (late Hauterivian to late Maastichtian).

Darragh & Kendrick (1994) placed *Opalia mathewsonii* (Gabb, 1864:321–322, pl. 32, fig. 278; Stewart, 1927: 321–322, pl. 24, fig. 20; Durham, 1937:504, pl. 56, fig. 23) in genus *Confusiscala.* As shown in our synonymy given earlier in this present paper, however, the specimen used by Durham (1937:504, pl. 56, fig. 23) is the holotype of *Confusiscala*? *sulfurea* Saul & Popenoe, 1993. As discussed earlier in this present paper, we have questionably placed *Opalia mathewsonii* (Gabb, 1864:321–322, pl. 32, fig. 278; Stewart, 1927:321–322, pl. 24, fig. 20) in *Opalia.*

Darragh & Kendrick (1994:42–44) reported that there is a worldwide array of very similar species of *Confusiscala* found in the following stages/substages and locales: upper Hauterivian and Aptian to Albian of Japan, Aptian of Syria, Albian of Europe, Turonian of California, Turonian to Santonian of southern India, Turonian to upper Maastrichtian of Europe, Senomanian of South Africa, and upper Maastrichtian of Australia. *Confusiscala newcombii,* from upper Santonian to middle Campanian of the Pacific slope of North America, can also be added to this list. We agree with Darragh & Kendrick (1994) that a close comparative study of all of these species is warranted.

Confusiscala newcombii (Whiteaves, 1903)

(Figures 62–65)

Mesostoma (?) *newcombii* Whiteaves, 1903:361, pl. 43, fig.
Hemiacirsa newcombii (Whiteaves). Ludvigsen & Beard, 1994:fig. 59 [in part]; 1997:fig. 70 [in part].

Supplementary description: Shell large (up to 69.5 mm high), turriculate, with high spire. Pleural angle approximately 25°. Protoconch and uppermost spire unknown. Teleoconch whorls approximately 11 (estimated), concave posterior half, convex anterior half; suture moderately impressed. Axial ribs stronger than spiral ribs. Axial ribs moderately closely spaced, strong, swollen on anterior half of whorl but with tendency to fade out on posterior half, straight, and prosocline. Growth lines confluent with axial ribs on posterior half of whorl reflexed leftward posteriorly. Axial ribs approximately 14 on last whorl, penultimate, and ante-penultimate whorls. Spiral ribs fine, closely spaced, numerous, and strongest on anterior half of whorl where single interribs also present. Basal keel strong and usually present as a subsutural rib. Basal disk covered by very faint spiral threads (weaker or approximately same strength as spiral near posterior suture) and with several sinuous, raised-growth lines confluent with primary axial ribs. Aperture subcircular.

Holotype: GSC 5928.

Dimensions of holotype: Nearly complete specimen of nine whorls, height 64.3 mm, diameter 24.9 mm.

Type locality: Sucia Island, San Juan County, Washington.

Geologic age: Late Cretaceous (Latest Santonian to middle Campanian).

Distribution: UPPERMOST SANTONIAN: Chico Formation, Musty Buck Member, Chico Creek, Butte County, northern California; Ladd Formation, middle part of Holz Shale Member, Orange County, southern California. UPPER SANTONIAN/LOWER CAMPANIAN: Haslam Formation, Vancouver Island, British Columbia (Ludvigsen & Beard, 1994, 1997). LOWER CAMPANIAN: Chico Formation, Ten Mile Member, Chico Creek, Butte County, northern California. MIDDLE CAMPANIAN: Cedar District Formation, Sucia Island, San Juan County, Washington (Whiteaves, 1903; Ludvigsen & Beard, 1994). SANTONIAN-MIDDLE CAMPANIAN UNDIFFERENTIATED: "Trent River Formation," Vancouver Island, British Columbia (Ludvigsen & Beard, 1994, 1997).

Discussion: *Confusiscala newcombii* is included in this paper because the original description is lacking in some details, no published photographs of the holotype existed before, and its stratigraphic occurrences have not been tabulated before. The original illustration of the holotype was a line drawing of the abapertural side. We include a photographic view of this side (Figure 62). The apertural side of the holotype is missing most of its shell. We also include the first photographic view of the base of this species (Figure 65).

At most localities, this species consists of small fragments, but at LACMIP loc. 23635 in the lowermost part of the Ten Mile Member of the Chico Formation, four large and well preserved specimens were collected.

The occurrence of *C. newcombii* in the middle part of Holz Shale Member of the Ladd Formation, Orange County, southern California (LACMIP loc. 10093) is a new stratigraphic record.

Ludvigsen & Beard (1994, 1997) placed Whiteaves' species in *Hemiacirsa* de Boury, 1890. Bouchet & Warén (1986) treated this genus as a synonym of *Acirsa* Mörch, 1857. Although the base of the shell may be angled in *Acirsa,* a basal keel and basal disk are not present (Bouchet & Warén, 1986; Weil et al., 1999); therefore, Whiteaves' species cannot be placed in *Acirsa* [= *Hemiacirsa*].

Genus *Claviscala* de Boury, 1909

Type species: *Scalia richardi* Dautzenberg & de Boury, 1897, by original designation; Recent, southwestern Europe, but not in the Mediterranean, usually in abyssal depths (Bouchet & Warén, 1986).

Diagnosis: Shell acuminate, whorls joined, and not umbilicate. Flat-sided whorls bearing broad axial ribs and fine spiral lines. Basal keel strong. Aperture rectangular. No pitting on surface of shell (Bouchet & Warén, 1986; Weil et al., 1999).

Discussion: Wenz (1940) reported the geologic range of *Claviscala* to be Neocomian (Early Cretaceous) to Recent, with fossil occurrences in North America and Europe and with Recent occurrences in the Atlantic Ocean. Abbass (1963), however, reported *Turriscala* (*Claviscala*) *darwishi* Abbass (1963:64, pl. 3, figs. 2, 2a) from Albian strata in Egypt. The preservation of the holotype of Abbass's species, however, is poor, and its placement in *Claviscala* seems to be somewhat tentative.

Claviscala sp.

(Figures 66, 67)

Description: Shell small (up to 17.5 mm high), cylindrical, with high spire. Pleural angle approximately 10°. Protoconch unknown. Teleoconch whorls approximately eight to nine (estimated), flattish; suture slightly impressed, with subsutural rib. Sculpture of broad axial ribs, moderately closely spaced, extending from suture to suture, not aligned from whorl to whorl, usually straight (rarely sinuous), prosocline, rarely reflexed leftward posteriorly near suture, approximately 16 on last whorl, and 14 to 15 on penultimate and ante-penultimate whorls. Fine spiral ribs near sutures. Basal keel strong. Basal disk with many very fine spiral ribs, partly obscured by a glossy callus; axial ribs obsolete on basal disk. Aperture oval, inner lip smooth.

Geologic age: Late Cretaceous (earliest Campanian to early late Campanian).

Distribution: LOWERMOST CAMPANIAN: Chico Formation, Ten Mile Member, Chico Creek, Butte County, northern California. LOWER UPPER CAMPANIAN: Jalama Formation, Santa Barbara County, southern California.

Discussion: The above description is based on two poorly preserved and apparently conspecific specimens from LACMIP locs. 23637 and 24140, from the Chico and Jalama formations, respectively. On each, the apex is missing and most of the shell is leached so that the sculpture is little more than indicated. We are, therefore, unable to name a new species based on such incomplete material. The specimens, however, do show the flat-sided whorls, strong broad axial ribs, fine spiral ribs, and strong basal keel that are diagnostic of this genus.

The name *Claviscala* has been used twice before for Cretaceous gastropods from the Pacific slope of North America. The first usage was *Nerinea dispar* Gabb (1864: 113, pl. 19, figs. 66, 66a). Stewart (1927:322) stated that the holotype of "*N.*" *dispar* is "probably related to "*Claviscala*" *clementina* d'Orbigny, 1842, from the Cretacous Albian of Europe." Saul & Squires (1998), furthermore, reported that Gabb's species, although originally described as a nerineid, is definitely not one and is probably an epitoniid. Durham (1937:503, pl. 56, fig. 20) stated that *Nerinea dispar* belongs to *Claviscala.* The holotype (UCMP 11944) of this species consists of a partial external mold and the internal mold of four whorls of an individual 55 mm high. Gabb (1864:pl. 19, fig. 66a) especially emphasized a collarlike band that is the edge of the basal disk, and although Anderson (1938, 1958) reported that this feature is not seen in the holotype, it is present on the external mold, as are fine spiral ribs that cross the strong axials, which do not quite reach the basal collar or the adapical suture. The holotype is from North Fork of Cottonwood Creek, Shasta County, northern California, in strata now referred to as the Budden Canyon Formation, which ranges in age from Early Cretaceous (Hauterivian) to Late Cretaceous (Turonian) (Murphy et al., 1969). It is not known from which member the holotype of *C. dispar* was collected, but the uppermost one, the Gas Point Member, is not present on North Fork, therefore, the age range is reduced to Hauterivian to Albian. Although Anderson (1938, 1958) stated that no additional specimens had been found, CAS collections from the Budden Canyon Formation in the vicinity of the North Fork of Cottonwood Creek have specimens from at least two of the members. Anderson (1958) suggested that Gabb's species was of Late Cretaceous or even Paleocene age, but the specimens from the North Fork of Cottonwood Creek vicinity indicate a Hauterivian to Albian age. More work is needed on this Early Cretaceous epitioniid in order to determine its exact geologic age and distribution. *Claviscala* sp. from the Late Cretaceous (Campanian) Ten Mile Member of the Chico Formation differs from *Claviscala dispar* by having a smaller size, a less prominent subsutural rib, axial ribs that extend from suture to suture, fewer axial ribs, and no evidence of fine spiral ribs forming a minute-cancellate pattern where they intersect the axial ribs.

The second usage of the name *Claviscala* for Cretaceous gastropods from the Pacific slope of North America was *Opalia* (*Claviscala*) n. sp. of Durham (1937:503). He put his unnamed species into synonymy with *Nerinea dispar*? Gabb (var.), Whiteaves (1895:127, pl. 3, fig. 4a) from the Nanaimo Group on Hornby Island, east coast of Vancouver Island, British Columbia. Most likely, *Nerinea dispar*? (var.) Whiteaves is from the middle to upper Campanian Spray Formation (see "Stratigraphy") part of the Nanaimo Group, because this formation crops out extensively on Hornby Island. *Nerinea dispar*? (var.) Whiteaves is probably not a *Claviscala* at all (Saul & Squires, 1998), and it looks more like the melanopsid genus *Boggsia* Olsson, 1929, which was studied by Squires & Saul (1997).

Opalia (*Claviscala*) n. sp. of Durham, 1937, was also put by him into synonymy with *Scalaria albensis* (?) d'Orbigny of Whiteaves (1876:50, pl. 9, fig. 5) [= *Scalaria clementina* d'Orbigny of Whiteaves, 1900:287] from the Queen Charlotte Islands, British Columbia. According to Bolton (1965), *S. albensis* (?) of Whiteaves and *S. clementina* of Whiteaves are based on the same specimen, and *S. albensis* (?) is from the Haida Formation. Thompson et al. (1991) reported the Haida Formation to be Albian in age. It is possible that *Scalaria albensis* (?) d'Orbigny of Whiteaves (1876) might be the above-mentioned *Claviscala dispar* (Gabb, 1864).

In summary, although there have been previous reports of *Claviscala* from the Pacific slope of North America, these pertain to either Early Cretaceous specimens or to misidentified Late Cretaceous ones. The specimen of *Claviscala* sp. from the lower Campanian Ten Mile Member of the Chico Formation in northern California represents the first confirmed occurrence of this genus in Late Cretaceous rocks of the Pacific slope of North America.

Superorder Caenogastropoda Cox, 1959

Superfamily Zygopleuroidea Bandel, 1991

Family Zygopleuridae Wenz, 1938

Discussion: Opisthocline-axial ribs and their distinctive parasigmoidal pattern on the posterior part of the whorls are typical of zygopleurids. Other zygopleurid morphologic features are the elongate-conical shape, strong-axial sculpture, and subordinate spiral ornament. In addition, some zygopleurids have a rounded aperture. Family Zygopleuridae has a geologic range from Late Permian (Kasmanian) to middle Late Jurassic (Callovian) (Tracey et al., 1993). The new genus described below extends the geologic range of zygopleurids from the Late Jurassic to the Late Cretaceous. Zygopleurids are reportedly extinct, but Houbrick (1979) showed that the modern deep-sea genus *Abyssochrysos* Tomlin, 1927, is a relict gastropod whose shell closely resembles that found in Zygopleuridae.

Genus *Zebalia* Squires & Saul, gen. nov.

Type species: ***Zebalia*** *suciaensis* (Packard, 1922); Late Cretaceous (middle Campanian), Sucia Island, Washington and southern California.

Diagnosis: A zygopleurid with very large size, acuminate spire. Whorls joined and not umbilicate. Axial ribs strong, opisthocline, but parasigmoidal and bladelike near suture. Spiral ribs fine and wavy. Basal disk only with raised growth lines.

Discussion: In terms of the general shape of the whorls and the presence of strong axial ribs, the new genus is most similar to *Zygopleura* Koken, 1892, known from Triassic to Late Jurassic (lower Kimmeridgian) (Knight et al., 1960). The new genus differs from *Zygopleura* in having axial ribs that taper posteriorly, at least some spiral sculpture, and a circular aperture. In terms of the shape of the aperture, the new genus is similar to the zygopleurid *Tyrsoecus* Kittl, 1892, known from Middle Triassic to Late Jurassic (Knight et al., 1960). The new genus differs from *Tyrsoecus* by having parasigmoidal-axial ribs and non-tuberculate axial ribs.

Zebalia suciensis generally resembles an epitoniid, but the parasigmoidal-axial ribs and giant size of this new gastropod are unlike any other epitoniid, fossil or modern-day. Although most workers do not provide much information on epitoniid growth-line morphology, our observations revealed that most epitoniids have prosocline growth lines, with a tendency for them to be slightly reflexed leftward near the posterior suture. A few have straight or even slightly sinuous (sigmoidal) growth lines, but no epitoniid teleoconch has parasigmoidal-growth lines like that seen on ***Z.*** *suciensis.* The protoconchs of some species of the deep-water epitoniid *Eccliseogyra* Dall, 1892, illustrated by Bouchet & Warén (1986:figs. 1131, 1132, 1134), however, do have parasigmoidal-axial ribs. Yet, the axial ribs on the teleoconchs of these same specimens are not parasigmoidal. Bouchet & Warén (1986) also mentioned that *Eccliseogrya* was originally considered an "archaeogastropod." It was transferred to the family Epitoniidae as a subgenus of *Epitonium* by Rex & Boss (1973).

Etymology: The genus is named for P. T. & G. P. Zebal, who found and donated the largest known specimen of the type species of this genus.

Zebalia *suciaensis* (Packard, 1922)

(Figures 68–72)

Cerithium (?) *suciaensis* Packard, 1922:430, pl. 35, fig. 4.
Confusiscala suciense (Packard). Saul & Popenoe, 1993: 359.

Diagnosis: Same as for genus.

Description: Shell very large (up to 161 mm high), turriculate, with high spire. Pleural angle approximately 19°. Protoconch and upper spire unknown. Teleoconch whorls approximately 10 to 11 (estimated), rounded, with a concave-subsutural area; suture slightly markedly impressed. Axial ribs strong, spaced proportionally same distance apart on each whorl, extending from suture to suture, generally aligned from whorl to whorl, straight on main part of early whorls, opisthocline on later whorls, and strongly parasigmoidal (reflected rightward near posterior suture and reflected strongly leftward within subsutural area). Axial ribs approximately 20–22 on penultimate and preante-penultimate whorls. Axial ribs thin significantly on spire, becoming bladelike (lamellar). Spiral sculpture (at least on anterior part of later whorls) consisting of numerous fine wavy spiral ribs between axial ribs and crossing them, with two secondary spiral threads between primary spiral ribs. Basal keel possibly present. Basal disk with raised growth lines. Aperture circular; inner lip thickened somewhat.

Dimensions of holotype: Very incomplete specimen of 1.5 whorls, height 53 mm, diameter 41.4 mm.

Holotype: UCMP 12303.

Type locality: UCMP loc. 2209.

Geologic age: Late Cretaceous (middle Campanian).

Distribution: Cedar District Formation, Sucia Island, San Juan County, Washington; Chatsworth Formation, Dayton Canyon area, eastern Simi Hills, Los Angeles and Ventura counties, southern California.

Discussion: The above description is based on the very incomplete holotype and a very large specimen (Figures 70–72) from the Chatsworth Formation. The last whorl of the Chatsworth specimen is missing most of its shell. There appears to be a basal keel, but this might be the result of weathering of the shell.

Zebalia *suciaensis* is similar to *Cerithium iddingsi* Olsson (1928:68–69, pl. 15, fig. 4), known from the Pale Greda Formation of early Eocene age (Bolli, 1957) of northwestern Peru. ***Zebalia*** *suciaensis* differs from *C. iddingsi* by having much more rounded whorl sides, a more impressed suture, axial ribs in the subsutural area more distinct and more sharply reflected, spiral ribs more numerous on anterior part of later whorls, and an absence of spiral ribs in the subsutural area. Unfortunately, the extreme basal part of the last whorl and the apertural and columellar features of *C. iddingsi* are not preserved. The overall shell shape and growth-line pattern of *C. iddingsi* are strongly suggestive that this species is a zygopleurid. Its growth-line pattern is unlike that of *Cerithium* Bruguière, 1789.

The Cedar District Formation on Sucia Island in Washington is correlative (Muller & Jeletzky, 1970) to the ammonite zone *Hoplitoplacenticeras vancouverense,* which is of middle Campanian age. This geologic age is close to that of the very large specimen of ***Zebalia*** *suciaensis* from the Chatsworth Formation.

The Chatsworth Formation specimen of ***Z.*** *suciensis* is from a bed slightly stratigraphically higher in the formation than are the middle Campanian epitoniids (reported elsewhere in this paper) from very fossiliferous exposures of the Chatsworth Formation in Dayton and Bell canyons. Nevertheless, the geologic age of ***Z.*** *suciaensis* is also middle Campanian because, as reported by Saul & Popenoe (1993), it is from that part of the Chatsworth Formation yielding the ammonite *Metaplacenticeras* aff. *M. pacificum* (Smith, 1900). This particular ammonite is slightly older than zonal species *Metaplacenticeras pacificum,* which is indicative of the late middle Campanian to early late Campanian (Elder & Saul, 1996).

Except for a few localized, richly fossiliferous lenses in the lower and upper parts of the formation, megafossils are generally scarce in the Chatsworth Formation and represent shallow-marine species displaced downslope via turbidity currents into deeper waters of bathyal depth (Squires et al., 1981). The specimen of ***Zebalia suciaensis*** is from a small pebbly conglomerate lens in massive sandstone in the middle part of the formation (LACMIP loc. 10716). Associated megafossils at this locality include such shallow-water mollusks as the gastropods *Turritella* and *Volutoderma,* the bivalves *Crassatella, Glycmyeris, Indogrammatodon, Meekia, Pterotrigonia,* and *Yaadia,* as well as the ammonite *Baculites* cf. *B. rex* Anderson, 1958. Macrofossils are generally rare in this part of the formation because of the high-sedimentation rates associated with the sand-rich, turbidite-channel deposits. It is likely that the specimen of ***Z.*** *suciaensis* was not transported very far, based on its nearly complete large size.

Based on the information of several labels found in the box containing ***Z.*** *suciaensis* from the Chatsworth Formation, the specimen has had an interesting identification history. It has been identified as various heteromorph ammonites (Early Cretaceous *Heteroceras*? sp., Late Cretaceous *Turrilites*? sp., and Late Cretaceous *Bostrychoceras*? sp.), but the ammonite expert T. Matsumoto personally studied the specimen and and wrote on a card that "he did not think it was an ammonite." We concur, as did Saul & Popenoe (1993), who identified it as the epitoniid *Confusiscala suciense* (Packard).

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LITERATURE CITED

ABBASS, H. L. 1963. A monograph on the Egyptian Cretaceous gastropods. United Arab Republic, Geological Survey and Mineral Research Department, Palaeontological Series, Monograph 2, 146 pp., 11 pls.

ADAMS, H. & A. ADAMS. 1852. On a new arrangement of British Rissoae. Annals of the Magazine of Natural History, series 2, 10:358–359.

ADAMS, H. & A. ADAMS. 1853–1854. The Genera of Recent Mollusca, Arranged According to Their Organization. John Van Voorst: London. 484 pp.

ANDERSON, F. M. 1938. Lower Cretaceous deposits in California and Oregon. Geological Society of America Special Papers 16, 339 pp., pls. 1–84.

ANDERSON, F. M. 1958. Upper Cretaceous of the Pacific coast. Memoir of the Geological Society of America 71, 378 pp., pls. 1–75.

BANDEL, K. 1991. Über triassische "Loxonematoidea" und ihre Beziehungen uz rezenten und paläozoischen Schnecken. Paläontologische Zeitschrift 65:239–268.

BERRY, S. S. 1910. Review of: Report on a collection of shells from Peru, with a summary of the littoral marine Mollusca of the Peruvian zoological province. By W. H. Dall. The Nautilus 23(10):130–132.

BOLLI, H. M. 1957. The genera *Globigerina* and *Globorotalia* in the Paleocene-lower Eocene Lizard Springs Formation of Trinidad, B.W.I. U.S. National Museum Bulletin 215:61–81.

BOLTON, T. E. 1965. Catalogue of type invertebrate fossils of the Geological Survey of Canada. Volume 2. Geological Survey of Canada. 344 pp.

BOUCHET, P. & A. WARÉN. 1986. Revision of the northeast Atlantic bathyal and abyssal Aclididae, Eulimidae, Epitoniidae (Mollusca, Gastropoda). Part 3. Società Italiana di Malacologia, Bollettino Malacologico, Supplemento 2:299–576.

BOURY, E. DE. 1886. Monographie des Scalidae vivants et fossiles. Partie I: Sous-genre *Crisposcala.* Comptoir Géologique de Paris. 52 pp.

BOURY, E. DE. 1887. Étude sur les sous-genres de Scalidae du Bassin de Paris. Published by the author: Paris. 43 pp.

BOURY, E. DE. 1890. Révision des Scalidea Miocènes et Pliocènes de l'Italia. Bulletino della Societa Macologia Italiana 14: 161–326.

BOURY, E. DE. 1909. Catalogue des sous-genres de Scalidae. Journal de Conchyliologie 57:255–258.

BRANDER, G. 1766. Fossilia Hantoniensia Collecta, et in Musaeo Britannico Deposita. London, 43 pp., 9 pls.

BRUGUIÈRE, J. G. 1789–1816. Encyclopédie Méthodique ou par Ordre et Matières. Histoire Naturelle des Vers, des Mollusques. Tome 1. Panckouche: Paris. 758 pp.

CASTELL, C. P. (preparator). 1975. British Caenozoic Fossils (Tertiary and Quaternary). 5th ed. British Museum (Natural History): London. 132 pp., 44 pls.

CLENCH, W. J. & R. D. TURNER. 1950. The genera *Sthenorythis, Cirsostrema, Acirsa, Opalia,* and *Amaea* in the western Atlantic. Johnsonia 2(29):221–246, pls. 96–107.

CONRAD, T. A. 1860. Descriptions of new species of Cretaceous and Eocene fossils of Mississippi and Alabama. Journal of Academy of Natural Sciences of Philadelphia, series 2, 4: 275–298, pls. 46, 47.

COSSMANN, M. 1912. Essais de Paléoconchologie comparée, Tome 9. Published by the author: Paris. 215 pp., 10 pls.

DAILEY, D. H. & W. P. POPENOE. 1966. Mollusca from the Upper Cretaceous Jalama Formation, Santa Barbara County, California. University of California Publications in Geological Sciences 65:1–27, pls. 1–6.

DALL, W. H. 1892. Contributions to the Tertiary fauna of Florida, with special reference to the Miocene *Silex*-beds of Tampa and the Pliocene beds of the Caloosahatchie River, part II. Transactions of the Wagner Free Institute of Science, Philadelphia 3(2):201–473, pls 13–22.

DARRAGH, T. A. & G. W. KENDRICK. 1994. Maastrichtian Scaphopoda and Gastropoda from the Miria Formation, Carnarvon Basin, northwestern Australia. Records of the Western Australian Museum Supplement 48:1–76, figs. 1–14.

DAUTZENBERG, P. & BOURY, E. DE. 1897. Diagnoses d'espèces nouvelles appartenant aux genres *Scalaria* et *Mathildia.* Bulletin de la Société Zoologique de France 22:31–32.

DESHAYES, P. G. 1861. Description des Animaux sans Vertèbres Découverts dans le Bassin de Paris. Volume 2. J.-B. Baillière et Fils: Paris. 432 pp.

DOCKERY, D. T., III. 1993. The streptoneuran gastropods, exclusive of the Stenoglossa, of the Coffee Sand (Campanian) of northeastern Mississippi. Mississippi Department of Environmental Quality, Office of Geology, Bulletin 129:191 pp., 42 pls.

D'ORBIGNY, A. 1842–1843. Paléontologie Française, Terrains Crétacés. Vol. 2. Gastèropodes. Published by the author. Paris, 465 pp., pls. 149–236.

DURHAM, J. W. 1937. Gastropods of the family Epitoniidae from Mesozoic and Cenozoic rocks of the west coast of North America, including one new species by F. E. Turner and one by R. A. Bramkamp. Journal of Paleontology 11(6):479–512, pls. 56–57.

DUSHANE, H. 1974. The Panamic-Galapagan Epitoniidae. The Veliger 16(Supplement) 1–84, figs. 1–154.

DUSHANE, H. 1979. The family Epitoniidae (Mollusca: Gastropoda) in the northeastern Pacific. The Veliger 22(2):91–134, figs. 1–68.

EHRENBERG, C. G. 1837. Zusätze zur Erkenntniss grosser organischer Ausbildung in den keinsten thierischen Organismen. Berlin Akademie Abhandlungen, 1835, 260 pp., 8 pls.

ELDER, W. P. & L. R. SAUL. 1993. Paleogeographic implications of molluscan assemblages in the Upper Cretaceous (Campanian) Pigeon Point Formation, California. Pp. 171–186, pls. 1-2 in G. Dunne (ed.), Mesozoic Paleogeography of the Western United States—II. Pacific Section, SEPM, Book 71: Los Angeles, California.

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.

FINLAY, H. J. & J. MARWICK. 1937. The Wangaloan and associated molluscan faunas of Kaitangata-Green Island Subdivision. New Zealand Geological Survey Palaeontological Bulletin 15:1–140, pls. 1–18.

FRETTER, V. & A. GRAHAM. 1978. The prosbranch molluscs of Britain and Denmark. Part 4-Marine Rissoacea. Journal of Molluscan Studies, Supplement 6:151–241.

GABB, W. M. 1864. Description of the Cretaceous fossils. California Geological Survey, Palaeontology 1:57–243, pls. 9–32.

GABB, W. M. 1869. Cretaceous and Tertiary fossils. California Geological Survey, Palaeontology 2:1–299, pls. 1–36.

GARDNER, J. S. 1876. On Cretaceous Gasteropoda—family Scalidae. The Geological Magazine, new series, 3:105–114, pls. 3–4.

GARVIE, C. L. 1996. The molluscan macrofauna of the Reklaw Formation, Marques Member (Eocene: lower Clairbornian) in Texas. Bulletins of American Paleontology 111 (no. 353): 1–177, pls. 1–23.

GRADSTEIN, F. M., F. P. AGTERBERG, J. G. OGG, J. HARDENBOL, P. VAN VEEN, J. THIERRY & Z. HUANG. 1994. A Mesozoic time scale. Journal of Geophysical Research, series B 99:24,051–24,074.

HAGGART, J. W. 1986. Stratigraphy of the Redding Formation of north-central California and its bearing on Late Cretaceous paleogeography. Pp. 161–178 in P. L. Abbott (ed.), Cretaceous Stratigraphy Western North America. Pacific Section, SEPM, Book 46: Los Angeles, California.

HAGGART, J. W. 1991. Biostratigraphy of the Upper Cretaceous Nanaimo Group, Gulf Islands, British Columbia. Pp. 223–256, pls. 1–5 in P. L. Smith (ed.), A Field Guide to the Paleontology of Southwestern Canada, Geological Association of Canada.

HAGGART, J. W. & P. D. WARD. 1984. Late Cretaceous (Santonian-Campanian) stratigraphy of the northern Sacramento Valley, California. Geological Society of America Bulletin 95:618–627.

HEUDE, R. P. M. 1886. Diagnoses molluscorum novorum, in Sinis collectorum. Journal de Conchyliologie 34:208–215.

HOUBRICK, R. S. 1979. Classification and systematic relationships of the Abyssochrysidae, a relict family of bathyal snails (Prosobranchia: Gastropoda). Smithsonian Contributions to Zoology 290:1–21.

KASE, T. 1984. Early Cretaceous Marine and Brackish-Water Gastropoda from Japan. National Science Museum: Tokyo. 263 pp., 31 pls.

KILBURN, R. N. 1985. The family Epitoniidae (Mollusca: Gastropoda) in southern Africa and Mozambique. Annals of the Natal Museum 27(1):239–337, figs. 1–171.

KITTL, E. 1892. Die Gastropoden der Schichten von St. Cassian der südalpinen Trias. Annalen des K. K. Naturhistorischen Hofmuseums 7:135–197.

KNIGHT, J. B., R. L. BATTEN, E. L. YOCHELSON & L. R. COX. 1960. Supplement—Paleozoic and some Mesozoic Caenogastropoda and Opishtobranchia. Pp. I310–I324, figs. 206–216 in R. C. Moore (ed.), Treatise on Invertebrate Paleontology. Part I. Mollusca 1. Geological Society of America and University of Kansas Press.

KOBELT, W. 1903. Iconographie der Schalentragenden Europäischen Meeresconchylien. Volume 3. Kreidel: Wiesbaden. Pp. 25–200.

KOKEN, E. 1892. Über die Gastropoden der rothen Schlernschichten nebst Bemerkungen über Verbreitung und Herkunft einiger triassischer Gattungen. Neues Jahrbuch für Mineralogie, Geologie und Paleontologie, serie 2, (1892):25–36.

LAMARCK, J. B. 1801. Système des Animaux sans Vertèbres ou Tableau Général des Classes, des Ordres, et des Genres de ces Animaux. Paris. 432 pp.

LAMARCK, J. B. 1822. Histoire Naturelle des Animaux sans Vertèbres. 7 Volumes. Published by the author: Paris. 711 pp.

LUDVIGSEN, R. & G. BEARD. 1994. West Coast Fossils—A Guide to the Ancient Life of Vancouver Island. Whitecap Books: Vancouver. 194 pp., 130 pls.

LUDVIGSEN, R. & G. BEARD. 1997. West Coast Fossils—A Guide to the Ancient Life of Vancouver Island. Revised ed. Harbour Publishing: Madeira Park, British Columbia. 216 pp., 157 pls.

MATSUMOTO, T. 1959. Upper Cretaceous ammonites of California. Part I. Memoirs of the Faculty of Science, Kyushu University, series D, Geology, Special Vol. VIII, no. 4:91–171, pls. 30–45.

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

MAXWELL, P. A. 1992. Eocene Mollusca from the vicinity of McCulloch's Bridge, Waihao River, South Canterbury, New Zealand: paleoecology and systematics. New Zealand Geological Survey Paleontological Bulletin 65:1–280, pls. 1–30.

MÖLLER, H. 1842. Index Molluscorum Groenlandiae. Naturhistorisk Tidsskrift 4:76–97.

MÖRCH, O. A. L. 1857. Prodrome Mollusca Grönlandica in H. J. Rink, Grønland Geographisk og Statisk Beskrevet, Band 2, pt. 4: Kjøpenhagn.

MULLER, J. E. & J. A. JELETZKY. 1970. Geology of the Upper Cretaceous Nanaimo Group, Vancouver Island and Gulf Islands, British Columbia. Geological Survey of Canada Paper 69–25:1–77.

MURPHY, M. A., W. P. POPENOE & J. P. ALBERS. 1957. The Cretaceous and associated formations of the Redding area, Shasta County, California. Geological Society of Sacramento Annual Field Trip, 16 pp., 4 pls.

MURPHY, M. A., P. U. RODDA & D. M. MORTON. 1969. Geology of the Ono Quadrangle, Shasta and Tehama counties, California. California Division of Mines and Geology Bulletin 192:1–28.

MUSTARD, P. S. 1994. The Upper Cretaceous Nanaimo Group, Georgia basin. Pp. 27–67 in J. W. W. Monger (ed.), Geology and Geological Hazards of the Vancouver Region, Southwestern British Columbia. Geological Survey of Canada Bulletin 481.

NAGAO, T. 1934. Cretaceous Mollusca from the Miyako district, Honshû, Japan (Lamellibranchia and Gastropoda). Journal of the Faculty of Science, The Hikkaido Imperial University, series 4, 2(3):177–277, pls. 23–39.

NEVILLE, B. 2001. The wentletraps (Epitoniidae): a study in white and white. American Conchologist 29(1):28–31, figs. 1–57.

NILSEN, T. H. 1984. Stratigraphy, sedimentology, and tectonic framework of the Upper Cretaceous Hornbrook Formation, Oregon and California. Pp. 51–88 in T. H. Nilsen (ed.), Geology of the Upper Cretaceous Hornbrook Formation, Oregon and California. SEPM Book 42: Los Angeles, California.

OLSSON, A. A. 1928. Contributions to the Tertiary paleontology of northern Peru. Part 1, Eocene Mollusca and Brachiopoda. Bulletins of American Paleontology 14(52):51–148, pls. 1–26.

PACKARD, E. L. 1922. New species from the Cretaceous of the Santa Ana Mountains, California. University of California Publications, Bulletin of the Department of Geological Sciences 13:413–462, pls. 24–38.

PALMER, K. V. W. 1937. The Claibornian Scaphopoda, Gastropoda and dibranchiate Cephalopoda of the southern United States. Bulletins of American Paleontology 7(32):1–730, pls. 1–90.

PERRILLIAT, M. C., F. J. VEGA & D. CORONA. 2000. Early Maastrichtian Mollusca from the Mexcala Formation of the State of Guerrero, southern Mexico. Journal of Paleontology 74(1):7–24, figs. 1–7.

PERVINQUIÈRE, L. 1912. Études de paléontologie Tunisienne. II. Gastropodes et lamellibranches des terrains Crétacés. Carte Géologisque de la Tunisie, 352 pp., 23 pls.

PONDER, W. F. 1984. A review of the genera of the Iravadiidae (Mollusca: Gastropoda: Rissoacea) with an assessment of the relationships of the family. Malacologia 25:21–71, figs. 1–23.

PONDER, W. F. 1985. A review of the genera of the Rissoidae (Mollusca: Mesogastropoda: Rissoacea). Records of the Australian Museum, Supplement 4, 221 pp., 153 figs.

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. 1943. Cretaceous: east side Sacramento Valley, Shasta and Butte counties, California. American Association of Petroleum Geologists Bulletin 27:306–312.

POPENOE, W. P. & L. R. SAUL. 1987. Evolution and classification of the Late Cretaceous-early Tertiary gastropod *Perissitys*. Natural History Museum of Los Angeles County, Contributions in Science 380:1–37, figs. 1–182.

POPENOE, W. P., L. R. SAUL & T. SUSUKI. 1987. Gyrodiform gastropods from the Pacific coast Cretaceous and Paleocene. Journal of Paleontology 61(1):70–100, figs. 1–7.

REUSS, A. E. 1845–1846. Die Versteinerungen der Böhmischen Kreideformation. Vol. 1. Pp. 58–148, 51 pls.

REX, M. & K. BOSS. 1973. Systematics and distribution of the deep-sea gastropod *Epitonium (Eccliseogrya) nitidum*. The Nautilus 87:93–98.

RÖDING, P. F. 1798. Museum Boltenianum. Johan Christi Trappii: Hamburg. 199 pp.

ROMAN, F. & P. MAZERAN. 1920. Monographie paléontologique de la faune du Turonien du bassin d'Uchaux et ses dépendances. Archives du Muséum d'Histoire Naturelle de Lyon 12:1–137, pls. 1–11.

SAUL, L. R. 1959. Senonian mollusks from Chico Creek. Unpublished Master of Arts Thesis, University of California, Los Angeles. 170 pp.

SAUL, L. R. 1961. Stratigraphy and correlation of the Chico Formation (Upper Cretaceous) at its type locality. Geological Society of Sacramento Annual Field Trip, 1961, pp. 16–21.

SAUL, L. R. 1982. Water depth indications from Late Cretaceous mollusks, Santa Ana Mountains, California. Pp. 69–76 in D. J. Bottjer, I. P. Colburn & J. D. Cooper (eds.), Late Cretaceous Depositional Environments and Paleogeography, Santa Ana Mountains, Southern California. Pacific Section, SEPM, Annual Convention Field Guidebook and Volume 24: Los Angeles, California.

SAUL, L. R. 1986. Pacific west coast Cretaceous molluscan faunas: time and aspect of changes. Pp. 131–135 in P. L. Abbott (ed.), Cretaceous Stratigraphy Western North America. Pacific Section, SEPM, Vol. 46: 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 Angles County, Contributions in Science 400:1–25, figs. 1–128.

SAUL, L. R. & W. P. POPENOE. 1992. Pacific slope Cretaceous bivalves of the genus *Calva*. Natural History Museum of Los Angles County, Contributions in Science 433:1–68, figs. 1–287.

SAUL, L. R. & W. P. POPENOE. 1993. Additions of Pacific slope Turonian Gastropoda. The Veliger 36:351–388.

SAUL, L. R. & R. P. SQUIRES. 1998. New Cretaceous Gastropoda from California. Palaeontology 41(3):461–488, pls. 1–3.

SOHL, N. F. 1960. Archaeogastropoda, Mesogastropoda and stratigraphy of the Ripley, Owl Creek, and Prairie Bluff formations. U.S. Geological Survey Professional Paper 331-A: 1–151, pls. 1–18.

SOHL, N. F. 1964. Neogastropoda, Opisthobranchia and Basommatophora from the Ripley, Owl Creek, and Prairie Bluff formations. U.S. Geological Survey Professional Paper 331–B:153–344, pls. 19–52.

SOWERBY, G. B. 1844. Monograph of the genus *Scalaria*. Thesaurus Conchyliorum 1(4):83–146, pls. 32–40.

SQUIRES, R. L. 1997. Taxonomy and distribution of the buccinid gastropod *Brachysphingus* from uppermost Cretaceous and Lower Cenozoic marine strata of the Pacific slope of North America. Journal of Paleontology 71(5):847–861, figs. 1–5.

SQUIRES, R. L., M. H. LINK & I. P. COLBURN. 1981. Introduction. Pp. 5–8 in M. H. Link, R. L. Squires & I. P. Colburn (eds.), Simi Hills Cretaceous Turbidites, Southern California. Pacific Section, SEPM, Volume and Guidebook: Los Angeles, California.

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.

SQUIRES, R. L. & L. R. SAUL. 2001. New Late Cretaceous gastropods from the Pacific slope of North America. Journal of Paleontology 75(1):46–65, figs. 1–6.

SQUIRES, R. L. & L. R. SAUL. 2003. New Late Cretaceous (Campanian and Maastrichtian) marine gastropods from California. Journal of Paleontology 77(1):50–63, figs. 1–4.

STEPHENSON, L. W. 1941. The Larger Invertebrate Fossils of the Navarro Group of Texas. The University of Texas Publication, no. 4101. 641 pp., 95 pls.

STEWART, R. B. 1927. Gabb's California fossil type gastropods. Proceedings of the Academy of Natural Sciences of Philadelphia 78:287–447, pls. 20–32.

SUTER, H. 1913. Manual of the New Zealand Mollusca with an Atlas of Quarto Plates. Government of New Zealand, Wellington, 1120 pp., 71 pls.

TERQUEM, O. & E. JOURDY. 1869. Monographie de l'étage Bathonian dans le départment de la Moselle. Mémoires Société Geologique de France, série 2, 9(1):1–175, pls. 1–15.

THOMPSON, R. I., J. W. HAGGART & P. D. LEWIS. 1991. Late Triassic through early Tertiary evolution of the Queen Charlotte basin, British Columbia, with a perspective on hydrocarbon potential. Pp. 3–29 in Evolution and Hydrocarbon Potential of the Queen Charlotte Basin, British Columbia. Geological Survey of Canada Paper 90–10.

TOMLIN, J. R. LE B. 1927. Reports on the marine Mollusca in the collections of the South African Museum, II: families Abyssochrysidae, Oocorythidae, Haliotidae, Tonnidae. Annals of the South African Museum 25(1):77–83, 4 figs.

TRACEY, S., J. A. TODD & D. H. ERWIN. 1993. Mollusca: Gastropoda. Pp. 131–167 in M. J. Benton (ed.), The Fossil Record 2. Chapman & Hall: London.

TRUJILLO, E. F. 1960. Upper Cretaceous foraminifera from near Redding, Shasta County, California. Journal of Paleontology 34:290–346.

USHER, J. L. 1952. Ammonite faunas of the Upper Cretaceous rocks of Vancouver Island, British Columbia. Geological Survey of Canada, Bulletin 21:1–182, pls. 1–30.

WEBSTER, M. L. 1983. New species of *Xenophora* and *Anchura* (Mollusca: Gastropoda) from the Cretaceous of Baja California Norte, Mexico. Journal of Paleontology 57:1090–1097.

WEIL, A., L. BROWN & B. NEVILLE. 1999. The Wentletrap Book, Guide to the Recent Epitoniidae of the World. Arti Grafiche La Moderna: Rome. 244 pp., 165 pls.

WELLS, F. E. & C. W. BRYCE. 1985. Seashells of Western Australia. Western Australian Museum: Perth. 207 pp., 74 pls.

WENZ, W. 1938–1944. Gastropoda. Teil 1. Allgemeiner Teil und Prosobranchia. Pp. 1–1639 in O. H. Schindewolf (ed.), Handbuch de Paläozoologie, Band 6, Prosobranchia, Teil 4. Gebrüder Borntraeger: Berlin. [reprinted 1960–1961]

WHITE, C. A. 1889. On invertebrate fossils from the Pacific coast. U.S. Geological Survey Bulletin 51:1–102.

WHITEAVES, J. F. 1876. On some additional fossils from the Vancouver Cretaceous, with a revised list of the species therefrom. Geological Survey of Canada, Mesozoic Fossils, 1(1): 1–92, pls. 1–10.

WHITEAVES, J. F. 1879. On the fossils of the Cretaceous rocks of Vancouver and adjacent islands in the Strait of Georgia. Geological Survey of Canada, Mesozoic Fossils 1(2):93–190, pls. 11–20.

WHITEAVES, J. F. 1895. On some fossils from the Nanaimo Group of the Vancouver Cretaceous. Transactions of the Royal Society of Canada, series 2, 1(4):119–133, pls. 1–3.

WHITEAVES, J. F. 1900. On some additional or imperfectly understood fossils from the Cretaceous rocks of the Queen Charlotte Islands, with a revised list of the species from these rocks. Canada Geological Survey, Mesozoic Fossils 1(4):263–307, pls. 33–39.

WHITEAVES, J. F. 1903. On some additional fossils from the Vancouver Cretaceous, with a revised list of the species therefrom. Geological Survey of Canada, Mesozoic Fossils 1(5): 309–416, pls. 40–51.

APPENDIX

LOCALITIES CITED

Unless otherwise stated, localities are LACMIP.

Sucia Island

10449. West end of peninsula on S side of Fox Cove, Sucia Island, San Juan County, Washington. Cedar District Formation. Age: Middle Campanian. Collectors: R. Durbin, H. L. Popenoe & W. P. Popenoe, 1935.

UCMP 2209. ?Sucia Island (no more information known).

Yreka Area

25401. Sandstone outcrop 549 m S and 914 m E of NW corner of section 26, T. 46 N, R. 6 W, U.S. Geological Survey Yreka quadrangle (30 minute, 1939), Black Mountain area, east of Yreka, Siskiyou County, northern California. Hornbrook Formation, Osburger Gulch Sandstone Member. Age: Turonian. Collector: W. P. Popenoe, May 16, 1944.

East of Redding

U.S. Geological Survey Millville quadrangle (15 minute, 1953), Shasta County, northern California. Redding Formation.

10786. [= CIT 1005]. Near crest of S slope of divide between Basin Hollow and Clover creeks, at approximately the SE corner of the NW ¼ of section 33, T. 32 N, R. 2 W. Member V (lower part) of Popenoe (1943). Age: Early Santonian. Collectors: W. P. Popenoe & D. W. Scharf, August 8, 1931.

10794. [= CIT 1246]. Float on hillsope on E side of "1000-foot hill," SE ¼ of NE ¼ of section 13, T. 32 N, R. 2 W. Member V of Popenoe (1943). Age: Santonian. Collector: W. P. Popenoe, August 1, 1936.

24217. Hard sandstone slabs in bed of Clover Creek, 213 m N and 366 m W of SE corner of section 22, T. 32 N, R. 2 W. Member VI of Popenoe (1934). Age: Late Santonian. Collectors: W. P. Popenoe & D. Dailey, August 27, 1959.

24246. SE side of Oak Run Valley, in sandstone below thick conglomerate, 518 m E and 549 m N from SW corner of section 15, T. 32 N, R. 2 W. Member V of Popenoe (1943). Age: Early Santonian. Collector: W. P. Popenoe, August 31, 1959.

Chico Creek

U.S. Geological Survey Paradise quadrangle (7.5 minute, 1953), Butte County, northern California. Chico Formation. Unless otherwise stated, Collectors: L. R. Saul & R. B. Saul, August, 1952.

10849. Sandstone layer about approximately 30 m below Cretaceous/lava flow contact, on hillside N and a little E of Mickey's house, NW ¼ of the SW ¼ of section 1, T. 23 N, R. 2 E. Musty Buck Member. Age: Late Santonian. Collectors: W. P. Popenoe & D. W. Scharf, August 18, 1931.
23624. First ravine to S of Mickey's house on W side of Chico Creek, 395 m N and 274 m E of SW corner of section 1, T. 23N, R. 2 E. Musty Buck Member. Age: Santonian.
23628. Fossils in brown and gray-blue sandstone on E bank of Chico Creek, 244 m S and 305 m E of NW corner of section 13, T. 23 N, R. 2E. Musty Buck Member. Age: Late Santonian.
23634. On E bank of Chico Creek, 518 m S and 160 m E of NW corner of section 13, T. 23 N, R. 2 E. Musty Buck Member/Ten Mile Member boundary. Age: Earliest Campanian.
23635. On E bank of Chico Creek, 549 m S and 122 m E of NW corner of section 13, T. 23 N, R. 2 E. Ten Mile Member. Age: Earliest Campanian.
23637. On E bank of Chico Creek, 381 m N of SE corner of and just barely inside E line of section 14, T. 23 N, R. 2 E. Ten Mile Member. Age: Early Campanian.
23639. In concretions in massive, greenish-gray sandstone, 373 m S and 293 m W of NE corner of section 23, T. 23 N, R. 2 E. Ten Mile Member. Age: Early Campanian.
23648. Sandstone bluff on W side of Chico Creek, 533 m S and 549 m E of NW corner of section 35, T. 23 N, R. 2 E. Ten Mile Member. Age: Early Campanian.

Pentz Area

24340. Conglomerate beds cropping out just below a drainage canal, SE side of Oroville Highway, about 1.2 km NE of intersection of the highway and Pentz-Magalia-Oroville Road, and 427 m S and 183 m W of the NE corner of section 36, T. 21 N, R. 3 E, U.S. Geological Survey Cherokee quadrangle (7.5 minute, 1949), Butte County, northern California. Chico Formation, Pentz Road member (informal). Age: Early Campanian. Collector: W. P. Popenoe, May 13, 1960.

Pigeon Point

USGS Mesozoic M8610 [= loc. 10 of Elder & Saul, 1993]. About 1 km E of Pigeon Point, U.S. Geological Survey Pigeon Point quadrangle (7.5 minute, 1955), San Mateo County, northern California. Pigeon Point Formation, southern sequence. Age: Probably early middle Campanian. Collector: Unknown.

Jalama Creek

U.S. Geological Survey Lompoc Hills quadrangle (7.5 minute, 1947), western Santa Ynez Mountains, Santa Barbara County, southern California. Jalama Formation. Age: Early late Campanian.

24108. Elevation 168 m, thin bed of hard, fine-grained, gray quartz sandstone in gully bottom and 9 m above on brush-covered sandstone face, 610 m N of Jalama Creek, 3.3 km S of the Jalama Ranch Headquarters, 4.2 km W and 1.3 km N of the SE corner of topographic quadrangle. Collector: D. Dailey, August, 1958.
24140. Elevation 152 m, fine-grained, dark-gray sandstone, 274 m N of Jalama Creek, 3 km E and 0.6 km S of the Jalama Ranch Headquarters, 4.7 km W and 1.2 km N of the SE corner of topographic quadrangle. Collector: W. P. Popenoe, September, 1938.

Simi Hills

U.S. Geological Survey Calabasas quadrangle (7.5 minute, 1952), Ventura County (unless otherwise stated), Simi Hills, southern California. Chatsworth Formation, unless otherwise stated, lower part of formation and of middle Campanian age.

6965. Same as 10715 (see below). Collector: J. Alderson, 1974.
10715. [= CIT 1159]. Prominent fossil bed on crest of spur between forks of Dayton Canyon 122 m E of Los Angeles-Ventura County Line, and 1829 m N23°W of SE corner of section 33, T. 2 N, R. 17 W, Los Angeles County. Collectors: R. Durbin, H. L. Popenoe & W. P. Popenoe, June 21, 1935.
10716. [= 26464 and CIT 1538]. Small pebbly conglomerate lens in massive Cretaceous sandstone near crest of Simi Hills, about 1.3 km west of Los Angeles-Ventura County line and 2.5 km N60°W of SE corner of section 33, T. 2 N, R. 17 W, and 320 m N and 1128 m W of SW corner of County line, section 28. Middle Campanian. Collectors: P. T. & G. P. Zebal, October 25, 1942.
26020. [= CIT 1158]. Fine-grained sandstone cropping out on high bare cliff, N bank of Bell Canyon, just E of mouth of large gully, 2743 m W and 152 m S of the NE corner of section 4, T. 1 N, R. 17 W. Collector: W. P. Popenoe, February 11, 1972.

Santa Ana Mountains

10093. Pebbly lens near top of shale series just below crest of ridge, first prominent NE-SW spur N of Santiago Creek near its junction with Harding Creek, about 914 m straight W of the dam in Harding Canyon, U.S.

Geological Survey El Toro quadrangle (7.5 minute, 1949), Orange County, southern California. Unless otherwise stated, Williams Formation, Pleasants Sandstone Member. Age: Late middle Campanian. Collector: W. P. Popenoe, 1933–1934.

Arroyo Santa Catarina

2853. Broken concretion with numerous fossils, just S of Arroyo Tiburon (a tributary on W side of Arroyo Santa Catarina). Near mouth of and along W side of Arroyo Santa Catarina, SE side of Mesa San Carlos, northern Baja California, Mexico (see Webster, 1983:fig. 1, for detailed locality map). Rosario Formation. Age: Late Campanian to early Maastrichitian. Collector: M. Webster, 1966.