

GYRODIFORM GASTROPODS FROM THE PACIFIC COAST CRETACEOUS AND PALEOCENE

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ABSTRACT—Seven previously described and seven new taxa of gyrodidform naticoids from West Coast Late Cretaceous–Paleocene age strata are discussed. *Gyrodes* (*Gyrodes*) *dowellii* White of Turonian age is a typical *Gyrodes*; *G. robustus* Waring from the Paleocene has the shape of *Gyrodes* s.s. but lacks the crenulations. *G. greeni* Murphy and Rodda, *G. yolensis* n. sp., *G. quercus* n. sp., *G. banites* n. sp., *G. canadensis* Whiteaves, *G. pacificus* n. sp., and *G. expansus* Gabb comprise the new subgenus *Sohlella*, which thus ranges from Cenomanian through Maastrichtian. *Gyrodes robsauli* n. sp. resembles “*Polinices*” (*Hypterita*) *helicoides* (Gray), and *Hypterita* is reassigned to the Gyrodinae as a subgenus of *Gyrodes*. *Gyrodes onensis* n. sp. of Albian age is similar to the *G. americanus* group of Sohl (1960). Three taxa—*Natica allisoni* (Murphy and Rodda) of Cenomanian age and *N. conradiana* Gabb and *N. conradiana vacculae* n. subsp. of Turonian age—which have all been previously considered to be *Gyrodes* are placed in *Natica*. Well marked relict color patterns on *N. conradiana* and *N. conradiana vacculae* suggest that these naticids from northern California and southern British Columbia were tropical forms.

Diversity of taxa and size of specimens are reduced at the end of the Turonian, suggesting a change in West Coast marine conditions at that time.

INTRODUCTION

W. P. POPENOE had written a first draft for the gyrodidform gastropods of the Pacific Coast, and T. Susuki had taken many of the photographs, but the manuscript remained incomplete at the time of Popenoe's death. L. R. Saul and T. Susuki have, therefore, completed the paper.

Geographic and stratigraphic distribution of fourteen species of gyrodidform naticid gastropods are found to assist in paleogeographic and paleoclimatic reconstructions of West Coast terranes from Baja California, Mexico, to Vancouver Island, British Columbia. These species are useful in correlating shallow-water sediments that lack ammonites and planktic foraminifers. All of the West Coast Cretaceous species previously assigned to *Gyrodes* are discussed. They range in age from Albian to Selandian (Figure 1). Only *Gyrodes dowellii* White, 1889, is considered to belong to the typical subgenus. *Gyrodes robustus* Waring resembles a typical *Gyrodes* in shape but lacks the crenulations near the suture and along the umbilical margin. *Sohlella* n. subgen. is erected to include *G. quercus* n. sp., *G. canadensis* Whiteaves, *G. pacificus* n. sp., and *G. expansus* Gabb. *Gyrodes greeni* Murphy and Rodda, *G. yolensis* n. sp., and *G. banites* n. sp. are questionably included in *Sohlella*. The subgenus *Hypterita* (Woodring, 1957) has a

gyrodidform growth line and is moved from the Polinicinae to the Gyrodinae, which increases the geologic range of *Gyrodes* to the present. The inclusion of *G. robsauli* n. sp. in *Hypterita* extends the geologic range of this subgenus back to Late Cretaceous. *Gyrodes onensis* n. sp. resembles Sohl's (1960) group of *G. americanus* (Wade, 1926), but *G. allisoni* Murphy and Rodda, *G. conradianus* (Gabb), and *G. conradianus vacculae* n. subsp. are probably not *Gyrodes* and are reassigned to *Natica*. This reassignment is supported by a funicle in the umbilicus of *G. conradianus* and *G. conradianus vacculae*, and relict color patterns retained on some specimens. Such markings are otherwise unknown in *Gyrodes*, an absence perhaps preservational rather than original. Color pattern is not usually recognized as being a generic characteristic, but the markings retained on *Natica conradiana* and *N. conradiana vacculae* are strikingly similar to those of such tropical naticas as *N. chemnitzii* Pfeiffer, 1840, *N. marochinensis* Gmelin, 1791, and *N. gaultieriana* Recluz, 1844.

PATTERNS OF OCCURRENCE

Sohl (1960, p. 117) found that Gulf Coast *Gyrodes* were present in all lithologic types from sandstone through limestone and were unaffected by facies changes, but West Coast

gyrodiiform gastropods occur most commonly in coarse to medium grained sandstone. They are represented by few specimens from fine grained sandstone to mudstone lithologies. Although naticids are confined to soft substrates (Taylor et al., 1980, p. 380), these West Coast gyrodiiform species are most abundant at localities where *Turritella* spp. are rare or lacking, and they may have inhabited shallower depths and higher energy bottoms than did the turritellas. But, as Recent European naticids confine their predation almost entirely to bivalves (Fretter and Graham, 1962, p. 242), the absence of gyrodiiform naticids from overwhelmingly turritellid or anchurid faunas may reflect food preference rather than water depth. Naticid predation on turritellas is, however, documented as early as Albion (Taylor et al., 1983). The pattern of occurrences of these genera in the Chico Formation of Butte County, California, supports a shallow depth habitat for these naticids—probably subtidal but shallower than 30 m.

Despite the abundance of naticids from many Pacific Coast Cretaceous localities naticid drill holes are either not recognized or are rare in associated shells. Naticid drill holes of Albion age from the Blackdown Greensand of England (Taylor et al., 1983) are not ascribed to ampullines or gyrodines, and Sohl (1969) connects the appearance of naticid drill holes to the rise of the Polinicinae. In West Coast faunas the gyrodiiform naticids are relatively more common than polinicipines until the Campanian. Probable naticid drill holes are found in *Meekia sella* Gabb of mid to late Maastrichtian age from near Martinez, Contra Costa County, California, and gastropod drill holes have been recognized in West Coast turritellas of latest Cretaceous and Paleocene age (Saul, 1983), but such holes are uncommon before the Eocene. West Coast naticids appear to lag behind Atlantic basin naticids in shell drilling.

Recent naticas from temperate and cooler waters are not marked with strong color patterns. The presence of these relict color markings on specimens of *Natica conradiana* and *N. conradiana vacculae* from the Redding area suggests warmer water than is presently found at that latitude. In the Panamic fauna *Natica chemnitzii*, *N. brunneolinea* McLean, 1970,

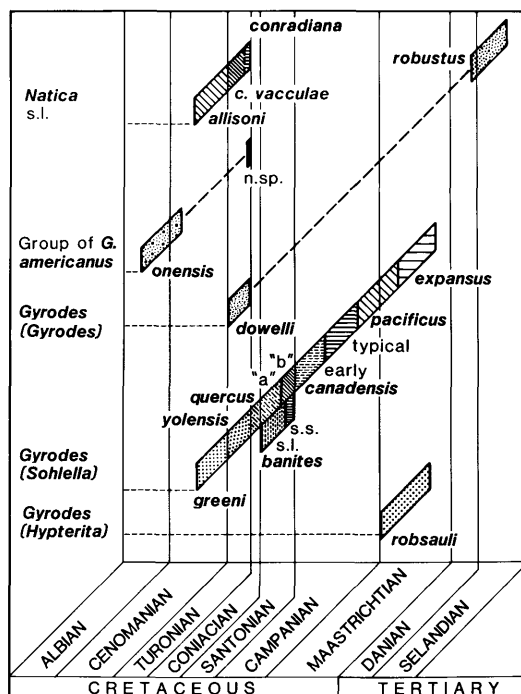


FIGURE 1—Stratigraphic ranges of West Coast gyrodiiform gastropods discussed in this paper.

and *N. inexpectans* Olsson, 1971, have color patterns somewhat similar to *N. conradiana vacculae*. Of these, *N. chemnitzii* ranges farthest north, being found in the Gulf of California and as far north as Magdalena Bay (approximately 25°N) on the Pacific Coast of Baja California, Mexico (Keen, 1971, p. 475). These Cretaceous naticas are abundant in pre-Senonian deposits, and *N. conradiana vacculae* occurs as far north as Sydney Island, British Columbia.

Size of specimens of gyrodiiform gastropods studied for this paper is not randomly distributed through the time period. Both large and small specimens of Albion through Turonian age were available. Only small specimens of Coniacian and Santonian age are present in the collections. Some early Campanian specimens are of moderate size as are most mid and late Campanian age specimens. Many specimens of Maastrichtian age are as large as specimens of Albion through Turonian age. The largest available are those of Paleocene age; they are also larger than specimens of *Gyrodes* measured by Sohl (1960, p. 117–118) from the Maastrichtian of Tennessee and Mississippi. Unlike the col-

or markings, size is not indicative of a climate zone, but abrupt changes in size distribution, such as that between late Turonian and early Coniacian specimens, suggest altered marine conditions.

The greatest diversity of these gyroform gastropods is in Albian through Turonian stages despite smaller and fewer collections from Albian and Cenomanian age strata. Mid Cretaceous species of gyroform gastropods discussed in this paper are placed in *Natica* and three *Gyrodes* subdivisions: *Gyrodes* s.s., group of *G. americanus*, and *Sohlella*. At the end of the Turonian, three out of four supraspecific taxa disappear from the West Coast Cretaceous record. Species of Late Cretaceous age are all *Gyrodes* and except for *G. (Hypterita) robsauli* n. sp. are *Sohlella* (Figure 1). The presence of *Gyrodes* (?*Sohlella*) *banites* n. sp. in the Santonian, a possible elaboration of the *Sohlella* lineage, temporarily increases post-Turonian diversity. A succession of species of *Sohlella* is represented by abundant specimens through the mid Maastrichtian. The only Paleocene species is doubtfully assigned to *Gyrodes* s.s.

Color markings, size distribution, and taxonomic diversity combine to indicate a marine event near or at the end of the mid Cretaceous. Whereas eastern North Pacific mid Cretaceous faunas contain species such as *Gyrodes* (*Gyrodes*) *dowelli* White related to those of the Western Interior and Gulf Coast in addition to the apparent tropical or Tethyan element, early Senonian faunas of this area are largely made up of genera with a long North Pacific history. In addition to a more temperate climate, the Senonian had decreased interchange with the Gulf Coast and Western Interior. This faunal change seems abrupt, occurring between late Turonian and early Coniacian. A gradual warming trend may be indicated by the increase in specimen size and diversity of taxa in the late Campanian–Maastrichtian, but tropical naticids do not reappear in California deposits until the Eocene (Marincovich, 1977).

TERMS

Terms used in describing the gyroform gastropods are diagrammed in Figure 2. A species is described as small if no specimen exceeds 20 mm in width, as medium if

“adult” specimens are between 20 and 39 mm in width, and large if some specimens exceed 40 mm in width. The umbilicus is the cavity left at the axis in shells whose adaxial whorl walls do not coalesce to form a solid columella. In the naticids discussed herein the umbilicus is at the adapical end of a semicircular depressed area, the umbilical depression. The umbilical depression is usually bounded by spiral biangulations on the base of the whorl and by the inner lip of the aperture. The funicle is a spirally wound ridge which extends adapically into the umbilicus from the inner lip. Its outer end at the inner lip is a usually semicircular umbilical callus. Adapical to the funicle is the sulcus. Its outer end at the inner lip is between the umbilical callus and the parietal callus. Abapical to the funicle is the channel. Its outer end at the inner lip is between the umbilical callus and the anterior end of the inner lip. On gyroline naticids the growth line forms an antispiral sinus within the umbilical area. This broadly arching sinus is terminated abaxially by a strongly prosocline flexure of the growth line. In gyroline having an angulate or subangulate margin to the umbilical area, this flexure coincides with the angulation. All of the naticids discussed in this paper have prosocline growth lines—that is, growth lines across the flank which lean adapically in the spiral direction.

The West Coast gyroform gastropods studied here are usually retrieved from well-cemented sandstone matrix which adheres to the often recrystallized shell. Some shells are coated with a thin skin of calcite that obscures sculpture, causes the shell to appear thicker, increases the apparent width, and may be difficult to distinguish from the shell itself. Many specimens are post-depositionally deformed. Recovery of complete specimens is unusual; the outer lip is thin and seldom found complete. Five measurements were made: height (h) of shell parallel to the axis of coiling; width (w) or diameter of shell normal to the axis of coiling (=MD, maximum diameter of Sohl, 1960); height of spire (s); height of penultimate whorl (p) measured at the aperture parallel to the axis of coiling; portion of penultimate whorl exposed adapical to the suture (e) measured near the aperture. To facilitate comparison the measurements were com-

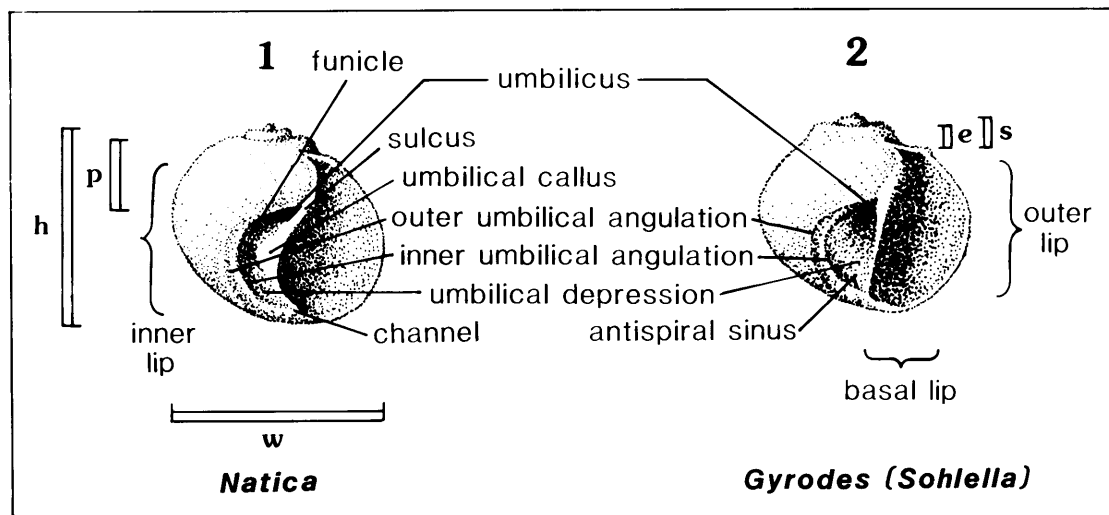


FIGURE 2—Diagrams of 1, *Natica* s.l., and 2, *Gyrodes* (*Sohlella*) to illustrate the morphologic terms used in the description of these gastropods. The following dimensions have been measured: height (h) of shell parallel to axis of coiling; width (w) of diameter of shell normal to the axis of coiling (=MD, maximum diameter of Sohl, 1960); height of spire (s); height of penultimate whorl (p) measured at the aperture parallel to the axis of coiling; portion of penultimate whorl exposed adapical to the suture (e) measured near the aperture.

bined into ratios of diameter to height (w/h), spire height to total height (s/h), height of penultimate whorl to total height (p/h), and portion of penultimate whorl exposed to height of penultimate whorl (e/p). These ratios and their means (where more than two specimens were measured) are plotted on Figure 3. As all of these gastropods are of gyroform shape—resembling slightly squashed marbles—the differences in their various ratios are not dramatic. The forms of *Gyrodes* (*Sohlella*) *quercus*, *G. (?S.) banites*, and *G. (S.) canadensis* discussed in the descriptions are plotted individually. Ratios of *G. (S.) quercus* “a” and *G. (?S.) banites* s.l. are similar, those of *G. (S.) quercus* “b” and *G. (?S.) banites* s.s. more distinct, especially for w/h and p/h , indicating a more expanded whorl. The dimensional changes between *G. (S.) quercus* “a” and “b” reverse the trend of those between *G. (S.) quercus* s.s. and “a”, but both w/h and p/h trends between *G. (?S.) banites* s.l. and s.s. continue in the direction of those between *G. (S.) quercus* s.s. and “a”. *Gyrodes* (*?S.) banites* and *G. (S.) pacificus* are relatively wider than the other species and *?N. allisoni* is the most equant. Species cannot be discriminated on measurements alone.

Institutional abbreviations used are: ANSP, Academy of Natural Sciences of Philadelphia; CAS, California Academy of Sciences; CGS, Canadian Geological Survey; CIT, California Institute of Technology; LACMIP, Los Angeles County Natural History Museum Invertebrate Paleontology; LSJU, Stanford University; UCB, University of California, Berkeley; UCBMP, University of California, Berkeley, Museum of Paleontology; UCLA, University of California, Los Angeles; UCR, University of California, Riverside; USGS, U.S. Geological Survey; USNM, U.S. National Museum.

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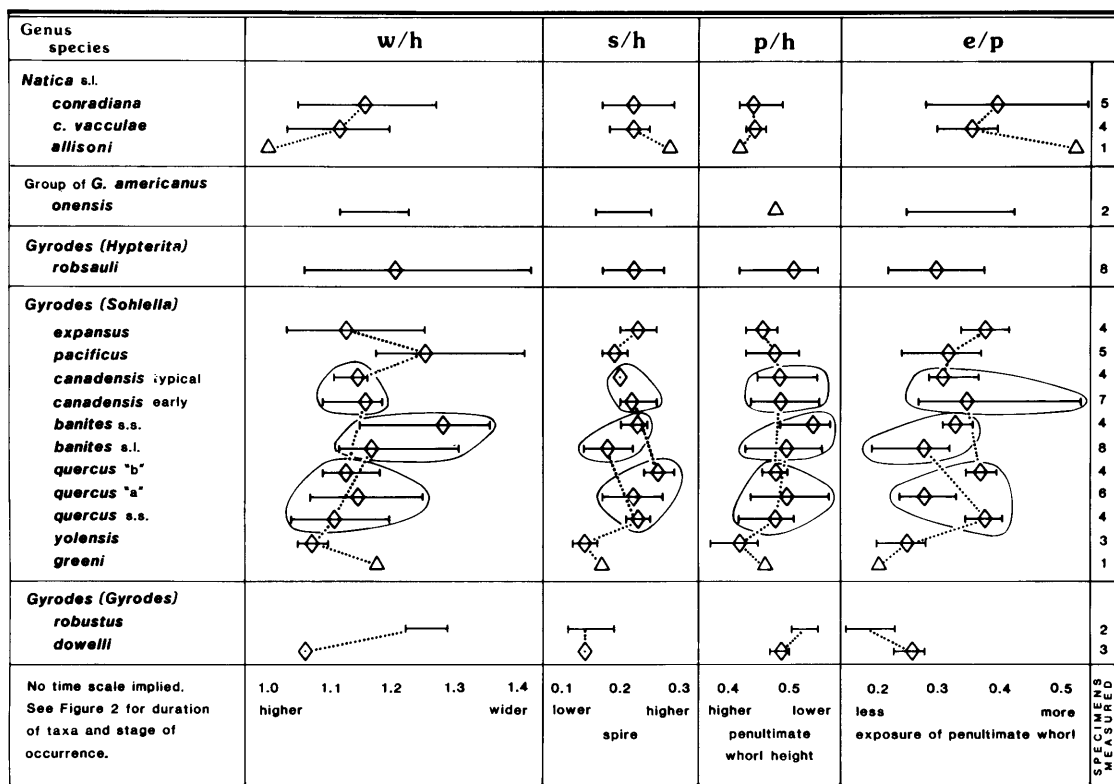


FIGURE 3—Ratios derived from five measurements h, w, s, p, and e of gyrodidform gastropods. See Figure 2 for explanation of measurements. Bar is total range of ratio and mean is indicated by diamond. Single specimen measurements (and 2 specimen measurements in which the ratios are the same) are plotted by triangle. Forms of a species discussed in the descriptions are encircled. Taxa inferred to be closely related are connected by dashed lines. Length of w/h bar is probably increased by slight post-depositional crushing of some specimens. Except for *Natica allisoni* all taxa are wider than high. *Gyrodes dowellii* is the least variable taxon. *G. (S.) banites* s.l. is contemporaneous with *G. (S.) quercus* "a"; *G. (S.) banites* s.s. is contemporaneous with *G. (S.) quercus* "b"; and the graph suggests increasing distinction of *G. (S.) banites* from *G. (S.) quercus*.

of the Geological Survey of Canada, and J. W. Durham of the Department of Paleontology, University of California, Berkeley. R. L. Cleavelly provided a cast of a naticid from the Upper Greensand which helped resolve a taxonomic quandry. H. Tappan and A. R. Loeblich assisted in the resolution of nomenclatorial problems and with manuscript revisions. Figures were expertly drafted by V. D. Jones. This paper has greatly benefited from the critical reading of M. A. Murphy and J. T. Smith, and R. B. Saul has improved its readability.

SYSTEMATIC PALEONTOLOGY

Phylum MOLLUSCA Linnaeus, 1758
Class GASTROPODA Cuvier, 1797

Order MESOGASTROPODA Thiele, 1927

Family NATICIDAE Forbes, 1838

Subfamily GYRODINAE Wenz, 1941

Discussion.—Marincovich (1977, p. 213) included Gyrodinae of Wenz in Ampullospirinae Cox, 1930, but ampullospirins are usually higher spired with a shell that is higher than wide and have a closed or very narrowly open umbilicus with a cord or ridge extending from the anterior inner lip into the umbilicus. Gyrodinae are low spired, and the shell is usually wider than high. Most have an open, usually wide open, umbilicus without a funicle (Wenz, 1941, p. 1017). Shell surface is textured by growth lines and is not polished. The growth line is strongly prosocline across the flank and within the umbilical depression

forms a characteristic, broadly U-shaped, antispiral sinus. Naticinae differ from Gyrodiinae, which are predominantly fossil, in having a less prosocline growth line that lacks a broadly U-shaped, umbilical, antispiral sinus.

Genus GYRODES Conrad, 1860

Type species.—*Natica* (*Gyrodes*) *crenata* Conrad, 1860. = *Rapa supraplicata* Conrad, 1858, by subsequent designation Gardner, 1916, p. 496.

Discussion.—*Gyrodes* comprises a distinctive group of naticid gastropods predominantly of later Cretaceous age. Some species of Aptian age are ascribed to it but do not belong to the typical subgenus. Of the few described Paleocene *Gyrodes*, only *G. robustus* resembles the typical subgenus.

Conrad (1860, p. 289) characterized *Gyrodes* as "Globose, thin in substance; whorl channelled above; umbilicus profound without a callus on the columella or base." He followed this diagnosis with the description of two new species, *Natica* (*Gyrodes*) *crenata* and *N. (Gyrodes) alveata*, and referred *Natica petrosa* Morton, 1834, to *Gyrodes*.

Gyrodes has been discussed subsequently by a number of workers, among whom may be mentioned Stoliczka (1868, p. 297), Meek (1876, p. 309), Fischer (1887, p. 768), Gardner (1916, p. 496), Cossmann (1925, p. 102), and Sohl (1960, p. 116). Sohl's diagnosis, which well represents the modern concept of the genus, defines it as comprised of "Medium- to large-sized subglobose low-spired shells with wide deep umbilicus free of callus; ornament restricted to growth lines and commonly nodes or crenulations near suture and at umbilical margins; aperture subovate, inclined; inner-lip callus very thin." The absence of umbilical callus in the genus is stressed by practically all workers. Cossmann (1925, p. 103) emphasized that this genus has a "columelle non calleuse, non réfléchi sur l'ombilic, dont la paroi interne ne comporte aucun épaissement ni aucune arête." Despite this universal exclusion from *Gyrodes* of forms having callosities in the umbilicus, three Pacific Coast taxa, *G. (Sohlella) quercus* n. sp., *G. (?Sohlella) banites* n. sp., and *G. (Hypterita) robsauli* n. sp., that possess callosities are included in *Gyrodes* s.l. because of their probable phylogenetic relationship to

forms that lack such structures and otherwise possess characteristics of *Gyrodes*.

Sohl (1960) suggested subdivision of *Gyrodes* into three main types, based upon characters of the umbilical margin and the suture: 1) species of the typical form—exemplified by *G. supraplicatus* [type-species]—have a crenulate and sharp umbilical margin and crenulations near the suture; 2) species resembling *G. americanus* (Wade, 1926) bear a smooth whorl-surface and rounded umbilical margin; 3) species similar to *G. spillmani* Gabb, 1861, have a rounded umbilical margin and a noncrenulate but distinctly channelled suture. The first group, *Gyrodes* s.s., is represented in the Pacific Coast Cretaceous only by *Gyrodes dowelli* White, 1889, a Turonian species. The Pacific Coast Paleocene species, *Gyrodes robustus* Waring, 1917, similar in shape to *Gyrodes* s.s. but lacking crenulations, is questionably assigned to *Gyrodes* s.s. One West Coast species, *G. onensis* n. sp., resembles *G. americanus* (Wade). With one exception the remaining Pacific Coast *Gyrodes* appear most similar to the group of *G. spillmani* Gabb—forms with a "distinctly channelled suture." In the multitude of specimens in Pacific Coast collections, this character is somewhat variable; specimens from separate collections of essentially the same age, and other lots from the same locality and horizon, have subsutural bands which vary from flattened to tabulate to more-or-less channelled. Additionally, these Pacific Coast forms have a distinctly biangulate umbilical margin rather than the rounded margin of the *G. spillmani* group. Consequently, these West Coast forms are assigned to a new subgenus, *Sohlella*. The final group is that of the subgenus *Hypterita*, which is represented by the new species *G. (H.) robsauli*.

Subgenus GYRODES Conrad, 1860

Diagnosis.—Species of *Gyrodes* with a crenulate and sharp umbilical margin, and crenulations near the suture, with growth lines adjacent to the suture commonly notched.

GYRODES (GYRODES) DOWELLI White, 1889 Figure 4.1, 4.5, 4.7

Gyrodes dowelli WHITE, 1889, p. 19, Pl. 3, figs. 8, 9; ANDERSON, 1958, p. 149, Pl. 21, figs. 8, 9; JONES, SLITER, AND POPENOE, 1978, p. XXII. 10, Pl. 1, figs. 13, 14.

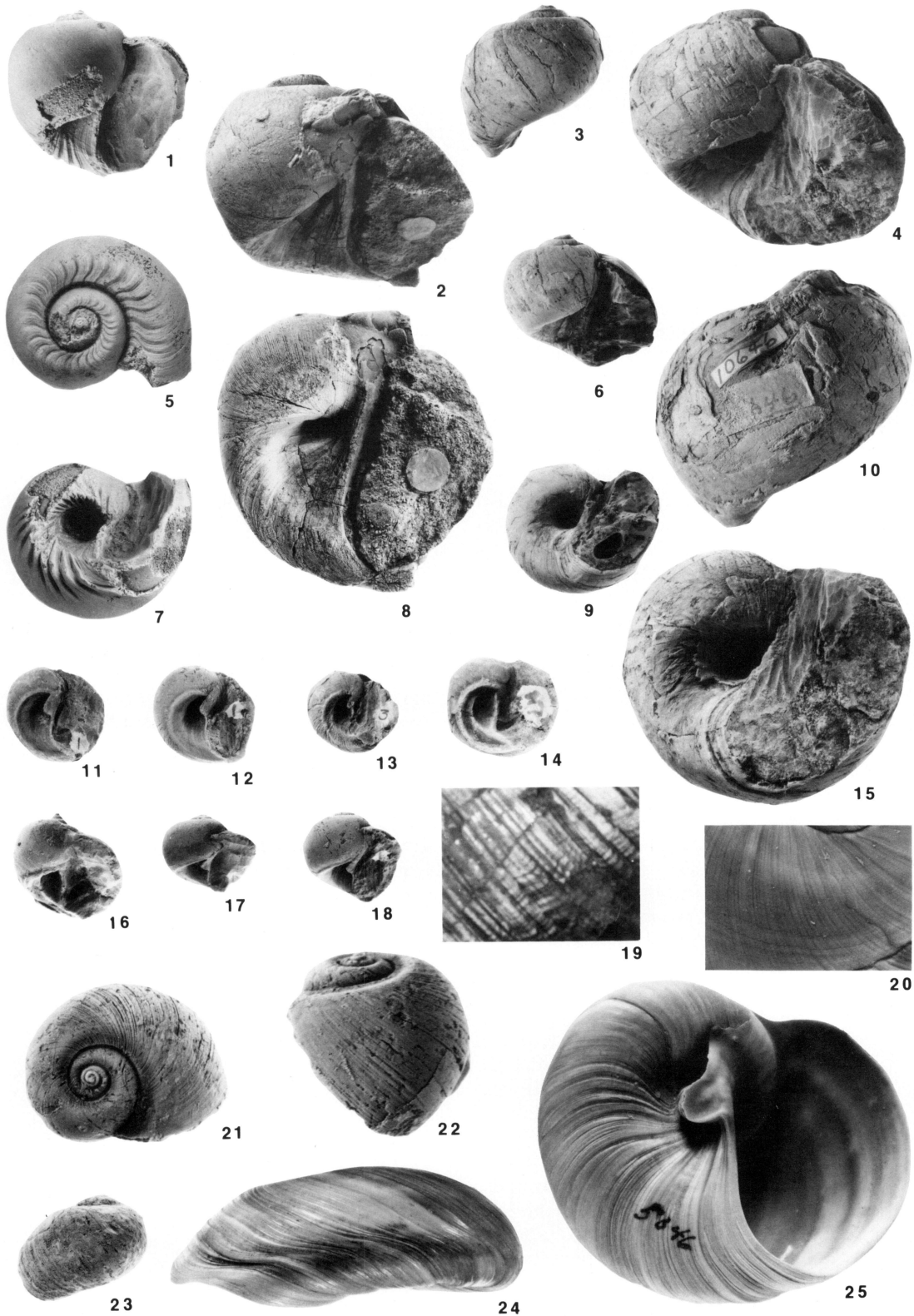


TABLE 1—Dimensions of hypotypes of *Gyrodes* (*Gyrodes*) *dowellii* White, in mm, * = incomplete. See Figure 2 for explanation of measurements.

	h	w	s	p	e	w/h	s/h	p/h	e/h	e/p
UCLA 59441	27.6*	29.3*	4.3	13.1	3.6	1.06	0.16	0.48	0.13	0.27
UCLA 59728	41.3*	43.9	6.0*	21.0	5.8	1.06	0.15	0.51	0.14	0.28
UCLA 59729	33.2	35.0	5.0	16.8	3.8	1.05	0.15	0.51	0.11	0.23

Description.—Shell medium to moderately large, slightly wider than high, thin; spire low, 15% of total height; protoconch of about 1½ smooth whorls; suture impressed, at posterior quarter of penultimate whorl; shoulder flattened but round edged and undulately crenulate; body sides broadly, evenly convex; umbilical margin abruptly angled and obliquely crenulate; umbilical wall smooth posterior to the clearly demarked crenulate band; umbilicus somewhat narrow, steep sided, and deep; aperture obliquely suboval; growth line notched at the suture, with a strong spiral antisinus on the shoulder, prosocline across the flank, abruptly flexed backward at the outer angulation, and forming a broad U-shaped sinus within the umbilicus; outer lip thin, projected near its posterior end, abruptly roundly notched near the suture; inner lip plain.

Holotype.—USNM 20126.

Hypotypes.—CAS 10648 from CAS loc. 1293-A, 1 mile (1.6 km) north of Frazier Corners, Shasta Co.; UCLA 58441, 59728–59729 all from CIT loc. 1444, south of Woodman Creek, Redding area, Shasta Co., California.

Type locality.—Near Jacksonville, Oregon.

Distribution.—Near the base of the Nanaimo Group at Hamley Point, Sydney Island, British Columbia; Hornbrook Formation near Jacksonville, and the vicinity of

Ashland, Oregon; in the Henley-Hornbrook region, and near Ager, Siskiyou Co.; Bellavista Sandstone, Frazier Silt, and Melton Sandstone of the Redding area, Shasta Co.; lower Venado Formation of Kirby on Logan Ridge, Colusa Co.; the Panoche Formation in the Dark Hole Quadrangle, near Coalinga, Fresno Co.; and the lower Ladd Formation in the Santa Ana Mountains, Orange Co., California.

Age.—Turonian.

Remarks.—This species differs from all other known Pacific Coast Cretaceous *Gyrodes* in its strongly wrinkled shoulder and umbilical margin, its relatively low and flattened spire, high and narrow last whorl, and narrow umbilicus. Its presence in association with *Cucullaea* (*Idonearca*) *gravid*a (Gabb, 1864), *Glycymeris pacificus* (Anderson, 1902), *Pterotrignia klamathonia* (Anderson, 1958), *Oonia?* *californica* (Gabb, 1864), and *Rostellinda dilleri* (White, 1889) at CGS 85511, Sydney Island, British Columbia, is the first indication of Turonian age sediments in the Nanaimo Basin (Jeletzky, 1977).

GYRODES (?GYRODES) ROBUSTUS

Waring, 1917

Figure 4.2, 4.8

Gyrodes robustus WARING, 1917, p. 84, Pl. 13, figs. 11, 12; MARINCOVICH, 1977, p. 243, Pl. 21, figs. 3–9.

FIGURE 4—All figures $\times 1$ except as noted. 1, 5, 7, *Gyrodes* (*Gyrodes*) *dowellii* White, 1889, hypotype, UCLA 59441, from CIT loc. 1444, Turonian. 2, 8, *Gyrodes* (?*Gyrodes*) *robustus* Waring, 1917, hypotype, UCLA 59730, from UCLA loc. 2582, early Selandian. 3, 4, 6, 9, 10, 15, *Gyrodes* s.l. *onensis* n. sp., from CAS loc. 1346A, Albion; 3, 6, 9, paratype, CAS 10647; 4, 10, 15, holotype, CAS 10646. 11–14, 16–19, 21–23, *Gyrodes* (*Hypterita*) *robsauli* n. sp., Maastrichtian; 11–14, 16–18, growth series showing development of callus tongue and umbilical angulations; 12, 17, UCLA 59782, holotype, from UCLA loc. 5902; 11, 13, 14, 16–19, 21–23, paratypes; 11, 18, UCLA 59787 from UCLA 6534; 13, UCLA 59784 from UCLA 5902; 14, 16, UCLA 59789, from UCLA loc. 6534, $\times 2$; 19, UCLA 59790 from UCLA loc. 6337, fine spiral striations and relatively strong growth lines, $\times 9.5$; 21, 22, UCLA 59783 from UCLA loc. 5902, $\times 2$; 23, UCLA 59786 from UCLA loc. 6465. 20, 24, 25, *Gyrodes* (*Hypterita*) *helicoides* (Gray, 1825), hypotype, UCLA 5046, from Magdalena Bay, Baja California, Mexico, Recent; 20, fine spiral striations, $\times 4$; 24, growth line flexure which bounds antispiral sinus.

TABLE 2—Dimensions of *Gyrodes* (?*Gyrodes*) *robustus* Waring, in mm, * = incomplete. See Figure 2 for explanation of measurements.

	h	w	s	p	e	w/h	s/h	p/h	e/h	e/p
UCLA 59730	33.0*	44.0*	6.0*	18.5	4.2	1.3	0.18	0.56	0.13	0.23
UCLA 59731	46.5	57.0*	5.5*	24.0	3.7	1.23	0.12	0.52	0.08	0.15

Description.—Shell large, wider than high; spire about 15% of total height, suture appressed, at posterior quarter of penultimate whorl; shoulder tabulate, angulate; whorl profile broadly convexly rounded; umbilical margin sharply angulate; umbilicus wide, sloping shallow, with second weaker angulation at the greatest growth-line flexure; growth lines slightly prosocline on the shoulder becoming strongly so on the flank, forming broad antispiral sinus at the inner umbilical angulation; aperture obliquely semicircular, rounded anteriorly, angulate posteriorly; outer lip projected posteriorly; inner lip unreflected, wrapped onto the last whorl posterior to the umbilical angulation.

Lectotype.—LSJU 147.

Lectoparatype.—LSJU 148.

Hypotypes.—UCR 6899/2; UCLA 59730 from UCLA loc. 2582; UCLA 59731 from UCLA loc. 3154; all from the Simi Hills, Ventura Co., California.

Type locality.—LSJU 2697: Simi Hills, Ventura Co., California.

Distribution.—Lower Santa Susana Formation of the Simi Hills, Ventura Co.; Coal Canyon Formation of the Santa Monica Mountains, Los Angeles Co., California.

Age.—Paleocene, Selandian, *Turritella peninsularis*–*T. infragranulata* Zone.

Remarks.—Large specimens of *G. (?G.) robustus* are larger than those of any other species discussed in this paper. A poorly preserved individual from the Coal Canyon Formation in Santa Ynez Canyon, Santa Monica Mountains. (UCLA 6738) has a width of 100 mm. Specimens are uncommon and usually poorly preserved.

Gyrodes (?*G.*) *robustus* is not similar to early Tertiary forms from Europe assigned to *Gyrodes* (*Sigaretopsis*). From *G. (S.) infundibulum* (Watelet, 1853), the type species of *Sigaretopsis* (Cossmann, 1888), *G. robustus* differs in being large, tabulate, and angulately umbilicate. In shape it resembles *Gyrodes* s.s. It differs from *G. supraplicatus* (Conrad) in

lacking the crenulations near the suture and on the umbilical margin. Its umbilicus has a shallower slope and narrower center and, although its outer umbilical angulation is strong, this angulation is not as prominent as that of *G. supraplicatus*. Unlike the inner angulation of *G. supraplicatus* that stands as a spiral chord within the umbilicus, the inner angulation of *G. robustus* is barely angulate; and the zone between the angulations is not sulcate as in *G. supraplicatus* but is flattened. The growth line of *G. (?G.) robustus* is not notched at the suture as is that of *G. supraplicatus* and *G. dowelli*.

Gyrodes robustus is most similar to *Eocernina hespericosta* Zinsmeister, 1983, also from the lower Santa Susana Formation in the Simi Hills, Ventura Co., California. *Eocernina hespericosta* is tabulate only on its early whorls and develops a slope-shouldered adult whorl profile; tabulate young *E. hespericosta* resemble *G. robustus*. Both species have a similar prosocline growth line with a strong antispiral sinus within the umbilical depression, a shallow sloping umbilicus bounded by an angulation, and a nearly straight inner lip which rounds abruptly into the basal lip at the umbilical flattening. *Eocernina hespericosta* has a thicker shell, thicker inner lip callus, and narrower umbilicus. The similarities are sufficiently strong to suggest that *Eocernina* is derived from *Gyrodes*.

SOHLELLA n. subgen.

Type species.—*Gyrodes* (*Sohlella*) *canadensis* (Whiteaves, 1903).

Diagnosis.—Species of *Gyrodes* with a usually tabulate, asymmetrically inflated whorl that is roundest anteriorly and has a biangulate to subrounded umbilical margin. The tabulation usually bears a slightly concave band.

Discussion.—*Sohlella* n. subgen. includes *G. quercus* n. sp., *G. canadensis* Whiteaves, *G. pacificus* n. sp., and *G. excavatus* (Gabb).

Also tentatively included is *G. greeni* Murphy and Rodda, *G. yolensis* n. sp., and *G. banites* n. sp. So constituted, the subgenus ranges from Cenomanian through mid Maastichtian. The shell surface is textured by growth lines; very well-preserved specimens have a silken luster but are not polished. *Sohlella* includes forms remarkable among *Gyrodes* for having umbilical callosities. *Gyrodes* (*S.*) *quercus* and *G.* (*S.*) *banites* have a reflected inner lip which in *G.* (*S.*) *banites* overhangs the umbilicus and forms an umbilical callus lobe similar to that of *Banis* and *Hyperita*. Most species assigned to *Sohlella* resemble Sohl's group of *G. spillmani* Gabb in their unornamented, slightly concave, tabulate shoulder, but differ from that group in having a more angulate umbilical margin. The questionably allotted *G. greeni* has the most sharply angulate umbilical margin; it differs from all other *Sohlella* in having a single rather than double umbilical angulation.

The subgenus is named for N. G. Sohl in celebration of his contributions to the delineation of Cretaceous naticids.

GYRODES (?SOHLELLA) GREENI

Murphy and Rodda, 1960

Figure 5.1, 5.10, 5.20

Gyrodes greeni MURPHY AND RODDA, 1960, p. 843, Pl. 101, figs. 27–29.

Holotype.—UCLA 28630.

Dimensions.—h, 26.8 mm; w, 31.6 mm; s, 4.7 mm; p, 12.6 mm; e, 2.6 mm; w/h, 1.18; s/h, 0.18; p/h, 0.47; e/h, 0.1; e/p, 0.2 (see Figure 2 for explanation of measurements).

Type locality.—UCLA 3465: north fork of Cottonwood Creek, Shasta Co., California.

Distribution.—Known only from the Bald Hills Member of the Budden Canyon Formation, Ono area, Shasta Co., California.

Age.—Cenomanian.

Remarks.—*Gyrodes* (*S.*) *greeni* resembles *G.* (*S.*) *yolensis* in being less tabulate at maturity than in youth and in having the growth line nearly orthocline at the suture. In *G.* (*S.*) *greeni* the inner lip is wrapped onto the penultimate whorl posterior to the umbilical angulation rather than at the angulation and the loss of tabulation at maturity is more complete than in *G.* (*S.*) *yolensis*. Of all the *Gyrodes* spp. discussed herein the whorls of *G.* (*S.*) *greeni* are narrowest posteriorly and

widest anteriorly. It is the only species with a single umbilical angulation assigned, even tentatively, to *Sohlella*. Murphy and Rodda have commented on the resemblance of *G.* (*S.*) *greeni* to *G.* (*S.*) *canadensis* and *G. excavatus*. Overall shape and umbilical characteristics of *G.* (*S.*) *yolensis* are intermediate between those of *G.* (*S.*) *greeni* and *G.* (*S.*) *quercus*. *Gyrodes greeni* and *G. yolensis* differ from other *Sohlella* spp. in the orthocline direction of the growth line immediately adjacent to the suture.

GYRODES (SOHLELLA?) YOLENSIS n. sp.

Figure 5.2, 5.11, 5.16, 5.21, 5.25, 5.30

Description.—Shell thin, medium sized, slightly wider than high, narrowly tabulate; spire about 15% of total shell height; suture appressed on early whorls, becoming depressed on last whorl, near posterior quarter of penultimate whorl; shoulder tabulate, angulate on early whorls, becoming rounded and obscurely noded on last whorl; whorl profile slightly concave abapical to the shoulder then roundly convexly expanded, contracted near the well-marked umbilical angulation; umbilical margin biangulate, the outer angulation sharper; umbilicus wide, sloping; growth line nearly orthocline at the suture, obliquely flexed at the shoulder, flexed at the umbilical angulations, curving into the umbilicus; aperture oblique, tear-drop shaped; outer lip thin, projected posteriorly; inner lip thin, wrapped around onto the previous whorl at the outer angulation.

Holotype.—CAS 61401.

Paratypes.—CAS 61402–61403 from CAS 31918.

Type locality.—CAS 31918: Thompson Creek, 1,200' N, 600' W of SE cor. sec. 20, T8N, T2W, Capay Quadrangle, Yolo Co., California.

Distribution.—Near the base of the Yolo Shale on Thompson Creek, Yolo Co.; and "Antelope Shale" of Kirby, probably slumped from basal Venado Formation, on Logan Ridge, Colusa Co., California.

Age.—Turonian.

Remarks.—This species is described from three well-preserved specimens, all of which have the outer lip broken. Two additional specimens—both leached and somewhat crushed—are from USGS M-175. The larger



FIGURE 5—All figures $\times 1$ except as noted. 1, 10, 20, *Gyrodes* (?*Sohlella*) *greeni* Murphy and Rodda, 1960, holotype, UCLA 28630 from UCLA loc. 3465, Cenomanian. 2, 11, 16, 21, 25, 30, *Gyrodes* (?*Sohlella*) *yolensis*, n. sp., from CAS loc. 31918, Turonian; 2, 11, 21, 25, holotype CAS 61401; 16, paratype, CAS 61402; 30, paratype, CAS 61403, $\times 2$. 3, 4, 7, 12, 17, *Gyrodes* (*Sohlella*) *quercus* n. sp., from CIT loc. 1007, Coniacian; 3, 4, 17, holotype, UCLA 59732; 7, paratype, UCLA 59733; 12, paratype, UCLA 59734. 5, 6, 8, 9, 15, 19, 24, *Gyrodes* (?*Sohlella*) *banites* n. sp. s.l., hypotypes, Santonian; 5, 8, 19, 24, UCLA 59760 from CIT loc. 1246; 6, 9, UCLA 59761 from CIT loc. 1246; 15, UCLA 59759 from UCLA loc. 4246. 13, 18, 22, 23, *Gyrodes* (*Sohlella*) *quercus* n. sp. form "a", hypotypes, Santonian; 13, 18, 22, from UCLA loc. 4106; 13, 18, UCLA 59741; 22, UCLA 59740; 23, UCLA 59746 from CIT 1313. 14, 26, 27, *Gyrodes* (*Sohlella*) *quercus* n. sp. form "b", hypotypes from UCLA 3627, Santonian; 14, 26, UCLA 59748; 27, UCLA 59747. 28, 29, *Gyrodes* (?*Sohlella*) *banites* n. sp., paratype, UCLA 59755 from UCLA loc. 3627, Santonian; 28, $\times 1.5$. 31–33, *Gyrodes* (*Sohlella*) *canadensis* Whiteaves, "early" form, hypotype, UCLA 59770 from UCLA loc. 4340, early Campanian.

TABLE 3—Dimensions of *Gyrodes (Sohlella?) yolensis* n. sp., in mm. See Figure 2 for explanation of measurements.

	h	w	s	p	e	w/h	s/h	p/h	e/h	e/p
CAS 61401	22.2	24.5	2.8	8.5	1.7	1.1	0.13	0.38	0.08	0.2
CAS 61402	20.5	21.8	3.1	9.5	2.5	1.06	0.15	0.46	0.12	0.26
CAS 61403	19.6	20.6	3.4	8.9	2.5	1.05	0.17	0.45	0.13	0.28

of these probably had a width of at least 30 mm and is of similar size to the holotype of *G. (?S.) greeni*. *Gyrodes (?S.) yolensis* differs from *G. (?S.) greeni* Murphy and Rodda in being lower spired, having obscure wrinkle-like nodes on the stronger shoulder, the slope of the inner lip at a narrower angle to the axis of coiling, and biangulate umbilical margin.

It differs from typical *Sohlella* in having its growth line orthocline at the suture, obscure wrinkle-like nodes on the shoulder, and the suture depressed at maturity.

The species is named for its occurrence in the Yolo Shale in Yolo County.

GYRODES (SOHLELLA) QUERCUS n. sp.

Figures 5.3, 5.4, 5.7, 5.12–5.14, 5.17, 5.18, 5.22, 5.26, 5.27, 6.1–6.4

Description.—Shell thin, small, wider than high; spire about 25% of total height, suture appressed, near posterior three-eighths of penultimate whorl; shoulder tabulate, angulate with shallow concave band adapically and slightly concave zone abapically; whorl profile obliquely convexly rounded anterior to the slight concavity adjacent to the shoulder; umbilical margin roundly biangulate; umbilicus narrow, steeply sloping; growth line obliquely prosocline; aperture oblique tear-drop shaped; outer lip thin, projected pos-

teriorly; inner lip thin anteriorly, with or without short posterior reflected tongue of callus overhanging the umbilicus.

Holotype.—UCLA 59732.

Paratypes.—UCLA 59733–59738 from CIT loc. 1007.

Hypotypes.—Form “a” UCLA 59740–59741 from UCLA loc. 4106, Clover Creek, Redding area, Shasta Co.; UCLA 59742–59743 from CIT loc. 1016, Chico Creek; UCLA 59744–59745 from UCLA loc. 3624, Chico Creek; UCLA 59746 from CIT loc. 1313, Chico Creek, Butte Co.; form “b” UCLA 59747–59748 from UCLA loc. 3627, Chico Creek, Butte Co., California; UCLA 59749–59750 from UCLA loc. 4217, Clover Creek, Redding area, Shasta Co., California.

Type locality.—CIT 1007: hills north of Oak Run, 1,250' S, 1,250' E of NW cor. sec. 16, T32N, R2W, Millville Quadrangle, Shasta Co., California.

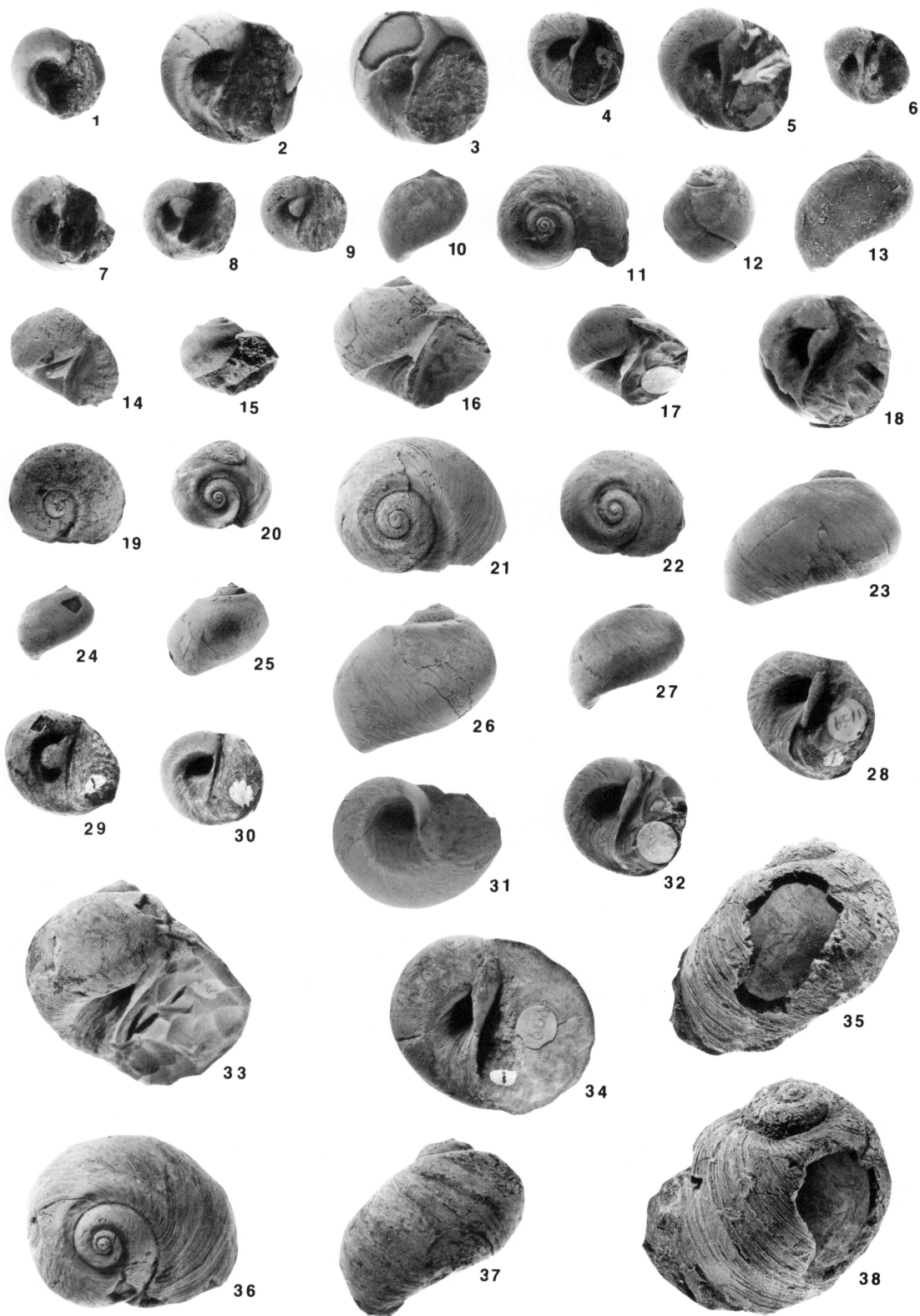
Distribution.—Members IV, V, and VI of the Redding area, Shasta Co. (Popenoe, 1943); Chico Formation, Musty Buck Member on Mill Creek, Tehama Co.; Musty Buck Member of the Chico Formation on Chico Creek, Butte Co., California.

Age.—Coniacian and Santonian.

Remarks.—*Gyrodes (S.) quercus* differs from *G. (?S.) yolensis* in its broader, unnoded

TABLE 4—Dimensions of *Gyrodes (Sohlella) quercus* n. sp., in mm, * = incomplete. See Figure 2 for explanation of measurements.

	h	w	s	p	e	w/h	s/h	p/h	e/h	e/p
UCLA 59732	15.2	18.2	4.0	7.9	2.8	1.2	0.26	0.52	0.18	0.35
UCLA 59733	13.7	15.4*	3.0	6.8	2.6	1.12	0.22	0.5	0.19	0.38
UCLA 59734	14.5	15.5*	3.2	7.4	2.7	1.07	0.22	0.51	0.19	0.36
UCLA 59735	18.7	19.4*	4.5	8.0	3.3	1.04	0.24	0.43	0.18	0.41
UCLA 59740	16.7	17.8	3.9	7.5	2.5	1.07	0.23	0.45	0.15	0.33
UCLA 59741	13.7	15.4	2.8	6.8	1.9	1.12	0.2	0.5	0.14	0.28
UCLA 59742	11.2	12.3	2.0	5.5	1.5	1.1	0.18	0.49	0.13	0.27
UCLA 59743	10.7	13.7	3.0	6.2	1.5	1.28	0.28	0.58	0.14	0.24
UCLA 59744	13.5	15.6	3.5	7.0	1.9	1.16	0.26	0.52	0.14	0.27
UCLA 59745	12.0	14.1	2.8	6.1	1.7	1.18	0.23	0.51	0.14	0.28
UCLA 59747	15.8	17.8	4.2	7.8	2.8	1.13	0.27	0.49	0.18	0.37
UCLA 59748	14.7	16.0	4.4	6.9	2.4	1.09	0.3	0.47	0.16	0.35
UCLA 59749	12.0	14.2	3.0	5.8	2.2	1.18	0.25	0.48	0.18	0.38
UCLA 59750	9.9	11.0	2.5	5.0	2.0	1.11	0.25	0.51	0.2	0.4



shoulder and slightly higher spire. It differs from *G. (S.) canadensis* in its propensity for developing tongues of callus on the inner lip edge which overhang the umbilicus, its less obliquely expanded whorl, and its more rounded umbilical margin. It differs from *G. (?S.) banites* in its more tabulate shoulder and less well-developed umbilical callus tongue. *Gyrodes (S.) quercus* grades into *G. (S.) canadensis* Whiteaves in the lower Tenmile Member, Chico Formation, on Chico Creek, Butte Co., California.

Included in *G. (S.) quercus* are three forms: 1) *quercus* s.s., specimens of Coniacian and earliest Santonian age which have a short reflected tongue of callus at the adapical end of the free inner lip; 2) form "a", specimens of early to late Santonian age which usually have a simple inner lip; and 3) form "b", specimens of late Santonian age (zone of *Baculites capensis*) which have a narrow reflected tongue of callus usually elongate along the free inner lip. Specimens from CIT 1260, Swede Basin, Redding area, are *quercus* s.s. and suggest a Coniacian or earliest Santonian age. Matsumoto (1960, p. 8, 105) identified *Baculites capensis* from this locality, but the *baculites* taper more rapidly and have a more subtrigonal cross section than *B. capensis* from the upper Musty Buck Member of the Chico Formation on Chico Creek, Butte Co., California. The three forms of *Gyrodes* differ mainly in development of the reflection and callus of the inner lip. The callus is not uni-

formly developed among specimens from a locality. Typical *quercus* is very similar to form "b", but the callus of "b" is usually more elongate along the inner lip and the umbilical depression of form "b" is usually more elongate parallel to the inner lip than is the depression of either *quercus* s.s. or form "a".

Hundreds of specimens of *G. (S.) quercus* are present in the collections, and all three forms are well represented. Specimens of Coniacian age develop a callus tongue when over 6 mm in height (Figure 6.3). The callus tongue starts as a short reflection of the free inner lip adjacent to its onlap of the previous whorl. With shell growth, a narrow sulcus forms between whorl and callus tongue. The sulcus is usually slightly wider in equivalent sized specimens of form "b" than it is in *quercus* s.s. Some specimens from UCLA loc. 3633 at the top of the Musty Buck Member on Chico Creek have the elongate callus of form "b" but lack a sulcus. Their inner lip is a somewhat more strongly reflected version of that of *G. (S.) canadensis*.

All specimens recognized as *G. (S.) quercus* s.s. are from Members IV and V of the Redding area; *G. (S.) quercus* form "a" are from Member V of the Redding area, the lower Musty Buck Member of the Chico Formation along Chico Creek, and from Mill Creek; *G. (S.) quercus* form "b" are from Members V and VI of the Redding area, the Tenmile Member of the Chico Formation on Mill

←

FIGURE 6—All figures $\times 1$ except as noted. 1–4, *Gyrodes (Sohlella) quercus* n. sp., paratypes from CIT loc. 1007, Coniacian, showing development of the callus tongue; 1, UCLA 59738, $\times 5$; 2, UCLA 59737, $\times 5$; 3, UCLA 59736, $\times 4$; 4, UCLA 59734. 5, 6, 11–13, 15, 25, *Gyrodes (Sohlella) canadensis* Whiteaves "early" form, hypotypes, early Campanian; 5, 6, 11–13, from UCLA loc. 3639; 5, UCLA 59767, $\times 2$; 6, UCLA 59769, $\times 2$; 11, UCLA 59768, $\times 2$; 12, UCLA 59767, $\times 1.5$; 13, UCLA 59769, $\times 3$; 15, 25, ANSP 4254, Gabb's paratype of *G. expansus* probably from Pentz, Butte Co., Calif. 7, *Gyrodes (?Sohlella) banites* n. sp. s.l., hypotype, UCLA 59759 from UCLA loc. 4246, Santonian, $\times 2$. 8–10, 14, 19, 24, 29, *Gyrodes (?Sohlella) banites* n. sp., Santonian; 8–10, 14, 19, 29, from UCLA loc. 3633; 8, 10, paratype, UCLA 59753, $\times 3$; 9, 19, paratype, UCLA 59752; 9, $\times 1.5$; 19, $\times 2$; 14, 29, holotype, UCLA 59751; 24, paratype, UCLA 59755 from UCLA loc. 3627; 7–9, 29, showing development of the callus tongue. 16, 20, 21, 26, 30, 31, *Gyrodes (Sohlella) canadensis* Whiteaves, 1903, Campanian; 16, 21, 26, 31, holotype, CGS 5777 from Sucia Island, Washington, $\times 2$; 20, 30, hypotype, UCLA 59763 from CIT 1041. 17, 18, 22, 23, 27, 28, 32, *Gyrodes (Sohlella) pacificus* n. sp.; 17, 22, 27, 32, holotype, UCLA 59773 from CIT loc. 976, late Campanian; 18, paratype, UCLA 59775 from CIT loc. 974, late Campanian, $\times 2$; 23, paratype, UCLA 59777 from UCLA loc. 7137, early Maastrichtian; 28, paratype, UCLA 59776 from CIT loc. 1159, late Campanian. 33–38, *Gyrodes (Sohlella) expansus* Gabb, 1864, Maastrichtian; 33, 34, 36, 37, hypotypes from CIT loc. 1602; 33, 36, UCLA 59780; 34, UCLA 59779; 37, UCLA 59781; 35, 38, lectotype, ANSP 4245 from Martinez, Contra Costa Co., Calif.

TABLE 5—Dimensions of *Gyrodes* (?*Sohlella*) *banites* n. sp., in mm, * = incomplete. See Figure 2 for explanation of measurements.

	h	w	s	p	e	w/h	s/h	p/h	e/h	e/p
UCLA 59760	13.5	16.0	2.8	7.3	1.7	1.19	0.21	0.54	0.13	0.23
UCLA 59761	12.0	13.7	2.7	6.2	2.0	1.14	0.23	0.52	0.17	0.32
UCLA 59758(1)	12.6	15.0	2.7	6.5	2.0	1.19	0.21	0.52	0.16	0.31
UCLA 59758(2)	10.3	11.6	1.7	5.3	1.0	1.13	0.16	0.51	0.1	0.19
UCLA 59762(1)	17.0	19.3	2.6	7.5	2.0*	1.13	0.15	0.44	0.12	0.27
UCLA 59762(2)	14.7	16.4	2.8	7.5	2.4	1.12	0.19	0.51	0.16	0.32
UCLA 59762(3)	10.8	14.3	2.4	6.0	1.8	1.32	0.22	0.56	0.17	0.3
UCLA 59762(4)	11.6	13.4	2.0	5.9	1.9	1.15	0.17	0.51	0.16	0.32
UCLA 59755	10.5	14.4	2.5	6.1	1.9	1.37	0.24	0.58	0.18	0.31
UCLA 59756	12.2	15.5	3.0	6.8	2.3	1.27	0.24	0.56	0.19	0.34
UCLA 59751	15.5	17.8	3.9	7.8	2.8	1.15	0.25	0.5	0.18	0.36
UCLA 59757	14.0	19.3	3.0	7.8	2.5	1.37	0.21	0.56	0.17	0.32

Creek, and the upper Musty Buck Member on Chico Creek. Specimens from the top of the Musty Buck Member on Chico Creek appear transitional to *G. (S.) canadensis*.

In the Chico Creek section *G. (S.) quercus* form "b" ranges through the *B. capensis* Zone to the *B. chicoensis* Zone. Haggart and Ward (1984) and Haggart (1984) infer that the zones of *Bostrychoceras elongatum* and *Inoceramus schmidtii* are missing from between the zones of *Baculites capensis* and *B. chicoensis* in the Chico Formation on Chico Creek. They consider the *Baculites capensis* Zone to be of late early Santonian age rather than late Santonian, as suggested by Matsumoto (1960). That zones may be missing from such shallow water deposits as the Musty Buck Member is not surprising. However, neither *Bostrychoceras elongatum* nor *I. schmidtii* has been found elsewhere in association with such a shallow water molluscan assemblage as occurs in the Musty Buck Member. Both are usually associated with more offshore assemblages. Their absence from Chico Creek may reflect shallow water depth rather than missing strata. *Gyrodes (S.) quercus* form "b" from UCLA 4217 on Clover Creek, Redding area, occurs with a *Perissitys* n. sp. which also occurs near the top of the Musty Buck Member on Chico Creek and with *I. schmidtii* in the Kingsley Cave Member of the Chico Formation on Mill Creek. The beds at UCLA 4217 on Clover Creek are probably correlatives of the Kingsley Cave Member and thus of late Santonian age (sensu Haggart and Ward, 1984, and Haggart, 1984); and the top of the Musty Buck Member and base of the Tenmile Member on Chico Creek are perhaps the shallower water correlative. Along

Chico Creek the *B. elongatum* and *I. schmidtii* Zones may be lacking or very thin—*Baculites chicoensis* has been collected less than 15 m above *B. capensis*. If there are no correlative strata on Chico Creek, the *G. (S.) quercus* record is incomplete and *G. (S.) quercus* form "b" may not be its latest variant.

The species is named for its occurrence in Oak Run: *quercus*, Latin, oak.

GYRODES (?SOHLELLA) BANITES n. sp.

Figures 5.5, 5.6, 5.8, 5.9, 5.15,
5.19, 5.24, 5.28, 5.29, 6.7–6.10,
6.14, 6.19, 6.24, 6.29

Description.—Shell thin, small, wider than high; spire about 22% of total height; suture appressed, at posterior 1/3 of penultimate whorl; shoulder obscure, sloping, with slight concave band adapically; whorl profile obliquely convexly rounded; umbilical margin roundly biangulate; umbilicus wide, steeply sloping with a narrow funicle; growth line obliquely prosocline with an antispinal flexure at the umbilical angulation; aperture oblique, tear-drop shaped; outer lip thin, projected posteriorly; inner lip thin anteriorly and posteriorly, reflected medially to form an overhanging callus tongue.

Holotype.—UCLA 59751.

Paratypes.—UCLA 59755 from UCLA loc. 3627; UCLA 59756 from UCLA loc. 3628; UCLA 59752–59753 from UCLA loc. 3633; UCLA 59757 from UCLA loc. 3630; all from Chico Creek, Butte Co., California.

Hypotypes.—UCLA 59758–59759 from UCLA loc. 4246, Oak Run Valley, Shasta Co.; UCLA 59760–59761 from CIT loc. 1246, Clover Creek Valley, Shasta Co.; UCLA

59762 from CIT loc. 1017, Chico Creek, Butte Co., California.

Type locality.—UCLA loc. 3633: Chico Creek, Paradise Quadrangle, Butte Co., California.

Distribution.—Upper Member V, east of Redding, Shasta Co.; upper Musty Buck and basal Tenmile Members of the Chico Formation on Chico Creek, Butte Co., California.

Age.—Santonian, from *Baculites boulei* through *Baculites capensis* Zones, and earliest Campanian.

Remarks.—Typical *G. (?S.) banites* is a common form through a narrow stratigraphic interval from 488 m (1,600 feet) to 536 m (1,760 feet) above the base of the Chico Formation on Chico Creek. The subspecies is also recognized near Redding, in Member V at CIT loc. 1246 and UCLA loc. 4246 and as low as CIT loc. 1017 on Chico Creek at 448 m (1,470 feet) above the base of the Chico Formation (Matsumoto, 1960, p. 15; Saul, 1983, p. 12), but none of these early Santonian specimens has as well developed an umbilical callus as do those from the *Baculites capensis* Zone.

Gyrodes (?S.) banites differs from *G. quercus* with which it occurs in having a large reflected, medially placed, tongue-like callus which overhangs the umbilicus, and in usually having a less well-developed tabulation at the suture. The callus is reminiscent of that of *Neverita* or *Hypterita*, but *G. (?S.) banites* is not as flattened or widely expanded as *N. josephina* (Risso, 1826) or *H. helicoides* (Gray, 1825). The growth line of *G. (?S.) banites* resembles that of *N. helicoides* in being prosocline at the suture rather than that of *N. josephina* which is nearly orthocline to the suture. *Gyrodes (?S.) banites* resembles *Banis siniformis* Stephenson (1941, p. 279, Pl. 50, figs. 14–16) from the Nacatoch Sand of the Navarro Group of Texas but has a rounder whorl profile, narrower more abruptly depressed umbilical depression, and a more adapically placed callus tongue. The callus tongue of *G. (?S.) banites* starts as a reflection of the free inner lip at its onlap of the previous whorl (Figure 6.7). The rounded callus tongue overlaps onto the previous whorl until the shell exceeds 7 mm in height (Figure 6.8), then, with further shell growth, becomes free of the previous whorl and overhangs the um-

bilicus. This growth of the callus tongue is similar to that of the smaller, less well-developed callus of *G. (S.) quercus*. *Banis* is characterized as having a thick reflected inner lip (Stephenson, 1941, p. 279), but the inner lip of *G. (?S.) banites* is thin except at the umbilical callus. This callus resembles that of *Hypterita*—a thin lobe suspended anteriorly from a pillar-like funicle (Marincovich, 1977, p. 296)—more than it does the more anteriorly placed, knob-like callus of *Banis siniformis* Stephenson. It differs from that of *Hypterita* in having a flat to convex surface rather than a concave surface.

In assigning *G. (?S.) banites* tentatively to *Sohlella*, we have considered the similarity of callus formation, the welt at the suture and the slight concavity and obscure shoulder tabulation, the path of the growth line, and the well-defined umbilical depression to indicate closer relationship to species of *Sohlella*—especially to *G. (S.) quercus*—than to *Banis*, *Hypterita*, or *Neverita*. Marincovich (1977, p. 215) considered that Ampullospirinae (in which he included Gyrodinae) do not have a distinct and compact umbilical callus, and, as previously mentioned, Conrad (1860), Cossmann (1925), and Sohl (1960), among others, have indicated the absence of umbilical callus in *Gyrodes*. A small umbilical callus is developed in *G. (S.) quercus* s.s. and *G. (S.) quercus* form “b”. Development in gyrodifform naticids of this structure, previously considered diagnostic of placement in another subfamily, further complicates classification within the family Naticidae (Wrigley, 1949).

The species is named for its resemblance to *Banis*; *banis* + *ites*, Greek, having the nature of, like.

GYRODES (SOHLELLA) CANADENSIS

Whiteaves, 1903

Figures 5.31–5.33, 6.5, 6.6,
6.11–6.13, 6.15, 6.16, 6.20,
6.21, 6.25, 6.26, 6.30, 6.31

Gyrodes expansa GABB, 1864, p. 108 [in part], Pl. 19, fig. 62c [only]; STEWART, 1927, p. 328 [in part], Pl. 22, fig. 3 [only].

Gyrodes excavata Michelin. WHITEAVES, 1879, p. 124, Pl. 16, figs. 2–2a [non *G. excavata* (Michelin)].

Gyrodes (Conradiana? Gabb, var.) *Canadensis* WHITEAVES, 1903, p. 365 [new name for above].

TABLE 6—Dimensions of *Gyrodes (Sohlella) canadensis* Whiteaves, in mm, * = incomplete. See Figure 2 for explanation of measurements.

	h	w	s	p	e	w/h	s/h	p/h	e/h	e/p
UCLA 59767	9.7*	11.5	2.0	5.4	1.6	1.19	0.21	0.56	0.16	0.3
UCLA 59768	8.9	10.2	2.4	4.6	1.4	1.15	0.27	0.52	0.16	0.3
UCLA 59769	6.8	7.7	1.5	3.4	1.1	1.13	0.22	0.5	0.16	0.32
UCLA 59770	23.7	27.0	5.8	10.7	5.8	1.14	0.24	0.45	0.24	0.54
UCLA 59771	18.9	22.1	4.0	8.9	3.0	1.17	0.21	0.47	0.16	0.34
UCLA 59772(1)	18.7	20.3*	3.9	9.0	3.2	1.09	0.21	0.48	0.17	0.36
UCLA 59772(2)	12.7*	14.4	2.8*	6.6	1.8	1.13	0.22	0.52	0.14	0.27
UCLA 59763	14.3	16	3.2	7.0	2.0	1.12	0.22	0.49	0.14	0.29
UCLA 59764	14.0	16.2	2.8	7.0	2.6	1.16	0.2	0.5	0.19	0.37
UCLA 59765	17.0	19.0	3.6	7.8	2.4	1.12	0.21	0.46	0.14	0.31
UCLA 59766	14.0	15.6	3.0	7.9	2.3	1.11	0.21	0.56	0.16	0.29

Not *Gyrodes canadensis* Whiteaves. WARING, 1917, p. 66, Pl. 9, fig. 7 = *G. (S.) pacificus* n. sp.

Not *Gyrodes expansus canadensis* Whiteaves. POPENOE, 1954, p. 17, fig. 4(9) = *G. (S.) pacificus* n. sp.

Description.—Shell thin, small to medium sized, spire about 22% of total height; suture appressed, at posterior one-third of penultimate whorl; shoulder sharply tabulate with concave band adapically and broad slightly concave zone abapically; whorl profile roundly inflated abapical to the concave zone; umbilical margin roundly biangulate; umbilicus comma-form, sides sloping; growth line obliquely prosocline with antispinal flexure at the umbilical angulation; aperture oblique, tear-drop shaped; outer lip thin, projected posteriorly; inner lip thin, wrapped onto the last whorl at the outer umbilical angulation.

Holotype.—CGS 5777.

Paratype.—CGS 5777b.

Hypotypes.—"Early" form: ANSP 4254 (smaller specimen figured by Gabb), probably from Chico Fm., near Pentz, Butte Co.; UCLA 59767–59769, "deformed" specimens from UCLA loc. 3639, Chico Fm., Tenmile Member, Chico Creek, Butte Co.; UCLA 59770–59771, from UCLA loc. 4340, Chico Fm., Musty Buck Member, near Pentz, Butte Co.; UCLA 59772, from UCLA loc. 4081, Chico Fm., ?Musty Buck Member, near Pentz, Butte Co., California; typical form: UCLA 59763, from CIT loc. 1041, Chico Fm., Tenmile Member, Butte Creek, Butte Co., California; UCLA 59763 from UCLA loc. 7006, UCLA 59765 from CIT loc. 1400, and UCLA 59766 from CIT loc. 1396, Cedar District Formation, Sucia Island, San Juan Co., Washington.

Type locality.—Sucia Island, San Juan Co., Washington.

Distribution.—Cedar District Formation of the Nanaimo Basin, Vancouver Island, British Columbia, and Sucia Island, San Juan Co., Washington; Chico Formation at Tuscan Springs, Tehama Co., Tenmile Member of the Chico Formation on Butte Creek, and Musty Buck Member of the Chico Formation near Pentz, Butte Co.; ?Pigeon Point Formation near Bolsa Point, San Mateo Co.; lower Chatsworth Formation in Bell Canyon, Simi Hills, Ventura Co.; upper Holz Shale Member of the Ladd Formation in the Santa Ana Mountains, Orange Co., California.

Age.—Early through mid Campanian, late *Submortonicer* *chicoensis* Zone and *Hoplitoplacenticer* *vancouverense* Zone.

Remarks.—*Gyrodes (S.) canadensis* is one of the most widely distributed and common species of *Sohlella*. It has been frequently misidentified as *G. expansus* Gabb from which it differs in usually having the tabulation slightly concave and clearly marked by an angulation, and in having a sharper umbilical angulation that is sharper in youth and subrounded in maturity. Specimens included in *G. (S.) canadensis* are of two forms. An "early" form characterized by a strongly concave zone abapical to the shoulder (Figure 5.33) occurs from 545 m (1,790 feet) to 872 m (2,860 feet) above the base of the Chico Formation, or roughly through the lower half of the Tenmile Member. Numerous small specimens (under 14 mm high) from this stratigraphic interval develop a strong spiral antisinus to the growth line abapical to the shoulder (Figure 6.11, 6.12); they also have a subrounded umbilical angulation, and the anterior half of the outer lip has a broad sinus.

TABLE 7—Dimensions of *Gyrodes (Sohlella) pacificus* n. sp., in mm, * = incomplete. See Figure 2 for explanation of measurements.

	h	w	s	p	e	w/h	s/h	p/h	e/h	e/p
UCLA 59773	15.8	19.3*	2.8	7.8	1.9	1.22	0.18	0.49	0.12	0.24
UCLA 59774	18.5*	23.0	4.0*	8.8	3.3	1.24	0.22	0.48	0.18	0.37
UCLA 59775	10.6	12.5	1.9	5.6	1.8	1.18	0.18	0.53	0.17	0.32
UCLA 28714	16.0	19.7	3.6	7.0	2.5	1.23	0.22	0.44	0.16	0.36
UCLA 59776	14.6	20.9	3.1	7.7	2.4	1.43	0.21	0.53	0.16	0.31

The aspect is of deformity caused by an injury, infection, or other environmental factor. The "condition" was not limited to Chico Creek, Butte Co.; similar, "deformed" specimens occur on Butte Creek and at Pentz in the Chico Formation and in the upper Holz Shale of the Ladd Formation in the Santa Ana Mountains, Orange Co., California. All localities at which such specimens are common are of early Campanian age from the earlier part of the *Baculites chicoensis* and *Submortonicer as chicoensis* Zones, and the *Turritella chicoensis holzana* Zone.

The change from the "early" form to typical *G. (S.) canadensis* with a less pronounced concave zone anterior to the shoulder is gradual. Specimens from the *Hoplitoplacenticer as vancouverense* Zone on Sucia Island have very little concavity and are similar to specimens from Bell Canyon, Simi Hills, Ventura Co., California. The stratigraphic position of the type specimens is unknown. They may have been collected from the *Hoplitoplacenticer as vancouverense* beds, but the concavity to their whorls suggests that they were collected from lower strata.

GYRODES (SOHLELLA) PACIFICUS n. sp.

Figure 6.17, 6.18, 6.22,
6.23, 6.27, 6.28, 6.32

Gyrodes canadensis Whiteaves. WARING, 1917, p. 66, Pl. 9, fig. 7.

Gyrodes expansus canadensis Whiteaves. POPENOE, 1954, p. 17, fig. 4(9).

Description.—Shell thin, medium sized, wider than high, surface strongly textured by growth lines, especially in larger individuals; spire 20% of total height; suture appressed, near posterior third of penultimate whorl; shoulder roundly tabulate with broad slightly concave zone abapically; whorl profile roundly inflated abapical to the concave zone; umbilical margin roundly biangulate; umbilicus comma-form; sides sloping; growth line

obliquely prosocline with antispiral sinus within the umbilicus; aperture oblique, tear-drop shaped; outer lip thin, projected posteriorly; inner lip thin anteriorly, a little reflected and slightly thickened posteriorly, wrapped onto the last whorl just posterior to the umbilical angulation.

Holotype.—UCLA 59773.

Paratypes.—UCLA 59774 from CIT loc. 976, UCLA 59775 from CIT loc. 974, and UCLA 28714 from UCLA loc. 2326, Santa Ana Mountains., Orange Co., California; UCLA 59776 from CIT loc. 1159, Simi Hills, Los Angeles Co., California; UCLA 59777 from UCLA loc. 7137, Punta Banda, Baja California, Mexico.

Type locality.—CIT loc. 976: Old Pleasants Ranch, Williams Canyon, 800' S, 600' W of NE cor. sec. 19, T5S, R7W, El Toro Quadrangle, Santa Ana Mountains., Orange Co., California.

Distribution.—Panoche Formation at top of Marlife Member in Panoche Hills, Fresno Co.; Chatsworth Formation of Lang Ranch area, Simi Hills, Ventura Co., and of Dayton Canyon, Simi Hills, Los Angeles and Ventura Counties; Jalama Formation of the Santa Ynez Mountains, Santa Barbara Co.; upper Tuna Canyon Formation of the Santa Monica Mountains, Los Angeles Co.; Pleasants Sandstone Member of the Williams Formation in the Santa Ana Mountains, Orange Co.; Rosario Formation of San Diego area, California; and Rosario Formation of northern Baja California, Mexico.

Age.—Late Campanian, zone of *Metapla-centricer as pacificum*, and early Maastrichtian.

Remarks.—*Gyrodes (S.) pacificus* is similar to *G. (S.) canadensis* with which it has been confused, but it has a more rounded shoulder and a wider umbilicus. The whorl is more expanded anteriorly and the inner lip is slightly thickened posteriorly. The concave

TABLE 8—Dimensions of *Gyrodes (Sohlella) expansus* Gabb, in mm, * = incomplete. See Figure 2 for explanation of measurements.

	h	w	s	p	e	w/h	s/h	p/h	e/h	e/p
UCLA 59778	17.0	21.4	3.9	8.4	2.9	1.26	0.23	0.49	0.17	0.34
UCLA 59779	27.5	30.8	5.7	13.2	5.6	1.12	0.21	0.48	0.2	0.42
UCLA 59780	33.0	33.9	7.6	14.5	5.2	1.03	0.23	0.44	0.16	0.36
UCLA 59781	28.8	31.6	7.7	13.8	5.8	1.1	0.27	0.48	0.2	0.42

zone to the whorl profile is especially similar to that of "early" *G. (S.) canadensis* from which *G. (S.) pacificus* can be distinguished by its thickening of the inner lip. Specimens from Chatsworth Formation outcrops in Bell Canyon (e.g., CIT loc. 1158; Saul and Anderson, 1981; Squires, 1981) have the narrower umbilicus of *G. (S.) canadensis*, but some have the more strongly reflected inner lip of *G. (S.) pacificus*. They appear to be intermediate between *G. (S.) canadensis* and *G. (S.) pacificus*.

Gyrodes (S.) pacificus differs from *G. (S.) expansus* in having a more angulate tabulation with a more noticeably concave zone to the whorl abapical to the tabulation and a wider umbilicus. With *G. (S.) pacificus* of typical whorl profile from the Rosario Formation of northern Baja California, Mexico, are specimens having a broader shoulder and a less concave zone. Their whorl profile thus is similar to that of *G. (S.) expansus*.

The species is abundant in the Chatsworth Formation at Dayton Canyon, near the Ventura-Los Angeles Co. line where it is associated with *Metaplacenticeras* sp. cf. *M. pacificum*. The largest specimens, however, are from the Rosario Formation in northern Baja California, Mexico, and are of early Maastrichtian age.

The species is named for its occurrence with *Metaplacenticeras pacificum*.

GYRODES (SOHLELLA) EXPANSUS Gabb, 1864 Figure 6.33–6.38

Gyrodes expansa GABB, 1864, p. 108 [in part], Pl. 19, fig. 62a–b [only; not fig. 62c = *G. canadensis* Whiteaves]; GRABAU AND SHIMER, 1909, p. 721, fig. 1048; STEWART, 1927, p. 328 [in part], Pl. 22, figs. 1, 1a [only; not fig. 3 = *G. canadensis* Whiteaves]; SHIMER AND SHROCK, 1944, p. 483, Pl. 198, figs. 21, 22; ANDERSON, 1958, p. 149 [in part; Maastrichtian specimens only].

Description.—Shell thick for the subgenus, medium to moderately large sized, surface strongly textured by growth lines especially in large individuals; spire about 24% of total height; suture appressed, at posterior third of penultimate whorl; shoulder roundly tabulate; whorl profile flattened abapical to the tabulation, then roundly inflated; umbilical margin roundly subangulate; umbilicus steeply sloping; growth line obliquely prosocline with antispiral flexure within the umbilicus; aperture broadly tear-drop shaped; outer lip thin, projected posteriorly; inner lip thin anteriorly, thickened posteriorly, wrapping onto the last whorl at the umbilical angulation.

Lectotype.—ANSP 4245.

Hypotypes.—UCLA 59778 from UCLA 6342, Ortigalita Peak Quadrangle, Merced Co.; UCLA 59779–59781 from CIT loc. 1602, near Martinez, Contra Costa Co., California.

TABLE 9—Dimensions of *Gyrodes (Hypterita) robsauli* n. sp., in mm, * = incomplete. See Figure 2 for explanation of measurements.

	h	w	s	p	e	w/h	s/h	p/h	e/h	e/p
UCLA 59782	14.7	15.6	2.7	7.9	2.2	1.06	0.18	0.54	0.15	0.28
UCLA 59783	12.5	16.8	2.4	7.0	1.8	1.34	0.19	0.56	0.14	0.26
UCLA 59784	12.3*	14.3	2.4	6.9	1.6	1.16	0.2	0.56	0.13	0.23
UCLA 59787	12.9	15.7	3.5	6.9	2.6	1.22	0.27	0.53	0.2	0.38
UCLA 59788	16.2	19.0	3.4	7.0	2.5	1.17	0.21	0.43	0.15	0.35
UCLA 59789	7.8	8.8	2.0	4.0	0.9	1.13	0.26	0.51	0.12	0.22
UCLA 59786	17.2	20.0	4.8	8.9	2.9	1.16	0.28	0.52	0.17	0.32
UCLA 59790	15.1*	21.7	3.6*	7.2	2.5	1.44	0.24	0.48	0.17	0.35

Type locality.—Vicinity of Martinez, Contra Costa Co., California.

Distribution.—Upper Great Valley Series in the vicinity of Martinez, Contra Costa Co., Tierra Loma and "Quinto B" Members of the Moreno Formation in the eastern foothills of the Diablo Range, Merced Co., California.

Age.—Middle to ?late Maastrichtian.

Remarks.—*Gyrodes* (*S.*) *expansus* has a narrower umbilicus, more broadly and roundly tabulated spire, and rounder umbilical angulation than *G.* (*S.*) *pacificus*. The average size of *G.* (*S.*) *expansus* is greater than that of any other West Coast Cretaceous species assigned to *Sohlella*. Specimen size is similar to that of *G. dowelli*, *G. onensis*, *Natica conradiana*, and *N. conradiana vacculae*; large *G.* (*S.*) *expansus* are smaller than the largest specimens of *G.* (?*G.*) *robustus* Waring. *Gyrodes* (*S.*) *expansus* differs from *G.* (?*G.*) *robustus* in having a more obliquely inflated whorl, a less clearly delimited tabulation, and a more rounded umbilical angulation.

Subgenus HYPTERITA Woodring, 1957

Type species.—*Natica helicoides* Gray, 1825, by original designation, Woodring (1957, p. 92).

Discussion.—*Hypterita* was proposed as a subgenus of *Neverita* by Woodring, but Keen (1971, p. 478) placed the type species in *Polinices* s.s. Marincovich (1977, p. 296) recognized the subgenus *Hypterita*, but it left it in *Polinices*. In addition to its characteristic and peculiar, thin, overhanging umbilical callus perched on the pillar-like funicle (Woodring, 1957, p. 92; Marincovich, 1977, p. 296), the type-species has a strong flexure to the growth line at the anterior edge of the flank (Figure 4.24). This flexure marks the outer (abaxial) side of a strong antispiral sinus. The flexure and sinus are typical of *Gyrodes* but not of *Polinices* or *Neverita*. Additionally, the growth line of *Hypterita* like that of *Gyrodes* is strongly prosocline. Assignment of *G.* (*H.*) *robsauli* n. sp. to this subgenus considerably extends the geologic range of *Hypterita*. Woodring assigned only two species to *Hypterita*—"Neverita" *helicoides*, a Holocene species which Woodring recognized from the Gatun Formation, and "*N.*" *nereidis* Maury,

1917, from the Cercado Formation. He considered both these fossil occurrences to be Miocene in age.

Hypterita may possibly derive from *Sohlella* by way of *G.* (?*S.*) *banites*, but *G.* (?*S.*) *banites* is closer to *Sohlella* than to *Hypterita*, and forms intermediate between *banites* and *G.* (*H.*) *robsauli* are not yet known.

GYRODES (HYPTERITA) ROBSAULI n. sp.

Figure 4.11–4.14, 4.16–4.19,
4.21–4.23

Description.—Shell thin, small to medium sized; spire about 23% of total height; suture appressed, near posterior three-tenths of penultimate whorl; shoulder obscure, with slight concave band adapically; whorl profile evenly convexly rounded; umbilical margin sharply biangulate in juveniles, obscurely biangulate in adults, outer angle stronger; umbilicus moderately wide, steeply sloping with a narrow funicle; growth line obliquely prosocline with an antispiral sinus within the umbilical depression; aperture oblique, subovoid; outer lip thin, projected posteriorly; inner lip wrapped onto the penultimate whorl at or just outside the outer umbilical angulation, thin anteriorly and posteriorly, reflected medially to form a small, thin, overhanging callus tongue with a concave surface.

Holotype.—UCLA 59782.

Paratypes.—UCLA 59783–59784 from UCLA loc. 5902, Anticline Ridge, Fresno Co.; UCLA 59786 from UCLA loc. 6465, Los Gatos Creek, Fresno Co.; UCLA 59790 from UCLA loc. 6337, Hancock Ranch, Monterey Co., California; and UCLA 59787–59789 from UCLA loc. 6534, Arroyo Santa Catarina, Baja California, Mexico.

Type locality.—UCLA 5902: Anticline Ridge, Joaquin Rocks Quadrangle, Fresno Co., California.

Distribution.—Garzas Sand in the Orestimba Quadrangle, Stanislaus Co.; Tierra Loma Shale member of Moreno Formation in the Ortigalita Peak Quadrangle, Merced Co.; "Ragged Valley Shale"? = Uhalde Shale of Panoche Group, north of Coalinga, Fresno Co.; Panoche Group on Hancock Ranch, Monterey Co., California; Rosario Formation at Arroyo Santa Catarina, Baja California, Mexico.

Age.—Early Maastrichtian, *Pachydiscus*

(*Neodesmoceras*) *catarinae* Zone, and mid Maastrichtian, *Baculites columna* Zone.

Remarks.—*Gyrodes* (*H.*) *robsauli* is based upon about 50 specimens, most of which are small. Half are from UCLA loc. 6534 on the west side of Arroyo Santa Catarina, Baja California, Mexico. Two poorly preserved specimens from mid Maastrichtian localities in the Ortigalita Peak Quadrangle are probably this species, as are specimens from the Garzas Sand along Orestimba Creek, Stanislaus Co., California.

The umbilical callus of *G. (H.) robsauli* resembles that of *Hyperita*. It is thin, perched atop a pillar-like funicle, and has a concave surface. *Gyrodes* (*H.*) *helicoideus* (Gray, 1825) is a much larger, more widely expanded shell, and its basal antispiral sinus overlaps slightly onto the flank rather than being confined to the umbilical depression. The surface of *G. (H.) robsauli* is strongly textured by growth lines as is that of *G. (H.) helicoideus*. Only the specimen of *G. (H.) robsauli* from Hancock Ranch (Figure 4.19) has a shell surface well enough preserved to show microscopic spiral stria similar to those of *G. (H.) helicoideus* (Figure 4.20). Juvenile *G. (H.) robsauli* have a strongly biangulate umbilicus. The inner angulation is early subdued, and the outer angulation migrates flankward but never achieves the position of the growth-line flexure of *G. (H.) helicoideus*.

Gyrodes (*H.*) *robsauli* resembles *G. (?Sohl-ella)* *banites* in having a tongue of callus overhanging the umbilicus, but in none of the available specimens is the callus tongue as large as on typical *G. (?S.) banites*. The whorl profile of *G. (H.) robsauli* differs from that of all *Sohlella* in being evenly rather than obliquely convex and in having the anterior lip concavely curved rather than straight. The umbilical angulations and shoulder tabulation of *G. (H.) robsauli* are stronger than are those of *G. (?S.) banites*. The inception of the callus tongue is earlier in *G. (?S.) banites*, and its development is similar to that in *G. (S.) quercus*. In juvenile *G. (H.) robsauli*, however, the inner lip is wrapped onto the previous whorl between the outer and inner umbilical angulations (Figure 4.14) and migrates outward (Figure 4.12, 4.13).

The species is named for Robert L. Saul who braved tall, dry herbs and cacti to help collect specimens.

?Group of *GYRODES AMERICANUS*

(Wade, 1926) Sohl, 1960

GYRODES s.l. *ONENSIS* n. sp.

Figure 4.3, 4.4, 4.6, 4.9,
4.10, 4.15

Natica (*Gyrodes*) *conradiana* (Gabb). ANDERSON, 1958, p. 149, Pl. 21, figs. 2, 3 [not *?Lunatia* (*Gyrodes*?) *conradiana* Gabb, 1864].

Ampullina avellana (Gabb). ANDERSON, 1958, p. 151, Pl. 4, figs. 2, 4 [not *Lunatia avellana* Gabb, 1864].

Description.—Shell moderately thick, medium sized, globular, wider than high; spire about 22% of total height; suture appressed on early whorls, becoming incised, near posterior third of penultimate whorl; shoulder slightly tabulate on early whorls, becoming rounded; whorl profile well rounded; umbilical margin angulate on early whorls, becoming subrounded; umbilicus moderately wide, round, steeply sloping; growth line obliquely prosocline with a small posterior antispiral sinus at the shoulder and a broad anterior antispiral sinus just within the umbilicus; aperture moderately oblique, semicircular, rounded anteriorly and angulate posteriorly; outer lip thin; inner lip thin, slightly reflected posteriorly, wrapped onto the last whorl at the outer umbilical angulation.

Holotype.—CAS 10646.

Paratypes.—CAS 10647 from CAS loc. 1346A; CAS 10776 (hypotype of *Ampullina avellana* of Anderson attached to holotype of *Pervinqueria sylvana* Anderson = *Mortoniceras gainesana* (Anderson, 1958) fide Murphy and Rodda, 1960, p. 855) from CAS loc. 1346; UCLA 59791 and 59802 from UCLA loc. 3778, Huling Creek, Tehama Co., California.

Type locality.—CAS loc. 1346A. In the California Academy of Sciences locality book CAS loc. 1346 = mouth of Huling Creek, Shasta Co., California, where it enters Cottonwood Creek, and CAS loc. 1346A = 1 mile (1.6 km) above the mouth of Huling Creek, Basal Chico Zone. But Anderson (1958) describes these localities as above (various distances) and below the mouth of Huling Creek on Cottonwood Creek or on Huling Creek. Murphy and Rodda (1960, p. 856) found *Mortoniceras gainesiana* (Anderson, 1958) only in the nodular limestone clasts from the lowest conglomerate unit of the Bald Hills

TABLE 10—Dimensions of *Gyrodes* s.l. *onensis* n. sp., in mm, * = incomplete. See Figure 2 for explanation of measurements.

	h	w	s	p	e	w/h	s/h	p/h	e/h	e/p
CAS 10646	38.0*	46.7	9.8	18.8	8.0	1.23	0.26	0.49	0.21	0.43
CAS 10647	21.4	24.0	3.6	10.4	2.6	1.12	0.17	0.49	0.12	0.25

Member exposed on the North Fork of Cottonwood Creek, Shasta Co., California. They collected two specimens of *G. onensis* at UCLA loc. 3778 in the Bald Hills Member (5 feet above the basal conglomerate) on Huling Creek. Murphy (personal commun.) places CIT loc. 1345 in the lowest conglomerate and CIT 1346A probably in the conglomeratic sandstone just downstream of East Fork of Huling Creek.

Distribution.—Chickabally? and lower Bald Hills Members of the Budden Canyon Formation, Ono area, Tehama and Shasta Counties; below the base of the Venado Formation, near Sites, Colusa Co., California.

Age.—?Early Albian to ?early Cenomanian.

Remarks.—Only eight specimens are identified as *G. onensis*. The holotype is the specimen figured by Anderson (1958, Pl. 21, fig. 2), and is probably of late Albian age. A broken specimen lacking much of its shell, from the early Albian *Leconteites lecontei* Zone (UCLA loc. 2874), is probably this species, as is one from the mid Albian *Oxytropidoceras packardii* Zone (UCLA loc. 3382) that is small for the species and somewhat crushed. A slightly smaller and more broken specimen from below the base of the Venado Formation near Sites, Colusa Co., California, has the well rounded whorls and slightly tabulate spire of this species. It bears California State Mining Bureau number 12787, and if collected with the California State Mining Bureau specimen of *Yaadia leana* (Gabb, 1864) numbered 12784 is probably of Cenomanian age (Saul, 1978, p. 38). Two paratypes are from the basal Bald Hills Member of the Budden Canyon Formation on Huling Creek (UCLA loc. 3778) and are of late Albian age (Murphy and Rodda, 1960; Murphy et al., 1969).

Gyrodes onensis resembles *Natica conradi* and *N. conradi* *vacculae* in size and globular shape, but lacks a funicle in the umbilicus. Its growth line is more like that of

Gyrodes s.s., as is its shallowly sloping umbilicus. Of the three groups defined by Sohl (1960), *G. onensis* is most similar to that of *G. americanus* (Wade, 1926). It resembles *G. depressus* Meek (1876, p. 159) and *G. depressus* Meek of Stanton (1893, p. 135) from the Western Interior Turonian but appears to have a lower spire.

The species is named for its occurrence in the Ono area west of Redding, Shasta Co., California.

GYRODES s.l. sp.

Discussion.—Four small specimens from CIT loc. 1346, Little Cow Creek, Redding area, Shasta Co., California, have umbilical characteristics of this group. These immature specimens from the Turonian Melton Sandstone have a slightly more expanded whorl than does *G. onensis*. The material is inadequate to serve as the basis of a new taxon.

Subfamily NATICINAE Forbes, 1838

Discussion.—Naticinae differ from other naticids in possessing calcareous rather than corneous opercula (Wenz, 1941; Cernohorsky, 1971; Marincovich, 1977; and others), but opercula are unknown for most fossil naticids. Wenz mentions the presence of strong color markings as characteristic of the subfamily, but cool water Naticinae lack such markings.

Genus NATICA Scopoli, 1777

Type species.—*Nerita vitellus* Linnaeus, 1758, by subsequent designation Anton, 1839, p. 31.

Discussion.—The genus *Natica* has a calcareous operculum. It has been subdivided into a number of subgenera, largely upon opercular characteristics. We have no opercula associated with the specimens we propose to include in *Natica*, and must consider them *Natica* s.l. despite the short collabral grooves on the shoulder of *Natica conradi* *vacculae*, which suggest *Naticarius* Dumaril.

These forms have been previously called *Gyrodos allisoni* Murphy and Rodda, *G. conradiana* (Gabb), and *G. siskiyouensis* Anderson. The funicle and the color markings present on well-preserved specimens of "*G.*" *conradiana* [= "*G.*" *siskiyouensis*] and *N. conradiana vacculae* n. subsp. suggest the inclusion of these forms in *Natica*. The pattern of these markings is similar to those of several Recent tropical *Natica* spp., e.g., *N. marochiensis* Gmelin, 1791, *N. gaultieriana* Recluz, 1844, and especially *N. chemnitzii* Pfeiffer, 1840. The umbilicus of these Cretaceous forms is unusually wide for *Natica*, but the shell is slightly thicker than that of most West Coast *Gyrodos*, and they lack the strong antispiral sinus to the growth line within the umbilical depression so characteristic of *Gyrodos*.

Gyrodos allisoni is included with *G. conradiana* and *G. conradiana vacculae* because its umbilicus resembles theirs in having the inner angulation strong and overhanging the very steeply sloping umbilical walls, and its growth line lacks the antispiral sinus within the umbilical depression.

?NATICA ALLISONI
(Murphy and Rodda, 1960)
Figure 7.1, 7.2, 7.5

Gyrodos allisoni MURPHY AND RODDA, 1960, p. 842, Pl. 101, figs. 19, 20.

Holotype.—UCLA 28629.

Paratype.—UCLA 28639.

Hypotype.—UCLA 59792 from UCLA loc. 4669: Camp Creek, Crook Co., Oregon.

Dimensions of hypotype.—In mm, * incomplete; h, 20.5*; w, 20.5; s, 6*; p, 8.9; e, 4.7; w/h, 1.0; s/h, 0.29; p/h, 0.43; e/h, 0.23; e/p, 0.53 (see Figure 2 for explanation of measurements).

Type locality.—UCLA loc. 3464: near the Gas Point Road, 1,900' S, 1,600' E of NW cor. sec. 16, T30N, R6W, Ono Quadrangle, Shasta Co., California.

Distribution.—Budden Canyon Formation, Bald Hills Member, Shasta Co., California; Camp Creek, Dayville Quadrangle, Crook Co., Oregon.

Age.—Cenomanian.

Remarks.—?Natica *allisoni* does not belong to any of Sohl's three groups of *Gyrodos* nor can it be placed in *Sohlella* or *Hypterita*.

Its umbilical characteristics differ from those of all five of these *Gyrodos* groups; its growth line lacks the gyroline antispiral sinus within the umbilical depression and is not as strongly prosocline on the flank. Although small to medium sized specimens have a doubly angulate umbilicus, as described by Murphy and Rodda (1960, p. 842), the outer angulation becomes rounded on specimens larger than any studied by Murphy and Rodda. The inner angulation remains strong and forms a slightly overhanging rim to the very steeply sloping umbilicus. Except for the absence of a funicle this umbilicus resembles that of *N. conradiana* and *N. conradiana vacculae*. Although we agree with Wrigley (1949) and Marincovich (1977) that umbilical characteristics are important in making generic assignments, some of these characteristics are inconstant; the funicle is variably present in *N. conradiana vacculae* (Figure 7.9, 7.10). The growth line of ?*N. allisoni* is similar to that of *N. conradiana* and *N. conradiana vacculae*. The shoulder tabulation of ?*N. allisoni* becomes rounded on larger specimens and the suture changes from appressed to depressed. The striations on the shoulder resemble those of *Natica conradiana* and *N. conradiana vacculae* n. subsp., but these two have a wider umbilicus and more expanded whorl, in addition to an umbilical plug.

NATICA CONRADIANA (Gabb, 1864)
Figure 7.4, 7.7, 7.8, 7.11,
7.13–7.15, 7.17–7.19

?*Lunatia* (*Gyrodos*?) *conradiana* GABB, 1864, p. 107, Pl. 29, fig. 219.

Gyrodos conradiana (Gabb). GRABAU AND SHIMER, 1909, p. 721; STEWART, 1927, p. 329, Pl. 22, fig. 2; SHIMER AND SHROCK, 1944, p. 483; SCHENCK AND KEEN, 1940, p. 26, Pl. 18, fig. 10; ANDERSON, 1958, p. 149 [in part, not Pl. 21, figs. 2, 3 = *G. onensis* n. sp.].

Gyrodos siskiyouensis ANDERSON, 1902, p. 76, Pl. 8, figs. 167, 168; ANDERSON, 1958, p. 150, Pl. 21, figs. 6, 7.

Not *Gyrodos conradiana* (Gabb). JONES, SLITER, AND POPENOE, 1978, p. XXII. 10, Pl. 1, figs. 16, 17 = *N. conradiana vacculae* n. subsp.

Description.—Shell of average thickness, medium sized to large; spire about 23% of total height; suture appressed becoming moderately incised, at posterior two-fifths of whorl; shoulder rounded; whorl profile well



FIGURE 7 — All figures $\times 1$ except as noted. 1, 2, 5, ?*Natica allisoni* (Murphy and Rodda, 1960), hypotype, UCLA 59792 from UCLA loc. 4669, Cenomanian. 3, 6, 9, 10, 12, 16, *Natica conradiana vacculae* n. subsp., Turonian; 3, 6, 12, holotype, UCLA 59796 from CIT loc. 1195; 3, $\times 2$; 9, paratype, UCLA 59800 from CIT loc. 1446; 10, paratype, UCLA 59799 from CIT loc. 1440; 16, paratype, UCLA 59801 from UCLA loc. 4416, relict color markings. 4, 7, 8, 11, 13, 17–19, *Natica conradiana* (Gabb, 1864), Turonian; 4, 7, 8, 11, 13, 17–19, hypotypes; 17, showing spiral sculpture, $\times 2$; 4, 7, 18, from CAS loc. 446; 4, CAS 61405, $\times 2$; 7, 18, CAS 61404; 8, 19, UCLA 59794 from CIT loc. 1532; 11, 13, 17, UCLA 59793 from CIT loc. 1264; 14, 15, lectotype, ANSP 4255 from San Luis Gonzaga Ranch, Merced Co., Calif.

rounded; umbilical margin doubly angulate, the inner angulation much the stronger and overhanging the umbilical depression; umbilicus moderately wide, round; umbilical depression made reniform by a funicle against the inner lip; growth line somewhat prosocline, bending across the shoulder to become orthocline; aperture moderately oblique, semicircular, rounded anteriorly, angulate posteriorly, outer lip thin; inner lip thickened by funicle, wrapped onto the last whorl at the outer umbilical angulation; spiral sculpture of incised lines strongest on the shoulder; remnant color markings of zig-zag prosocline stripes.

Lectotype (here designated). — ANSP 4255. Gabb's original material of *Natica conradiana* consisted of two incomplete specimens from San Luis Gonzaga Ranch in Pacheco Pass, Merced Co., California. He designated neither as holotype. The larger of these two syntypes (UCBMP 31411; height, incomplete, 38.8 mm) was listed as "type material" by Merriam (1895) and was erroneously referred to as the holotype by Stewart (1927). It is essentially a steinkern and could not have provided Gabb with the growth lines or whorl shape present in his drawing, and it is noticeably larger than Gabb's drawing which is said to be "natural size." As this specimen cannot have been the sole basis for Gabb's illustration, there was no reason to consider it the holotype. Its lack of shell renders it of little use as a reference for precise identification of species, and it would be a poor choice for lectotype. Furthermore, although Stewart designated other lectotypes in the same paper, he indicated this one as holotype, suggesting that he mistakenly believed it to be such, and was not designating it as lectotype.

The smaller specimen (ANSP 4255; height, incomplete, 35.3 mm) was figured by Stewart (1927; reprinted by Schenck and Keen, 1940). Although considered poorly preserved by Stewart, it is much the better of the two specimens, retaining enough of the shell to indicate the whorl profile, path of the growth line, and presence of striations on the shoulder. The cleaned umbilicus has a funicle. Additionally, this specimen is as close in size to Gabb's drawing as can be expected considering Gabb's propensity for idealization and reconstruction. Gabb must have relied heavily

on this specimen for his drawing; but, as the umbilical area and inner lip were covered by matrix, he presumably based his open umbilicus on that of the steinkern (UCBMP 31411). As neither of Gabb's specimens can be considered to be the holotype as discussed above, and neither has previously been chosen as lectotype, the more complete specimen (ANSP 4255) is designated as lectotype.

Lectoparatype. — UCBMP 31411.

Hypotypes. — UCLA 59793 from CIT loc. 1264; UCLA 59794 from CIT loc. 1532; UCLA 59795 from CIT loc. 1042; CAS 61404–61405 from CAS loc. 446; and CAS 41 (=holotype of *Gyrodontes siskiyouensis* Anderson).

Type locality. — San Luis Gonzaga Ranch, Pacheco Pass, Merced Co., California; of *G. siskiyouensis*, 4 miles southwest of Ashland, Jackson Co., Oregon.

Distribution. — Panoche Formation, Diablo Range; Hornbrook Formation, Siskiyou Co.; upper Frazier Silt and Melton Sandstone, Shasta Co., California; Hornbrook Formation, Jackson Co., Oregon.

Age. — Late Turonian, with *Subprionocyclus neptuni* (Geinitz) and *S. normalis* (Anderson).

Remarks. — Gabb's specimens are not well-preserved, but indications of spiral sculpture on the shoulder and the strong funicle of the lectotype suggest that it and *G. siskiyouensis* Anderson are conspecific. It has a diameter of 35+ mm and is larger than most of the specimens from the Hornbrook Formation. Fewer specimens of *N. conradiana* than of the subspecies *N. conradiana vacuolae* were available for study. The largest collections of this species are from Siskiyou Co., California, and Jackson Co., Oregon. Both specimens upon which relict color markings can be discerned are from Rancheria Gulch, Hornbrook Quadrangle, Siskiyou Co., California. A specimen (Figure 7.7) from 4 miles (6.4 km) south of Ashland, Oregon, appears never to have had spiral grooves. It also lacks a well-defined funicle (Figure 7.18). Sculpture on a specimen (Figure 7.8) from Salt Creek, Millville Quadrangle, Shasta Co., California, has been virtually obliterated by endolith burrows, but the specimen has the most nearly complete outer lip available. In the absence of the spiral sculpture it is difficult to differ-

TABLE 11—Dimensions of *Natica conradiana* (Gabb), in mm, * = incomplete. See Figure 2 for explanation of measurements.

	h	w	s	p	e	w/h	s/h	p/h	e/h	e/p
UCLA 59793	17.8	20.4	3.8	8.6	3.0	1.15	0.21	0.48	0.17	0.35
UCLA 59794	32.2	36.0	9.8	14.5	8.0	1.12	0.3	0.45	0.25	0.55
UCLA 59795	15.5	19.8	3.3	7.8	2.5	1.28	0.21	0.5	0.16	0.32
CAS 61405	18.5	19.4*	3.4	7.9	2.2	1.05	0.18	0.43	0.12	0.28
CAS 61404	27.4	33.5	6.5	13.4	6.4	1.22	0.24	0.49	0.23	0.48

entiate between *N. conradiana* and *N. conradiana vacculae*.

NATICA CONRADIANA VACCULAE n. subsp.

Figure 7.3, 7.6, 7.9, 7.10,
7.12, 7.16

Gyrodes conradiana (Gabb). JONES, SLITER, AND POPNOE, 1978, p. XXII. 10, Pl. 1, figs. 16, 17. Not ?*Lunatia* (*Gyrodes*?) *conradiana* Gabb, 1864.

Description.—Shell of moderate thickness, medium sized; spire about 25% of total height; suture appressed to moderately incised, at posterior one-third of whorl; shoulder subangulate becoming rounded; whorl profile well rounded; umbilical margin doubly angulate, the inner angulation much the stronger and overhanging the umbilical depression; umbilicus moderately wide, round; umbilical depression made reniform by a funicle against the inner lip; growth line obliquely prosocline, bending across the shoulder to become orthocline, periodically impressed near the suture to form short collabral grooves; aperture moderately oblique, semicircular, rounded anteriorly, angulate posteriorly; outer lip thin; inner lip thickened by funicle, wrapped onto the last whorl at the outer umbilical angulation; spiral sculpture of very fine raised threads somewhat stronger and wider spaced on the shoulder; remnant color marking of zig-zag prosocline stripes.

Holotype.—UCLA 59796.

Paratypes.—UCLA 59440 from UCLA loc. 4416, Stinking Creek, Redding Quadrangle, Shasta Co.; UCLA 59799 from CIT loc. 1440, Salt Creek, Millville Quadrangle, Shasta Co.; UCLA 59800 from CIT loc. 1446, Woodman Creek, Millville Quadrangle, Shasta Co.; UCLA 59797 from CIT loc. 1195, Stinking Creek, Redding Quadrangle, Shasta Co., California.

Type locality.—CIT loc. 1195: Stinking Creek, Shasta Co., California.

Distribution.—Bellavista Sandstone and lower Frazier Silt, Redding area, Shasta Co.; Hornbrook Formation, Siskiyou Co., California; ?basal Nanaimo Group, Hamley Point, Sydney Island, British Columbia.

Age.—Early and mid Turonian. The Bellavista Sandstone is early Turonian, the lower Frazier Silt mid Turonian on the basis of ammonites (Matsumoto, 1960, p. 7; Jones et al., 1978), but foraminiferal correlations suggest a Cenomanian age for these units (Jones et al., 1978).

Remarks.—The major difference between *N. conradiana vacculae* and *N. conradiana* is in the sculpture. *Natica conradiana* typically has spiral grooves rather than fine threads. These spiral grooves are commonly stronger on the shoulder than are the fine threads of *N. conradiana vacculae*. The fine spiral threads are crossed or interrupted by the stronger growth lines to produce a finely dimpled texture on the shell. In the Redding area well-preserved specimens, some of which exhibit color markings but which characteristically have only very fine spiral threads, have been collected from the Bellavista Sandstone; well-preserved specimens from the Melton Sandstone are usually distinctly spirally grooved on the shoulder. *Natica conradiana vacculae* thus appears to indicate an earlier horizon than does *N. conradiana*. Strength of sculpture and extent of whorl covered vary considerably. In all collections some specimens are without any; in some cases the absence appears to be original, in others to result from obliteration.

The strength of the funicle also varies from a slight thickening to a well rounded cord which ends at the inner lip in a semicircular umbilical callus. This callus is nearly midway in the umbilical depression along the inner

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LOCALITIES

Gyrodiiform gastropods from more than 200 localities were studied, but only the localities cited in this paper are listed here. Descriptions for nearly half of the cited numbered localities have been previously published. These are listed briefly with a reference.

- M 175 USGS, S of Logan Ridge, Lodoga Quad., Colusa Co., Calif., probably slumped downhill from Venado Fm. (Turonian) (Saul, 1978, p. 55).
- 446 CAS, Clawson Quarries, 4 miles (6.4 km) S of Ashland, Jackson Co., Oregon. Coll: BSC. Hornbrook Fm. (Turonian).
- 974 CIT, Santa Ana Mts., El Toro Quad., Orange Co., Calif. Williams Fm., Pleasants Sandstone Member (late Campanian, *Metaplaenticeras pacificum* Zone) (Matsumoto, 1960, p. 99).
- 976 CIT, Santa Ana Mts., El Toro Quad., Orange Co., Calif. Williams Fm., Pleasants Sandstone Member (late Campanian, *Metaplaenticeras pacificum* Zone) (Matsumoto, 1960, p. 99).
- 1007 CIT, Oak Run, Millville Quad., Shasta Co., Calif. Member IV (Coniacian) (Matsumoto, 1960, p. 100).
- 1016 CIT, About halfway up slope of W bank of Big Chico Creek, in first ravine flowing into Chico Creek N of bridge S of Mickey's house, 800' N, 700' E of SW cor. sec. 1, T23N, R2E, Paradise Quad., Butte Co., Calif. Coll: Popenoe and Scharf, 1931. Chico Fm., lower Musty Buck Member (Santonian).
- 1017 CIT, About 100' (30.5 m) below lava contact W side Chico Creek, N and a little W of Mickey's house, 1,650' N, 1,300' E of SW cor. sec. 1, T23N, R2E, Paradise Quad., Butte Co., Calif. Coll: Popenoe and Scharf, 1931. Chico Fm., Musty Buck Member (Santonian).
- 1041 CIT, Butte Creek, Paradise Quad., Butte Co., Calif. Chico Fm., Tenmile Member (late early Campanian, *Turritella chicoensis* Zone) (Saul and Popenoe, 1962, p. 328).

- 1042 CIT, N bank of Rancheria Gulch, about 1.5 mi (2.4 km) W of Henley, 210' S, 800' E of NW cor. sec. 30, T47N, R6W, Hornbrook Quad., Siskiyou Co., Calif. Coll: Popenoe and Findlay, 1933. Hornbrook Fm., Osburger Gulch Sandstone Member (late Turonian, *Subprionocyclus neptuni* Zone).
- 1158 CIT, SE slope of Simi Hills, N bank Bell Canyon, 500' (152.4 m) S, 9,000' (2743.2 m) W of NE cor. sec. 4, T1N, R17W, Calabasas Quad., Ventura Co., Calif. Coll: Popenoe, 1935. Chatsworth Fm. (?mid Campanian, *Turritella chicoensis* Zone).
- 1159 CIT, Crest of spur between forks of Dayton Canyon, Simi Hills, about 400' (121.9 m) E of Los Angeles-Ventura Co. line, 400' (121.9 m) N, 2,350' (238.7 m) W of SE cor. sec. 28, T2N, R17W, Calabasas Quad., Los Angeles Co., Calif. Coll: Durbin and Popenoe, 1935. Chatsworth Fm. (late Campanian, *Metaplacenticerias pacificum* Zone).
- 1195 CIT, Bed of Stinking Cr., 2,600' (792.5 m) N, 1,100 (335.3 m) E of SE cor. sec. 6, T32N, R3W, Redding Quad., Shasta Co., Calif. Coll: Popenoe and Ahlroth, 1936. Bellavista Sandstone (early Turonian).
- 1246 CIT, Clover Creek valley, Millville Quad., Shasta Co., Calif. Member V or VI (early Santonian) (Matsumoto, 1960, p. 104).
- 1260 CIT, Swede Basin, Millville Quad., Shasta Co., Calif. Member IV, lower part (Coniacian or earliest Santonian) (Matsumoto, 1960, p. 8, 105).
- 1264 CIT, Little Cow Creek, Millville Quad., Shasta Co., Calif. Melton Sandstone (late Turonian, *Subprionocyclus neptuni* Zone) (Matsumoto, 1960, p. 105).
- 1313 CIT, Left bank of Chico Creek, 5.6 mi (9.0 km) upstream from Ten-mile House, and approx. 20' (6.2 m) above stream bed in road cut, approx. 1,200' (365.8 m) N, 1,750' (533.4 m) E of SW cor. sec. 12, T23N, R2E, Paradise Quad., Butte Co., Calif. Chico Fm., Musty Buck Member (Santonian).
- 1346 CAS, Mouth of Hulén Creek, Shasta Co., California, where it enters Cottonwood Creek. Coll: F. M. Anderson. Budden Canyon Fm., Bald Hills Member (late Albian).
- 1346A CAS, 1 mile (1.6 km) above mouth of Hulén Creek, basal Chico Zone, Shasta Co., California. Budden Canyon Fm., Bald Hills Member (late Albian).
- 1346 CIT, Little Cow Creek, Millville Quad., Shasta Co., Calif. Melton Sandstone (late Turonian, *Subprionocyclus normalis* Zone) (Matsumoto, 1960, p. 106).
- 1396 CIT, Sucia Island, Orcas Island Quad., San Juan Co., Washington. Cedar District Fm. (mid Campanian, *Hoplitoplacenticerias vancouverense* Zone) (Saul, 1974, p. 1093).
- 1400 CIT, Sucia Island, Orcas Island Quad., San Juan Co., Washington. Cedar District Fm. (mid Campanian, *Hoplitoplacenticerias vancouverense* Zone) (Matsumoto, 1960, p. 107).
- 1440 CIT, Redding area, Millville Quad., Shasta Co., Calif. Bellavista Sandstone (?early Turonian) (Saul, 1974, p. 1093).
- 1444 CIT, S side Woodman Creek, approx. 2,400' (731.5 m) S of NE cor. sec. 35, T33N, R3W, Millville Quad., Shasta Co., Calif. Coll: Popenoe, 1940. Bellavista Sandstone (early Turonian).
- 1446 CIT, near top of N slope of hillside SE of Alturas-Redding highway, S side Woodman Creek, 2,250' (746.8 m) S, 500' (152.4 m) W of NE cor. sec. 35, T33N, R3W, Millville Quad., Shasta Co., Calif. Coll: Popenoe, 1940. Bellavista Sandstone (early Turonian).
- 1532 CIT, Salt Creek, Millville Quad., Shasta Co., Calif. Frazier Silt (?late Turonian) (Matsumoto, 1960, p. 107).
- 1602 CIT, NW side of crest of ridge just W of prominent bend in road, highway between Martinez and Crockett, approx. 1.8 mi (2.9 km) N 75°W of shore end of ferry pier at Martinez and S of Benicia city wharf, Benicia Quad., Contra Costa Co., Calif. Coll: Popenoe, 1944. Great Valley Sequence (?mid Maastrichtian).
- 2326 UCLA, Crest of spur S of Santiago Truck trail and Harding Canyon, 600' S, 175' W of NW cor. sec. 32 and E edge of topo sheet, T5S, R7W, El Toro Quad., Santa Ana Mts., Orange Co., Calif. Coll: Popenoe, 1946. Williams Fm., Pleasants Sandstone Member (late Campanian, *Turritella chicoensis pescaderoensis* Zone).
- 2582 UCLA, Western base of 1st hill W of Barclay Ranch rd, approx. 1,600' (487.7 m) S, 600' (182.9 m) W of NE cor. sec. 23, T2N, R18W, Calabasas Quad., Simi Hills, Ventura Co., Calif. Coll: Murphy, 1950. Lower Santa Susana Fm. (early "Martinez" ≈ early Selandian, *Turritella peninsularis* Zone).
- 2697 LSJU, (Waring loc. 4, in part) Simi Hills, 3 mi (4.8 km) ENE of Simi Peak, near head of E fork of Las Virgenes Canyon, Camulos Quad., Ventura Co., Calif. Lower Santa Susana Fm. (early "Martinez" ≈ early Selandian, *Turritella peninsularis* Zone).
- 2874 UCLA, 4,780' (1452.9 m) N, 25.5°E of the confluence of Huling Creek and N fork of Cottonwood Creek on E fork of Huling Creek, on S limb of hairpin meander, Ono Quad., Shasta Co., Calif. Coll: M. A. Murphy, summers 1951-1953. Budden Canyon Fm., Chica-bally Member (Early Albian, *Leconteites lecontei* Zone).
- 3154 UCLA, First small rise S of hill 2,150' S of the road, 12,690' (3,869.9 m) S, 28.5°E of NW cor. Calabasas (1929) Quad., Simi Hills, Ventura Co., Calif. Coll: Fantozzi, 1953. Lower Santa Susana Fm. (early "Martinez" ≈ early Selandian, *Turritella peninsularis* Zone).
- 3382 UCLA, 2 ft (0.62 m) thick ledge of graywacke above siltstone along N side of Clear Creek, 2,000' (609.6 m) ESE of Reading Bar, 2 mi (3.2 km) SSW of Centerville at junct. of Ono-Redding and Horsetown-Centerville rds., SW¼ sec. 36, T31N, R6W, Anderson Quad., Shasta Co., Calif. Coll: Murphy and Rodda, 1955. Budden Canyon Fm., upper Aiken Member (mid Albian, *Oxytropidoceras packardi* Zone).
- 3464 UCLA, W of the Gas Point Rd., Ono Quad., Shasta Co., Calif. Budden Canyon Fm., Bald Hills Member (Cenomanian) (Murphy and Rodda, 1960, p. 856).
- 3465 UCLA, North Fork of Cottonwood Cr., Ono Quad., Shasta Co., Calif. Budden Canyon Fm., Bald Hills Member (Cenomanian) (Murphy and Rodda, 1960, p. 856).
- 3625 UCLA, First ravine to S of Mickey's Place on W side of Chico Creek about 100' (30.5 m) below fork in ravine, 800' (243.8 m) N, 900' (274.3 m) E of SW cor. sec. 1, T23N, R2E, Paradise Quad., Butte Co., Calif., Coll: L. R. and R. B. Saul, 1952. Chico Fm., Musty Buck Member (early Santonian).
- 3627 UCLA, Chico Creek, Paradise Quad., Butte Co., Calif. Chico Fm., Musty Buck Member (Santonian, *Baculites capensis* Zone) (Matsumoto, 1960, p. 156).
- 3628 UCLA, E bank Chico Creek approx. 100' (30.5 m)

- S of northernmost H_B fence, 800' (243.8 m) S, 1,000' (304.8 m) E of NW cor. sec. 13, T23N, R2E, Paradise Quad., Butte Co., Calif. Coll: L. R. and R. B. Saul, 1952. Chico Fm., Musty Buck Member (Santonian, *Baculites capensis* Zone).
- 3630 UCLA, W side Chico Creek valley about 1/5 mi (0.54 km) up deep ravine and 2/3 mi (1.1 km) S of Mickey's Place, approx. elev. 1,160' (353.6 m), 1,750' (533.4 m) S, 200' (61.0 m) E of NW cor. sec. 12, T23N, R2E, Paradise Quad., Butte Co., Calif. Coll: L. R. and R. B. Saul, 1952. Chico Fm., basal Tenmile Member (?late Santonian or earliest Campanian).
- 3633 UCLA, Chico Creek, Paradise Quad., Butte Co., Calif. Chico Fm., near top of Musty Buck Member (Santonian, *Baculites capensis* Zone) (Matsumoto, 1960, p. 15, 156).
- 3639 UCLA, Chico Creek, Paradise Quad., Butte Co., Calif. Chico Fm., Tenmile Member (early Campanian, *Turritella chicoensis holzana* Zone) (Saul, 1983, p. 121).
- 3778 UCLA, Huling Creek, Ono Quad., Shasta Co., Calif. Budden Canyon Fm., Bald Hills Member (late Albian) (Murphy and Rodda, 1960, p. 857).
- 4081 UCLA, S of Pentz, Cherokee Quad., Butte Co., Calif. Chico Fm., ?Musty Buck Member (early Campanian) (Saul and Popenoe, 1962, p. 328).
- 4106 UCLA, N of Clover Creek, Millville Quad., Shasta Co., Calif. Member VI (early Santonian) (Popenoe, 1983, p. 765).
- 4127 UCLA, Hard ss. slabs in bed of Clover Cr., 700' (213.4 m) N, 1,200' (365.8 m) W of SE cor. sec. 22, T32N, R2W, Millville Quad., Shasta Co., Calif. Coll: Popenoe and Dailey, 1959. Member VI (late Santonian).
- 4246 UCLA, SE side Oak Run Valley, in ss. below thick cgl. 1,800' (548.6 m) N, 1,700' (518.2 m) E of SW cor. sec. 15, T32N, R2W, Millville Quad., Shasta Co., Calif. Coll: Popenoe, 1959. Member V (early Santonian).
- 4340 UCLA, SE of Pentz, Cherokee Quad., Butte Co., Calif. Chico Fm., ?Musty Buck Member (early Campanian) (Saul and Popenoe, 1962, p. 329).
- 4416 UCLA (=CIT 1195), Stinking Creek, Redding Quad., Shasta Co., Calif. Bellavista Sandstone (Turonian) (Matsumoto, 1960, p. 104).
- 4669 UCLA, Camp Creek drainage, ss. cropping out in field about 1/4 mi. (0.4 km) N of road from Suplee to Paulina, and in center of SW 1/4 sec. 23, T17S, R25E, Dayville Quad., Crook Co., Oregon. Coll: Imlay and Popenoe, 1959. (Cenomanian.)
- 5902 UCLA, In gullies tributary to Oil Canyon at its source, just west of center of sec. 7, T19S, R15E, Joaquin Rocks Quad., Fresno Co., Calif. Coll: Popenoe, 1949. Panoche Fm., "Ragged Valley Shale" (early Maastrichtian).
- 6337 UCLA, W side Cottonwood Creek, Hancock Ranch, 2,000' (609.6 m) S, 3,750' (1,143 m) E of NW cor. sec. 6, T24S, R16E, Cholame Valley Quad., Monterey Co., Calif. Coll: Alderson, 1976. Panoche Fm. (early Maastrichtian).
- 6342 UCLA, W side San Joaquin Valley, cgl. reef bed cropping out on NW slope of Los Baños Cr., about 3,200' (975.4 m) N, 1,800' (548.6 m) W of SE cor. sec. 12, T11S, R9E, Ortigalita Peak Quad., Merced Co., Calif. Coll: Stewart and Popenoe, 1944. Panoche Fm., "Quinto B" beds (early Maastrichtian).
- 6465 UCLA, "Rob's loc.," S-facing slope of E-flowing gulch just above 4 on map, 2,375' (723.9 m) S, 2,375' (723.9 m) E of NW cor. sec. 4, T20N, R14E, N of Los Gatos Creek, Coalinga Quad., Fresno Co., Calif. Coll: L. R., R. B., R. B., and R. L. Saul, 1972. Panoche Fm., "Ragged Valley Shale" (early Maastrichtian).
- 6534 UCLA, S side short cul de sac having prominent bare vertical outcrop on N side, W side Arroyo Santa Catarina, almost opposite road into Arroyo, approx. 8.1 km N, 4.2 km E of mouth of stream NW side Arroyo Santa Catarina, N 19°W of S tip Punta Canoas, Baja Calif., Mexico. Coll: L. R. and R. L. Saul and W. P. Popenoe, 1968. Rosario Fm. (early Maastrichtian).
- 7006 UCLA, Wave-cut shelf on S side Sucia Island, sec. 25, T38N, R2W, Orcas Island Quad., San Juan Co., Washington. Coll: L. R. and R. B. Saul, 1958. Cedar District Fm. (Campanian).
- 31918 CAS, Thompson Cr., 1,200' (365.8 m) N, 600' (182.9 m) W of SE cor. sec. 20, T8N, R2W, Monticello Dam Quad., Yolo Co., Calif. Coll: Kennett, 1943. Just above base of Yolo Shale (Turonian).
- 85511 CGS, Hamley Point, Sydney Island, lat. 48°36'05"N, long. 123°16'05"W, British Columbia, Canada. Coll: Muller, 1970. Nanaimo Group, near base (Turonian).