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PTEROPODS (MOLLUSCA: GASTROPODA) FROM TERTIARY FORMATIONS OF WASHINGTON AND OREGON

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ABSTRACT—*Praehyalocylis cretacea* (Blanckenhorn, 1889), a pteropod previously known only from upper Eocene to middle Miocene strata in Europe and Turkey, is reported for the first time in similar age rocks in the northwestern United States. Of the 238 specimens, most occur as molds and casts in concretions in deep-water deposits from the Keasey Formation in Oregon, and from the Quimper Sandstone, Blakeley Formation, Pysht Formation, and Astoria Formation of Washington. *Praehyalocylis* has not been reported previously from the Western Hemisphere.

Clio berglundi n. sp. and *C. goederti* n. sp. are reported from upper Oligocene to lower Miocene rocks in Washington. Eleven specimens were found mostly as internal molds in concretions in deep-water deposits of the Lincoln Creek, Pysht, and Astoria Formations of Washington. Cenozoic species of *Clio* have not been reported previously from the West Coast of the United States.

INTRODUCTION

PTEROPODS ORIGINATED during the Late Cretaceous (Herman, 1978) and evolved rapidly. Many taxa of Tertiary pteropods have been reported from the Gulf Coast of the United States (Collins, 1934; K. A. Hodgkinson, personal commun.), but only a few fossil pteropods have been reported from the West Coast of the United States. Durham (1944) reported an unidentified Oligocene species from Washington; Gabb (1869) reported one Miocene species from California; Valentine (1956) reported an upper Pleistocene species from California; and Collins (1934) mentioned a different Pleistocene species from California. Phillips et al. (1976) reported an unidentified lower Miocene pteropod from California. The specimen is very poorly preserved and possibly is a plant fragment, not a pteropod.

This report is the first detailed account of any upper Eocene, Oligocene, and lower Miocene pteropods from the West Coast of the United States. Two genera, *Praehyalocylis* Korobkov, 1962, and *Clio* Linné, 1767, are represented. The stratigraphic range of *Praehyalocylis* is Eocene to middle Miocene, and previously it was known only from Asia Minor, West Germany, and Australia (Korobkov and Makarova, 1962; Bernasconi and Robba, 1982). Its geographic range can now be extended into the Western Hemisphere with upper Eocene occurrences in Oregon and Washington and Oligocene to lower Miocene occurrences in Washington (Figure 1).

Praehyalocylis most likely originated in the Tethys Sea region, as suggested by Bernasconi and Robba (1982). Exactly when it originated is not known, but it is now known with certainty that the earliest known species, *P. cretacea,* was present in the southern Soviet Union and the northwestern United States during late Eocene time. This species remained in the northwestern United States until just after the beginning of early Miocene time. The youngest stratigraphic occurrence of *P. cretacea* is in southern Turkey where Avnimelech (1945) reported it from middle Miocene strata.

The geologic range of *Clio* is Late Cretaceous to Recent (Herman, 1978). Previously, its earliest known occurrence in North America was in the Caribbean region during the early Miocene (Bernasconi and Robba, 1982). Its geologic and geographic ranges in North America can now be extended to the late Oligocene on the West Coast with the upper Oligocene to lower Miocene occurrences in Washington.

Average size of the West Coast pteropods is about 10 mm in length and 2 mm in width, but specimens can be up to 24 mm in length and 5 mm in width. A total of 238 specimens is known. Most belong to *Praehyalocylis cretacea* (Blanckenhorn, 1889), a species previously known only from West Germany and Asia Minor. Most of the pteropods are preserved either as thin remnants of shell or as internal molds, external molds, or casts. A few have pyritized shell remnants. Specimens are mostly found in concretions that have been eroded from beach cliffs and are now in the intertidal zone. Only 11 specimens of *Clio* were found, and they represent two new species, both of which resemble Western European Tertiary species or Recent species.

Many of the pteropods occur as fragments in clusters of numerous individuals (Figure 2.1). Other fossils in the pteropod-bearing concretions are uncommon and may include benthic

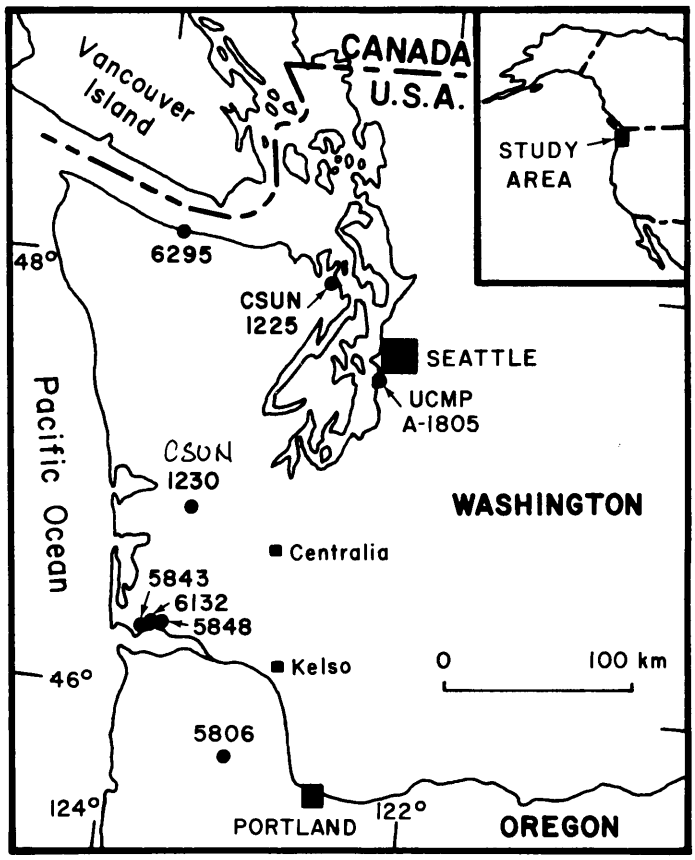

FIGURE 1—Index map to pteropod collecting localities, Oregon and Washington, northwestern United States. Unless otherwise indicated, localities are LACMIP localities.

foraminifers, scaphopods, small gastropods, articulated and disarticulated bivalves (mostly small), complete and incomplete crabs, fish scales, teredinid-bored wood, carbonized wood, and two localities (CSUN 1225 and LACMIP 6295) also yielded leaves. These fossils, which are commonly fragmental, consist of mixed assemblages with most of the remains apparently derived from deep-water, low-diversity benthic communities. Some of the remains are derived from pelagic communities (e.g., pteropods) and nearby nonmarine communities (e.g., wood, leaves). Only the Keasey Formation in northwestern Oregon has received any detailed paleoenvironmental studies, but it seems to be representative of all the formations. Hickman (1976) assigned the deposits to depths greater than 200 m (bathyal).

The specimens were collected over many years by James L. and Gail H. Goedert of Gig Harbor, Washington, and Ross and Marion Berglund of Bainbridge Island, Washington. Pteropods are rare fossils in each formation. Ninety-nine percent of the concretions are barren. Several hundred specimens are now known, which is testimony to the dedication and careful collecting of these individuals.

Abbreviations used for catalog and/or locality numbers are: CSUN, California State University, Northridge; LACMIP, Natural History Museum of Los Angeles County, Invertebrate Paleontology Section; and UCMP, University of California Museum of Paleontology, Berkeley.

SYSTEMATIC PALEONTOLOGY

Phylum MOLLUSCA Cuvier, 1797
Class GASTROPODA Cuvier, 1797
Subclass OPISTHOBRANCHIA Milne-Edwards, 1848
Order THECOSOMATA Blainville, 1824
Suborder EUTHECOSOMATA Meisenheimer, 1905
Family CAVOLINIIDAE Gray, 1850
Genus PRAEHYALOCYLIS Korobkov
in Korobkov and Makarova, 1962

Type species.—By original designation, *Praehyalocylis chivensis* Korobkov and Makarova, 1962. Upper Eocene, southern part of the USSR.

Diagnosis.—Shell large, conical, straight-sided with prominent transverse annulations; apical area very narrow and very elongate, separated from rest of shell by a narrow neck.

Discussion.—Korobkov (1962) designated *Praehyalocylis chivensis* Korobkov and Makarova, 1962, as the type species. In this paper, however, this species is considered, in part, to be a junior synonym of *Praehyalocylis cretacea* (Blanckenhorn, 1889).

As mentioned by Korobkov (1962), *Praehyalocylis* is closely related to the genus *Hyalocylis* Fol, 1875, known from the Pliocene to the Recent (Noda, 1972; Bernasconi and Robba, 1982). *Praehyalocylis* differs from *Hyalocylis* in the following features: larger, circular cross section rather than an oval one, initial part of the shell elongated into a thin tube rather than truncate, and shell not dorsally curved nor somewhat dorsoventrally compressed in the anterior half of the shell. Collins (1934, p. 149) reported that the juvenile shell of *Hyalocylis* is bulbous and is shed at an early stage of development and that the apex is blunt and closed by a septum. Other workers (Keen, 1971; Abbott, 1974), however, have observed that the tip of the shell is open and truncate in *Hyalocylis*.

Material.—The genus *Praehyalocylis* includes *P. cretacea* (Blanckenhorn, 1889), *P. chivensis* Korobkov and Makarova, 1962, *P. maximus* (Ludwig, 1864), and possibly *P.? annulata* (Tate, 1887). The latter species is poorly known but it has a long, slender, straight shell that suggests assignment to *Praehyalocylis*. The apical area, however, is somewhat bulbous, which is a *Hyalocylis*-like feature.

The geologic age of the southern Australian strata in which *Praehyalocylis? annulata* (Tate, 1887) has been found is uncertain, although Bernasconi and Robba (1982) assigned the strata to the Eocene.

Korobkov and Makarova (1962) included the Miocene *P. haitensis* (Collins, 1934) in *Praehyalocylis,* but the apex is not preserved in the two known specimens of this species so it is difficult to be certain of its generic placement. The shell has a pleural angle of about 30° and is dorsally curved. Both of these features suggest assignment to *Hyalocylis*. Collins (1934) originally placed this species in *Hyalocylis*. Bernasconi and Robba (1982) included *P. euphratensis* (Avnimelech, 1945) in *Praehyalocylis,* but the apical end is obscured in the single known specimen of this species. The shell is distinctly curved, which suggests assignment to *Hyalocylis*. Avnimelech (1945) originally placed this species in *Hyalocylis*. He considered it Miocene in age, but Bernasconi and Robba (1982) considered it to be Eocene.

K. A. Hodgkinson (personal commun.) found a fragment of a *Hyalocylis*-like pteropod in oil-well cuttings from the Eocene Sparta Formation, Louisiana, southeastern United States.

Occurrence.—Upper Eocene to middle Miocene. Upper Eocene: southern Soviet Union, Oregon, Washington, and Australia. Oligocene: West Germany and Washington. Lower Miocene: Washington. Middle Miocene: Turkey.

PRAEHYALOCYLIS CRETACEA (Blanckenhorn, 1889)
Figure 2.1–2.5

Tentaculites cretaceus BLANCKENHORN, 1889, p. 600, Pl. 22, figs. 8, 9; 1890, p. 120, Pl. 9, figs. 22, 23.
Tentaculites maximus var. *densecostatus* Ludwig. BLANCKENHORN, 1889, p. 602, Pl. 22, figs. 10, 11.
Clio cretaceum (Blanckenhorn). AVNIMELECH, 1945, p. 644, text-fig. 9.
Balantium sp. DURHAM, 1944, p. 190, Pl. 18, fig. 2.
Praehyalocylis chivensis KOROBKOV AND MAKAROVA, 1962, p. 85–87 (in part), Pl. 3, figs. 1, 3, 5–8.
Praehyalocylis maximus var. *densecostatus* Ludwig (Blanckenhorn, 1889). KOROBKOV AND MAKAROVA, 1962, Pl. 3, figs. 12, 13.
not *Praehyalocylis chivensis* KOROBKOV AND MAKAROVA, 1962, p. 85–87 (in part), Pl. 3, figs. 2, 4 [=*Praehyalocylis maximus dense-annulatus* (Ludwig, 1864)].

Supplementary description.—Very thin, conical, large shell (up to 24 mm long and 5 mm wide), pleural angle approximately 20°, apex closed; embryonic region narrow, elongate, and tube-like, versus rapidly divergent neck region and less divergent straight-sided main part of shell; transverse annulations begin about 0.5 mm from the apex of shell, continuing to aperture, spacing of annulations wider toward aperture, about 15/mm in

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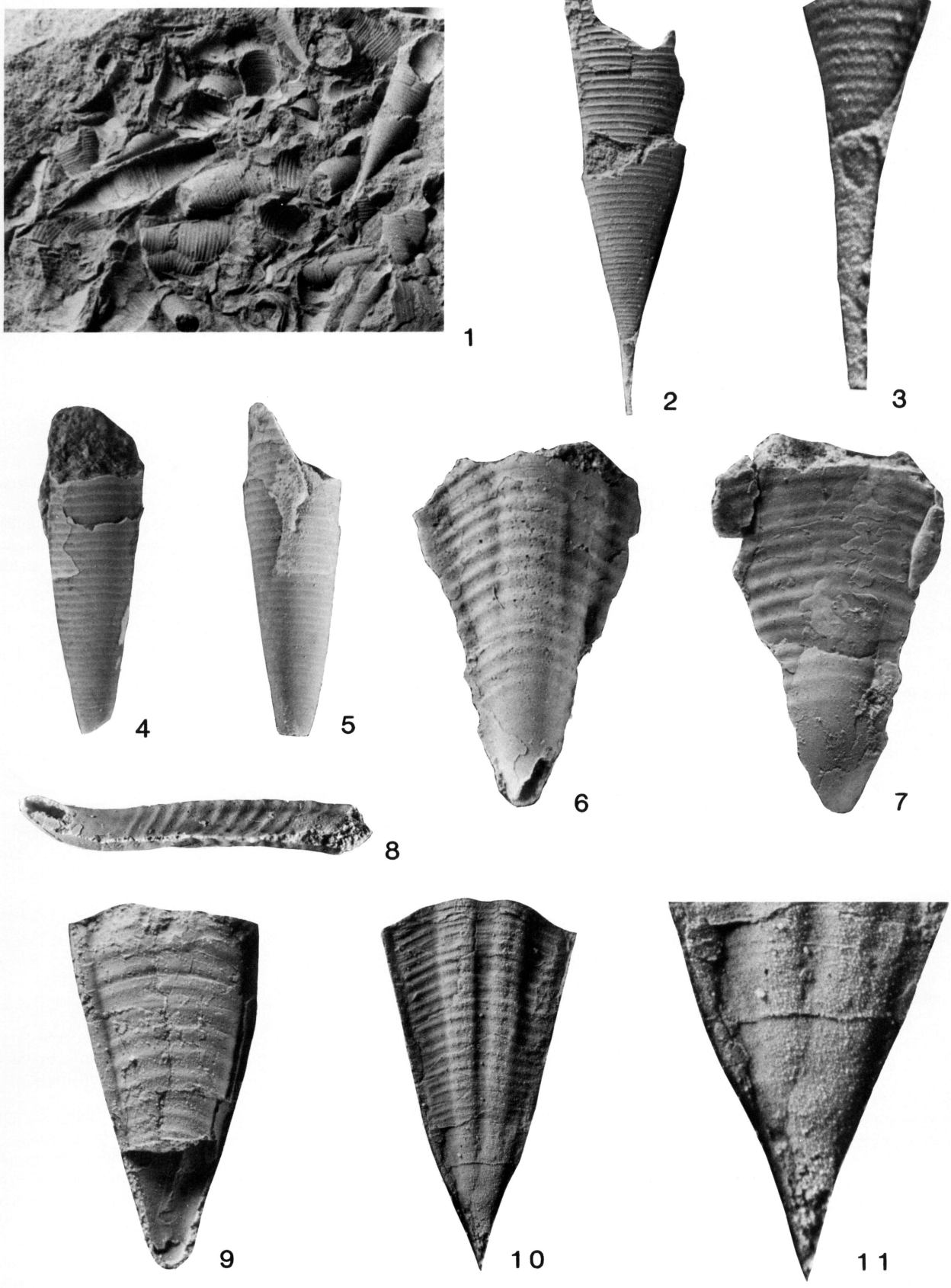
FIGURE 2—*1–5, Praehyalocylis cretacea* (Blanckenhorn, 1889), locality LACMIP 5806. *1–3,* hypotype, LACMIP 7971; *1,* rock surrounding LACMIP 7971 (shown in upper right-hand corner), ×3; *2,* dorsal? view, ×7.5; *3,* enlargement of embryonic region, dorsal? view, ×28; *4, 5,* hypotype, LACMIP 7972, ×6.3; *4,* dorsal? view; *5,* lateral view. *6–9, Clio berglundi* n. sp. *6–8,* holotype, LACMIP 7973, locality CSUN 1230, ×7.2; *6,* dorsal view; *7,* ventral view; *8,* lateral view; *9,* paratype, LACMIP 7986, locality LACMIP 6295, ventral view, ×7. *10, 11, Clio goederti* n. sp., holotype, LACMIP 7987, locality LACMIP 6132. *10,* dorsal view, ×4.7; *11,* enlargement of embryonic region, ×13.5.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apical region, about 7/mm in neck region, and about 4–6/mm in apertural region; aperture slightly oval.

Dimensions.—Hypotype, LACMIP 7971, length 10 mm, width 2 mm; hypotype, LACMIP 7972, length 9 mm (apex missing), width 2.5 mm.

Discussion.—The suffix "a" is used for this species name because it agrees in gender with the feminine generic name.

Determination of dorsal versus ventral side of *P. cretacea* has never been discussed, thus the views of *P. cretacea* (Figure 2.2–2.4) are questionably assigned as dorsal views. Only a few specimens of *P. cretacea* found in this study could be removed as three-dimensional specimens from the matrix. One of these (hypotype, LACMIP 7972) is shown as a dorsal? view (Figure 2.4) and as the corresponding lateral view (Figure 2.5). Note that in lateral view the sides are less parallel than those shown in dorsal? view. Also, in this study only a few specimens show the embryonic region.

Praehyalocylis cretacea has more widely spaced annulations and a more elongate neck than *P. maximus* var. *dense-annulatus* (Ludwig, 1864, p. 318–319, Pl. 50, fig. 21a, b). *Praehyalocylis cretacea* has much less widely spaced, less squared-off annulations and a more elongate neck than *P. maximus* var. *laxe-annulatus* (Ludwig, 1864, p. 319, Pl. 50, fig. 22a, b).

Praehyalocylis chivensis Korobkov and Makarova (1962, Pl. 3, figs. 2, 4) is judged to belong to *Praehyalocylis maximus* var. *dense-annulatus* (Ludwig, 1864) because of the very close spacing of the annulations.

Korobkov and Makarova (1962, Pl. 3, figs. 12, 13) used the name *Praehyalocylis maximus* var. *densecostatus* with Ludwig as the author of the variety *densecostatus*. Blanckenhorn (1889), however, was the author of that variety.

Blanckenhorn (1889) regarded *Praehyalocylis cretacea* (=*Tentaculites cretaceus*) as Late Cretaceous in age. Avnimelech (1945), however, showed it to be middle Miocene in age.

A new stratigraphic occurrence of *Praehyalocylis cretacea* in northwestern Oregon (locality LACMIP 5806) is in the upper part of the middle member of the Keasey Formation. This formation is of late Eocene age (Hickman, 1976, 1980; Armentrout et al., 1983). A total of 70 specimens of *P. cretacea* was found at locality 5806 in several calcareous concretions taken from a blue-gray siltstone. One concretion yielded about 50 fragmental specimens concentrated in a cluster. A portion of this cluster is shown in Figure 2.1.

A new stratigraphic occurrence of *P. cretacea* in northwestern Washington (locality CSUN 1225) is in the Quimper Sandstone. This formation is of late Eocene age and is a temporal equivalent of the Keasey Formation (Armentrout et al., 1983). A total of 155 specimens of *P. cretacea* was found in numerous concretions. Some concretions yielded small concentrations of about five to eight specimens. One concretion contained a shell hash consisting of about 25 fragmental specimens. In a few cases, the *Praehyalocylis* specimens show a bimodal preferred orientation. Some of the pteropod specimens at locality 1225 have been pyritized.

Durham (1944) reported the pteropod *Balantium* sp. (locality UCMP A-1805) from the type Blakeley Formation in northwestern Washington. The species is recognized for the first time in this report as *Praehyalocylis cretacea*. Durham (1944) assigned this locality to the *Liracassis rex* Molluscan Zone (=*Echinophoria rex* Molluscan Zone). Moore (1984) reported that the *Liracassis rex* Molluscan Zone is equivalent to the lower Oligocene. Only a single fragmentary specimen of *P. cretacea* was reported by Durham.

Another new stratigraphic occurrence of *P. cretacea* in northwestern Washington (locality LACMIP 6295) is the Pysht Formation. This formation is of late Oligocene age (Armentrout et al., 1983). Only two specimens were found, and they are poorly preserved in concretions. One specimen, although an external mold, shows the diagnostic narrow apical region.

A new stratigraphic occurrence of *P. cretacea* in southwestern Washington (locality LACMIP 6132) is in the Astoria Formation. This formation is of early Miocene age (Armentrout et al., 1983), and this occurrence of *P. cretacea* is its geologically youngest. A single specimen was found in siltstone at locality 6132.

Two specimens of *P. cretacea* were found in a concretion at locality LACMIP 5848 in southwestern Washington. Wolfe and McKee (1968) mapped strata in the vicinity as the lower member of the Astoria? Formation. Armentrout et al. (1983) assigned these strata to the lower Miocene.

Material.—About 227 specimens showing fair to good preservation as shell remnants, internal and external molds, and casts. Hypotypes, LACMIP 7971 and 7972.

Occurrence.—Upper Eocene to middle Miocene. Upper Eocene: Baloglinskiy stratum, northern Caucasus Mountains and *Variamussium fallax* Zone, south coast of Aral Sea, southern Soviet Union (Korobkov and Makarova, 1962); Keasey Formation, northwestern Oregon (locality LACMIP 5806); Quimper Sandstone, northwestern Washington (locality CSUN 1225). Lower Oligocene: Blakeley Formation, northwestern Washington (locality UCMP A-1805, Durham (1944) as *Balantium* sp.). Middle? Oligocene: West Germany (Blanckenhorn, 1889). Upper Oligocene: Pysht Formation, northwestern Washington (locality LACMIP 6295). Lower Miocene: Astoria Formation, southwestern Washington (locality LACMIP 6132); Astoria? Formation (locality LACMIP 5848). Middle Miocene: southern Turkey (Blanckenhorn, 1889; Avnimelech, 1945).

Genus Clio Linné, 1767

Type species.—By original designation, *Clio pyramidata* Linné, 1767. Recent, cosmopolitan except for polar waters.

Diagnosis.—Shell large, pyramidal, somewhat flattened, generally with a longitudinal dorsal ridge (or ridges), but can be smooth; sharply defined lateral borders; apex straight or curved; protoconch bulbous and retained.

Discussion.—The dorsal and ventral sides of the shell in *Clio* can be quite different. The dorsal side usually has one or more prominent longitudinal ribs whereas the ventral side usually is smooth. It is critical, therefore, when making identifications of fossil *Clio* to know what both sides look like.

Material.—Numerous species of *Clio* have been tabulated by Bernasconi and Robba (1982).

Occurrence.—Oligocene to Recent.

Clio berglundi n. sp.
Figure 2.6–2.9

Diagnosis.—*Clio* with transverse annulations covering most of shell; dorsal arch separated by a narrow groove on each side from flanking ramp areas; ventral side with well-marked lateral keels.

Description.—Thin, triangular large shell, pleural angle approximately 30°, straight-sided, dorsal side arched with broad arch flanked by ramps that widen anteriorly, each ramp separated from dorsal arch by slight groove that does not persist posteriorly, each ramp separated from flattened shell margin by another low groove that does not persist anteriorly, lateral margins of dorsal part of shell not preserved, transverse annulations (3/mm) cover dorsal side and extend to shell margin region but not onto the apical region; ventral side of shell flat with transverse annulations (3/mm) that do not persist onto apical region,

keel areas well marked along lateral sides of shells; very faint growth lines cover entire shell; apex pointed and closed.

Dimensions.—Holotype, LACMIP 7972, length 8.5 mm, width 5.5 mm; paratype, LACMIP 7986, length 9 mm, width 5 mm.

Discussion.—Specimens are mostly fragmentary. The holotype (LACMIP 7973) is unusually free of matrix, showing both dorsal and ventral sides of the shell (Figure 2.6, 2.7); however, the lateral margins are poorly preserved. The upward-bent apex of this specimen (Figure 2.8) is due to post-burial compaction. In other specimens the apex can be flat or downward bent. Only one specimen (LACMIP 7986) (Figure 2.9) was found that shows fairly well preserved lateral margins of the ventral side.

The new species resembles *Clio fallauxi* (Kittl, 1886, p. 62–63, Pl. 2, figs. 23–26) from Miocene strata of Austria. *Clio berglundi* n. sp. differs from *C. fallauxi* in the following features: narrower, dorsal arch bordered by a groove on each side, and transverse annulations more widely spaced.

Clio berglundi resembles *Clio pedemontana* (Mayer, 1868, p. 104–105, Pl. 2, fig. 2) reported by Bernasconi and Robba (1982) from Oligocene to lower Miocene strata in southern Europe. Kittl (1886, p. 64–65, Pl. 2, figs. 28, 33) also figured this species, but the dorsal and ventral views of his specimens show a lateral keel on the shell margins that is not present on the holotype (dorsal or ventral view not indicated) of *C. pedemontana*. *Clio berglundi* differs from the holotype of *C. pedemontana* in the following features: dorsal arch bordered by a groove on each side and transverse annulations more widely spaced.

Clio berglundi also resembles the living species *C. scheelei* (Munthe, 1888) from the Coral Sea (see Newman and Greenwood, 1987, p. 91–92, 94, figs. 2A, 3E–H). *Clio berglundi* differs from *C. scheelei* (dorsal view) in the following features: dorsal arch bordered by a groove on each side and 3/mm rather than 5/mm transverse annulations in central portion of shell.

Clio berglundi n. sp. differs from *Clio goederti* n. sp. in the following features: a single longitudinal ridge on the central dorsal surface rather than two narrow ones separated by a narrow median groove and transverse annulations more widely spaced.

Possibly the oldest stratigraphic occurrence of *C. berglundi* is in the Lincoln Creek Formation (locality CSUN 1230) in Grays Harbor County, southwestern Washington. Armentrout et al. (1983) assigned this formation in this area to the undifferentiated Oligocene. Only one specimen was found in siltstone.

Clio berglundi is most abundant in the Pysht Formation (locality LACMIP 6295) in the Olympic Peninsula, northwestern Washington. Armentrout et al. (1983) assigned this formation in this area to the upper Oligocene. Seven specimens, two of which are fragmental, were found in concretions.

Clio berglundi was also found in the upper part of the Lincoln Creek Formation (locality LACMIP 5843), Knappton area, southwestern Washington. Moore (1984) assigned these strata to the lower Miocene or possibly the upper Oligocene. Only one specimen was found in a concretion.

The youngest stratigraphic occurrence of *C. berglundi* is in the lower member of the Astoria? Formation (locality LACMIP 5848) in the Altoona area, southwestern Washington, as mapped by Wolfe and McKee (1968). Armentrout et al. (1983) assigned these strata to the lower Miocene. Only one specimen, the holotype, was found in a concretion.

Etymology.—The species is named for Ross and Marion Berglund.

Material.—Ten internal molds showing fair preservation. Holotype, LACMIP 7973; paratype, LACMIP 7986.

Occurrence.—Oligocene (undifferentiated): Lincoln Creek Formation, Grays Harbor County, southwestern Washington. Upper Oligocene: Pysht Formation, Olympic Peninsula, Clallam County, northwestern Washington, locality LACMIP 6295. Lower Miocene or upper Oligocene: upper part of the Lincoln Creek Formation, Knappton area, Pacific County, southwestern Washington, locality LACMIP 5843. Lower Miocene: lower member Astoria? Formation, Wahkiakum County, southwestern Washington, locality CSUN 1230.

CLIO GOEDERTI n. sp.
Figure 2.10, 2.11

Diagnosis.—*Clio* with transverse annulations covering most of shell, two narrow longitudinal dorsal ridges separated by median groove.

Description.—Triangular large shell, pleural angle about 28°, straight-sided, dorsoventrally compressed; dorsal side of shell with two prominent narrow longitudinal ridges separated by a narrow median groove, all of which do not persist in posterior part of shell; two longitudinal ridges each flanked by a broad flat area that passes into narrow lateral keel; prominent transverse annulations (3/mm, increasing to about 5/mm where longitudinal ridges die out) cover dorsal side except in apical region; apex pointed, closed.

Dimensions.—Holotype, LACMIP 7973, length 13.5 mm, width 6.75 mm.

Discussion.—Only the dorsal side of the single specimen of this species is visible. The ventral side is embedded in matrix. *Clio goederti* resembles the living *C. balantium* Rang, 1828 (see Tesch, 1948, p. 14–16, Pl. 1, fig. 1A–H). *Clio goederti* differs from *C. balantium* in the following features: two rather than three longitudinal ridges, a median longitudinal groove rather than a median longitudinal ridge, apical area shorter and wider, and apex not curved.

Clio goederti differs from *C. berglundi* in the following features: dorsal surface much more flattened, two narrow longitudinal ridges separated by a narrow groove rather than a single broad longitudinal arch, and lateral sides of shell flatter.

Clio goederti is known only from the lower Miocene Astoria Formation (locality LACMIP 6132).

Etymology.—The species is named for James and Gail Goedert.

Material.—One well-preserved internal mold. Holotype, LACMIP 7987.

Occurrence.—Lower Miocene: Astoria Formation, Pacific County, southwestern Washington (locality LACMIP 6132).

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APPENDIX

LOCALITIES

Pteropods from eight localities were studied (Figure 1). Unless otherwise specified, quadrangle maps listed below are 7.5 minute.

CSUN 1225.—Fossils found as float on beach in concretions which cover the beach in the south-central part of sec. 18, T29N, R1E, west side of Oak Bay, Jefferson County, Norland, Washington, quadrangle, 1953 (photorevised 1973). Quimper Sandstone.

CSUN 1230.—In siltstone exposed in a north-facing logging-road cut (J-line) in the SW¼, sec. 31, T17N, R6W, 9.6 km southwest of South Elmo, Grays Harbor County, Malone, Washington, 15-minute quadrangle. Lincoln Creek Formation. = LACMIP

LACMIP 5806.—Abandoned Smithwick Haydite quarry, NE¼, sec. 8, T3N, R4W, 0.4 km north of the abandoned railroad trestle across Oregon Highway 47, 13.7 km south of Vernonia, Washington County, Vernonia, Oregon, quadrangle, 1979. Keasey Formation.

LACMIP 5843.—From landslide block between Knappton and Grays Point, on the Columbia River, 305 m south and 430 m east of NW corner, sec. 9, T9N, R9W, Pacific County, Knappton, Washington, quadrangle, 1973. Upper part of the Lincoln Creek Formation.

LACMIP 5848.—East shore of Gray's Bay, intertidal zone south of Pigeon Bluff, southern portion sec. 9, immediately north of point where sections 9 and 16 meet on beach, T9N, R8W, Wahkiakum County, Rosburg quadrangle, Washington–Oregon, 1949 (photorevised 1984). Lower member, Astoria? Formation.

LACMIP 6132.—Collected as float from exposure of mostly thin-bedded, upper unit, on north bank of Columbia River, Washington, from 61 m to 305 m east of mouth of stream at ghost town of Frankfort, sec. 11, T9N, R9W, Pacific County, Knappton, Washington, quadrangle, 1973. Astoria Formation.

LACMIP 6295.—Fossils found as float in concretions which cover the beach between 850 m and 300 m west of mouth of Murdock Creek, NW¼, sec. 29, T31N, R9W, south shore of Strait of Juan de Fuca, Clallam County, Disque, Washington, quadrangle, 1950 (photorevised, 1978).

UCMP A–1805.—South side of Akki Point, east shore of Puget Sound, southwest part of city of Seattle, King County, Duwamish Head, Washington, quadrangle, 1968. Blakeley Formation.