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First Oligocene Records of *Calyptogena* (Bivalvia: Vesicomyidae)

by

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Abstract. Fossils of the vesicomyid bivalve *Calyptogena* (*Calyptogena*) *chinookensis* Squires & Goedert, 1991, from probable subduction-related localized limestones in the Lincoln Creek and Pysht formations, and turbidity-flow deposits in middle part of the Makah Formation in western Washington, are the first unequivocal Oligocene records for the genus. Previously, *C.* (*C.*) *chinookensis* was known only from late middle to late Eocene subduction-related cold-methane-seep communities in limestones in southwestern Washington. The geologic range of *C.* (*C.*) *chinookensis* is now extended from late middle Eocene to late Oligocene. The hinge dentition of this species is observed for the first time and compares well with that of the subgenus *Calyptogena.*

INTRODUCTION

The vesicomyid bivalve genus *Calyptogena* includes modern species that can be members of deep-sea chemosynthesis-dependent communities near hydrothermal vents (BOSS & TURNER, 1980), subduction-zone related cold-seeps (OHTA & LAUBIER, 1987), hydrocarbon seeps (KENNICUTT *et al.,* 1985; CALLENDER *et al.,* 1990), and even decaying whale carcasses (SMITH *et al.,* 1989). The fossil record of *Calyptogena* extends from late middle Eocene to Recent (GOEDERT & SQUIRES, 1990; SQUIRES & GOEDERT, 1991). Ancient examples of chemosynthetic communities containing *Calyptogena* are rare and so far have been confined to subduction-related communities in Miocene and Pliocene deposits in Japan (KANNO *et al.,* 1989; NIITSUMA *et al.,* 1989) and late middle to late Eocene limestones in southwestern Washington (GOEDERT & SQUIRES, 1990; SQUIRES & GOEDERT, 1991). These deposits in Washington contain *Calyptogena* (*C.*) *chinookensis* Squires & Goedert, 1991, which is the earliest known species of the genus.

Recent field work indicates that *Calyptogena* (*C.*) *chinookensis* is present sporadically throughout the Paleogene deep-marine sediments in western Washington State (Figures 1, 2). Newly collected specimens (Figures 3–5) from several Oligocene formations in western Washington allow for a geologic range extension of this species into the late Oligocene and also allow, for the first time, a description of the hinge. Some of the new material is associated with localized limestones that apparently were derived in association with subduction-zone processes. The presence of *C.* (*C.*) *chinookensis* in these formations represents the first unequivocal Oligocene occurrences of the genus *Calyptogena.* Previously, BOSS & TURNER (1980:163–164) had tenuously reported *Calyptogena* as ranging from Oligocene to Recent.

The institutional abbreviation, LACMIP = Natural History Museum of Los Angeles County, Invertebrate Paleontology Section, Los Angeles, California, is used for locality and catalog numbers.

MATERIALS AND METHODS

Specimens of *Calyptogena* (*C.*) *chinookensis* were collected from blocks of weathered limestone in the upper part of the Lincoln Creek Formation at locality LACMIP 5843

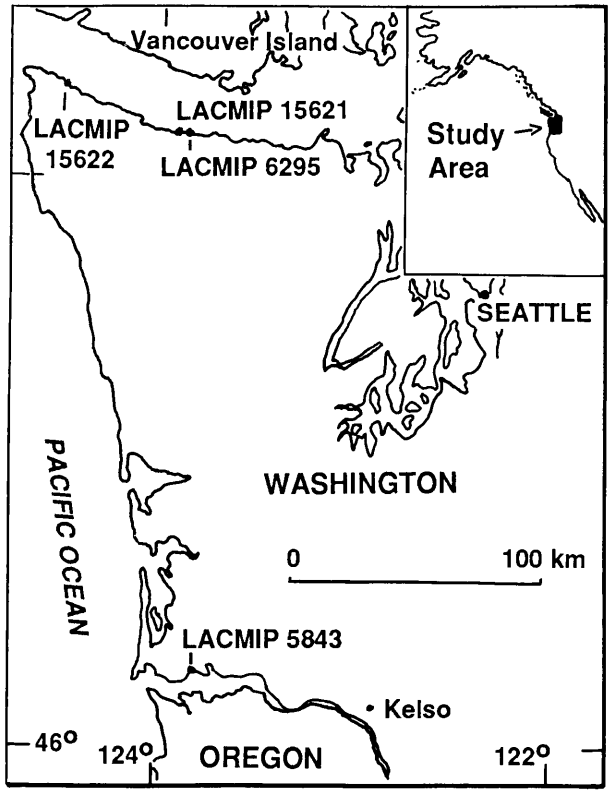


Figure 1

Index map of western Washington State showing new collecting localities for *Calyptogena* (*C.*) *chinookensis*.

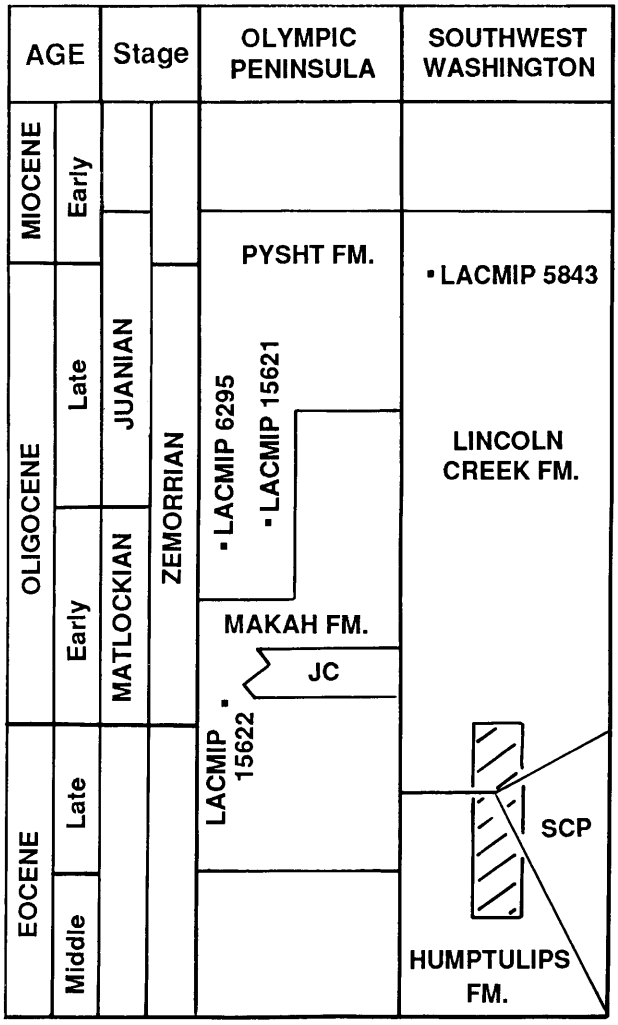


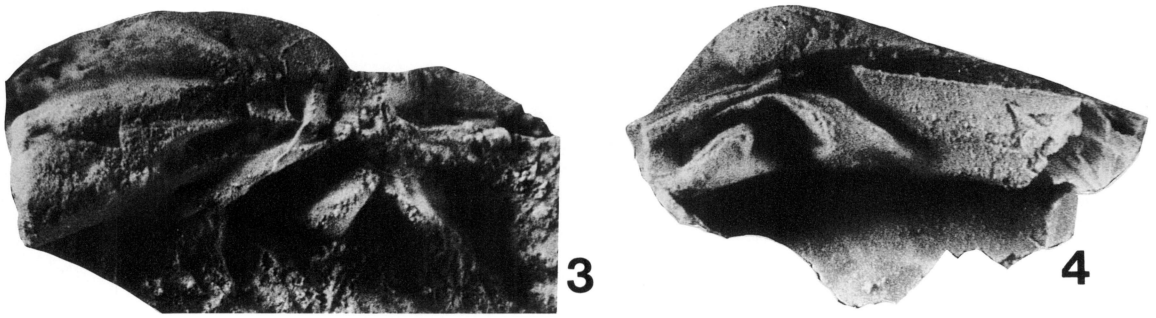
Figure 2

Time-stratigraphic chart showing previous range (slanted lines) of *Calyptogena* (*C.*) *chinookensis* and position of new localities for this species. Data in part from ARMENTROUT *et al.* (1983). JC = Jansen Creek Member of the Makah Formation; SCP = "Siltstone at Cliff Point" of WELLS (1989).

near the townsite of Knappton, Washington (Figure 1). This locality is one of several along the north shore of the Columbia River that have together yielded a diverse and well studied fossil invertebrate fauna (ZULLO, 1982; RIGBY & JENKINS, 1983; MOORE, 1984a, b; SQUIRES, 1989). The presence of *C.* (*C.*) *chinookensis* in this fauna was not previously noticed.

At locality LACMIP 5843, most collections of fossils are usually from abundant concretions that have eroded from mudstone exposed on the beach terrace and in modern landslides (MOORE, 1984b). The concretions range in size from a few millimeters to more than 1 m in diameter, and most are barren of fossils. The specimens of *Calyptogena* (*C.*) *chinookensis* were found in blocks of micritic limestone that have been transported downslope in landslides and are now mixed with the more abundant concretions. The limestone blocks are up to 1 m long and differ from the concretions in being more angular and lighter in color. The limestone blocks also have a strong petroliferous odor when freshly broken, and they contain thin-to-thick wavy crusts of calcite and numerous small tubes or cavities lined with calcite or quartz crystals. The limestone is locally brecciated and usually bioturbated. Where the limestone contains fossils, they are usually articulated specimens of the bivalves *C.* (*C.*) *chinookensis* (up to 33 mm length), *Thyasira* sp. (up to 40 mm length), and *Modiolus willapaensis* Squires & Goedert, 1991 (up to 30 mm length). In addition to these, the limestone also contains rare specimens of the bivalve *Acharax* sp., venerid(?) bivalves, small gastropods, and wood fragments. Some of the thyasirids are hollow and lined with calcite or quartz crystals. A few of the specimens of *Calyptogena* are partially silicified, and a fragment of the right-valve hinge (Figure 4) was recovered by etching with dilute formic acid.

Specimens of *Calyptogena* (*C.*) *chinookensis* were also found at localities LACMIP 6295 and LACMIP 15621 in the lower part of the Pysht Formation west of the mouth of Murdock Creek, Clallam County, Washington (Figure 1). Invertebrate macrofossils from these rocks were studied



Explanation of Figures 3 and 4

Figures 3, 4. *Calyptogena (C.) chinookensis* Squires & Goedert, 1991. Figure 3. Left-valve hinge, ×6, hypotype LACMIP 12099, locality LACMIP 15622. Figure 4. Right-valve hinge, ×8.9, hypotype LACMIP 12097, locality LACMIP 5843.

by DURHAM (1944), but he did not note the presence of *Calyptogena*. At these localities, concretions are abundant as lag materials eroded from beach cliffs and the beach terrace along the south shore of the Strait of Juan de Fuca. Mixed with the concretions are blocks of micritic limestone up to 1 m across. This limestone is almost identical to that from the Lincoln Creek Formation at Knappton (LACMIP 5843).

Where the limestone at localities LACMIP 6295 and LACMIP 15621 contain fossils, they are articulated specimens of the bivalves *Calyptogena (C.) chinookensis* (from 5.5 to 25 mm length), *Thyasira* sp. (up to 33 mm length), and *Modiolus willapaensis*? (up to 42 mm length). In addition, the limestone may contain a few pogonophoran(?) tubes, minute gastropods, spatangoid echinoids, crinoid (*Isocrinus*?) parts, and rare wood fragments. Some of the bivalves are hollow and lined with quartz crystals. This limestone has not yet been seen *in situ* at locality LACMIP 6295 or LACMIP 15621, but field observations suggest that the source rock is the same as that producing the abundant concretions.

A few specimens of *Calyptogena (C.) chinookensis* were collected from approximately the middle part of the Makah Formation at locality LACMIP 15622, southeast of the mouth of Bullman Creek, Clallam County, Washington (Figure 1). This locality is in the toe of a modern landslide that largely consists of dark-colored mudstone beds with thin slabs of turbidite sandstone and conglomerate most likely from stratigraphically below the Jansen Creek Member of the Makah Formation. The Jansen Creek Member, which is situated in the middle part of the Makah Formation, is exposed on the beach terrace in all directions from the toe of the landslide. Some of the slabs of thin turbidites eroding from the landslide consist of graded sandstone to pebble conglomerate containing glauconite, foraminifera, some mollusk fragments, rare shark teeth, fish otoliths, and usually articulated specimens of *C. (C.) chinookensis* (22 to 42 mm length) and *Thyasira* sp. (up to 40 mm length). The bivalves are usually together in clusters of several randomly oriented individuals in fine-grained sediment between larger clasts (up to 9.5 cm across) of siltstone (reworked concretions?) and sandstone. The bivalves do not appear to have been transported, but they have been slightly crushed by sediment compaction. One specimen of *C. (C.) chinookensis* was prepared to reveal the left-valve hinge (Figure 3).

DEPOSITIONAL ENVIRONMENTS AND GEOLOGIC AGES

Molluscan fossils from the upper part of the Lincoln Creek Formation near Knappton, including locality LACMIP 5843, suggest that deposition took place at depths between 100 and 350 m; however, foraminifers indicate a depth of 1000 m or possibly deeper (MOORE, 1984b:7–8). Molluscan fossils referable to the Juanian Molluscan Stage, along with microfossils, indicate a late Oligocene to earliest Miocene age (MOORE, 1984a, b).

Foraminifera from rocks in the vicinity of localities LACMIP 6295 and LACMIP 15621 indicate that deposition probably occurred at a depth of between 300 and 2000 m during late Oligocene (Zemmorian) time (RAU, 1964). Localities LACMIP 6295 and LACMIP 15621 are both within DURHAM's (1944) *Echinophoria rex* Molluscan Zone in the lower part of the "Twin Rivers For-

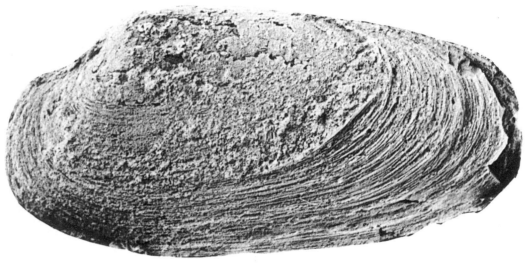


Figure 5

Calyptogena (C.) chinookensis Squires & Goedert, 1991. Left-valve exterior, ×3.9, hypotype LACMIP 12098, locality LACMIP 15621.

mation" (now Pysht Formation of the Twin River Group, see SNAVELY *et al.*, 1977). The *Echinophoria rex* (now *Liracassis rex*) Molluscan Zone is correlative with the Matlockian Molluscan Stage and the lower Zemmorian Foraminiferal Stage, which is early Oligocene in age (MOORE, 1984a). DURHAM (1944) considered these rocks to be middle Oligocene, and DOMNING *et al.* (1986:7) stated that these rocks are middle or late, but not latest, Oligocene in age. The zonal gastropod *Liracassis apta* (Tegland, 1931) has also been collected from this part of the Pysht Formation (GOEDERT, 1988:100). The *L. apta* Molluscan Zone is correlative with the Juanian Molluscan Stage, the upper part of the Zemmorian Foraminiferal Stage, and is late Oligocene to earliest Miocene in age (MOORE, 1984a). The age of the entire Pysht Formation is shown as late Oligocene and earliest Miocene by ARMENTROUT *et al.* (1983). Because both *L. rex* and *L. apta* are present in the lower part of the Pysht Formation west of Murdock Creek, this part of the formation is herein considered temporally equivalent to the upper part of the Makah Formation (Figure 2).

The co-occurrence of *Calyptogena* (*C.*) *chinookensis* in essentially identical limestones at localities LACMIP 5843, LACMIP 6295, and LACMIP 15621, along with the same associations of thyasirid and modiolid species, are much like those previously described from Eocene deep-water strata in western Washington by GOEDERT & SQUIRES (1990) and SQUIRES & GOEDERT (1991). Those Eocene associations were interpreted as fossil cold-methane-seep communities, and the associations from localities LACMIP 5843, LACMIP 6295, and LACMIP 15621 may have also been chemosynthesis-dependent communities supported by cool-fluid seepage.

The occurrence of *Calyptogena* (*C.*) *chinookensis* at locality LACMIP 15622, with associated thyasirids in turbidites of the Makah Formation (Figure 2), is the first in which the species is not in a limestone. *Calyptogena* has been reported living in association with thyasirids in modern turbidity flow deposits (MAYER *et al.*, 1988), and rocks at locality LACMIP 15622 may represent a similar depositional environment. Rocks of the Makah Formation were rapidly deposited in a submarine-fan setting at lower to middle bathyal depths, and are late Eocene to Oligocene in age (SNAVELY *et al.*, 1980). The rocks containing the specimens of *C.* (*C.*) *chinookensis* are from below the Jansen Creek Member and are early Oligocene in age. Macrofossils are rare in these deep-water strata, although a few thyasirid, modiolid, and lucinid bivalves have been found associated with fossil cetacean skeletons (SQUIRES *et al.*, 1991). These associations were the first known fossil examples of chemosynthesis-dependent organisms supported by whale bone-oil seepage.

SYSTEMATIC PALEONTOLOGY

Family VESICOMYIDAE Dall & Simpson, 1901

Genus *Calyptogena* Dall, 1891

Type species: *Calyptogena pacifica* Dall, 1891

Subgenus *Calyptogena* s.s.

Calyptogena (*Calyptogena*) *chinookensis* Squires & Goedert, 1991

(Figures 3–5)

Supplementary description: Right-valve hinge—anterior tooth solid, peglike, and directed posteriorly; central tooth triangular and prolonged anteriorly into a very thin plate that overlaps dorsal part of anterior tooth; posterior tooth area unknown. Left-valve hinge—apparently no anterior tooth; central tooth bifid with a solid posterior part and a thin anterior part; posterior tooth area unknown.

Discussion: The hinge of this species closely resembles that of *Calyptogena* (*C.*) *pacifica* Dall, 1891, illustrated by BERNARD (1974:text fig. 2A) and BOSS & TURNER (1980: fig. 10b). Because of this close similarity, it is herein concluded that *C. chinookensis* should be assigned to the subgenus *Calyptogena.*

BOSS & TURNER (1980) suggested that *Calyptogena* ranged from as early as Oligocene time on the basis of the tenuous inclusion of the genera *Pleurophopsis* Van Winkle, 1919, and *Hubertschenckia* Takeda, 1953, in their synonymy of *Calyptogena. Pleurophopsis* is known from Oligocene(?) rocks of the West Indies, Central America, and northwestern South America (KEEN, 1969). The close relationship between *Calyptogena* and *Pleurophopsis unioides* VAN WINKLE (1919:24, pl. 3, fig. 12), the type species of *Pleurophopsis,* was first noted by WOODRING (1938). The geologic age of *P. unioides* remains in question, and it may be as young as Pliocene (BOSS & TURNER, 1980:164).

OLSSON (1931) reported two species of *Pleurophopsis* from probable late Oligocene-age rocks in northern Peru. One of these, *P. lithophagoides* OLSSON (1931:140, pl. 4, figs. 2, 5, 7, 9) shows close affinity with *Calyptogena* (*C.*) *chinookensis. Calyptogena* (*C.*) *chinookensis* differs in having the following features: larger size (up to 100 mm length rather than 40 mm), presence of a narrow ridge posteroventrally from the umbo, and posterior end more tapered.

BOSS & TURNER (1980) mentioned a possible Oligocene occurrence of *Pleurophopsis* from Colombia. The hinge structure is unknown for this specimen(s), and no stratigraphic information was given. As mentioned by OLSSON (1931), *Unio bitumen* COOKE (1919:130, pl. 9, fig. 3a–c) from presumed Oligocene-age rocks in Cuba probably also is congeneric with *Pleurophopsis.* The hinge structure is also unknown for this species, and stratigraphic information is limited.

Hubertschenckia Takeda, 1953, is known from late Oligocene rocks in Japan (TAKEDA, 1953; KEEN, 1969). The close relationship between *Calyptogena* and *Hubertschenckia* was first suggested by KANNO (1971). Future work may prove that these two genera are the same, but *H. ezoensis* (YOKOYAMA, 1890:pl. 25, figs. 6a, b, 7, 8), the type species

of *Hubertschenckia,* has a shell that is much higher relative to length than do most species of *Calyptogena.*

As indicated by BOSS & TURNER (1980), it is quite likely that *Pleurophopsis* and *Hubertschenkia* are actually synonyms for *Calyptogena.* If so, then *Calyptogena* is tenuously known from Oligocene rocks in the West Indies, Central America, northwestern South America, and Japan. The occurrences of *C.* (*C.*) *chinookensis* in the upper part of the Lincoln Creek, lower part of the Pysht, and middle part of the Makah formations in Washington are the first unequivocal Oligocene records for this genus and the first report of it in the Oligocene in North America.

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LACMIP 6295. Float on beach terrace between 300 m and 850 m W of the mouth of Murdock Creek, NW¼ section 29, T31N, R9W, Disque quadrangle (USGS), 7.5 minute, 1950 (photorevised 1978), Clallam County, Washington. Lower part of Pysht Formation. Age: Early(?) Oligocene. Collectors: J. L. & G. H. Goedert, 31 May 1992.

LACMIP 15621. Limestone blocks on beach terrace, S shore of Strait of Juan de Fuca, approximately 1500 m NW of the mouth of Murdock Creek, 450 m W and 200 m N of the SE corner of section 19, T31N, R9W, Twin Rivers quadrangle (USGS), 7.5 minute, 1950 (photorevised 1979), Clallam County, Washington. Lower part of Pysht Formation. Age: Early(?) Oligocene. Collectors: J. L. & G. H. Goedert, 23 March 1992.

LACMIP 15622. Thin slabs of turbidite sandstone and pebble conglomerate in dark mudstone in toe of a landslide, approximately 2050 m SE of the mouth of Bullman Creek, NW¼ SW¼ section 22, T33N, R14W, Neah Bay quadrangle (USGS), 7.5 minute, prov. ed. 1984, Clallam County, Washington. Approximately middle part of Makah Formation (directly below the Jansen Creek Member). Age: Early Oligocene. Collector: J. L. Goedert, 18 May 1992.

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