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Gastropods of the Quiriquina Formation (Maastrichtian) in Central Chile: Paleobiogeographic relationships and the description of a few new taxa

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with 1 figure and 3 plates

Abstract: Gastropods of the Maastrichtian Quiriquina Formation in Central Chile are revised taxonomically and regarding their paleobiogeographic relationships. Approximately 40 taxa are present of which 23 are described at the species level. *Petropoma biroensis, Pyropsis (Chilenopsis) quinzioensis, Pyrifusus (Deussenia) gigantea, Concepcionella* and *Crenilabium (Eacteon) valdovinensis* are new taxa described herein. In contrast to the ammonites which are Indopacific in character, the gastropod fauna is highly endemic, and no major faunal exchange is recognised between shelf areas of the southern Gondwana continent. For example, no migration of gastropod species is apparent from New Zealand via the Antarctic Peninsula to southern South America or vice versa. It is concluded that the Quiriquina gastropods must have remained free of immigrants for a considerable amount of time.

Zusammenfassung: Die Gastropoden der zentral-chilenischen Quiriquina Formation werden taxonomisch revidiert und bezüglich ihrer paläobiogeographischen Verwandtschaftsverhältnisse untersucht. Von den etwa 40 Taxa werden 23 auf Artniveau beschrieben. Unter diesen sind *Petropoma biroensis, Pyropsis (Chilenopsis) quinzioensis, Pyrifusus (Deussenia) gigantea, Concepcionella* und *Crenilabium (Eacteon) valdovinensis* neue Arten. Im Gegensatz zum deutlich indopazifischen Charakter der Ammonitenfauna sind die Gastropoden weitgehend endemisch, und ein deutlicher Faunenaustausch zwischen den Schelfgebieten des südlichen Gondwana-Kontinentes fand offensichtlich nicht statt. So ist etwa keine Migration von Gastropoden Neuseelands über die Antarktische Halbinsel ins südliche Südamerika feststellbar, und auch der umgekehrte Weg wurde nicht beschritten. Daraus wird gefolgert, daß die Gastropodenfauna der Quiriquina Formation für einen beträchtlichen Zeitraum frei von Zuwanderung gewesen sein muß.

Resumen: Se pretende revisar la taxonomía y las relaciones paleobiogeográficas de la fauna de gasterópodos de la formación Quiriquina (Maastrichtiano) de Chile Central. Aproximadamente 40 taxones estan presentes, de los cuales se describen 23 a nivel de especie. *Petropoma biroensis, Pyropsis (Chilenopsis) quinzioensis, Pyrifusus (Deussenia) gigantea, Concepcionella* y *Crenilabium (Eacteon) valdovinensis* son nuevas especies descrítas aquí. Al contrario del carácter indopacífico de los ammonites, la fauna de gasterópodos es altamente endémica y no se determinó ningún intercambio mayor entre áreas neríticas de la parte Sur del continente Gondwana. Por ejemplo, no se reconocieron migraciones de gasterópodos nuevo-zélandeses, através de la Peninsula Antártida hacia la parte Sur de América

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del Sur o vice versa. Se concluye que la fauna de gasterópodos de la formación Quiriquina haya quedado libre de inmigrantes por un período considerable de tiempo.

1. Introduction

Marine sediments of the Late Cretaceous Quiriquina Formation occur locally along the Pacific coast of Central Chile, from Algarrobo near Valparaiso in the North to the eastern part of the Arauco Peninsula in the South. These sediments are detrital and were deposited in a shallow water environment, notably under the conditions of a rocky shore. Transgression was on folded rocks of the Hercynian basement that forms the Chilean coastal cordillera.

The best known and stratigraphically most complete lithological sequences are found in the vicinity of Concepción. These outcrops are located along the West Coast of Quiriquina Island in the Bay of Talcahuano and form the type localities of the Quiriquina Formation, whereas other good sections are located on the East coast of the Bay of Talcahuano, i.e, the coastal cliffs near the villages of Cocholgue and Tome.

The Quiriquina Formation has long been known for its abundant and well preserved invertebrate fauna. Recent descriptions of the ammonites and bivalves as well as biostratigraphic and paleoecologic data have been published by STIN-

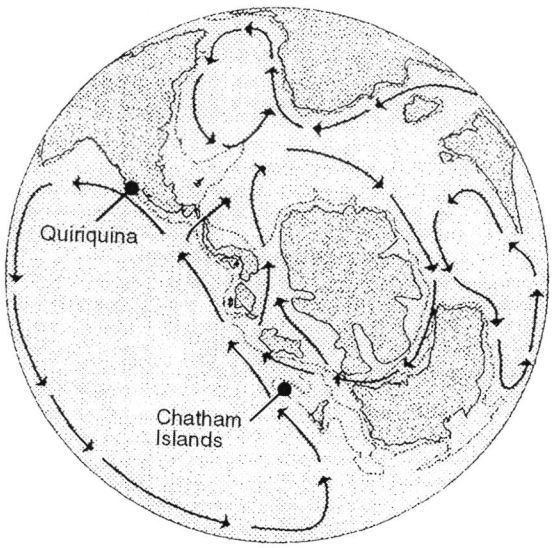


Fig. 1. Redrawn Reconstruction of the paleogeography and currents of southern Gondwana; from STILLWELL (1997), with position of Chatham Islands and Quiriquina redrawn. Note that the gastropod fauna of Quiriquina does not support this model.

NESBECK (1986). This author established a Maastrichtian age for the sediments and also suggested an Indo-Pacific character of the ammonite fauna.

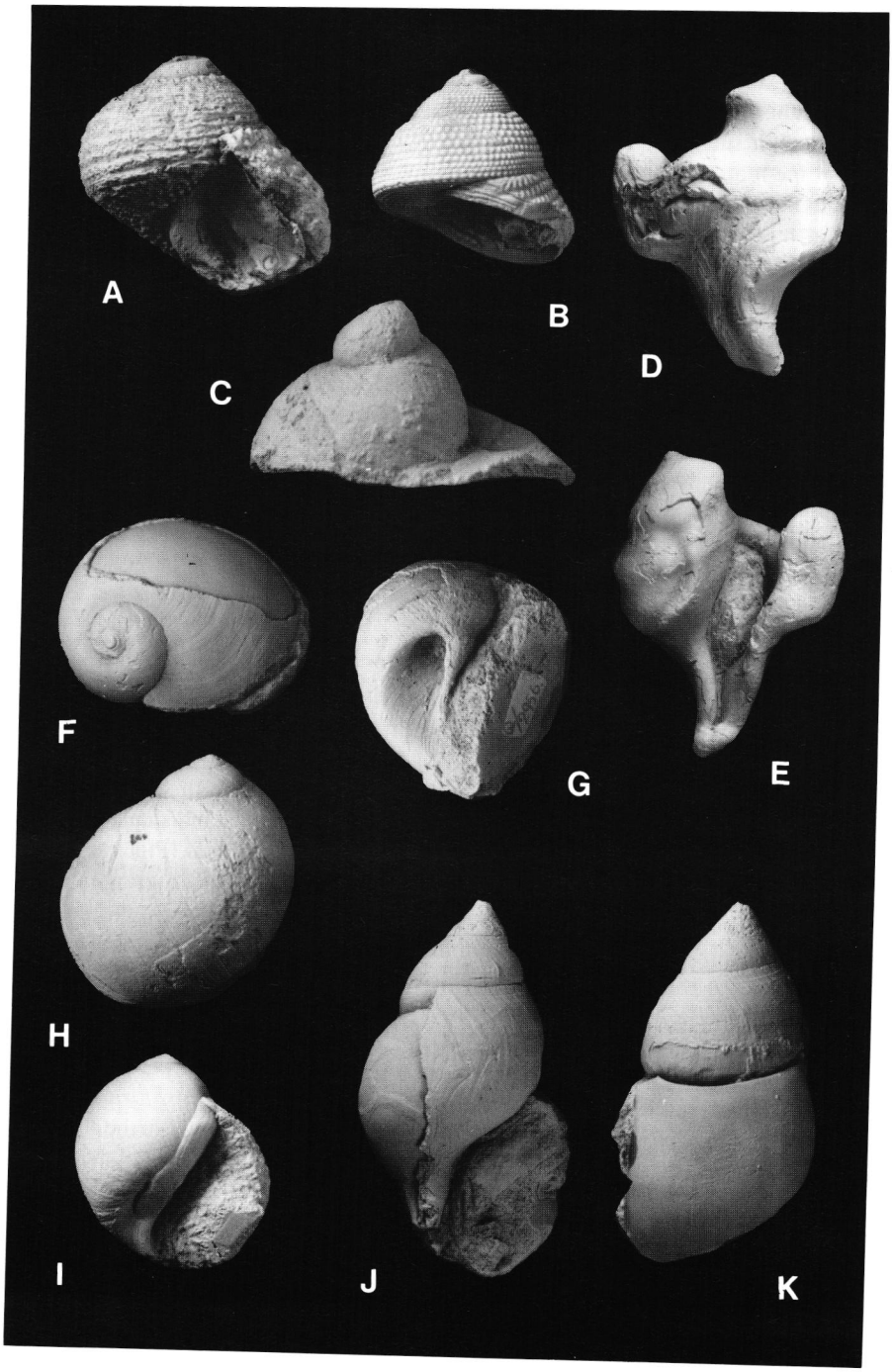
The Maastrichtian coast line was very close to the position of the modern coast in this central Chilean portion of the South American continental margin. Even though subduction was active more or less continuously since late Cretaceous time it did not change much the position of the coastal region here.

In the present paper we report on the taxonomy and the paleobiogeographic relationship of gastropods from the Quiriquina Formation. Our new collections in outcrops on Quiriquina Island and Cocholgue in addition to the revision of the gastropods of the Biro collection in the University of Concepción reveals the presence of about 40 species. Interestingly, most specimens are larger than 5 mm. This is probably because very small individuals and protoconchs are not easily preserved in the coarse-grained coastal deposits. Sediments are diagenetically indurated forming calcareous sandstones, thus, additionally complicating preparation of the fauna.

Our new data suggest that the Quiriquina gastropods differ from the ammonites regarding their paleobiogeographic relationship. Most taxa are endemic to the Maastrichtian of central Chile while other species resemble North American and South African taxa. Relationships to gastropods from contemporaneous New Zealand or Antarctica localities are much less certain.

2. Examples from the Archaeogastropoda

Archaeogastropoda are represented by 7 species two of which are described with more detail. All belong to the Vetigastropoda, and within this group to the Trochoidea. Most lived on the rocky shore within the intertidal and shallow subtidal environment. Among the Archaeogastropoda *Margarites unio* (PHILIPPI 1887) is the most common. Its shell is smooth, about 5 mm large, of trochoid shape, round aperture, and simple umbilicus. It resembles a small trochid from the Late Cretaceous Umzamba Formation (Santonian-Campanian) in South Africa. *Tegula ovallei* (PHILIPPI 1887) is also common and resembles the modern *Tegula* from the warm water Pacific, or *Gibbula* MONTEROSATO 1888, which is common in the Mediterranean Sea. The turbinid *Petropoma biroensis* n. sp. is a rare species which appears to be related to an older species from Early Cretaceous of Peru (*Petropoma peruanum* GABB 1877). The fauna also contains species of *Semisolarium* COSSMANN 1915 and *Ozodochilus* COSSMANN 1918 with possible relatives in the Jurassic of France. A smooth depressed umboniid of the Quiriquina fauna may have lived in the sand, similar to the modern *Umbonium* LINK 1807. These species are endemic to Chile but fit in the general trend known from archaeogastropods of that time.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Family Tegulinae, genus *Tegula* Lesson 1835

Tegula ovallei (Philippi 1887)

Pl. 1, B.

Description: Philippi (1887, Pl. 12, Fig. 4) called this common shell *Trochus ovallei*. According to him, the conical shell is ornamented by granulated spiral ridges of about equal width which are situated on the flattened whorl sides with an angular basal edge. It measures 13 mm in height and 12 mm in width.

Newly collected shells were found fairly common in cliff situations. Here they are up to 20 mm high and 17 mm wide and consist of 5–6 whorls. Whorl flanks are more or less weakly convex and ornamented by 8–10 beaded spiral ribs visible on the whorls of the spire. The umbilicus has a spiral edge and groove as recognized in *Tegula (Tegula)* by Wenz (1939, Fig. 681). The genus is based on a living species. *Tegula* is a common gastropod in rocky beach environments.

Remarks: Möricke (1895) described a badly preserved trochid shell from Quiriquina Island as *Trochus* cf. *ovallei*. Stinnesbeck (1986) recognized *Turbo ovallei* from the locality Cocholgue which is a very similar environment to that of Quiriquina. He found *Trochus ovallei* characteristically associated with *Leiostoma difficilis* (*Austrosphaera*) within the *Ostrea* assemblage, representing the rocky shore environment. Wetzel (1930) considered *Trochus (Ziziphinus) ovallei* to represent a calliostomatid, while it is considered to represent a turbinid by Stinnesbeck (1986); here it is placed with the Trochinae, Trochinidae.

Family Turbininae, genus *Petropoma* Gabb 1877

Description: The shell is turbiniform with flattened whorls that are ornamented with spiral rows of nodules also present on the convex base. The aperture is round-

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Plate 1. **A.** *Petropoma biroensis* n. sp. The holotype from Quiriquina Formation. The shell is 2,5 cm high and wide and consists of evenly rounded whorls ornamented by about 15 spiral rows of nodules. **B.** *Tegula ovallei* (Philippi 1887) seen from the side. The shell is 17 mm in high and 18 mm wide. **C.** *Calyptraea (Trochita) laevis* Philippi 1887, View from the side with the aperture forming the base. The shell is almost 2,5 cm wide. **D.** *Tephlon tumidus* (Gabb 1860) seen from behind. The inner lip is covered by a thick callus pad, which partly adsorbes the apertural part of the penultimate whorl. The adult shell measures 36 mm in height and 28 mm in width. **E.** *Tephlon tumidus* Apertural view of the specimen illustrated in D. **F.** *Gyrodes (Dockeryella) euryomphalus* (Philippi 1887) seen in apical view. **G.** *Gyrodes (Dockeryella) euryomphalus* in umbilical view. The specimen illustrated in F with is 20 mm high and 22 mm wide. **H.** *Polinices (Polinella) ganae* (Philippi 1887) seen from the side. The shell is about 3 cm high. **I.** *Polinices (Polinella) ganae* in apertural view. The shell is approximately 2 cm wide, elongate, with acute shape, rounded whorls, and a narrow callus pad. **J.** Apertural view of *Austrosphaera difficilis* (Orbigny 1842) with a well-preserved spire. The shell is 5 cm high and ovate. **K.** The same shell as in J, seen from behind.

Calyptraea (Trochita) laevis (Philippi 1887)

Pl. 1, C.

Description: According to Philippi (1887, Pl. 11, Fig. 3) the wide shell is of elevated conical shape. It has an internal lip and a height of 20 mm and diameter of 28 mm. Wilckens (1904) mentioned that the shell surface is rough and whorls increase in diameter rapidly. According to our observations the shell consists of four whorls of the teleoconch and reaches a size of about 4 cm in width and 2,5 cm in height. The shell is spirally coiled and of conical shape, a little wider than high, and with a rounded central apex. The whorls are separated externally by a depressed spiral suture. The base is concave with the margin forming a continuous outer lip. The inner lip (labrum) forms a flat concave shell like that of modern *Calyptraea*. Sculpture consists of growth lines which are strongly oblique and somewhat irregular.

Remarks: Wilckens (1904, Pl. 17, Figs. 9a, b) placed *Trochita laevis* into the genus *Galeropsis* which was accepted by Wetzel (1930). *Calyptraea* (*Clypeola* = *Trochita*) *lybicus* Quaas 1902 from the Maastrichtian Ammonite Hills in the Egyptian Western Desert (Bandel & Riedel 1994, Pl. 7, Figs. 2–3) resembles *C. laevis* from Quiriquina. But in difference the Egyptian species is only a little wider than high, is smaller, and has an ornament of spiral and/or oblique costellae. The modern *Calyptraea (Trochita) trochiformis* (Born 1778) occurs commonly in the Concepción area and has a close relative in the Miocene sediments of Lebu on the Arauco Peninsula (own observatins). Marincovich (1973, Fig. 65) noted the presence of *C. trochiformis* on hard surfaces not far below the intertidal zone. It is known to exist from Ecuador to Valparaiso, Chile.

Family Naticidae

In contrast to the Calyptraeidae the mid-Chilean coastal waters do not support species of the Naticidae today, but there were several species living in the area at Cretaceous times. Typical naticid activity is demonstrated by the presence of drill holes commonly encountered in the shells of other molluscs, since these carnivorous neomesogastropods apparently have reached and still reach their prey by etching a hole into their calcareous shell. Naticidae have only evolved with the beginning of the Late Cretaceous (Bandel 1993, 1999a).

In addition to the two common species described here, three more species were mentioned by Philippi (1887). These may partly represent varieties of *Polinices* (*Polinella*) *ganae* or even correspond to their internal moulds, as was suggested by Wilckens (1904). *Gyrodes (Dockeryella) euryomphalus* is a distinct Chilean species that has close relatives in the Late Cretaceous shallow water faunas of many southern and northern hemisphere localities.

Genus *Gyrodes* Conrad 1860

The subglobose, low-spired shell has a deep umbilicus with a crenulate and sharp umbilical margin and crenulation near the suture. Growth lines near the suture may be notched (Popenoe et al. 1987, Bandel 1999a, b). The aperture is oval in outline and inclined. The type is *Gyrodes supraplicata* (Conrad 1858), a Maastrichtian species from the Owl Creek localities of the Ripley Formation.

Subgenus *Gyrodes (Dockeryella)* Bandel 1999

The large-sized shell has a slightly concave subsutural ramp not connected to the apertural notch, and a broad umbilicus with noncrenulate margin. The type is *Gyrodes major* Wade 1926 from Coon Creek, Tennessee (Sohl 1960, Pl. 16, Figs. 6, 7, 10) and from Coffee Sand, Mississippi (Dockery 1993, Pl. 20, Figs. 13, 14).

Gyrodes (Dockeryella) euryomphalus (Philippi 1887)

Pl. 1, F, G.

Description: According to Philippi (1887, Pl. 9, Fig. 21) *Natica euryomphalus* has a semiglobular shell with wide open umbilicus that is surrounded by a keel. The shell is 20 mm high and 22 mm wide. Wilckens (1904) noted larger individuals reaching the size of 4 cm in width and height. This later observation can be confirmed. In younger growth stages the shell is wider than high, with a very narrow flattened apical portion of the whorl that accompanies the suture. The spire comprises less than one fourth of shell height. The shoulder is evenly rounded in early whorls and becomes even more convexly rounded on the last whorl. The umbilical margin is angular and the umbilicus is a wide and deep conical depression. Growth lines are nearly straight at the suture, obliquely flexed on the shoulder, and are bent on the angulation of the umbilicus. The aperture is oblique; young individuals cover their former whorl with the inner lip whereas adult specimens form a thick callus tongue.

Remarks: *Gyrodes (Dockeryella) tenellus* (Stoliczka 1868), as described by Rennie (1930, Pl. 25, Figs. 1–3) from the South African Umzamba Formation (Santonian) has a more rounded umbilical margin. It is slightly wider than high and has a more concavely flattened apical portion accompanying the suture similar to *G. (D.) euryomphalus*. The callus of the inner lip, however, is much thicker in the Chilean species than in the South African one. *Gyrodes (Sohlella?) yolensis* Popenoe, Saul & Suzuki 1987 from the Turonian of California is very similar in size and shape, differing only by an umbilicus with two angulations (Popenoe et al. 1987), whereas the Chilean and South African *Gyrodes* only present one. *G. (D.) euryomphalus* also resembles *Gyrodes rotundus* Stephenson 1941 from the Maastrichtian of Texas

and *Gyrodes* (*Dockeryella*) *major* WADE 1926 from Coon Creek which have more rounded umbilical margins. *Gyrodes (Sohlella) spillmani* GABB 1861 is similar in shape and size but differs by its suture, which remains accompanied by a groove and lacks a tongue-like callus of the inner lip (DOCKERY 1993, BANDEL 1999a).

Genus *Polinices* MONTFORT 1810

According to SOHL (1960) the shell in the genus *Polinices* is ovoid, commonly thick, and sutures are shallow. The aperture is subovate, posteriorly angular and well rounded anteriorly. The inner lip is covered by a thick callus invading and partly or totally filling the umbilicus. The genotype is a modern species from the Indo-Pacific. SOHL (1960, Pl. 17, Figs. 1–4, 8, 9) included the Late Cretaceous *Polinices kummeli* SOHL 1960 from Owl Creek (Mississippi) in this genus. MARINCOVICH (1977) noted that species of *Polinices* have been living along the California coast during most of the Tertiary up to now.

Subgenus *Polinices* (*Polinella*) BEU & MAXWELL 1990

The shell is up to 4,5 cm high, ovate to globose and has a low, pointed spire. It consists of about 6 whorls, with the last whorl strongly convex and capacious. Ornament consists only of growth lines. The aperture is semicircular, the inner lip almost straight except for a shallow excavation near the adapical end. The inner lip callus is narrow, parallelly sided, and may fill the umbilicus completely or in part. The outer lip is strongly prosocline. The type species *Uber finlayi* MARWICK 1924 is from the Early Paleocene (Wangaloan) of New Zealand (BEU & MAXWELL 1990, Pl. 2 j, k).

Remarks: According to BEU & MAXWELL (1990), *Polinices* (*Polinella*) differs from *Polinices (Polinices)* by a narrower and less extensive callus pad of the inner lip. With the exception of specimens from the Quiriquina Formation in Chile, the subgenus is restricted to New Zealand where it occurs from the Paleocene to the Pliocene.

Polinices (Polinella) ganae (PHILIPPI 1887)

Pl. 1, H, I.

Description: According to PHILIPPI (1887, Pl. 10, Fig. 5), *Natica ganae* is 19 mm high and 13 mm wide. It is elongate, acute, and has rounded whorls and a narrow callus pad. Our material demonstrates that the shell is up to 3,5 cm high and 2,7 cm wide, ovate to globose. It has a low, pointed spire and consists of about 5,5 whorls of the teleoconch, with the last whorl strongly convex and large. Ornament consists only of growth lines. The aperture is semicircular, the inner lip almost

straight. The inner lip callus is almost parallelly sided, and it fills the umbilicus completely or in part. The callus pad varies among individuals. It may end before reaching the margin of the umbilical depression thus leaving a groove on its anterior end. In other individuals it covers almost the entire columellar lip and there is no anterior depression. The outer lip is strongly prosocline.

Remarks: According to WILCKENS (1904) *Natica ganae* represents a fully grown *N. australis*. But when comparing the illustrations provided by PHILIPPI (1887, Pl. 10, Figs. 6, 7), his *Natica ganae* has the callus pad which is also present in our abundant collection of this species. In contrast PHILIPPI's drawing of *Natica australis* ORBIGNY 1842 shows a narrow and regular callus pad and a definite narrow and deep umbilicus, whereas *Natica araucana* PHILIPPI 1887 shows no callus pad at all. *Natica oliviformis* PHILIPPI 1887 may well represent a variaty of *P. (P.) ganae*. According to PHILIPPI (1887, Pl. 10, Fig. 6) the species has an ovate solid shell with elongated callus pad and is 39 mm high and 29 mm wide. Since the general shell shape of these species is the same, and the callus pad can break off during collection or preparation, these four species may be preservation artifacts of one and the same species.

The North American *Polinices kummeli* and *Euspira rectilabrum* (CONRAD 1858) from the Maastrichtian of the Gulf Coast are of very similar shell shape and present a similar callus ribbon of the inner apertural lip (SOHL 1960, Pl. 17, Figs. 1–9, 12–14).

5. Examples from the Proto-Neogastropoda

Genus *Austrosphaera* CAMACHO 1949

Description: The fusiform shell is almost biconical, up to 5 cm in height and 3 cm in width, and presents a pointed spire that is commonly corroded. Whorls are weakly convex on the spire and sutures are shallow. The body whorl is evenly rounded but may also be somewhat flattend with an ornament consisting of fine growth lines and minute spiral lirae. The aperture is pointed posteriorly and extends anteriorly into a short siphonal canal. The genotype is *Austrosphaera glabra* CAMACHO 1949 from the Paleocene of Tierra del Fuego, Argentina.

Species *Austrosphaera difficilis* (ORBIGNY 1842)

Pl. 1, J, K; Pl. 2, A, B, C. D.

Description: *A. difficilis* (as *Fusus*) is characterized by an ovate shell with an apical angle of about 55°, a short siphon, a height of 40 mm and width of 25 mm (PHILIPPI 1887, Pl. 3, Fig. 2). *Fusus chilensis* PHILIPPI (1887, Pl. 3, Figs. 3, 24) has an ovate fusiform shell 48 mm high and 24 mm wide. It presents a pointed spire and is smooth. The two species are thus similar. *F. chilensis* is distinguished from

A. difficilis by its longer spire. WILCKENS (1904, Pl. 18, Fig. 6) illustrated small specimens of *A. difficilis* and noted that this very common species grows up to 45 mm high and up to 31 mm wide. WILCKENS suggested that *Fusus chilensis* may represent an interior mould of *A. difficilis,* and not an independent species. Personal observations on this very common species indicate that it lived on the rocky and sandy shore within the intertidal regime. Here, the thick-shelled species grew to a size of 5 cm in height and 3 cm in width. Its spire commonly became corroded down to a rounded shape on these sand-scoured rocky beaches, but may also have been preserved in specimens that lived in less exposed positions. In the latter case the posterior whorls have an acute shape with whorls weakly convex and sutures shallow. The ornament consists of fine growth lines and minute spiral lirae which may not be preserved. The whorl flank can be evenly rounded, but in other individuals it is more or less flattened and develops a shoulder. The aperture is pointed posteriorly and extends into a short siphonal canal anteriorly. The inner lip is smooth and covered with a callus, while the outer lip is crenulated on its inner surface. WETZEL's (1930) observation on the preservation of color patterns in the shape of dark bands and dots is confirmed by us.

Remarks: WETZEL (1930, Pl. 11, Figs. 3–4) placed *A. difficilis* in the genus *Leiostomus* SWAINSON 1840 which is a synomym to *Sycostoma* COX 1931. The latter is based on the Mid-Eocene *Sycostoma bulbiforme* (LAMARCK) from the Paris Basin (WENZ 1939, Fig. 3475). A species similar to the Quiriquina individuals was described from the Paleocene of Patagonia as *Austrosphaera* CAMACHO 1949 by FURQUE & CAMACHO (1949). GRIFFIN & HÜNICKEN (1994) illustrated and described Paleocene species of this genus from the Rio Turbio region of central Patagonia. OLEINIK & ZINSMEISTER (1996) found similar shells in the Paleocene of Seymour Island which they named *Seymourosphaera.* But the latter equals *Austrosphaera* (compare illustrations of GRIFFIN & HÜNICKEN, 1994 and OLEINIK & ZINSMEISTER, 1996) and *Seymourosphaera* is here considered a synonym of *Austrosphaera.*

Austrosphaera very closely resembles *Fusus difficilis* and *F. chilinus* from the Maastrichtian Quiriquina Formation as described and illustrated by PHILIPPI (1887). According to OLEINIK & ZINSMEISTER (1996) the high variability in the Paleocene representatives of *Seymourosphaera* (= *Austrosphaera*) gives evidence of the diversification of neogastropods after the K-T extinctions and was therefore interpreted as stock of new species. OLEINIK & ZINSMEISTER (1996) observed an abrupt radiation of the buccinids with *Seymourosphaera* presumably representing a member of the Pseudolivinae, in addition to the sudden appearance of the Buccinidae and Nassariidae. The Maastrichtian *Austrosphaera*, however, shows a similar variability. Their interpretation, in consequence, is not convincing. We conclude that *Austrosphaera* changed very little from the Maastrichtian to the Paleocene in regard to the variability of shell shape, shape and composition of its thick shell, and the type of sandy shore environment in which it lived.

Subfamily Pyropsinae Stephenson 1941

The subfamily Pyropsinae is characterized by a fusiform shell, peripherally swollen whorls, and a low spire with broad subsutural collar or inclined ramp. The characteristics are found in the common genus *Pyropsis*. *Trochifusus* has a characteristic large shell with an almost flat apical spire. The last whorl is thickened and drawn up to form a varix, while younger growth stages resemble *Pyropsis*.

Genus *Pyropsis* Conrad 1860

The medium to large-sized subpyriform shell has a low to very low spire, peripherally expanded whorls that are shouldered, and is strongly constricted anteriorly. There is a long tapering siphonal canal. The ornament is dominated by noded spinose spiral cords. The aperture is thickened on the inside, with the inner lip covered by a thick callus. The inner lip is simple and smooth except for a broad weak to strong swelling above the siphonal canal. This swelling leaves an umbilical chink at the upper edge of the columellar lip. The genotype type species is *Pyropsis perlata* (Conrad 1860) from the Maastrichtian Ripley Formation, Mississippi, USA.

Subgenus *Pyropsis (Chilenopsis)* n. subgen.

Diagnosis: The shell shape resembles *Pyropsis*, with a short spire, peripherally expanded whorls that are strongly constricted anteriorly, and a long siphonal canal. The aperture is thickened on the inner side of the outer lip and concave posteriorly with a swelling above the siphonal canal. Ornament consists only of fine spiral lirae. The type is *Pyropsis (Chilenopsis) quinzioensis* from the Quiriquina Formation.

Differences: *Pyrula rugosa* Philippi 1887 (Philippi 1887, Pl. 3, Fig. 20) is the homonym to *Tudicla rugosa* (Wetzel 1930). It differs from *Trochifusus hombroniana* only by its smaller size and more rugged ornament. This species closely resembles the type species of *Pyropsis* from the Maastrichtian Ripley Formation. *Pyropsis (Pyropsis)* differs from *Pyropsis (Chilenopsis)* by having strong spiral ribs.

Derivatio nominis: The subgenus is named after a combination of Chile and an ending as in *Pyropsis*.

Pyropsis (Chilenopsis) quinzioensis n. sp.

Pl. 2, I.

Diagnosis: The shell is about 3,5 cm high and 3 cm wide, and shaped as stated in the diagnosis of the subgenus.

Description: The spire is low and the teleoconch consists of about 4 whorls, with the last one forming most of the shell height. The suture is distinct and growth lines below it form a sinus, but there is no distinct subsutural ribbon developed. The whorl has a flattened upper flank, a rounded margin and side, and is evenly rounded in its anterior constriction that leads into the siphonal pillar. The outer lip of the aperture is evenly rounded and the inner lip subdivided in the concave posterior portion that ends in a swelling on the beginning of the siphonal canal. The inner lip is thickend and the siphon straight. The posterior notch of the outer lip is indistinct. Ornament consists of numerous fine spiral lirae and sinuous growth lines. These are close to each other near the aperture, indicating that the shell was fully grown.

Holotype, Derivatio nominis, and Stratum typicum: *Pyropsis (Chilenopsis) quinzioensis* is based on one specimen that was collected from Quiriquina Island. It is deposited in the collection of the Geology Department of the University of Concepción, and was named after Luis Arturo Quinzio, the paleontological colleague and friend from that department.

Difference: *Pyropsis (Pyropsis) rugosa* (Philippi 1887) is similar in size when fully grown, but differs not only regarding the presence of a strong spiral ornament, but also by a more strongly developed subsutural ribbon and an angulation in the outer lip. These characteristics and the well developed notch indicate, that *P. (Chilenopsis)* is not just a smooth variety, but represents a species sufficiently different to be regarded an independant subgenus. *P. (Chilenopsis) quinzioensis* could well represent a member of a group of Pyropsinae in which a transition to the genus *Austrosphaera* may be seen. Especially varieties of *Austrosphaera* with more angular whorl shapes are similar.

Genus *Trochifusus* Wade 1926

The large shell is marked by an almost flat apical spire and a last whorl which is characteristically thickened and drawn up forming a varix. The genus is based on *Trochifusus perornatus* Wade 1926 from the Coon Creek locality of the Maastrichtian Ripley Formation Tennessee, USA, as described and figured as *Pyropsis* by Sohl (1964, Pl. 34, Figs. 2–4, 11, 13).

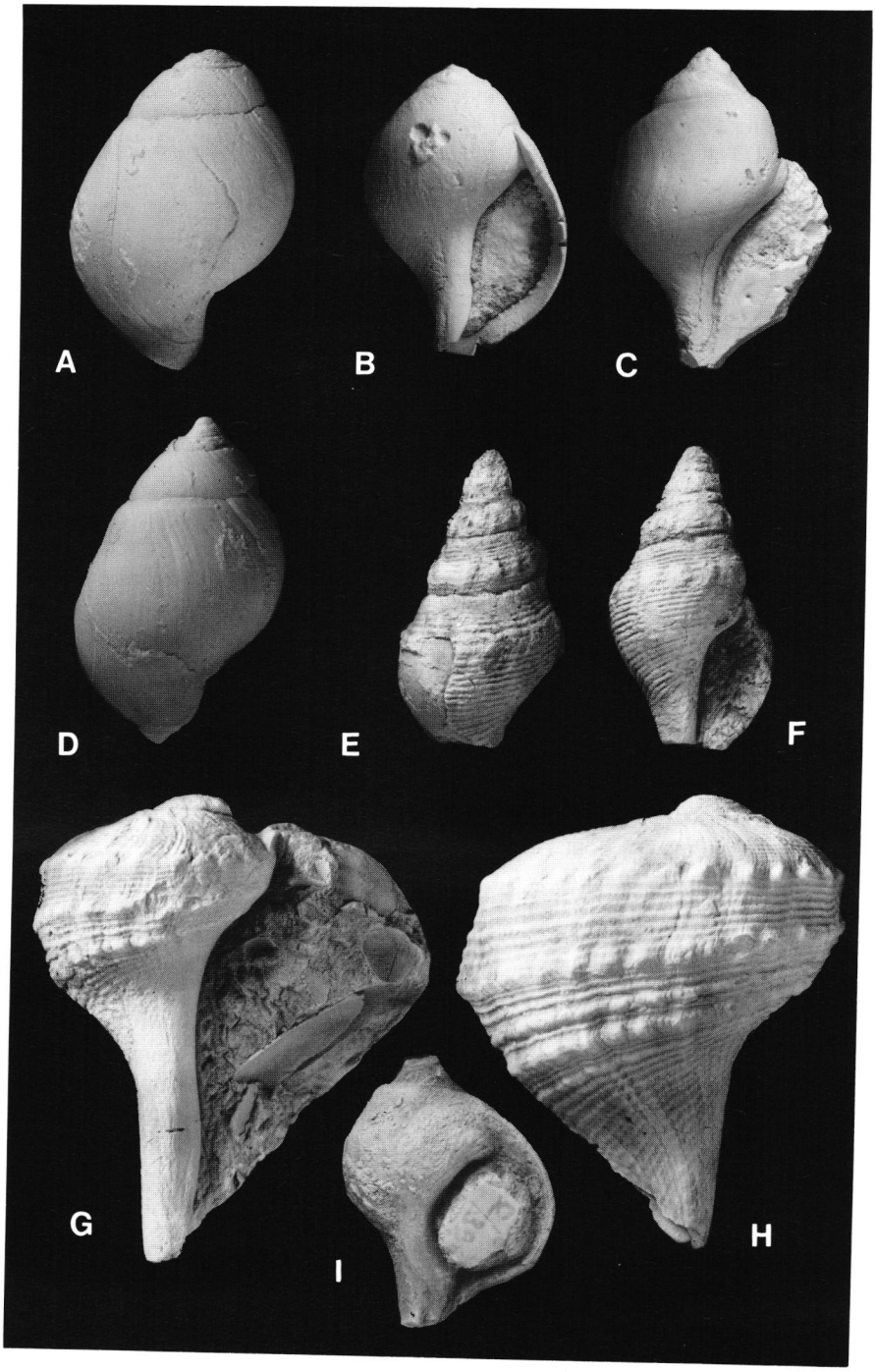
Differences: *Trochifusus* differs from *Pyropsis* by the outer lip which expands across the margin of the spire in the last whorl of the fully grown shell, thereby forming a varix. The fully grown individuals of *Trochifusus* thus differ from juveniles which are similar to *Pyropsis*.

Trochifusus hombroniana (Orbigny 1846)

Pl. 2, G, H.

Description: The subpyriform shell has a low spire that extends little from the body whorl. The spire is low and flattened with four spiral ribs ornamenting each whorl. There are about 5 whorls of the teleoconch with deep sutures between them. The whorls are peripherically expanded and shouldered, forming an angle of almost 90° with the sides. The whorls expand rapidly and the body whorl is large and flattened at the sides and constricted anteriorly. A siphonal canal is formed which is long, initially straight and later curved outwards. The ornament is dominated by noded spinose spiral cords. A single row of nodes in the juvenile develops to four or five rows in the fully grown shell, with each new row beginning below the older one. In addition to the rows of nodes, the other sculptural elements are rounded spiral ridges of which an increasing number is present between periphery and the siphonal column. These spiral ribs are noded when crossed by the regular sinuous growth increments. Growth lines cover an otherwise unornamented narrow subsutural ribbon. From there onwards they form a low peripheral lobe and are almost straight into the long siphonal pillar. The aperture is thickened on the inner side, with the inner lip forming a callus and a smooth columella. The posterior notch is well developed. Fully grown shells are up to 16 cm high and 9 cm wide with the last whorl shells expanding in size. It then covers much of the spiral ramp, while juvenile shells are more *Pyropsis*-like in shape.

Remarks: The large species was named *Pyrula hombroniana* (Orbigny 1842) by Philippi (1887, Pl. 4, Fig. 3), while Möricke (1895) placed it with *Pyropsis*. Wilckens (1904, Pl. 18, Figs. 8, 9) noted that *T. hombroniana* resembles *Pyropsis bairdi* Meek & Hayden 1857 from the Fox Hills Formation of South Dakota, USA. This species as illustrated by Sohl (1964 Pl.33, Fig. 9) looks extremely similar to juvenile stages of *T. hombroniana* before formation of the adult varix. Wetzel (1930, Pl. 11, Figs. 1, 2) called it *Tudicla (Pyropsis) hombroniana* and noted its maximum height of 15 cm. The large *Trochifusus hombroniana* resembles *Trochifusus perornatus* from the North American Ripley Formation as well as the large *Trochifusus africanus* (Woods 1906) from the South African Umzamba Formation. *T. perornatus* reaches a size of up to 9.5 cm in height and 7.5 cm in width. It presents rounded shoulders and an ornament of strong nodose spiral cords and spines on the last whorl (Sohl 1964). The last (fifth) whorl expands forming a varix. In the older (Santonian) *T. africanus,* the adult shells differ from juveniles by a less nodular ornament, while juveniles closely resemble *Pyropsis perornatus* from the Ripley Formation. Woods (1906) already noted the similarity of the South African species with *T. hombroniana* from the Maastrichtian Quiriquina Formation, but the African species it smaller, with a maximum height of 9 cm (personal observation).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Subfamily Pyrifusinae n. subfam.

The Pyrifusinae unite Late Cretaceous species with siphonate and fusiform shells. They usually bear a ramp or collar below the suture as expression of a posterior notch of the outer lip of the aperture. Ornament usually consists of axial folds crossed by spiral lirae. The inner lip is callus-covered and smooth. It may form an angulation where the siphonal canal begins, or may have one or more plications. The new subfamily Pyrifusinae belongs to the Pyrifusidae as introduced by BANDEL (1999b), and is based on the genus *Pyrifusus*.

Genus *Pyrifusus* CONRAD 1858

The pyriform shell has sub-shouldered whorls. The shell has a spire which reaches half the shells' height. Its ornament consists of strong spiral cords and transverse costae. The aperture is elongate and posteriorly notched, with the siphonal canal well developed, straight or curved. The columella is thick and smooth. Genotype: *Pyrifusus subdensatus* CONRAD 1858 from the Maastrichtian of Mississippi (SOHL 1964, Pl. 24, Figs. 1–4).

Subgenus *Pyrifusus (Deussenia)* STEPHENSON 1941

The whorls of the fusiform shell are constricted posteriorly to a moderately broad subsutural collar. Ornament consists of spiral cords and transverse ribs which are accentuated to nodes at the shoulders, but smoothen above and below. The aperture is notched posteriorly, anteriorly connected to a siphonal canal, and the columella is smooth. The subgenotype is *Deussenia cibolensis* STEPHENSON 1941 from the Maastrichtian of Texas (STEPHENSON 1941, Pl. 64, Figs. 13, 14).

Plate 2. **A.** *Austrosphaera difficilis* (ORBIGNY 1842) seen from behind. The shell is 4 cm high and characterized by a strongly worn spire. **B.** *Austrosphaera difficilis* in apertural view. The siphon is short and the spire strongly worn (3 cm high). **C.** *Austrosphaera difficilis* in apertural view. The outline of the body whorl is a more angular and the spire strongly worn. (3,5 cm high). **D.** *Austrosphaera difficilis* of illustration C seen from behind. **E.** *Pyrifusus (Deussenia) gigantea* n. sp., the holotype seen from behind. The shell is slender, fusiform 10 cm long and 5 cm wide. **F.** *Pyrifusus (Deussenia) gigantea* n. sp. of illustration E. Note that a narrow subsutural ribbon and numerous spiral ribs are present along with approx. 17 sinuous axial ribs which are best expressed on the margin of the shoulder. **G.** *Trochifusus hombroniana* (ORBIGNY 1846) in apertural view. The spire is low and flattened, the posterior notch, the outer lip expanded, and the siphonal canal long, initially straight and later outwards (9 cm high). **H.** *Trochifusus hombroniana* illustrated in G. View from behind. Note that four of five rows of nodes and rounded spiral ridges form the ornament. **I.** *Pyropsis (Chilenopsis) quinzioensis* n. sp., the holotype. The shell is 3,5 cm high and 3 cm wide, shaped like a *Pyropsis*, but with a smooth shell surface.

Pyrifusus (Deussenia) gigantea n. sp.

Pl. 2, E, F.

Diagnosis: The slender fusiform shell has a spire of about the same height as the body whorl. The shell is 10 cm long and 5 cm wide, but probably not even fully grown. The subsutural ribbon is narrow and the remainder of each whorl ornamented by numerous spiral ribs. There are about 17 sinuous axially rounded ribs on the body whorl which are best developed on the shoulder and end above and below.

Description: The fusiform shell has a spire of about half of the total shell height. This is more than 10 cm while the maximum width is about 5 cm. The whorls are constricted above a tuberculated shoulder and below the base of the body. Ornament consists of coarse transverse ribs that are strongest on the shoulder but smoothen below the periphery and on the collar above it. Spiral ornament consists of about 30 rounded ribbons separated from each other by narrow furrows. Only about 9 of these are visible on the whorls of the spire, while the others are covered by the succeeding whorl. Growth lines are strong and form the only ornament on the narrow subsutural ramp (collar). The aperture is posteriorly notched, anteriorly drawn out to a wide siphonal canal that is broken off, but at its end may have been twisted to the left. The inner lip is callus-covered and narrow. The outer lip is thin and suggests that the shell is not a fully grown specimen.

Derivatio nominis and locus typicus: This *Pyrifusus* is rather large (*giganteus*) for the genus and it has been found on Quiriquina Island, in the beds of Quiriquina Formation. The holotype is the illustrated specimen, housed in the Collection of the Department of Geology in Concepción.

Difference: *Pyrifusus (Deussenia) gigantea* is very large compared to the usual species of this genus and subgenus. The larger species from the Ripley Formation measure only up to 5 cm in height (Sohl 1964), which is small compared to the 10 cm of this species from the Quiriquina Formation.

Remarks: There are several other species in the Quiriquina Formation that are related to *Pyrifusus*. One has been described as *Triton luisae* Wilkens 1904 and misplaced with the Cassoidea, the other, *Struthiolariopsis ferrieri* (Philippi 1887), was thought to belong to the Stromboidea. At least two more species are present in the Quiriquina Formation. Pyrifusidae represent members of the stem group of the Neogastropoda and are present in all Late Cretaceous marine faunas in the world (Bandel 1993).

Genus *Concepcionella* n. gen.

Diagnosis: The large (almost 8 cm high in the type), thick shell has a fusiform shape, with the spire about as high as the body-whorl. The whorl is keeled with a flattened ramp above and concave side below, up to the indistinct suture. The

aperture is ovoid, with a rounded and angular posterior end, notched at the keel. Anteriorly it extends into a short siphonal canal that has a slight twist to the left. The inner side of the thickened outer lip is crenulated and the inner lip forms a callus with an edge raised over the columella. The type is *Concepcionella bonillana* n. sp. from the Quiriquina Formation, Quiriquina Island, Chile.

Derivatio nominis: The genus is named after the Chilean city of Concepción, which is located close to Quiriquina Island.

Concepcionella bonillana n. sp.

Pl. 3, A.

Diagnosis: As genus.

Description: The shell is solid, with the anterior portion of the siphonal tube broken off, and measures 7 cm in length and 4,5 cm in width. The teleoconch consists of 5–6 whorls and presents a characteristic central keel with rounded top and flattened to slightly concave margins. Additional ornament may consist of fine spiral lirae and growth lines, but these are not well developed on this fully grown shell. The body whorl is angular between the whorl flank and the siphonal pillar, thereby forming a groove with the siphonal pillar. The aperture demonstates a thickened outer lip, with a very distinct narrow canal reaching into the keel. The posterior edge of the outer lip is angular and unnotched. On the inner side of the outer lip, a rounded crenulation by ridge-like swellings is present. The inner lip is formed by a callus that is smooth and forms in its columellar portion a raised platform on the siphonal pillar.

Holotype, Locus typicus, and Derivatio nominis: The genus and species is based on one specimen found on Quiriquina Island, at the base of the Quiriquina Formation. It was collected in 1997 by the senior author and Ramiro Bonilla (University of Concepción), after whom it received its name.

Remarks: *Concepcionella bonillana* is a quite unusual potential neogastropod from the Late Cretaceous that differs from all common Pyropsidae of that time by the absence of a posterior notch. Instead, a notch is present on the keeled flank of the outer lip of the aperture. Minor onsets of such a notch may also be noted in *Pyropsis rugosa* from the Quiriquina fauna or in *Protobusycon cretaceum* WADE 1917 from the Ripley Formation of the USA (SOHL 1964, Pl. 23, Figs. 23, 24). This latter species is also somewhat similar in size and shape, with a sulcus below the inflated part of the body and flattend flanks. A notched keel on the outer lip is often present among modern Neogastropoda (e.g. in *Rapana* SCHUMACHER 1817, *Latiaxis* SWAINSON 1840, *Melongena* SCHUMACHER 1817, *Busycon* RÖDING 1798, *Tudicla* RÖDING 1798). These genera belong to rather different goups within the Muricoidea of the Neogastropoda and are not closely related to each other. It is possible that *Concepcionella bonillana* represents an early neogastropod of a type that was rare in the Late Cretaceous but became common after the K/T mass extinction.

6. Examples from the Heterostropha

Several representatives of cephalaspidean opisthobranchs are present in the Quiriquina fauna and demonstrate relationhips to other faunas. Bullomorphs are also present as for example *Atys subglobosa* (Philippi 1887) originally regarded as *Bulla* by Philippi (1887 Pl. 13, Fig. 2). This species is smooth, subglobular in outline, about 2 cm in height and width and presents a large aperture. According to Wilckens (1904, Pl. 18, Fig. 11), the shell consists of about 4 whorls. Wetzel (1930, Pl. 11, Fig. 6) described it as *Atys* since he noted one or two columellar folds, which had not been observed by Wilckens (1904). *Philine chilensis* Philippi 1887 presents a subquadarate orbicular shell with about 1,5 cm height and width and an arcuate outer lip that extends upwards beyound the apex (Philippi 1887, Pl. 13, Fig. 23). It was called *Cylichna chilensis* (Orbigny 1846) by Wilckens (1904). Two types of limpets are present, one is decribed as *Anisomyon* and the second as *Brunonia* Müller 1898 emend. Kase 1988.

Superfamily Ringiculoidea Fischer 1883, family Ringiculidae Philippi 1853

Genus *Avellana* Orbigny 1843

Avellana is characterized by a rounded shell shape, low dome-shaped spire and thickened inner-lip callus. There is one strong plication on the columellar lip, and the inner side of the outer lip is denticulated or smooth. Additional denticles and plicae may be present on the inner and outer lip, thereby distinguishing subgenera. The outer lip forms a thickened varix; there is a shallow canal on the posterior and a rounded notch on the anterior side of the aperture. The ornament consists of a pattern of spiral grooves that are crossed by collabral bridges to form a row of pits.

Subgenus *Avellana (Eriptycha)* Meek 1867

The type is *Auricula decurtata* Sowerby 1831 from the Cenomanian of France. The low-spired shell has a thickened outer lip that is dentate on its inner side. The columellar lip has one plica. The inner lip is thickened with a callus ridge and bears folds of variable shapes forming an axial ridge. There is an anterior canal between the outer and inner lip. Shell ornament consists of punctate spiral grooves separated by flattened ridges. Our definition of the genus follows Kase (1984) who stated that discrimination between the *Eriptychia* and *Avellana* is difficult.

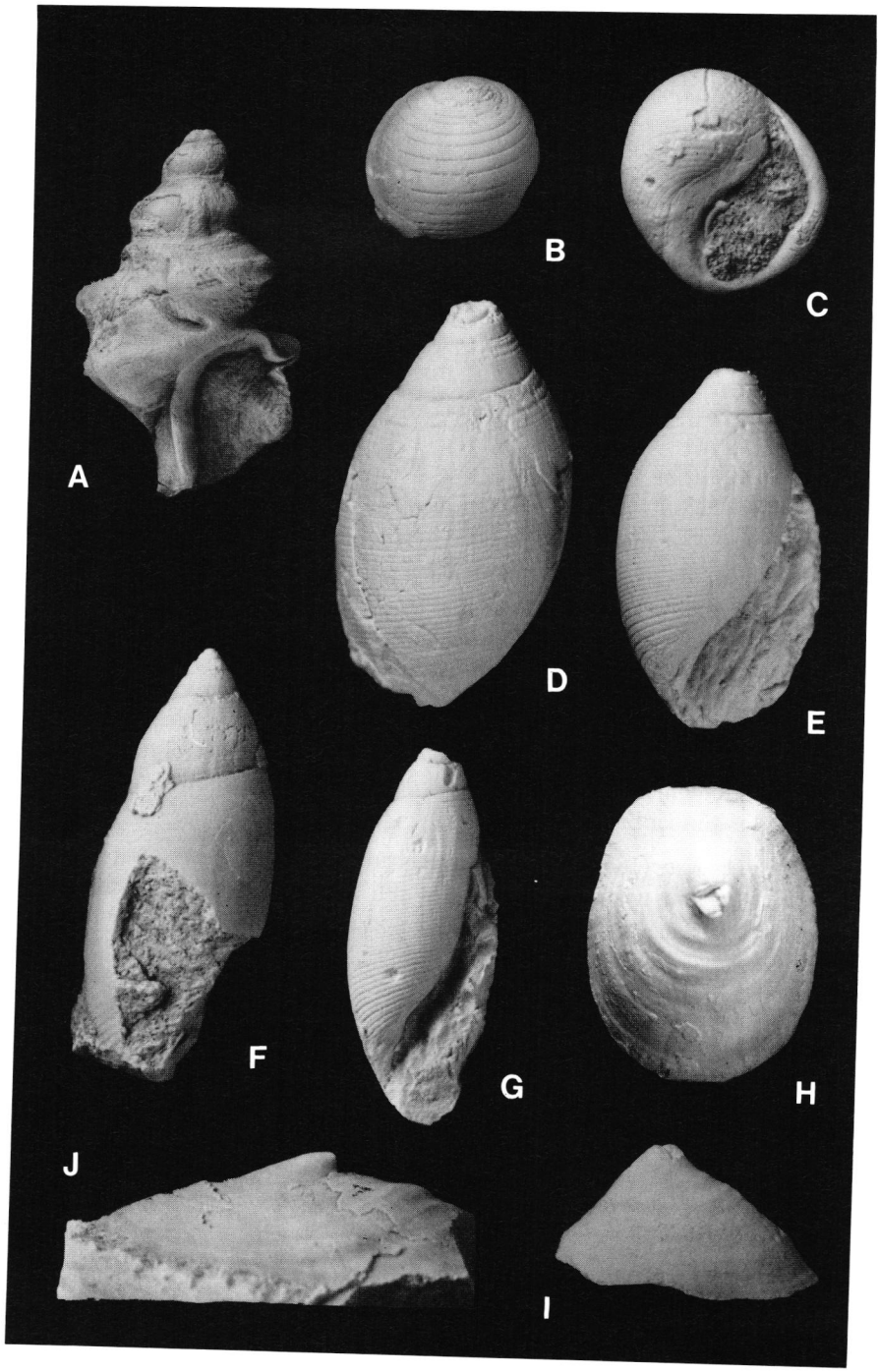
Avellana (Eriptycha) chilensis (Orbigny 1846)

Pl. 3, B, C.

Description: The shell consists of three whorls of the teleoconch, and spiral lines are closer to each other above and below the median whorl. The aperture is thickened and oblique. Personal observations on several individuals indicate that the globulose shell of adult specimens is up to 11 mm in height, but may also be much smaller and reach 5 mm in size. The heterostrophic protoconch is apically included in a depression. Ornament consists of linear spiral grooves regularly pitted by growth increments and separated by broad flat interspaces. The apertural rim of the outer lip almost reaches the apex. It is thickened on the middle of its inner side, but otherwise smooth. The inner lip forms a sinuous ribbon of the callus with a groove impressed. There are two denticles, one in anterior position of the columellar lip and the other one posterior to it but still on the parietal lip; the two are connected by a narrow ridge.

Difference: The type of *A. (Avellana)* Orbigny 1843, *A. avellana* (Brongniart 1822) from the Cenomanian of France, has one columellar plica and two denticles on the inner lip. It thus has more columellar denticles than *A. (Eriptycha) chilensis*. *A. (Oligoptycha)* Meek 1876 (Sohl 1964, Pl. 48, Figs. 27–33, 36, 37) has a strong anterior fold and weaker parietal folds. Unlike *A. (Eriptycha)* these are not connected by a ridge. In addition, *A. (Oligoptycha)* is characterized by a crenulated inner side of the outer lip and no central swelling. The North American *A. (O.) americana* and *A. (O.) corrugata* from the Ripley Formation (Sohl 1964, Pl. 48, Figs. 27–33, 36, 37) differ from *A. (E.) chilensis* by the absence of the ridge that connects the columellar with the parietal denticle. The larger *A. (O.) corrugata* Sohl 1963 is similar in size .

Remarks: Orbigny (1846) originally described the Chilean species as member of the genus *Avellana*, whereas Philippi (1887, Pl. 11, Fig. 11) placed it with *Cinulia* Gray 1840. In Philippi's illustration of the species, the inner lip appears smooth and no thickening of the outer lip was noted. Wilckens (1904, Pl. 18, Fig. 10) described the features of the inner lip but not the swelling on the inner side of the outer lip. In consequence, he placed this species with *Eriptycha*. The swelling was discovered by Wetzel (1930). Möricke (1895) in (Steinmann et al. 1995, Pl. 7, Figs. 3, 4) illustrated this species in detail and related it to *Cinulia pusilla* Whiteaves 1884 from the Late Cretaceous of Canada. He suggested that both represent the same Pacific species, even though occurring in separate hemispheres of the globe. *Cinulia* sp. Wilckens (1910) from the Antarctic Peninsula resembles A. *(Eriptycha) chilensis*, whereas *Eriptycha punamutica* Wilckens 1922 from New Zealand appears to be intermediate between the Chilean and the North American species (Wilckens 1922, Pl. 5, Fig. 5).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Family Acteonidae Orbigny 1842

Genus *Crenilabium* Cossmann 1889

The ovate shell may be supplied with a tilted or a non-tilted protoconch, and the last whorl covers much of the rest of the shell. Ornament consists of spiral grooves that are crossed by axial lirae creating rows of pits. The aperture is tear-shaped and the outer lip forms no varix. The columellar lip has no plication. The genotype is represented by a living species.

Subgenus *Crenilabium (Eoacteon)* Stephenson 1955

The ovate elongate shell has a spire of one fourth to one third of the total shell height. The sculpture consists of incised spiral grooves crossed by fine axial threads. The aperture is elongate and the columella bears one low plica that is not visible in the aperture or only present as a weak fold. The type is *Solidulus linteus* Conrad, 1858 (Sohl 1964, Pl. 47, Figs. 5, 10–12) from Owl Creek, Mississippi (Maastrichtian).

Remarks: *C. (Eoacteon)* is close to *Acteon* but usually larger and has no columellar plicae.

Plate 3. **A.** *Concepcionella bonillana* n. sp. The holotype in apertural view. The shell measures 7 cm in length and 4,5 cm in width. The aperture is provided with a thickened outer lip and a narrow canal reaching into the keel. The posterior edge of the outer lip is angular and not notched. A groove separates the body whorl from the siphonal pillar. The inner lip is formed by a callus raised in its columellar portion. **B.** *Avellana (Eriptycha) chilensis* (Orbigny 1846) seen from behind. The globulose shell is about 8 mm in height. Ornament consists of linear spiral grooves regularly pitted by growth increments and separated by broad flat interspaces. **C.** *Avellana (Eriptycha) chilensis* seen in apertural view. The shell is approximately 8 mm high and presents an outer lip of the aperture which is thickened especially on the middle of its inner side. The inner lip forms a sinuous ribbon of the callus with a groove impressed and two denticles connected by a narrow ridge. **D.** *Crenilabium (Eacteon) valdovinosensis* n. sp. from behind. The shell is ovate, elongate, 18 mm high and 10 mm wide. **E.** *Crenilabium (Eacteon) valdovinosensis* n. sp. apertural view of the holotype illustrated in D. The ornament consists of incised spiral grooves. The aperture is elongate with simple columella. **F.** *Crenilabium (Nonacteonina) chilensis* (Orbigny 1846) seen from behind. The shell is about 1,5 cm high with dense ornament of spiral grooves. The spire occupies about one third of the shell height. **G.** *Crenilabium (Nonacteonina) chilensis* in apertural view. Note that the columella is simple. **H.** *Anisomyon patelliformis* Meek & Hayden (1860) seen from above. The limpet-like shell that is about 1,8 cm long. The apex appears to be a small tip which is directed backwards and is broken off. **I.** *Anisomyon patelliformis* seen from the side (same as in H). The apex is directed backwards. **J.** *Brunonia* sp. seen from the side.The shell is low limpet-like and 2 cm wide.

Crenilabium (Eacteon) valdovinosensis n. sp.

Pl. 3, D, E.

Diagnosis: The shell is ovate, elongate, and presents a spire of about one fourth of the shell height and two broad furrows immediatly below the suture.

Description: The shell is ovate, elongate, 18 mm high and 10 mm wide, and has a spire of about one fourth of the total shell height. The sculpture consists of incised spiral grooves crossed by fine axial threads and wide interspaces, except for the suture where two broad grooves are present. The aperture is elongate and the columella simple with a raised edge of the callus.

Derivatio nominis, Locus typicus, and Holotype: This species from Quirinquina Island and the Quiriquina Formation is based on the illustrated specimen. It is called after Claudio Valdovinos, a Chilean collegue from Concepción University working on gastropods. The holotype is deposited in the Department of Geology at the University of Concepción.

Difference: *C. (Eacteon) valdovinosensis* closely resembles *C. (Eacteon) linteus* (Conrad 1858) (Sohl 1964, Pl. 47, Figs. 5, 10–12) from the Owl Creek Formation in Mississippi. It differs by a slightly wider shell and by the two subsutural furrows. Wetzel (1930) described the North American species *Actaeon linteus* Conrad 1858 with one inclined columellar fold. Wetzel's species may be identical with *C. (Eacteon) valdovinosensis* but since it was not illustrated it could also belong to *C. (Nonacteonina) chilensis.*

Subgenus *Crenilabium (Nonacteonina)* (Stephenson 1941)

The shell is slender and sublenticular in shape with a high spire that amounts to more than one third of the total shell height and an elongate body whorl. The sutures are flat and sharp. Ornament consists of impressed punctate spiral grooves and arcuate growth lines that appear as raised transverse threads in three grooves. The aperture is narrow posteriorly and rounded anteriorly with a callus restricted to a narrow band on the columellar lip. The columellar edge is smooth and twisted. The subgenotype is *Nonacteonina graphoides* Stephenson 1941 from the Upper Cretaceous of Texas (Navarro Group) (Stephenson 1941, Pl. 73, Figs. 24, 25).

Difference: *C. (Nonacteonina)* is close to *C. (Eoacteon)* in shape of the shell but is somewhat more slender and has a higher spire.

Crenilabium (Nonacteonina) chilensis (Orbigny 1846)

Pl. 3, F, G.

Description: Philippi (1887, Pl. 13, Fig. 4) considered this species to represent *Actaeon*. According to his description, the shell is 10 mm high and 6,5 mm wide with elongate-ovate "melampoid" shape and an ornament of spiral striae. New material is represented by shells up to 15 mm high and 5 mm wide. The ornament of spiral grooves is quite dense and commonly each second furrow is less deeply incised. The spire occupies about one third of the shell height and the columella is simple. Wetzel (1930) described this species from the Quiriquina Formation as *Scaphander chilensis* (Orbigny 1846).

Remarks: *C. (Nonactaeonina) chilensis* resembles the North American *C. (Nonacteonina) deflexa* of Stephenson (1941, Pl. 73, Figs. 26, 27) from the Maastrichtian Nacatoch Sand, Texas and may actually represent the same species.

Genus *Anisomyon* Meek & Hayden 1860

Pl. 3, H, I.

The shell is medium sized (about 2 cm wide), cup-like, patelliform. The apex is situated between the middle and anterior the end or nearly central. The shell is thin, longer than wide, with an oval base. The frontal part of the shell is a little wider than its posterior part. The sides are weakly convex or nearly flat, with the surface marked by fine concentric growth lines and very indistinct radial lirae. The apex is directed backwards and the muscle impression is U-shaped, with an open anterior end. The type is *Anisomyon patelliformis* from the Cretaceous of Montana.

Anisomyon patelliformis Meek & Hayden 1860

Pl. 3, H, I.

Description: The limpet-like shell is about 2 cm long and 1,5 cm wide. It has an obscure horse-shoe-like muscle impression on the steinkern that opens towards the front. The apex is positioned in the anterior half of the oval shell. It appears to be a small tip which is directed backwards and is broken off. There is clearly a short spoon-like internal septum present below the apex that initiates right behind the coil of the early juvenile and is inclined towards the posterior margin.

Remarks: Stephenson (1941, Pl. 74, Figs. 11–15) found individuals of *Anisomyon haydeni* Shumard 1861 from the Nacotoch sand in Texas to be similar to the type species. He noted their variable shell outline and height. According to Akers & Akers (1997), *Anisomyon patelliformis* occurs in Campanian and early Maas-

trichtian sediments from South Dakota to Texas, from the Atlantic coastal plains to California and from New Mexico to Wyoming and Canada.

Genus *Brunonia* Müller 1898 emend. Kase 1988

The genotype is *Brunonia grandis* Müller, 1898 from the Santonian of northern Germany where it occurs in the area of Braunschweig.

Brunonia sp.

Pl. 3, J

Description: The low limpet-like shell has almost circular shape and an almost central apex. It is about 20 mm wide and long, but only about 4 mm high. The posterior portion of the shell flank is a little humped between apex and shell margin. The anterior flank is evenly inclined. The apex shows only a very slight spiral twist to the right, less than seen on modern *Siphonaria*. The shell is thin and ornamented with undulating concentric ribs and some very low and indistinct irregular radial ribs. The internal cast demonstrates an U-shaped muscle attachment scar that opens to the right front. Here the steinkern of the interior mould shows some elongate striations similar to those on the internal shell surface of a modern *Siphonaria*.

Remarks: The low cap-shaped limpet probably belongs to the heterostrophic gastropods, either of the pulmonate siphonariids or the opisthobranch umbraculoideans. Hayami & Kanie (1980) interpreted *Brunonia* as members of the Capulidae. Kase (1988), on the other hand, suggested that they represent a member of the Carinariidae Reeve, 1841 within the heteropods (Caenogastropoda), whereas Müller (1898) interpreted *Brunonia* to be a siphonariid archaeopulmonate. Dieni (1990) created a new subfamily Brunoniinae with representatives appearing during the Jurassic and disappearing by the end of the Cretaceous. The shell of *Brunonia* is ornamented with undulating concentric ribs and some very low and indistinct irregular radial ribs. The muscle scar and the general shell shape indicate that Müller (1898) was probably correct by suggesting that *Brunonia* related to the Siphonariidae among the Archaeopulmonata.

7. Paleobiogeographic relationships of the gastropod fauna

Late Cretaceous gastropods of shallow marine environment are well known from California, the Mexican Gulf coast, Peru, the Antarctic Peninsula, New Zealand, eastern South Africa, south-eastern India, Japan, the Western Desert of Egypt, northern Spain, and central Europe. When compared to these faunas, the Quiriquina gastropods stand out as a different faunal mixture. The Quiriquina fauna is

distinctive as a Late Cretaceous gastropod fauna in general, as its approximately 40 species represent mostly endemics. Regarding the Archaeogastropoda all species encountered appear to be endemic. Here, migration during the early ontogeny is limited, since they all develop through lecithotrophic non-feeding larvae, and no long-term planktotrophic larvae exist within this group.

Planktotrophic larvae are potentially present in the Caenogastropoda and the Heterostropha. It is here that we note several species which could also have lived elsewhere. *Turritella* as well as *Confusiscala* are usually present in faunas of that age but at closer inspection the Quiriquina representatives demonstrate to be independent species. *Tephlon tumidus* is a rather characteristic endemic of Chile and the two or three aporrhaid species of the fauna still need to be compared in detail. *Calyptraea (Trochita) laevis* as well as *Turritella* have changed very little since Cretaceous times. *C. (Trochita) laevis* is not known from other localities of the same age. *Gyrodes (Dockeryella) euryomphalus* and *Polinices (Polinella) ganae* have close relatives in faunas of similar age all over the world and are related to species that occur after the K/T event.

Austrosphaera difficilis is an unusual faunal element of the Quiriquina fauna which is not known from other localities of the same age. The occurrence of a very close relative in Paleocene sediments of the Antarctic Peninsula (Oleinik & Zinsmeister 1996) and of Patagonia (Griffin & Hünicken 1994), however, gives evidence for the persistance of this genus into Paleocene time. This can not be demonstrated for its potential relatives *Pyropsis (Pyropsis) rugosa*, *Pyropsis (Chilenopsis) quinzioensis* and the more distant *Trochifusus hombroniana*. The latter is clearly an endemic species that lived on rocks similar to the modern "loco" (*Concholepas*) of that region, but unrelated to it. Its closest relative is Santonian-Campanian in age and lived on the rocky shore in South Africa. *Pyrifusus* and relatives represent a very characteristic Late Cretaceous group of southern and northern hemisphere gastropods. The genus comprises numerous species. Among the species in the Quiriquina Formation the large *Pyrifusus (Deussenia) gigantea* is a rather distinct endemic representative. *Concepcionella bonillana* is an unusual higher caenogastropod of distinctly neogastropod shell characteristics, that is not known elsewhere.

The Heterostropha show a close relationship to North American species. While *Avellana (Eriptycha) chilensis* appears to be endemic although closely related to species with global distribution, *Crenilabium (Eacteon) valdovinosensis* and *Crenilabium (Nonacteonina) chilensis* had very close relatives in Texas and Mississippi. *Brunonia*, although taxonomically somewhat problematic, is present in Japan as well as in Europe and *Anisomyon patelliformis* is known to exist in the Interior Seaway of North America. Both disappeared at the end of the Cretaceous. In addition, modern looking cephalaspideans in the Quiriquina fauna are *Atys subglobosa* and *Cylichna chilensis* which resemble species that are found in most faunas of that time.

The Maastrichtian fauna of coastal Chile thus comprises an amount of endemic species similar to modern faunas from the region. With the exception of *Calyptraea* and *Turritella* no genus has survived from the Cretaceous to now.

About 40 species are present and of these the following can be adressed:

Margarites unio (PHILIPPI 1887)
Tegula ovallei (PHILIPPI 1887)
Petropoma biroensis n. sp.
Semisolarium sp.
Ozodochilus sp.
Umbonium sp.
Turritella landbecki PHILIPPI 1887
Turritella leptogramma PHILIPPI 1887
Confusiscala sp., 3 species
Tephlon tumidus (GABB 1860)
two aporrhaid species
Calyptraea (Trochita) laevis PHILIPPI 1887
Gyrodes (Dockeryella) euryomphalus (PHILIPPI 1887)
Polinices (Polinella) ganae (PHILIPPI 1887)
Natica australis ORBIGNY 1842
Natica oliviformis PHILIPPI 1887
Austrosphaera difficilis (ORBIGNY 1842)
Pyropsis (Pyropsis) rugosa (PHILIPPI 1887)
Pyropsis (Chilenopsis) quinzioensis n. sp.
Trochifusus hombroniana (ORBIGNY 1846)
Pyrifusus sp., several species
Pyrifusus (Deussenia) gigantea n. sp.
Concepcionella bonillana n. sp.
Atys subglobosa (PHILIPPI 1887)
Cylichna chilensis (ORBIGNY 1846)
Avellana (Eriptycha) chilensis (ORBIGNY 1846)
C. (Eacteon) valdovinosensis n. sp.
Crenilabium (Nonacteonina) chilensis (ORBIGNY 1846)
Anisomyon patelliformis MEEK & HAYDEN 1860
Brunonia sp.

CRAME (1996) reviewed the fauna around Antarctica with regard to its origin. He concluded that species are derived from the Mesozoic province in southern Gondwana, from migration from pole to pole during different times, and from evolution, i.e. radiation within groups. But among the Late Cretaceous gastropods he recognized hardly any that appears to be present in the Quiriquina fauna. CRAME (1996) also took no notice of those forms that had actually been well established since the study of PHILIPPI (1887), and had been confirmed by MÖRICKE (1895), WETZEL (1930) and WILCKENS (1904). Apparently none of these studies have been consulted to any degree in more recent publications like those of DEL VALLE & MEDINA (1979), DEL VALLE et al. (1982), MACELLARI (1988), ZINSMEISTER & MACELLARI (1988) and ZINSMEISTER et al. (1989).

KAUFFMAN (1973) based his "Austral Province" on the similarity of bivalves in southern South America, the Trichinopoly Cretaceous of southern India, Australia and New Zealand. WILCKENS (1910), in contrast, noted no similarity between

Late Cretaceous gastropods of the Quiriquina-Formation and contemporaneous faunas from the Antarctic Peninsula. WILCKENS (1922) also found no relationship to New Zealand faunas. This view is confirmed by our study even though a continuous shelf region and similar temperatures are thought to have existed from Chile along the Antarctic continent to New Zealand and Australia (ZINSMEISTER 1982). This reconstruction of a current regime passing along the coast of the ancient Gondwana Continent from New Zealand to Chile has recently been repeated by STILWELL (1997, Fig. 5). This author discussed the general relationship of the Maastrichtian fauna of the Chatham Islands, New Zealand, with faunas of the South Pacific of that time. He suggested that during Late Campanian times a current system passed the Chatham Islands and reached Chile and the Quiriquina region. However, the gastropod species described by STILWELL (1998) from the Chatham Islands reveal no relatives to the Quiriquina fauna. Only *Euspira* (=*Polinices*) and *Eriptycha* are identical genera, but they are present in almost all faunas of the Late Cretaceous. The fauna described by STILWELL (1998) from the Late Cretaceous of New Zealand confirms the differences noted by WILCKENS (1910, 1922).

ZINSMEISTER (1982) assumed that the shallow southern margin of the Pacific Basin was isolated during the Late Cretaceous from other shallow water regions in the world. During Maastrichtian times the gastropod fauna of Central Chile was largely endemic. ZINSMEISTER (1979) speculated on the presence of a Weddellian Biotic Province from Campanian to Eocene times according to which a shallow water region extended from southeastern Australia across New Zealand, the margin of the Antarctic continent on to southern South America. ZINSMEISTER (1982) reconstructed a prevailing ocean current along this margin of the Gondwana Continent that held the Weddellian biota separated from the Caribbean-American faunas an the Asian province. According to his interpretation the tropical Tethys Ocean provided a strong dividing factor.

Gastropods thus demonstrate an endemic nature of the Quiriquina fauna, in contrast to ammonites and bivalves. KAUFFMAN (1973) suggested the presence of an Austral Province for the high latitudinal zone of the southern hemisphere including southern South America, New Zealand, Australia, New Caledonia, and southern India. A similar southern Indo-Pacific Province based on ammonites has been recognized by HENDERSON (1970) who also included the Antarctic Peninsula. This province has later been confirmed by STINNESBECK (1986) based on bivalves and ammonites from the Quiriquina Formation.

The Maastrichtian gastropod fauna preserved in the shallow marine deposits of the Quiriquina Formation presents us with puzzling paleobiogeographic data. Apparently multiple relationships existed to the North American faunal regime (*Crenilabium*) as well as to South Africa (*Trochifusus*), but very little or no relationship to New Zealand. The Quiriquina fauna must have been free of immigrants for quite some time, but had relations during earlier times. The K/T event extinguished most of the Pyrifusidae, *Brunonia* and *Anisomyon*, similar as to what happened to these taxa in other parts of the world. On the other hand some faunal elements survived the K/T event in these southern areas (*Tegula*, *Turritella*, *Calyptraea*). During the older Tertiary they migrated to the south (*Austrosphaera*) as far as New Zealand (*Polinices*).

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