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OXFORDIAN AND LATE CALLOVIAN AMMONITE FAUNAS AND BIOSTRATIGRAPHY OF THE NEUQUÉN-MENDOZA AND TARAPACÁ BASINS
(JURASSIC, AMMONOIDEA, WESTERN SOUTH-AMERICA)

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Abstract.- During the Jurassic Period in the western border of Gondwana settled the Neuquén-Mendoza and Tarapacá basins, separated by the "Antofagasta Land". In these basins there is a thick record of marine rocks with ammonites of the interval late Callovian-late Oxfordian (considering the Oxfordian/Kimmeridgian boundary at the base of the Platynota Zone of the primary international chronostratigraphic scale). The rocks of this interval are included in the Lotena, La Manga, Barda Negra (subsurface) and Auquilco formations. The ammonite faunas of the Neuquén-Mendoza Basin, their stratigraphic distribution and their relationships with those of the Tarapacá Basin and other regions of the world were poorly known in this interval of the Jurassic. In this report are presented the results of the first comprehensive study of the ammonite faunas and their biostratigraphy in these basins. The name *Araucanian Sea* is here introduced for the marine system of the Neuquén-Mendoza Basin, and *Tarapacá Sea* for the marine system of the homonymous basin. A new formal biostratigraphic classification is introduced for the Neuquén-Mendoza Basin, based on the revision of all the antecedents published, description of several species of ammonites and analysis of their succession. The studied ammonites belong to the following genera: *Lissoceratoides* Spath, *Oxycerites* Rollier, *Hecticoceras* Bonarelli, ?*Taramelliceras* Del Campana, *Trimarginites* Rollier, *Neoprionoceras* Spath, *Neocampylites* Callomon, *Rehmannia* Schirardin, *Peltoceras* Waagen, *Peltoceratoides* Spath, *Euaspidoceras* Spath (including *E. veranadaense* n. sp. and *E. tarapacaense* n. sp.), *Cubaspidoceras* Myczyński, *Choffatia* Siemiradzki, *Pseudopeltoceras* Spath, ?*Alligaticeras* Buckman, *Perisphinctes* Waagen (including *P. hillebrandti* n. sp.), *Subvinalesphinctes* Wierzbowski, *Cubasphinctes* Chudoley & Furrazola, *Passsendorferia* Brochwicz-Lewinski, *Lithacosphinctes* Olóriz, ?*Orthosphinctes* Schindewolf, and *Araucanites* Westermann & Riccardi (including *A. prereyesi* n. sp.). The biostratigraphic classification proposed is based on the subdivision of the interval in six first-occurrence-biozones (with the conjugated homonymous, non-standard chronozones): *Patagoniense* Bz. (index species: *Rehmannia patagoniense*; age: late Callovian), *Pressulus* Bz. (index species: *Peltoceratoides pressulus*; age: early Oxfordian), *Pseudokranaus* Bz. (index species: *Subvinalesphinctes pseudokranaus*; age: early middle Oxfordian, Plicatilis Zone), *Passendorferia* Bz. (index species: *Passendorferia* cf. *teresiformis*; age: middle Oxfordian, Transversarium - ?early Bifurcatus zones), *Tarapacaense* Bz. (index species: *Euaspidoceras tarapacaense* n. sp.; age: middle Oxfordian, Bifurcatus - early Bimammatum zones), and *Desertorum* Bz. (index species: *Lithacosphinctes desertorum*; age: late Oxfordian, Bimammatum - Planula zones). The *Lithacosphinctes* aff. *janus* Horizon is introduced, comprising beds of the lower part of the Auquilco Fm. in Chacay Melehué and Rahuecó. The Patagoniense Zone may be correlated with the "Athleta" and Primus Zones of the Tarapacá Basin; the Pressulus Z. with the Dimorphosus, Eugenii and Dunkeri zones; the Pseudokranaus and Passendorferia zones with the "Transversarium" Zone; the Tarapacaense and Desertorum zones are defined in the Tarapacá Basin and are represented in the Neuquén-Mendoza Basin.

Key-words: Western South America, late Callovian, Oxfordian, Ammonites, Biostratigraphy, Biogeography.

Resúmen.- ***Faunas de amonites y bioestratigrafía del Caloviano tardío y Oxfordiano de las Cuencas Neuquén-Mendoza y Tarapacá (Jurásico, Ammonoidea, América del Sur occidental).*** Durante el Período Jurásico en el borde occidental del Gondwana se desarrollaron las cuencas Neuquén-Mendoza y Tarapacá, separadas por la "Tierra de Antofagasta". En estas cuencas existe un importante registro de rocas marinas con amonites del intervalo Caloviano tardío-Oxfordiano tardío (considerando el límite Oxfordiano/Kimmeridgiano como la base de la Zona Platynota del estándar cronoestratigráfico primario internacional). Las rocas de este intervalo son incluídas en las Formaciones Lotena, La Manga, Barda Negra (subsuelo) y Auquilco. Las faunas de amonites y su distribución estratigráfica en este intervalo del Jurásico para la Cuenca Neuqúen-Mendoza y sus relaciones con las de la Cuenca Tarapacá y otras regiones del mundo eran pobremente conocidas. En este informe se presentan los resultados del primer estudio sistemático y comprensivo de las faunas de amonites y su bioestratigrafía en estas cuencas. El nombre Mar Araucano es introducido para nombrar el sistema marino de la Cuenca Neuqúen-Mendoza, y Mar Tarapacá para el correspondiente a la Cuenca Tarapacá. Una nueva clasificación bioestratigráfica formal para la Cuenca Neuquén-Mendoza es introducida, basada en la revisión de todos los antecedentes publicados, la descripción de numerosas especies de amonites y el análisis de sus sucesiones estratigráficas. Los amonites estudiados pertenecen a los siguientes géneros: *Lissoceratoides* Spath, *Oxycerites* Rollier, *Hecticoceras* Bonarelli, ?*Taramelliceras* Del Campana, *Trimarginites* Rollier, *Neoprionoceras* Spath, *Neocampylites* Callomon, *Rehmannia* Schirardin, *Peltoceras* Waagen, *Peltoceratoides* Spath, *Euaspidoceras* Spath (incluyendo *E. veranadaense* n. sp. y *E. tarapacaense* n. sp.), *Cubaspidoceras* Myczyński, *Choffatia* Siemiradzki, *Pseudopeltoceras* Spath, ?*Alligaticeras* Buckman, *Perisphinctes* Waagen (incluyendo *P. hillebrandti* n. sp.), *Subvinalesphinctes* Wierzbowski, *Cubasphinctes* Chudoley & Furrazola, *Passsendorferia* Brochwicz-Lewinski, *Lithacosphinctes* Olóriz, ?*Orthosphinctes* Schindewolf, and *Araucanites* Westermann & Riccardi (incluyendo *A. prereyesi* n. sp.). La clasificación biostratratigráfica propuesta está basada en la subdivisión de este intervalo en seis biozonas de primera ocurrencia (con sus cronozonas conjugadas homónimas, no-estándar): Biozona *Patagoniense* (especie índice: *Rehmannia patagoniense*; edad: Caloviano tardío), Bz. *Pressulus* (especie índice: *Peltoceratoides pressulus*; Oxfordiano temprano), Bz. *Pseudokranaus* (especie índice: *Subvinalesphinctes pseudokranaus*; Oxfordiano medio, Zona Plicatilis), Bz. *Passendorferia* (especie índice: *Passendorferia* cf. *teresiformis*; Oxfordiano medio, zonas Transversarium - ?*Bifurcatus* temprana), Bz. *Tarapacaense* (especie índice: *Euaspidoceras tarapacaense* n. sp.; Oxfordiano medio, zonas Bifurcatus - Bimammatum temprana), y Bz. *Desertorum* (especie índice: *Lithacosphinctes desertorum*; Oxfordian tardío, zonas Bimammatum a Planula). Se introduce el Horizonte Lithacosphinctes aff. janus que comprende capas de la parte inferior de la Fm. Auquilco en Chacay Melehué y Rahuecó. La Zona Patagoniense puede correlacionarse con las zonas "Athleta" y Primus de la Cuenca Tarapacá; la Z. Pressulus con las zonas Dimorphosus, Eugenii y Dunkeri; las zonas Pseudokranaus y Passendorferia con la Z. "Transversarium"; las zonas Tarapacaense y Desertorum son definidas en la Cuenca Tarapacá y están representadas en la Cuenca Neuquén-Mendoza.

Palabras clave: América del Sur occidental, Caloviano tardío, Oxfordiano, Amonites, Bioestratigrafía, Biogeografía.

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INTRODUCTION

The western border of South America has been for a long period of geological time, including all the Jurassic, the western border of Gondwana (Fig. 1). In this Pacific border of Gondwana the subduction of the Pacific Plate below the South American Plate defined the geodynamic conditions which evolved a complex of marine epicratonic basins. Fig. 2 shows an updated map based on the information available and results of present study.

The Andean Callovian to Kimmeridgian marine rocks outcrop as a belt extended about 2000 km long (12°-40°S), through western Argentina, Chile and Peru. The successions are composed of marine and continental sedimentary rocks and volcanics following the Andean Cordillera. In west-central Argentina, central-north Chile and southern Peru there may be considered two basins separated by the "Antofagasta Land", about 28°-30°S (Fig. 2): (1) the Neuquén-Mendoza Basin (30°-40°S) (NMB) extended along west-central Argentina and central Chile (Fig. 3), and (2) the Tarapacá Basin (12°-28°S) (TB) extended along northern Chile and southern Peru (Fig. 4). These pericratonic, back-arc basins were developed longitudinally, bounded in the west by active volcanic arches and in the east by lands formed by Precambrian to Triassic volcanics, plutonics and metamorphics (Riccardi et al. 1992, Legarreta & Uliana 1996). A late Jurassic-early Cretaceous intra-arc basin through eastern-central and northern Chile was suggested by Charrier (1984). In northwestern South America (northern Peru, Ecuador, Venezuela and Colombia) marine basins were developed during the Oxfordian but they were rather small and are poorly known (see Bürgl 1960 and Geyer 1973, 1979; recent reviews by Jaillard et al. 1995 and Mojica et al. 1996) and there seem to be no published records of ammonites for the interval studied.

The late Callovian-Oxfordian is practically the only interval of the marine Andean Jurassic of the Neuquén-Mendoza Basin which had not been studied systematically. There exists an extensive record of ammonite successions recognized in the last years. There are no monographic papers on these important faunas, only some few papers with puntual descriptions of ammonites and several mentions to their occurrence in papers mainly devoted to biostratigraphy (see chapter Antecedents). This unbalanced treatment was largely determinate by historical reasons. Leanza (1947a) described a discrete ammonite fauna from beds of the Lotena and La Manga fms. at Chacay Melehué and Rahuecó under the genera *Idoceras, Nebrodites* and *Euaspidoceras*, and dated them as early Kimmeridgian. In this way the rocks between the evaporitic Tábanos and Auquilco formations (Fig. 5) were assumed Kimmerigian in age and independence of both units was disregarded and denied under different but forced explanations for decades. The main source of confusion were the complex tectonic perturbations, which typically produce repetition of beds masking the true succession. This phenomenon leads to interpret the evaporites of the Tábanos Fm. as repetitions of the Auquilco Fm. (see Stipanicic 1966 for further discussion). The first evidence based on ammonites about the Oxfordian age of the La Manga Fm. was the paper of Stipanicic (1951) where he described an assemblage of Perisphinctinids and Aspidoceratids of undoubtedly Oxfordian age. The next step was the paper of Dellapé et al. (1979) where the correct normal succession of Tábanos, Lotena, La Manga, Auquilco and Tordillo formations was described based on the section of Chacay Melehué. Moreover, in that paper the assignations of Leanza (1947a) were questioned. Actually, these ammonites (described below) have an early Oxfordian age (see Parent 1998a).

Better known are the faunas from northern Chile (see Hillebrandt et al. 2000, and references below in the chapter Antecedents). The Peruvian Oxfordian seems to be hard to access and strongly affected by tectonics (Palacios-Moncayo 1995).

The objective of this paper is to present the most significant results obtained after a broad study which consisted of recognition and description of the late Callovian to late Oxfordian ammonite faunal successions in western South America, based on both, new collections of last years and available material. Some sparse citations of Oxfordian ammonites are in geological research reports, sometimes unpublished and most commonly these ammonites are lost or they were seen in the field but not collected. It was made an effort in compiling, and review when merits, all published information to conform an inventory as far complete as possible. A large collection of ammonites sampled by C. Gulisano is in the Museo de La Plata. The largest part of this collection was studied by the author some years ago (see Parent 1998a). Unfortunately only some few photographs and casts were obtained before the collection became hardly accessible. These ammonites were taken in consideration but new collected material has allowed to control former identifications and to have more complete and detailed ammonite successions based on material colected bed-by-bed.

The Oxfordian/Kimmeridgian boundary is taken in this report at the base of the Platynota Zone (Cariou et al. 1971), although is now demonstrated that the Planula and part of the Bimammatum Zones are equivalents of the Subboreal Kimmeridgian (Matyja & Wierzbowski 1997, Schweigert & Callomon 1997, Cariou et al. 1997).

ANTECEDENTS

The Oxfordian stratigraphy and ammonite fauna of Argentina, Chile and Perú have been studied or merely mentioned in different ways by several authors since the 1800's. The following is a first compilation survey of bibliography; pertinent details of many of the papers are given through the text below. Large lists of Jurassic literature of Argentina and Chile may be found in Rivera (1956), Hoffstetter et al. (1957), Schauer (1965) and Riccardi & Damborenea (1993). A detailed account of the history of stratigraphic studies in the Andean Jurassic since 1835, including the earliest discoveries and reports of Jurassic fossils of Argentina and in part of Chile was given by Stipanicic (1996).

The first to describe actually Oxfordian ammonites traceable in collections appears to have been Steinmann (1881; most of the material is kept in the Geological Institute of the University of Bonn), material from Caracoles (then part of Bolivia, nowadays part of Chile). Burckhardt (1900a, b) published two extensive monographs about the Jurassic and Cretaceous of Argentina and parts of Chile; later (Burckhardt 1903) all those results were reviewed. Burckhardt (1900a) defined the unit "Calcaires gris a *Gryphaea calceola*" in Bardas Blancas, Mendoza (Fig. 5); these Oxfordian rocks are widely spread throughout the Neuquén-Mendoza Basin and part of the Tarapacá Basin, conforming a conspicuous horizon of the La Manga Fm., which is known informally as "Calizas azules con *Gryphaea*" (CAG) (see Riccardi & Damborenea 1993). Kühn (1914) collected abundant fossils in the High Cordillera of San Juan Province, within which he cited *Peltoceras* sp. from Yeguas Heladas and several bivalves from other localities. Stehn (1923) described several species (mostly

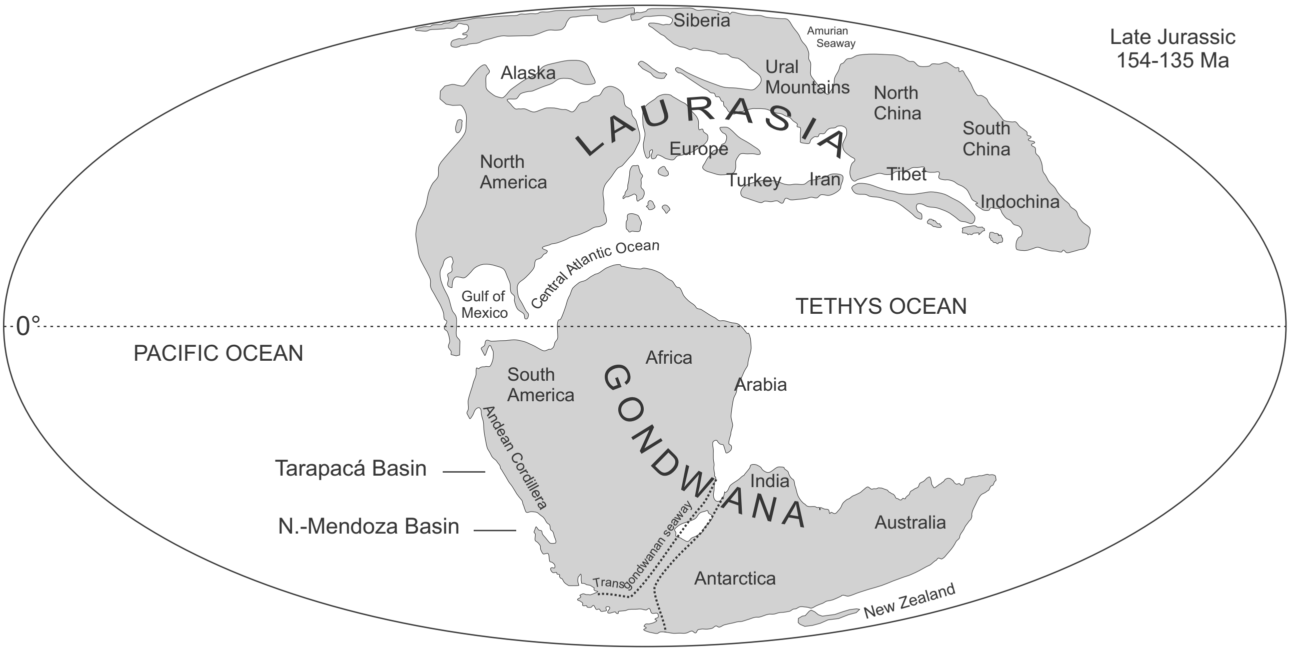


Figure 1. Late Jurassic geography: continental configuration and coast lines with indication of the basins studied in this paper. Adapted from Scotese (2002, 2004). The transgondwanan seaway is shown as in Enay & Cariou (1997). Numerical age after Odin & Odin (1990).

in need of revision) within which some of them are late Callovian or Oxfordian in age: *Perisphinctes* [*Lithacosphinctes*] *desertorum* Stehn, "*Trimarginites arolicus* Oppel", "*Ochetoceras canaliculatum* Münster", "*Perisphinctes* cf. *agrigentinus* Gemmellaro". Jaworski (1926) described but not illustrated several probably Oxfordian ammonites: (1) "*Peltoceras* sp. indet." and indeterminated perisphinctids from Río del Cobre and Laguna del Fierro; (2) "*Perisphinctes* cf. *plicatilis* (d'Orb.)" from Arroyo Blanco (p. 265); and (3) "*Perisphinctes* ind. forma B" from Arroyo Negro. Weaver (1931) although did not identify Oxfordian fossils, published some sections which actually include Oxfordian rocks. Groeber (1918, 1921, 1923, 1929, 1933, 1946, 1947a, b, c) described several sections of Neuquén and Mendoza mentioning the CAG and ammonites attributed to the Callovian and the Auquilco Fm. to the Oxfordian-Kimmeridgian, but assigning the CAG mainly to the upper Callovian. Later, Groeber (1951) revised his former time-correlations assigning definitely the CAG to the Oxfordian, based on ammonites collected by Stipanicic and Mingramm, later partially described by Stipanicic (1951). In a broader review of the Andean Jurassic (Groeber 1953) and in his last paper (Groeber 1963) the CAG was retained in the Oxfordian. Herrero-Ducloux & Leanza (1943) studied the stratigraphy and reineckeid ammonites of the Lotena Fm. of several localities of Neuquén. A.F. Leanza (1946, 1947a, b) published the description of upper Callovian and Oxfordian ammonites from Rahuecó and Chacay Melehué and from Caracoles. Leanza & Zöllner (1949) published a stratigraphic analysis of sections of the Chacay Melehué area including the Tabanos, Lotena, La Manga and Auquilco formations (middle Callovian to lower Kimmeridgian); previously Herrero-Doucloux (1948) presented a detailed analysis of the same formations but comprising almost the whole Neuquén-Mendoza Basin. A review of these later papers and a reinterpretation of the successions were given by Dellapé et al. (1979). Oxfordian ammonites and biostratigraphy of the Neuquén-Mendoza Basin were described by Stipanicic (1951, 1966, 1969) and Stipanicic et al. (1976). A first attempt to classify the Oxfordian of the Neuquén-Mendoza Basin in terms of local ammonite assemblages of the Neuquén-Mendoza Basin was made by Riccardi (1984), later revised by Riccardi et al. (1990, see also Riccardi & Damborenea 1993). Based on extensive collection by C. Gulisano several Oxfordian taxa from the Lotena and La Manga formations through several localities of the basin were cited by Riccardi & Westermann (1991); most of these ammonites are reinterpreted and described in the present paper. Cornejo et al. (1982) and Muñoz & Niemeyer (1984) have figured several lower and middle Oxfordian ammonites (described below) from Cajón Troncoso. Ramos (1985) studied the stratigraphy and ammonites from the Middle and Upper Jurassic of San Juan, including Oxfordian (La Manga Fm.). Sanguinetti (1987, 1989) studied the stratigraphy of the Upper Jurassic of Quebrada Vargas (northern Mendoza) where she collected upper Oxfordian *Lithacosphinctes desertorum* (Stehn, 1923) from La Manga and Auquilco formations. Some of the first modern studies of the interval Callovian-Kimmeridgian of northern Chile (Tarapacá Basin), with citation of several ammonite species were those of Biese (1957, 1961). Hillebrandt (1970, 1972, 1973, 1980) published results of detailed studies of the ammonite successions and their biostratigraphy, especially for the Tarapacá Basin. The paleontological and biostratigraphical studies on ammonites of the Tarapacá Basin of Gygi & Hillebrandt (1991), Hillebrandt & Gröschke (1995), Gröschke & Hillebrandt (1985), Hillebrandt et al. (2000) and Gröschke & Kossler (1999) include a local biostratigraphic classification. A first modern description of interesting Callovian oppeliids from Argentina, Chile and Peru was given by Gröschke & Zeiss (1990). Förster & Hillebrandt (1984) and Gröschke et al. (1988) figured or cited Oxfordian and Kimmeridgian aspidoceratids (*Cubaspidoceras* and *Orthaspidoceras*) from Quebrada del Profeta. Chong et al. (1984), Meléndez & Myczyński (1987, 1994), Meléndez et al. (1988), Callomon (*in* Hillebrandt et al.

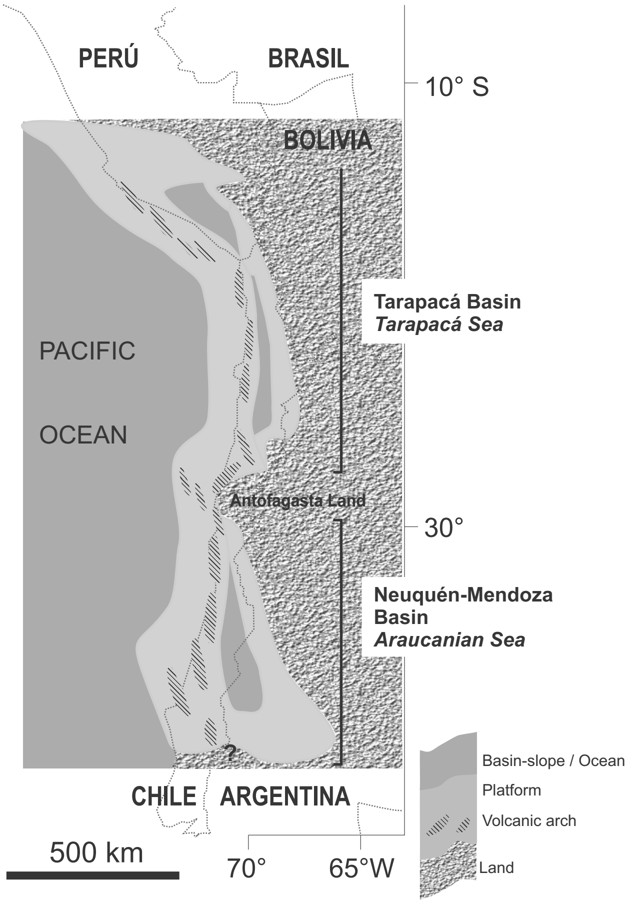


Figure 2. Oxfordian (154-146 Ma) geography of western South America superimposed on a recent geography (based on Groeber 1953, Uliana & Biddle 1988, Gröschke et al. 1988, Westermann & Riccardi 1985, Palacios-Moncayo 1995, and results of present study). Araucanian Sea and Tarapacá Sea are names introduced in the present report (see text). Numerical age after Odin & Odin (1990).

1992), and Myczyński et al. (1998) have reviewed the ammonite identifications and their implied time-correlation from existing data or new (but unfigured) ammonites at that moment from Chile. Parent (1998a) correlated this biostratigraphic framework with the standard chronostratigraphic scale based on new ammonite collections (described below) from northern Neuquén and southern Mendoza (NMB).

PALEOGEOGRAPHY

The Late Jurassic was a period of relative high sea-level stand (see Hallam 2001 for a recent review) with a geographic dynamics largely controlled by tectonic events related with definitive fragmentation of Gondwana. The South American continent (Fig. 1) comprised less than a third of the Gondwana area (Smith 1999). The northwestern margin has a geologic history related to the complex tectonics of the Caribbean region and the aperture of the Central Atlantic Ocean. In Colombia and Venezuela, it was developed an intracratonic basin with a poorly known marine record, and which could have been connected with the northern end of the Tarapacá Basin in northern Peru.

There is some advanced knowledge about the paleogeography of the NMB and TB (see Gulisano et al. 1984, Gulisano 1992, Legarreta & Uliana 1996, Gulisano & Gutierrez 1995, Hillebrandt et al. 1986, Gröschke et al. 1988). Since early studies (*e.g.* Groeber 1918, 1929, 1953) there were recognized several depocenters along the Neuquén-Mendoza Basin, like in the Tarapacá Basin (*e.g.* Gröschke et al. 1988). These depocenters have been considered as basins or sub-basins by some authors. The Middle and Upper Jurassic geography of the NMB and TB (Fig. 2) was formerly depicted by Groeber (1953), later by Harrington (1961), Westermann & Riccardi (1985), Hillebrandt et al. (1986), Gröschke et al. (1988), among others. The Callovian-Oxfordian geometry of these longitudinal basins defined narrow N-S elongated seas. The name *Araucanian Sea* is here introduced for the marine system of the Neuquén-Mendoza Basin, and *Tarapacá Sea* for the marine system of the homonymous basin. Tectonical dynamics and vulcanism in combination with eustatic changes configured a very dynamic and complex geographic scenario for ammonoids and remaining organisms.

Occurrences of ammonites are frequently poor in individuals and sporadic in the successions, separated by more or less broad intervals devoid of macrofossils. In few cases, although frequently in the Tithonian (e.g. Gründel & Parent 2001), beds with gastropods and/or bivalves are intercalated. This pattern of occurrence of rather scattered faunal levels throughout the NMB and TB appears to have been controlled by local tectonic dynamics in combination with sea level changes. The intrabasinal sea level changes should most likely be rather independent of the general eustatic dynamics because of the control of input of oceanic waters into the basins by the gaps of volcanic arches. Longitudinal-type and latitudinal-type basins are expected to generate very different biogeographic patterns and scenarios, imposing geographic features which should constraint the evolution of the faunas in particular ways. Among the major effects of the longitudinal setting of the Neuquén-Mendoza Basin must be considered the gradient patterns such as climatic belts, which have predominated during late Jurassic at least, crossing a wide range of latitudes south of the Paleoequator. One of the major consequences of this situation is expected to be some degree of differentiation of the faunas along, and especially between, basins, and thus the inherent complications in correlation. Although the current knowledge and new evidence are not enough for a detailed characterization of the patterns, along the present study some evidence has emerged and is discussed in the final chapter.

The high sea-level during the Oxfordian was a condition that created shallow epeiric seas and attached ramp shelves around the Gondwana. The Andean basins were consequently well communicated between each other and with the Tethys and adjacent areas, through the Hispanic Corridor (Central Atlantic Ocean, see Fig. 1) enabling the exchange and global homogenization of marine faunas (principally those elements of platforms). The assumption of faunal similarities as direct faunal affinities is expected to allow close correlations to be made with the Tethyan chronostratigraphic standard scale. This approach was adopted in a previous paper (Parent 1998a) and previously by other authors (Gygi & Hillebrandt 1991, Hillebrandt & Gröschke 1995, Chong et al. 1984).

LITHOSTRATIGRAPHIC FRAMEWORK

The geology of the Andean belt is relatively well known, recent summaries may be found in Riccardi et al. (1992) and Legarreta & Uliana (1996). The stratigraphic framework used as reference in this paper is well described in recent papers by

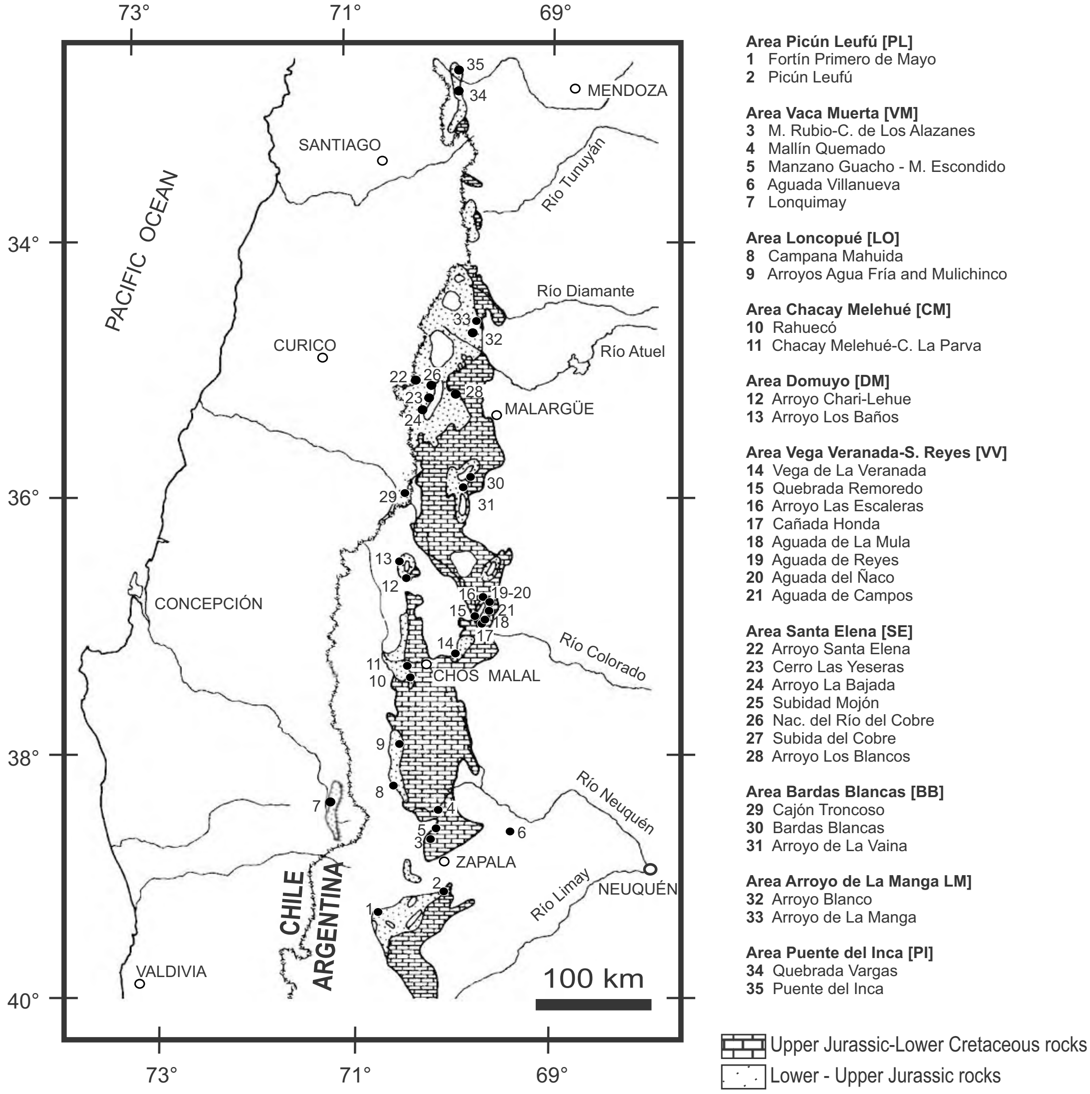


Figure 3. Main Jurassic outcrops of west-central Argentina and central Chile with indication of main ammonite localities. Adapted from Yrigoyen (1979).

Riccardi & Gulisano (1990), Riccardi et al. (1992), Digregorio et al. (1984), Gulisano et al. (1984), Gulisano & Gutierrez (1995), Hillebrandt et al. (1986), Gröschke & Hillebrandt (1985), and references therein.

The lithostratigraphic classification of the Callovian to Kimmeridgian rocks of the Neuquén-Mendoza Basin is rather homogeneous and well-known (Fig. 5). Complete definitions and references may be found in the Volume Jurasico of the *Lexico Estratigráfico de la Argentina* (Riccardi & Damborenea 1993). Most relevant features of lithostratigraphic units for the present study are the following:

Auquilco Formation (Weaver, 1931).- It is composed by thick banks of anhydrite and gypsum, stratified, sometimes laminated (Polansky 1972), or nodular. In several localities the evaporites are pure but in others is sandy gypsum. In fresh color is white to grey-white. It may contain (*e.g.* Vega de la Veranada) nodules of colloidal silica and quartz crystals (Holmberg 1976). Typically the base contains intercalations of limestone and finely sandy limestone. Age: late Oxfordian - Kimmeridgian.

La Manga Formation (Stipanicic & Mingramm in *Groeber, 1951)*.- Equivalent to the Barda Negra Formation with which grades laterally eastward subsurface. Outcrops homogeneously as calcareous rocks with bluish-brownish grey color in weathered. In Arroyo de La Manga (Mendoza) it consists of lutites, marls and sandy marls, partially oolithic; with reddish brown, limonitic coat or scabs but light bluish-grey in fresh cut; towards the upper part become more calcareous (Stipanicic 1951). In Sierra de Vaca Muerta it consists of very hard, bluish to greenish-grey limestones with chert concretions, which in some points form reefs of up 2 km long and 80 m thickness of corals and sponges with sandy intercalations. In Vega Veranada (Neuquén) the base consists of lutites. The thickness is very variable, may reach 220 m; the greatest thickness is developed in platform facies (> 100 m) and the smallest in the inner part of the basin (5-15 m). In the center of the basin progrades over clastic facies of the Lotena Fm. (partially synchronic in the upper part of this latter); at top is paraconcordant with the Auquilco Fm. Age: early to late Oxfordian.

Lotena Formation (Weaver, 1931).- The top grades with sedimentary continuity with the La Manga Fm. (Dellapé et al.

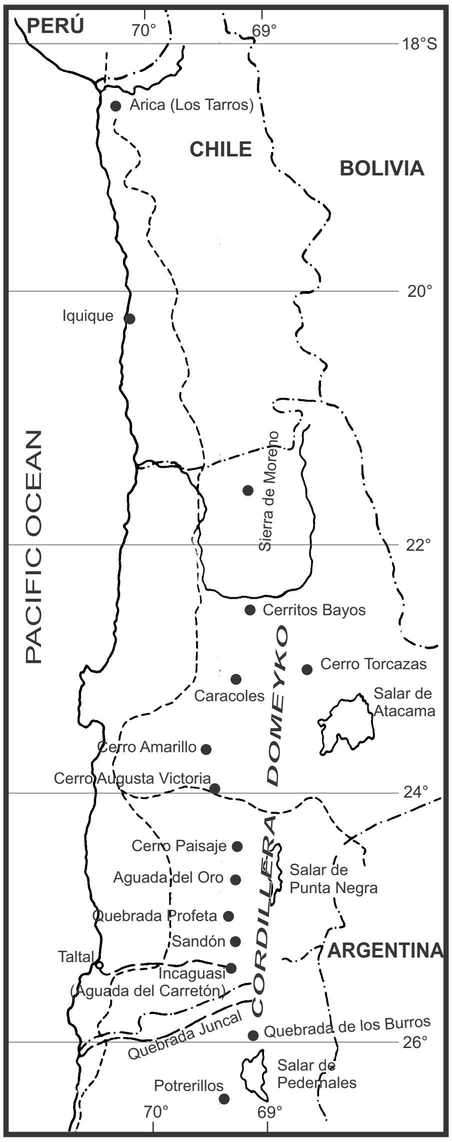


Figure 4. Main Jurassic outcrops and Upper Jurassic ammonite localities of the Tarapacá Basin, Northern Chile (based on Pérez d´A 1982 and Gygi & Hillebrandt 1991).

1979). Thickness is variable, depending on the position of the basin. Age: (middle?) late Callovian to early Oxfordian.

50 m	Massive conglomerates with intercalations of coarse sandstones, tuff clasts of 1 to 40 mm diameter, and volcanic rocks.
73 m	Brownish-grey, medium to coarse sandstones with conglomerate lenses.
81 m	Brownish-grey, massive conglomerates interbedded with medium to coarse sandstones, forming lenticular bodies with abundant fossil wood.
40 m	Light brownish-grey, coarse sandstones with fossil wood.
60 m	Brownish-grey conglomerate in the upper part; light grey sandstone to conglomerate in the middle part; coarse conglomerate in the lower part.
18 m	Brownish-grey, massive sandstone, medium grain; in the base is a massive conglomerate with clasts up to 20 mm in diameter.

This lithology is characteristic of marginal, shallow portions of the basin. In distal, deeper portions of the basin are typical thick beds of black to greenish gray and bluish siltstone and mudstone with very scarce limestone, typically as local concentrations. In different positions of the basin the base erodes the upper part of the Tábanos (depocentre), Los Molles, Lajas and Challacó formations.

LOCAL SECTIONS AND AMMONITE FAUNAS

Neuquén-Mendoza Basin

The record of ammonites and their stratigraphic position in sections are indicated below, and described in the chapter Systematic Paleontology. The studied localities are grouped by *areas* as indicated in Fig. 3. Any bed or set of adjoining beds (the rocks) containing ammonites (the fauna) are treated here as *faunal levels*. Each faunal level is labeled with consecutive numeration, from below, in the sections with a prefix relative to the area name as indicated in Fig. 3. Any faunal level is assumed as a proxy to a time-plane and some of them could be considered as faunal horizons (*sensu* Gabilly 1971, Callomon 1995), see discussion in the chapter Biostratigraphy.

Picún Leufú area (Fig. 6).- This is the southernmost area of the NMB with ammonites, although the marine record for the studied interval is very scarce. Geology of the area was dealt in detail by Groeber (1953), Leanza (1973) and Leanza & Hugo (1997). In a new section of the upper part of the Lotena Fm. (Fig. 6) several samples of *Rehmannia (Loczyceras) patagoniense* [M&m] and a specimen of *Choffatia*? sp. were collected which define the faunal level PL-1. In the locality Fortín Primero de Mayo, C. Gulisano collected a perisphinctid labelled as *Perisphinctes (Otosphinctes?)* sp. [MLP16909], faunal level PL-2, but the specimen was not seen during this study. The Challacó Fm. yields an abundant marine to brackish water fauna of bivalves, gastropods and scarce, poorly preserved Middle Jurassic ammonites.

Sierra Vaca Muerta area (Figs. 7-8).- Transect including, from South: Portada Covunco, Manzano Escondido, Manzano Grande, Mallín del Rubio, Mallín de la Cueva and Mallín Quemado. The geology of the area was described by Weaver (1931), Lambert (1956), Leanza (1973), Groeber (1953), Gulisano & Gutierrez (1995), and Zavala & González (2001). New sections at Manzano Escondido, Riscos Bajos and Mallín Quemado (Fig. 7), on the SE flank of the Sierra de Vaca Muerta anticline, were sampled in 2003 and 2005. Details of the lithological and faunal successions are shown in Fig. 8. At Cañadón de los Alazanes, close to Manzano Escondido, it was colected by C. Gulisano in 1983 (MLP 19617, level G-377) a specimen of *Euaspidoceras chilense* Leanza, 1947, close to *E. hypselum*, indicating the faunal level VM-8 as in Portada Covunco (see Fig. 8) after a citation of Groeber (1953).

The coral-reef facies of the La Manga Fm. (see Morsch 1990) is well exposed in a new fresh section at Cañadón Alazanes. It consists of more than 50 m: a) the lower third composed by massive greenish-grey (sandy) limestone containing silicified planar corals, b) the middle third comprises lumachellic silty limestone (marl) with an abundant fauna, typical of coral reefs: silicified tabular corals, gastropods, at least two species of bivalves, sponge spicules, echinoderms and decapods, c) the upper third shows similar lithology but is poorer in fauna, only “tabular” corals.

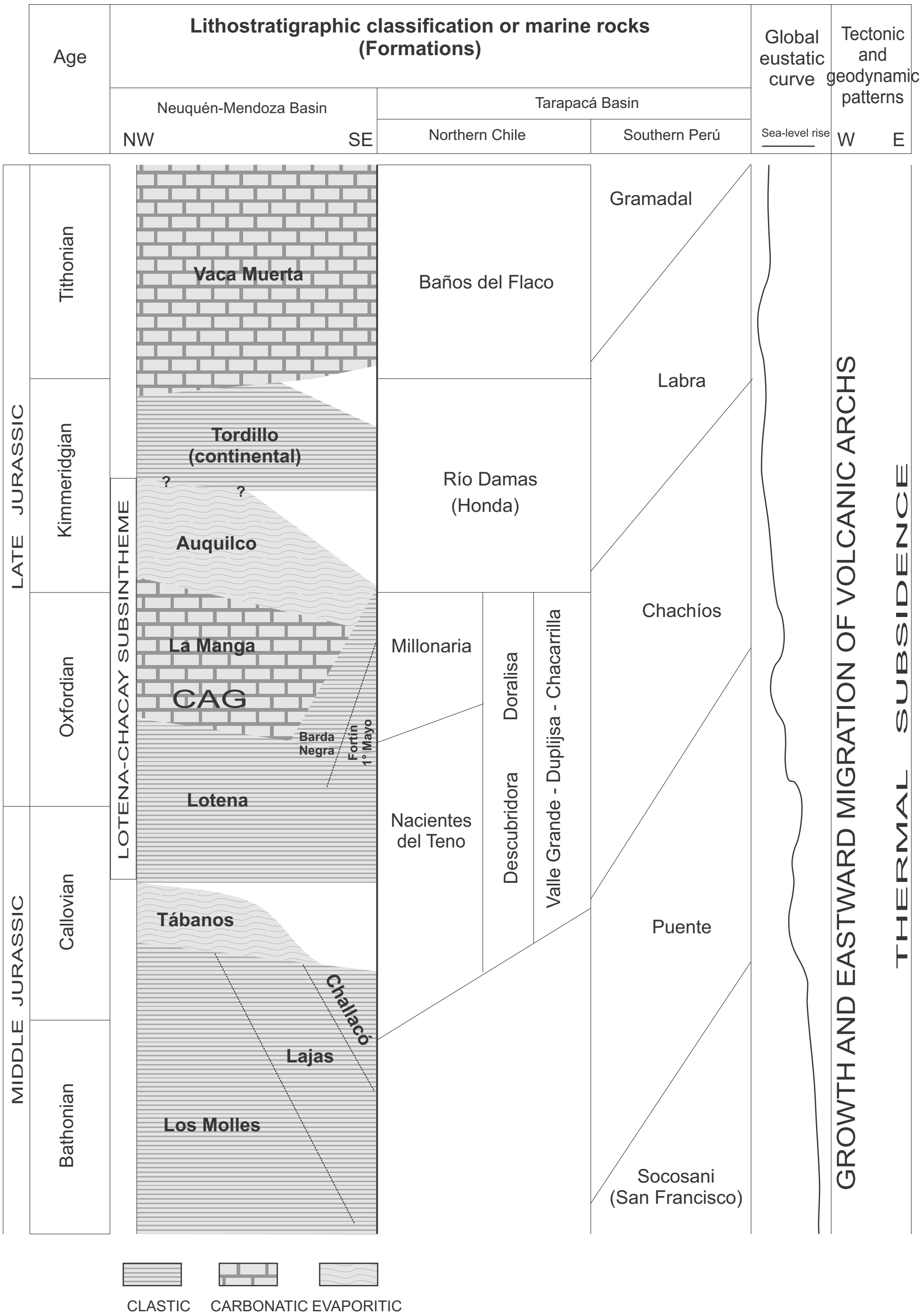


Figure 5. Stratigraphic classification of the Bathonian to Tithonian rocks of western South American Neuquén-Mendoza and Tarapacá basins. Based on Digregorio et al. (1984), Gulisano & Gutierrez (1995), Riccardi et al. (1992), Benavides (1962), Palacios-Moncayo (1995) and results of present study. Age of Lotena, La Manga, Barda Negra and Auquilco formations according with results in this paper. The Lotena-Chacay Subsintheme is a rock-unit which embraces conveniently the whole range of rocks included in the present study, bounded by wide regional discontinuities or discordances: the Intra-Malmic Discontinuity (DIM) and the Intra-Callovian Discontinuity (DIC). CAG: "Calizas Azules con *Gryphaea*" (Blue limestones with *Gryphaea*). Eustatic curve after Hallam (2001). Note that (1) vertical scale represents time, but by no means continuous, and (2) vertical range of lithostratigraphic units does not represent actual thickness but estimated chronostratigraphic age.

Unfortunately only poorly preserved ammonites (*Cubasphinctes*) were found in this outcrop.

At Portada Covunco a section was measured with a detailed exposure of the Lotena, La Manga, Tordillo and Vaca Muerta (Tithonian) formations (Fig. 8). The Lotena and La Manga formations are of interest here although no ammonites were found.

In the westernmost border of the basin at this latitude, in Lonquimay, Chile (Fig. 3) De La Cruz & Suarez (1997: 18) have cited Callovian Reineckeiidae (in beds probably equivalent to VM-1 - VM-2, see Fig. 8) which are up-today the latest Jurassic ammonites recorded in that margin of the basin at this longitude (cf. Chotin 1969); nevertheless upwards in the section occur abundant ?Oxfordian echinoderms in carbonates,

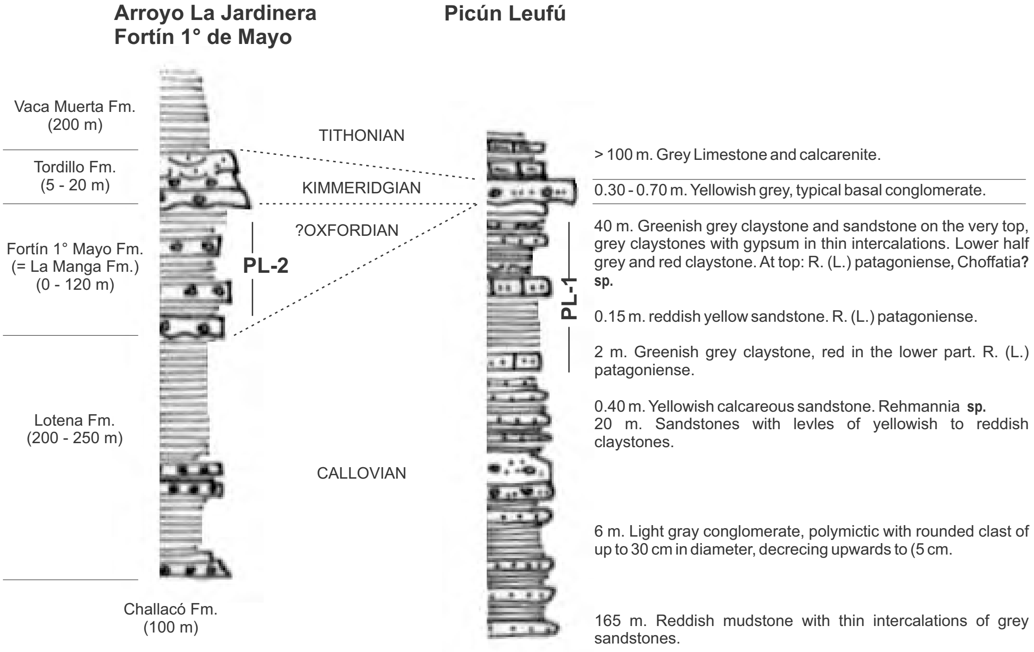


Figure 6. Log-sections of Arroyo La Jardinera (modified from Gulisano & Gutierrez 1995) and Picún Leufú (this report and Leanza & Hugo 1997), southern Neuquén-Mendoza Basin. Ocurrence of ammonites indicated as faunal level PL-1 (*Patagoniense* Biozone, *Patagoniense* Horizon) with abundant *Rehmannia (L.) patagoniense* [M&m] and *Choffatia* sp.; faunal level PL-2 (?*Pseudokranaus* Biozone) with *Perisphinctes (Otosphinctes?)* sp. (not seen during this study).

recalling the bed PC(1)-1 of the Portada Covunco section in fauna and lithology. The easternmost Oxfordian ammonite recorded at this longitude come from the subsurface rocks of the Barda Negra Fm., equivalent to La Manga Fm. in fauna and age (see Digregorio 1965, Stipanicic 1966). It consists of *Peltoceratoides* Spath, described by Leanza (1967 unpublished *fide* Digregorio 1972) from samples of Aguada Villanueva (Fig. 3), well-log N.AV.x-3 (2175 - 2180 m depth), most probably belonging to the *Pressulus* Bz. (see chapter Biostratigraphy)

Loncopué area (Fig. 9).- The Loncopué area, west-central Neuquén, depocentre, comprises the localities Campana Mahuida, Arroyo Agua Fría, and Arroyo Mulichinco. Geology of the area was studied by Groeber (1953), Dellapé et al. (1979), Zanettini (1979) and Riccardi & Westermann (1991). The sections and the sequence of faunal levels are shown in Fig. 9.

Chacay Melehué area (Figs. 10-12).- The localities comprised in this area are Chacay Melehué, Rahuecó and Estación Rajapalo, all representing central basinal sedimentary record. Geology of the area was described by Herrero-Ducloux (1948), Zöllner & Amos (1973), Dellapé et al. (1979), Zanettini et al. (1987), and more recently by Gulisano & Gutierrez (1995). The sections and sequence of faunal levels are shown in Figs. 10-12.

The section of Chacay Melehué yielded scarce ammonites in scattered outcrops. The complete ammonite succession is shown in Fig. 11. Some ammonites are described in the following chapter and most of the Perisphinctids were already described (Parent et al. 2006 *in print*). In the lower part of the section (faunal levels CM-1 and CM-2) there is a rich fauna partially described below, nevertheless collection bed-by-bed is difficult and its correct succession is not yet well known. Some additional figures of ammonites of these beds (*Oxycerites oxynotus* and *Rehmannia patagoniense*) are in Dellapé et al. (1979).

The section of Rahuecó was recently described by Gulisano & Gutierrez (1995) and summarized by Parent (1998a). In Fig. 12 a complete new section is shown comprising the Lotena, La Manga and basal Auquilco formations and the ammonite succession with indication of the faunal levels defined. Ammonites are abundant in some beds, but mainly fragmentary and/or crushed. In the upper half of the Lotena Fm. the best specimens are found in local concentrations of limestone in the form of small lenses of marl or small nodules. In the basal part of the Lotena Fm. ammonites and bivalves, like *Retroceramus* cf. *patagonicus* Philippi, 1899 (Fig. 13), occur better preserved in sandy marls and fine sandstones but they very hard to obtain in good condition or a single piece. In the lower part of the La Manga Fm. ammonites are also very hard to colect, they tend to occur in the lower face of the carbonate beds, mostly in the junction with the marl intercalations.

In Estación Rajapalo, as Riccardi & Westermann (1991: 12) pointed out, the Tábanos Fm. seems to be replaced by about five meters of conglomerate. The section of Lotena, La Manga and Auquilco formations is similar to that of Chacay Melehué, from top:

Auquilico Fm. (not observed).
La Manga Fm. (17.5 m): dark-gray limestones. Scarce bivalves
Lotena Fm. (135 m): the typical facies of greenish-gray to dark-gray sandstones and calcareous mudstones.
CM-4 (Bed G 246): 27 m below top: *Tenuisphinctes herreroduclouxi.*
CM-1 (Bed G 243): 90 m below top: *Rehmania* cf. *paucicostata.*
At base: 5 m of conglomerates.

Los Molles Fm. (367 m), not sampled.

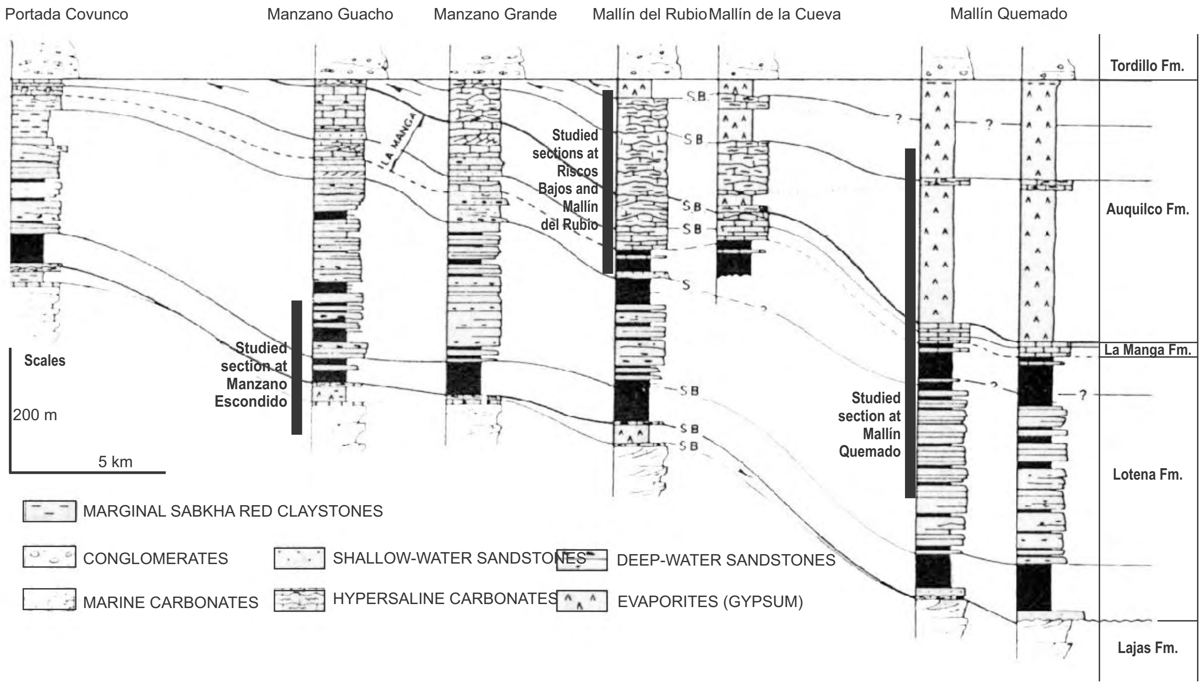


Figure 7. General Callovian-Oxfordian log-sections following facial geometry through a S - N cross section of the Sierra Vaca Muerta. Solid connecting lines indicate sequence boundary correlation, and cut-line the Lotena-La Manga Fms. boundary. SB: sequence boundary. More detailed sucessions of Portada Covunco, Manzano Guacho and Mallín Quemado / Mallín del Rubio in the following figure of the present report. Modified from Gulisano & Gutierrez (1995).

Vega de la Veranada-Sierra de Reyes area (Fig. 14).- This area comprises the localities Vega de la Veranada (Neuquén Province) and several localities of the Sierra de Reyes (Mendoza Province): Quebrada Remoredo, Arroyo de las Escaleras, Cañada Honda, Aguada de la Mula, Aguada de Reyes, Aguada del Ñaco and Aguada de Campos. The geology of the area was studied by Groeber (1933), Stipanicic (1966) and Riccardi & Westermann (1991). Selected columnar sections and the sequence of faunal levels are shown in Fig. 14.

Domuyo area (Fig. 15).- This area, named after the volcano Domuyo, comprises the localities Arroyo Los Baños and Arroyo Chari Lehue. The stratigraphy of this area was studied by Dellapé et al. (1979, see references therein). Most of the ammonites significant for this study were collected by C. Gulisano in 1981. Four faunal levels, DM-1 - DM-4, are distinguished (Fig. 15).

Bardas Blancas area (Fig. 16).- This area comprises the localities Bardas Blancas, Arroyo de la Vaina and Cajón Troncoso (Southwestern Laguna Maule, 36°10-20'S, 70°35-50'W, High Cordillera). The stratigraphy of this area was studied by Groeber (1953), Stipanicic (1966), Cornejo et al. (1982), Muñoz & Niemeyer (1984), Riccardi & Westermann (1991), Gulisano & Gutierrez (1995) and Beresi (2003). Oxfordian sponges were described by Beresi (2003). There is one of the sections described by Cornejo et al. (1982) of interest here, the outcrops at Estero Cristales (Column 2 in fig. 3 of Muñoz & Niemeyer 1984), summarized and reinterpreted in Fig. 16. Ammonites from Bardas Blancas and Arroyo de La Vaina were collected by C. Gulisano and from Cajón Troncoso by Cornejo et al. (1982). All the material was observed for this study (a set of casts of all the specimens of Cajón Troncoso was kindly prepared by Ernesto Pérez d'A, Santiago). It may be composed a succession with five faunal levels as shown in Fig. 16.

Santa Elena area (Fig. 17).- Localities included in this area are Arroyo Santa Elena, Cerro Las Yeseras, Arroyo La Bajada, Subida Mojón, Río del Cobre, Subida del Cobre, and Arroyo Los Blancos. The geology and stratigraphy of the area was formerly studied by Gerth (1925) and later reviewed by Stipanicic (1966, see references therein). The position of some of the ammonites in the rock succession is not sharply defined because the scanty occurrences through many of the thick and discontinuous outcrops of this area (cf. Gerth 1925, Stipanicic 1966, Stipanicic et al. 1976, Riccardi & Westermann 1991). Nevertheless reliable information about the relative positions of the ammonite assemblages is available, mainly based on the column of Cabeceras Arroyo Santa Elena as described by Stipanicic (1966). Ammonite occurrences are indicated in Fig. 17, mainly based on material collected by C. Gulisano.

Arroyo de la Manga area (Fig. 18).- This area comprises the localities Arroyo de La Manga and Arroyo Blanco. The normal lithostratigraphic sequence of the Tábanos, Lotena, La Manga, Auquilco and Tordillo formations is well represented (Sitpanicic 1951, 1966, Stipanicic et al. 1976, Riccardi & Westermann 1991). Data from Stipanicic (1951, 1966), discussed in Parent (1998a), and collections by C. Gulisano, indicate a succession of five faunal levels (LM-1 - LM-5) as shown in Fig. 18.

Puente del Inca area.- This area comprises outcrops of northwestern Mendoza and southwestern San Juan: Quebrada Vargas, Paso del Espinacito and Puente del Inca properly. This region belongs to the Cordillera Principal (Main Cordillera) and the geology was described by Schiller (1912), Gerth (1931), and more recently by Ramos (1985) and Sanguinetti (1987, 1989). The upper Jurassic stratigraphy has been dealt by Groeber (1951) and Stipanicic (1966), but upper Callovian to Kimmeridgian rocks remain poorly documented. The records include ammonites which define two faunal levels, from top:

Portada Covunco

Vaca Muerta Fm.

Opposite flank of the anticlinal. Marls, shales and nodular limestones, grey to black with abundant fauna of Tithonian ammonoids.

Tordillo Fm.

Yellowish brown sandstones and conglomerates, ferrugineous. There are clasts of up to 200 mm diameter in the upper part of the formation.

La Manga Fm. (inclination = 24°)

Bed PC(1)-15 (3 – 6 m): Thick and massive banks of greyish green, micritic limestones, upwards thin beds of light brown sandstone. This bed cups in the base of the conglomerate which conforms the base of the Tordillo Fm. *Euaspidoceras* sp. (cited by Groeber 1953); gastropods (Nerinaceans), ostreids and other bivalves. **[VM–8]**

Bed PC(1)-14 (0.20 m): Shaly-laminated, greenish grey fine sandstone, micaceous, with abundant ferrugineous inclusions.

Bed PC(1)-13 0.73 m): Massive limestone, greyish green, sometimes bluish, with concretions.

Bed PC(1)-12 (0.86 m): Green, laminated sandstone.

Bed PC(1)-11 (0.25 m): Yellowish brown, laminated sandstone and shales, micaceous with large concretions up to 200 mm in diameter.

Bed PC(1)-10 (1.13 m): Borravine red sandy limestone.

Bed PC(1)-9 (1.24 m): Biogenic limestone, greenish grey to greyish green, with abundant molluscs. At base there is a thin lenticular lumachelle, 0–30 mm thickness. Gastropods (Nerinaceans), bivalves.

Bed PC(1)-8 (1.77 m): Sandstones, locally laminated, borravine red. Lenses of greenish grey sandstone, micaceous. Abundant small nodules of dark red siltstone. Fossils at top: bivalves and gastropods.

Bed PC(1)-7 (0.13 m): greyish green shale with ferrugineous bands.

Bed PC(1)-6 (0.20 m): Sandstone, dark red, nodular and micaceous. Gastropods (Nerinaceans) and bivalves.

Bed PC(1)-5 (0.50 m): Greenish grey sandstone, locally shaly and micaceous.

Bed PC(1)-4 (0.20 m): Greenish grey, nodular sandstone with ferrugineous spots.

Bed PC(1)-3 (2.46 m): Limestone to calcarenite, greenish grey, with ferrugineous spots.

Bed PC(1)-2 (0.74 m): Shaly sandstone, greenish grey, micaceous.

Bed PC(1)-1 (> 4 m): Massive bank of greyish white limestone. It consists of a reef or bioherm very conspicuous in the field. Abundant fauna composed by minute gastropods, bivalves and brachiopods; tabular corals in the upper part, and flat corals in the upper 2 m of the bank. Base covered.

Lotena Fm.

Sandstones (non observed).

Manzano Escondido

La Manga Fm.

Bed ME(1)-16: Several meters of carbonates with corals (non-exposed).

Bed ME(1)-15: 10 m of yellowish gray sandstone, scarce ostreids at base.

Bed ME(1)-14: 1 m of gray sandy limestone with abundant ostreids in lumachellic concentrations (non-exposed).

[covered]

Lotena Fm.

Bed ME(1)-13: Several meters (> 10) of gray to greenish and reddish tabular sandstones. No fossils.

[covered]

Bed ME(1)-12: 2 m of sandy limestone.

Bed ME(1)-11: 0.20 m tabular sandstone with thin shaly partitions.

[covered]

Bed ME(1)-10: 15.6 m of gray to greenish calcareous nodular mudstones with thin partitions of shale. Abundant ferrugineous material dispersed. Loose in the field: *Araucanites* cf. *prereyesi* n. sp. **[VM-4]**.

[covered].

Bed ME(1)-9: 3.6 m of greenish gray mudstone, ferrugineous material dispersed.

Bed ME(1)-8: 0.20 m bed of nodular greenish gray marl in nodules, yellow weathered. Abundant small limonitic fossils dispersed in the field coming from this bed: gastropods (LPB 740/1), bivalves (LPB 470/2), including a specimen of "*Lucina*" sp. (LPB 716), brachiopods, and equinoderm pieces. Ammonites: *Hecticoceras* cf. *lairense* (abundant), *H.* cf. *virguloides*, lytoceratid (fragment of a large specimen), *Paracuariceras*? sp., *Concavites*? sp., *Peltoceras* cf. *convexum* (Hillebrandt); large number of nuclei of at least three species belonging to the Eurycephalitinae, Perisphinctidae and Hecticoceratinae. **[VM-3].**

Bed ME(1)-7: 5 m of gray to greenish brown mudstone and siltstone, with beds of dark gray marl intercalated.

Bed ME(1)-6: 0.50 m of shaly marl with large black concretions, pinkish weathered. *Choffatia*? sp.

Bed ME(1)-5: 1 m of gray to greenish brown mudstone and siltstone, with beds of dark gray marl intercalated. Thin beds of yellow laminated sandstone intercalated.

Bed ME(1)-4: 0.01 – 0.05 m bed of yellow sandstone very conspicuous in all the sections of the locality.

Bed ME(1)-3: 5 m of dark greenish gray siltstone, polyedric disjunctions in small nodules. There is no well defined bedding, and upwards massive material with some local concentrations of calcareous forming nodular bodies. There occur some siliceous and calcareous small bodies dispersed in the matrix. There is much ferrugineous material, mostly concentrated in dense concretions with abundant ammonites rather completely preserved as internal molds. In the siltstone the ammonites are well preserved but some times only as impressions. In the upper part: *Choffatia* spp. A & B, *Alligaticeras*? aff. *raguini*, *Euaspidoceras* n. sp. aff. *ovale* (seen in the field), *Hecticoceras* (*Sublunuloceras*) cf. *lairense*, *H. (S.)* cf. *discoides*, *Hecticoceras hersilia* (d'Orbigny *sensu* Maire) (seen in the field), *Taramelliceras*? sp. A. In the lower part: *Rehmannia patagoniense*, *R.* cf. *patagoniense*, *Araucanites* cf. *prereyesi* n. sp. **[VM-2]**.

(?) Base of Bed ME(1)-3: *Choffatia* sp. in pinkish calcareous musdstone (MOZP-6822).

Bed ME(1)-2: 1-2 m of yellowish to gray and reddish tabular and massive sandstones. *Rehmannia patagoniense*. **[VM-1]**.

[covered]

Lajas Fm.

Bed ME(1)-1: Coarse orange to gray conglomerate with large rounded clasts dispersed. This bed forms a conspicuous elevated crest in the locality and topographically backwards follows the underlying Lajas Fm.

Riscos Bajos / Mallín del Rubio

Auquilco Fm.

Bed RB(1)-7: c. 50 m of gray calcareous sandstone with scarce small hard fossil fragments.

La Manga Fm. (total 100 m)

Bed RB(1)-6: c. 70 m of bluish gray marl, withish weathered. This bed makes the floor of the climbing road towards the antena from the quarry. *Cubasphinctes*? sp. **[VM-7]**

Bed RB(1)-5: 0.40 – 1.00 m of gray and greenish sandstone. Abundant large and medium bivalves as internal molds.

Bed RB(1)-4: 5 m of gray limestone with so abundant ramose corals that is forming a coral-reef (identical to bed 15 of Portada Covunco section).

Bed RB(1)-3: c. 10 m greenish gray sandstone.

[covered]

Bed RB(1)-2: 5 – 15 m of blue to dark gray, hard biogenic limestone. Abundant corals, large gastropods and diverse bivalves, scarce ammonites. *Araucanites reyesi*. **[VM-6]**.

Lotena Fm. (total 300 m)

Bed RB(1)-1: c. 50 m gray and yellowish sandstones. Bivalves as internal molds in the upper part.

[covered].

Mallín Quemado

Auquilco Fm.

Bed MQ(1)-4: c. 350 m of gypsum.

La Manga Fm.

Bed MQ(1)-3: c. 30 m of bluish-greenish gray marl. Near top: *Passendorferia* cf. *torcalense*, *Perisphinctes* cf. *mindowe*, *Cubasphinctes cubanensis*. The base is covered so that the passage to the underlying Lotena Fm. is not visible. **[VM-7]**.

Lotena Fm. (some 340m)

[covered]

Bed MQ(1)-2: c. 60 m of dark gray to greenish mudstones with black marly and yellowish sandy limestone partitions. Top of the segment: perisphinctid poorly preserved in a bed of greenish marl. *Peltoceratoides* cf. *presssulus* from a lower marl bed, and a belemnite in concretion from a lower sandy limestone bed, below the ammonite. **[VM-5]**.

[covered]

Bed MQ(1)-1: c. 100 m of sandy mudstone and siltstone like in Manzano Escondido.

[non-observed]

Figure 8. Sierra Vaca Muerta area: Portada Covunco (bridge Ruta 22 over Arroyo Covunco, near Zapala), Manzano Escondido, Riscos Bajos / Mallín del Rubio, and Mallín Quemado log-sections, ammonite occurrences and faunal levels. The occurrence of *Euaspidoceras* sp. in VM-8 of Covunco section corresponds to a citation by Groeber (1953). Biostratigraphy: VM-1- VM-4: *Patagoniense* Bz.; VM-5: *Pressulus* Bz; VM-6: *Pseudokranaus* Bz.; VM-7: *Passendorferia* Bz.; VM-8: *Tarapacaense* Bz.

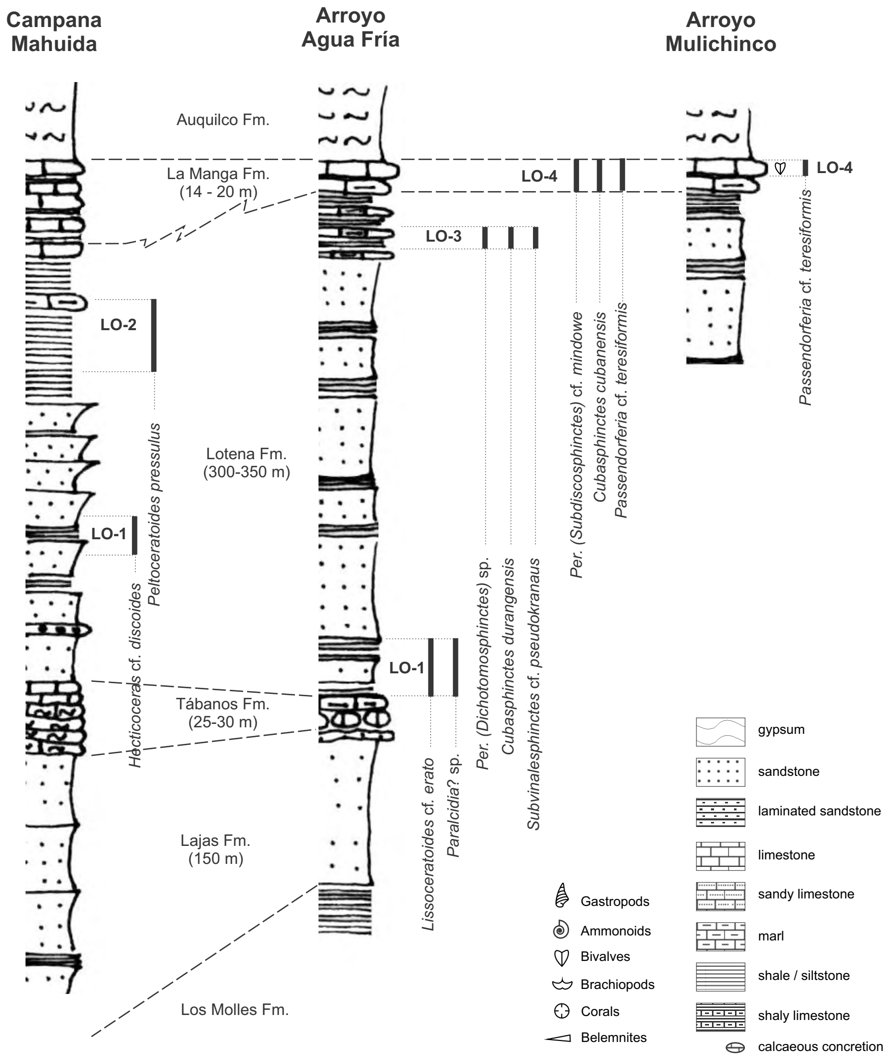


Figure 9. Loncopué Area. Log-sections, ammonites and faunal levels (LO-1 - LO-4) of Campana Mahuida, Arroyo Agua Fría and Arroyo Mulichinco. Log sections based on Groeber (1953), Dellapé et al. (1979), Riccardi & Westermann (1991) and present report (Arroyo Mulichinco). Broken lines connecting logs indicate lithostratigraphic correlation. Equivalence of faunal level with field-levels of Gulisano in labels of Museo de La Plata: LO-1 = G390 (Arroyo Agua Fría); LO-2 = G324 (Campana Mahuida); LO-3 = G391 (Arroyo Agua Fría); LO-4 = G398 (Arroyo Agua Fría). Biostratigraphy: LO-1: *Patagoniense* Biozone; LO-2: *Pressulus* Biozone; LO-3: *Pseudokranaus* Biozone; LO-4: *Passendorferia* Biozone.

PI-2: *Lithacosphinctes desertorum* (Stehn) in sandy limestones of La Manga Fm. at Quebrada Vargas (Sanguinetti 1987, 1989), and *Euaspidoceras* sp. (Ramos 1985). In the collection of the Museo de La Plata there is a specimen (MLP 3328) from Paso del Inca labeled as "*Peltoceras*", which actually belongs to *Euaspidoceras* closely resembling *E.chilense* Leanza. [*Desertorum* Biozone].

PI-1: *Rehmannia (L.) patagoniense* (Weaver) and *Oxycerites* sp. in reddish sandstones of Lotena Fm. at Paso del Espinacito (Alvarez 1996, see Parent 1998a). [*Patagoniense* Biozone].

Tarapacá Basin

The most of the late Callovian and Oxfordian ammonites recorded in this basin is known from Northern Chile (Fig. 4) and was described in several papers in last years (Gröschke & Zeiss 1990, Gygi & Hillebrandt 1991, Hillebrandt & Gröschke 1995, Gröschke & Kossler 1999, Hillebrandt et al. 2000). These papers contain descriptions of several faunas and a local biostratigraphic subdivision. In addition to these recent papers what follows consists of a re-evaluation and description of ammonites collected by A. Hillebrandt (housed at the Natural History Museum of Basel) which had not been described, and the review of the ammonite succession described by Pérez d´A (1982) from the Callovian of Quebrada Asientos (southernmost TB), which are useful for correlation between the NMB and the TB. In the following discussion we refer the Chilean localities as in Fig. 4.

Potrerillos, Quebrada Asientos.- This is the southernmost locality of the Tarapacá Basin, close to the Antofagasta Land (Fig. 2), with record of Callovian ammonites. The detailed stratigraphic study of Pérez d'A (1982) indicates the occurrence of late Callovian ammonites in the section at 6.1 km west of Estación Montandón. The upper part of the section was described as follows, from top downwards (ammonite identifications as in Pérez d'A 1982):

Asientos Fm.
Bed P38A (8 m): Limestone. *Gryphaea* sp.
Bed P37A-C (> 110 m): Volcanics
Bed P36B (7.5 m): Limestone

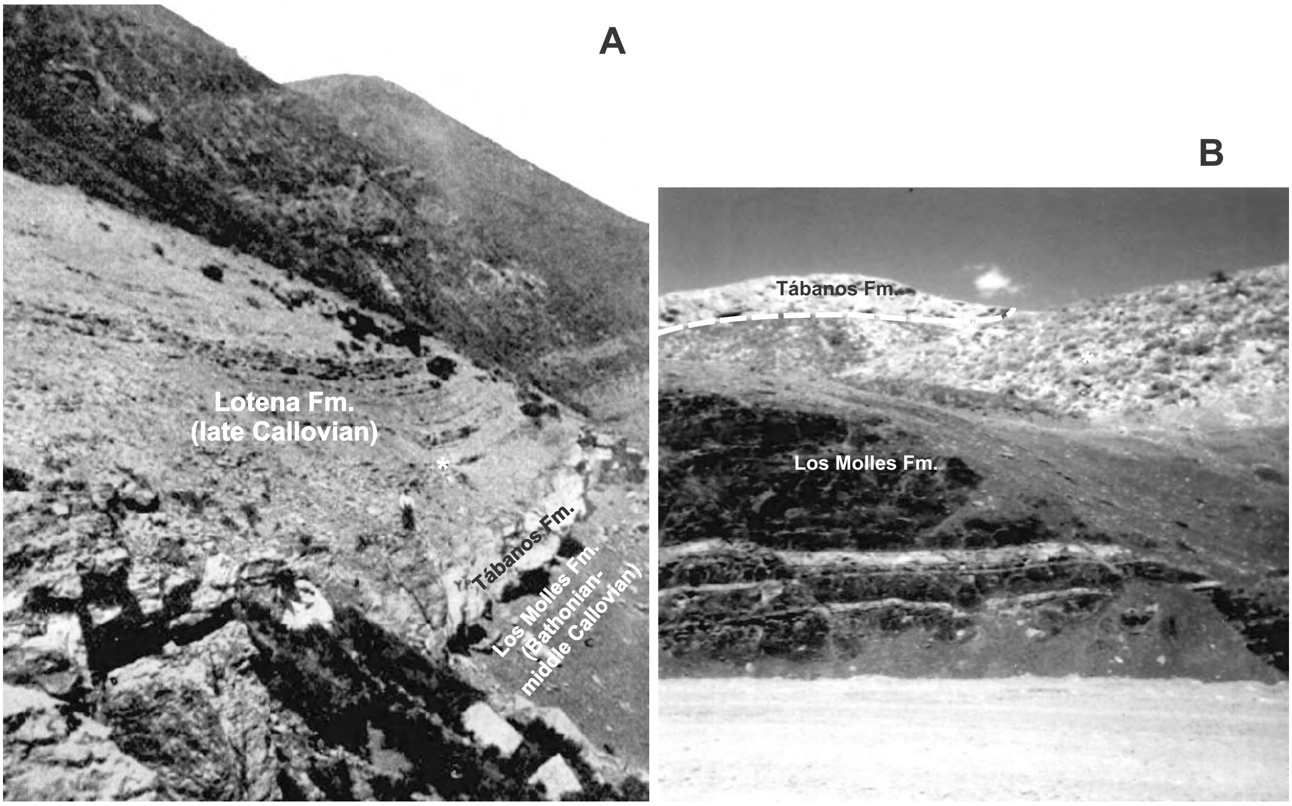


Figure 10. Chacay Melehué sections showing the upper part of Los Molles Fm., the Tábanos Fm. (4 - 10 m in thickness) and the lower part of the Lotena Fm. **A**: Reproduction of the original photograh of Leanza (1946: fig. 1) showing the bed (*) from where was collected the type series of *Oxycerites oxynotus* (Leanza, 1946). The current lithostratigraphic nomenclature distinguish clearly the individuality of the Tábanos Fm., underlying the Lotena Fm. (late Callovian to early Oxfordian in age). **B**: Photograph taken in 1987 during the construction of a new part of the National Road 43, cutting the Los Molles Fm. coronated by the conspicuous bank of gypsiferous limestones of the Tabanos Fm. Approximately 30 km from Chos Malal. Stratigraphy and paleontology of Los Molles Fm. in this section (late Bathonian to early Callovian) is described in Parent (1998b).

Bed P36A (6 m): Limestone. *Gryphaea* sp.
Bed P35B-D (20 m): Limestone. Bivalves and ammonites in four levels:
    4- *Reineckeia* sp.
    3- *Peltoceras* sp., *Pseudopeltoceras* sp., "*Reineckeites*" sp.
    2- *Reineckeia* sp., *Reineckeia (Kellawaysites)* sp.
    1- *Reineckeia* ex gr. *densestriata*, *R*. cf. *paucicostata*, *Reineckeia* ex gr. *inermis*, *Reineckeia*? sp.
Bed P35A (6.5 m): Limestone and sandstone. Ammonites in two levels:
    2-*Pseudopeltoceras* cf. *cricotum*, *Parawedekindia*? sp.
    1- *Pseudopeltoceras* cf. *monacanthum*, *Pseudopeltoceras* sp., *Reineckeia* cf. *douvillei*, *Reineckeia* sp.
Bed P34B (16 m): Volcanics
Bed P34A (22.5 m): Limestone. Bivalves, hexacorallia, gastropods. Ammonites in the lower part:
    Reineckeia cf. *eauctis*, *Reineckeia* sp.
Beds P33-P32 (63 m): Volcanics
Bed P31A-B (11 m): Limestone. Bivalves, corals, brachiopods and gastropods.
- Follows below about 80 m of massive sandstone without ammonites.

A preliminary biostratigraphic classification indicates that beds P38A to P36A could belong to the *Pseudokranaus* Bz. accounting for the occurrence of *Gryphaea* comparable to those of the Arroyo de La Manga. Bed P35B-D to P35A may belong to the *Patagoniense* Bz. accounting for the occurrence of *Pseudopeltoceras* and microconchiate *Peltoceras* in the form of "*Parawedekindia*? sp.", and accessory *R*. cf. *paucicostata* like in Estación Rajapalo (NMB).

Quebrada de los Burros, Aguada del Carretón, Aguada el Oro (Fig. 19).- This transect is important here for two main reasons: (1) It includes the type locality and section of *Perisphinctes hillebrandti* n. sp. and *Araucanites prereyesi* n. sp., both recorded also in the NMB; and (2) the ammonte successions may be clearly correlated with those of the Neuquén-Mendoza with some confidence (discussion below). Descriptions of the stratigraphy and the ammonites were given by Gygi & Hillebrandt (1991) and Hillebrandt & Gröschke (1995). Discussion and re-interpretation of some of those ammonites are given below.

***Quebrada Sandón*.-** In an intensely folded section Hillebrandt (see Gygi & Hillebrandt 1991) collected in 1966 some perisphinctid ammonites (subfamily Vinalesphinctinae, described below) which are important for correlation with the NMB and for paleobiogeography. The most probable normal succession is as follows, from top (bed numbering after Gygi & Hillebrandt 1991: fig. 8a):

About 70 m of gypsum.
About 250 m of limestones and marls with calcareous concretions.

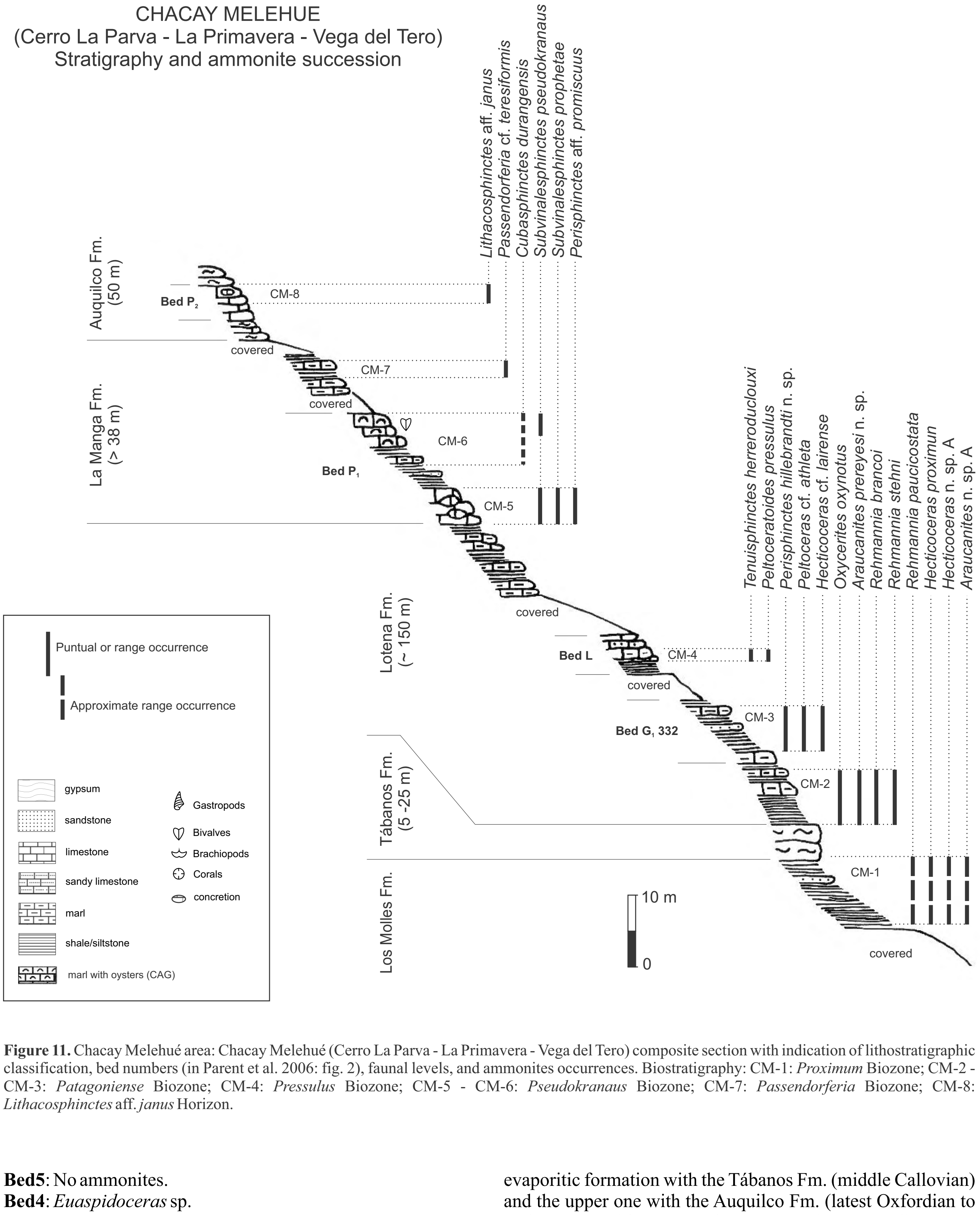


Figure 11. Chacay Melehué area: Chacay Melehué (Cerro La Parva - La Primavera - Vega del Tero) composite section with indication of lithostratigraphic classification, bed numbers (in Parent et al. 2006: fig. 2), faunal levels, and ammonites occurrences. Biostratigraphy: CM-1: *Proximum* Biozone; CM-2 - CM-3: *Patagoniense* Biozone; CM-4: *Pressulus* Biozone; CM-5 - CM-6: *Pseudokranaus* Biozone; CM-7: *Passendorferia* Biozone; CM-8: *Lithacosphinctes* aff. *janus* Horizon.

Bed5: No ammonites.
Bed4: *Euaspidoceras* sp.
Bed3: No ammonites.
Bed2: *Cubasphinctes durangensis* (Burckhardt); other perisphinctids not examined.
Few meters of gypsum and limestone.
More than 20 m of marls and limestones with concretions.
Bed1: *Reineckeia* sp.
Porphyrite.

It is interesting to note the time-equivalence of the lower evaporitic formation with the Tábanos Fm. (middle Callovian) and the upper one with the Auquilco Fm. (latest Oxfordian to early Kimmeridgian) of the NMB (Fig. 5). Indicating a synchronic paleogeographic dynamics with at least the southern part of the TB during the Callovian-Oxfordian interval.

Placilla Caracoles, Caracoles.- Harrington (1961) described the Oxfordian succession of Placilla Caracoles as “Doralisa Shales” distinguishing three lithological units O_1-O_3 (Harrington *in* Leanza 1947b: 287). The succession consists of

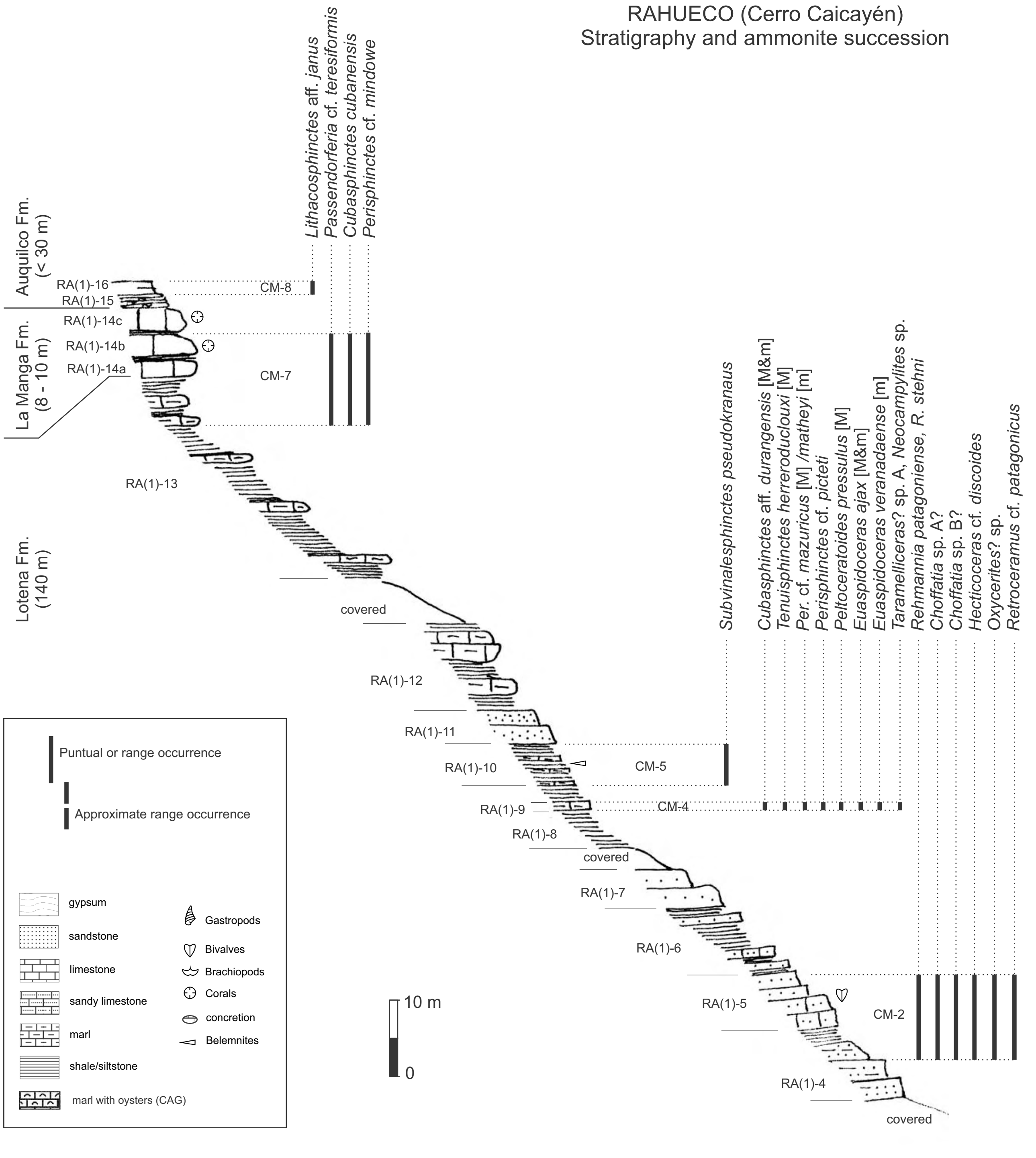


Figure 12. Chacay Melehué area: Rahuecó (Cerro Caicayén) section with indication of lithostratigraphic classification, bed numbers, faunal levels, and ammonite occurrences. Biostratigraphy: CM-2: *Patagoniense* Biozone; CM-4: *Pressulus* Biozone; CM-5: base of *Pseudokranaus* Biozone; CM-7: *Passendorferia* Biozone; CM-8: *Lithacosphinctes* aff. *janus* Horizon.

about 70 m of shales and marls towards the top becoming highly gypsiferous, what correlates in lithology, and roughly in age, with the Auquilco Fm. of the NMB. The ammonite fauna was recently discussed by Chong et al. (1984) concluding that its age should be mainly Bifurcatus to early Bimammatum zones. The ammonites of level O_3 show significant resemblance with those of level 3 of Aguada Carretón (see Fig. 19) at the southern portion of the TB (see Gygi & Hillebrandt 1991: 146), here attributed to the upper Transversarium-lower Bifurcatus zones. *Euaspidoceras chilense* Leanza may be supposed Bifurcatus Zone in age. *Perisphinctes harringtoni* Leanza, 1947 [M] is roughly identical at comparable diameter with *Perisphinctes (Dichotomoceras) andium* Steinmann, 1881 [m] suggesting they are a sexual dimorphic pair. Inner whorls of these species are finely and closely spaced ribbed, in the form of typical *Perisphinctes* s.s. of the late Transversarium-early Bifurcatus zones (cf. Myczynski et al 1998). Comparison with Tethyan species leads to *P. (D.)*

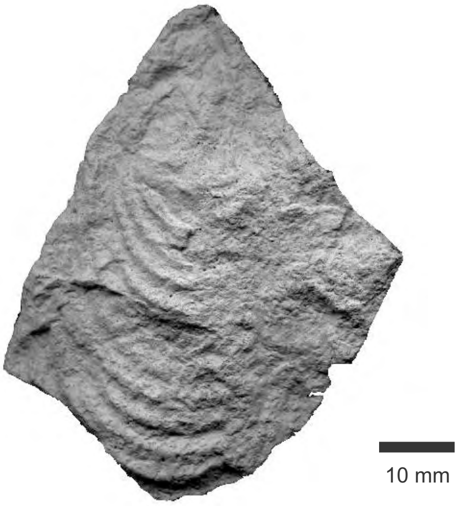


Figure 13. *Retroceramus* cf. *patagonicus* (Philippi, 1899), Rahuecó (C. Caicayén) base of Lotena Fm., faunal level CM-2, *Patagoniense* Biozone. Specimen LPB 756. Natural size (x1).

stenocycloides Siemiradzki, 1891 as indicated by Gygi & Hillebrandt (1991: 152) and the macroconch *P. (P.)* gr. *panthieri* Enay, 1966 (in Meléndez 1989: pl. 28: 1-3, pl. 29: 1, pl. 31: 1a-b; cf. Malinowska 1972: pl. 10: 1).

Southern Peru, northern Tarapacá basin (Fig. 2).- Knowledge of the northern part of the TB, e.i. southern Peru, is very poor and consists of relatively recent data given by Dávila (1988) from ammonites of the Puente Fm. (Yura Group) of Cailloma, listed by this author as: *Reineckeia* cf. *douvillei* Steinmann, *R.* cf. *brancoi* Steinmann, *R.* cf. *tuberosa* Burckhardt, *Lilloettia* sp., *Bositra buchii* (Roemer), *Megasphaeroceras* sp., *Ostrea* sp. and *Subgrossouvria* sp. indicating, nominally, Bajocian to Callovian age; and *Perisphinctes* sp. assigned to the Oxfordian by Dávila (1988: 15). Gröschke & Zeiss (1990) described several Oppeliidae from the Chachíos Fm. (sic) at Yura and Omate (Arequipa Province), including *Hecticoceras singulicostatum* Gröschke & Zeiss, 1990 (late Callovian), *Horioceras* aff. *bidentatum* (Quenstedt, 1846) (late Callovian), *Distichoceras* aff. *nodulosum* (Quenstedt, 1887) (late Callovian), *Distichoceras bicostatum* (Stahl, 1824) (late Callovian). There are many other scattered citations of ammonites which could belong to late Callovian and/or Oxfordian forms but unfortunately they are non-figured and the material could not be traced. A small sample of badly preserved perisphinctids comes from a section of the "upper series" of the Yura Group at Río Parco, Apurimac, Antabamba (72°42'59"W, 14°35'29"S). These ammonites (Servicio Geológico y Minero de Peru: SGM 1037, SGM 1037-1) were cited as *Perisphinctes (Dichotomosphinctes)* cf. *neohispanicus* Burckhardt (Palacios-Moncayo 1994: 16) but after inspection of photographs kindly prepared by O. Palacios-Moncayo (INGENMET, Lima) it was concluded that they could belong to any middle to late Oxfordian species of *Perisphinctes.* There is a citation of *Euaspidoceras* sp. (Montoya et al. 1994: 23) collected from the lower part of the Guaneros Fm. mapped at the Lomitas-Palpa-Nasca-Puquio, but the specimen seems to be lost (Palacios-Moncayo, *pers. comm.* 05/07/1995). Benavides (1962) indicates with no more details the occurrence of *Perisphinctes* of Oxfordian aspect (sic). It may be concluded that the record of marine late Callovian to Oxfordian rocks with ammonites in southern Peru (northern portion of the Tarapacá Basin), although up today poorly known, could be widespread.

Northwestern South America: Venezuela and Colombia

There is no published record, according to the knowledge of the author, of Oxfordian ammonites from this region. Bürgl (1960) cited *Nebrodites* and *Idoceras* which nominally indicate a Kimmeridgian age.

SYSTEMATIC PALEONTOLOGY

Procedure and conventions

The studied material is housed at the Laboratorio de Paleontología y Biocronología (LPB), Universidad Nacional de Rosario; Museo Prof. Olsacher (MOZP), Zapala, Neuquén; Museo de La Plata (MLP); Servicio Nacional de Geología y Minería de Chile, Santiago (SNGM) and Natural History Museum of Basel (NHMB-J). Casts and photographs of types and other specimens were kindly provided by Ernesto Pérez d'A (SNGM), Gerhard Schairer (Bayerische Staatssammlung für Paläontologie und Geologie, BSPM), Milena Pika-Biolzi (ETH Zürich, Switzerland), and Georg Heumann and Martin Sander (Bonn University Museum, IPB). Bodychamber is abbreviated with Bc and phragmocone with Ph; macroconch (female): [M], microconch (male): [m]. Measurements of figured specimens are listed in Appendix 1, and are indicated as follows: diameter (D), diameter at the last adult septum (D_{ls}), final adult diameter at peristome (D_p), umbilical width (U), whorl width (W), whorl height (H_1), and whorl ventral (or apertural) height (H_2), all given in millimeters [mm]; approximated or estimated values marked with (^{e}); length of bodychamber (L_{Bc}) in degrees [°]. Number of primary (P) and ventral (V) ribs per half whorl. This form of counting ribs per half whorl has two advantages respect countings per complete whorl: (1) it is more sensitive, reflecting smaller changes in ribbing density, (2) is less exigent with quality of material, giving more complete sets of measurements for ontogenetic trajectories with incomplete specimens. The only serious disadvantage arises when comparisons with published data are attempted, because most authors since many years ago (e.g., Arkell 1935-1948, Enay 1966, Gygi & Hillebrandt 1991) have used the counting of ribs per a complete whorl, and direct transformations are not yet studied. Open nomenclature follows Bengtson (1988). The biozones used for describing the distribution of the species are defined in the chapter on biostratigraphy.

Delimitation of species

The choice of limits between species depends on the species concept adopted. A preliminar, straight approach is to consider the species as the group of specimens which resemble each other enough (morphologic continuity) to can be distinguished from the closest or most similar groups (morphologic discontinuity) within the same genus. It is the essence of any morphologic taxonomy or classification, where the limits are set for each author in different ways. This procedure is empirical, and non-arbitrary (*sensu* Simpson 1951: 286), underlying in some form all possible biospecific classifications. Moreover, the morphologic classification is applied in neontology whereas the criterion of interfecundity is rarely considered, even when this fact is the core of the species

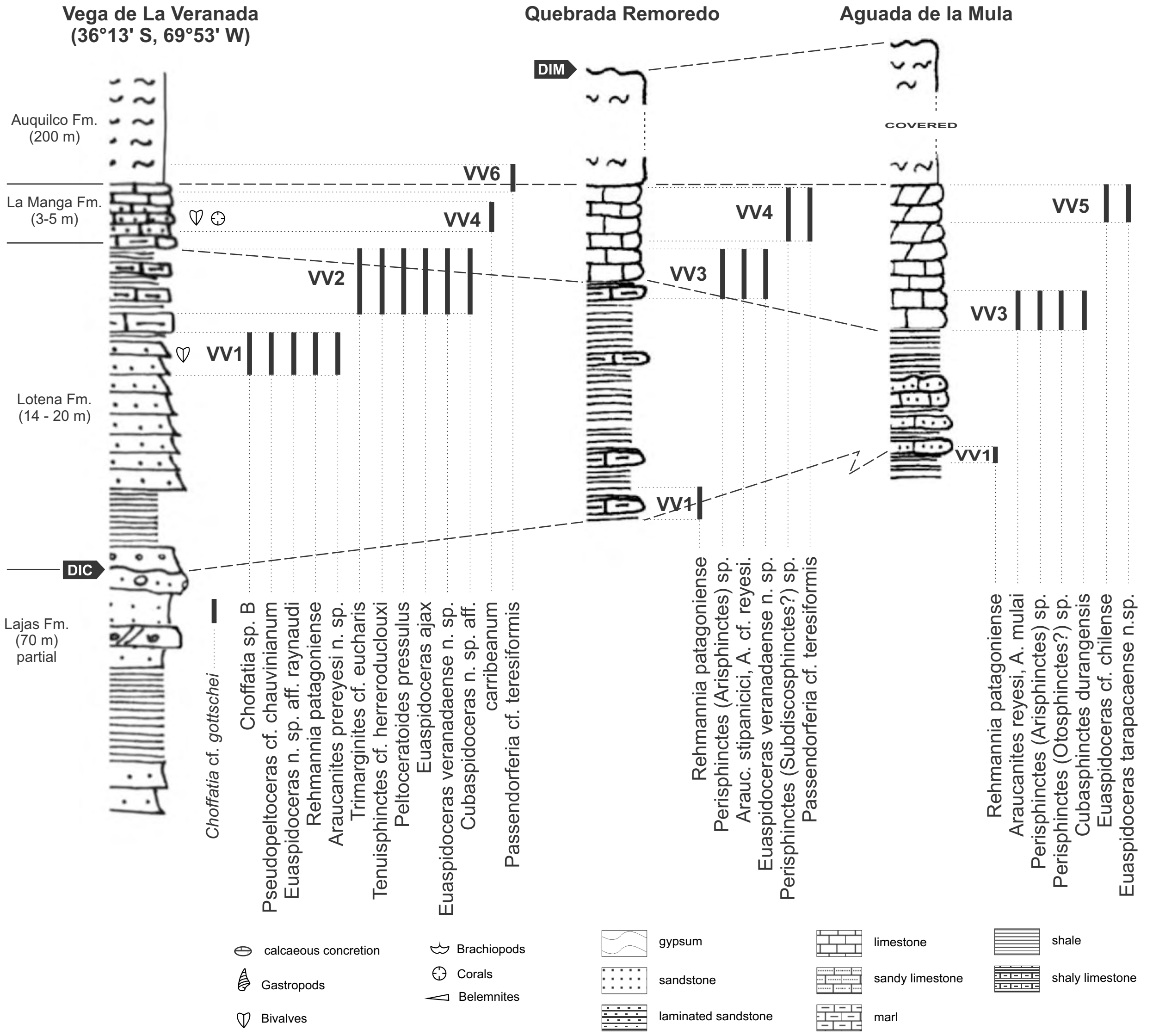


Figure 14. Log sections and ammonite occurrences of Vega de la Veranada-Sierra de Reyes area. VV-1 - VV-7 faunal levels as discussed in text. Dashed lines lithostratigraphic correlation. Thickness of formations indicated numerically for V. Veranda section and proporcionally in remaining sections. Correspondence between faunal levels and beds of C. Gulisano and Riccardi, Damborenea & Manceñido (labels in collection): Vega de la Veranada (G1 286 = VV-1, G1 287 = VV-2, G1 288 = VV-5), Quebrada Remoredo (G 1139 = VV-1, G 1140 = VV-2), and Aguada de la Mula (M 222 = VV-1, M 224-225 = VV-3, M 227-229 = VV-6). Biostratigraphy: VV-1: *Patagoniense* Biozone; VV-2: *Pressulus* Biozone; VV-3: *Pseudokranaus* Biozone; VV-4: *Passendorferia* Biozone; VV-5: *Tarapacaense* Biozone; VV-6: ?*Desertorum* Biozone.

concept (Simpson 1951, Tintant 1952, see Miller 2001 for a recent discussion). A good example of morphologic classification of living cephalopods with subsequent support of genetic variation is in the studies on *Nautilus* by Saunders (1987), Swan & Saunders (1987), Woodruff et al. (1987), Wray et al. (1995). Nevertheless the life-history of ammonoids was very different from that of nautiloids to be taken as a guide; moreover their shells have different growth modes as indicated by the different laws under which are established the relationships between the dimensions of their shells during growth (Parent & Greco 2006 *in print*). The study of delimitation of species in other groups of living cephalopods, especially coleoids, would be an interesting starting point for arriving to reliable criteria for delimitation of ammonoid species by means of their shells.

A robust biospecific approach for classification of ammonites has been widely elaborated by Callomon (1985, 1988) and Callomon et al. (1992) arriving to an arbitrary and reliable procedure by which morphological similarity is relegated to a secondary place. This biospecific approach seems to be more natural than the morphospecific but is not applicable in the present study, because of the early stage of knowledge of the described faunas. The taxonomic approach adopted here is mainly a vertical, morphospecific classification (*sensu* Callomon 1985). The horizontal classification, assuming intraspecific variability sometimes beyond the limits accepted in the morphologic approach, is limited by the incipient knowledge on several new forms. The local nominal species, when available, have been mainly preserved, in spite of some evidence of possible synonymy with Caribbean and/or

		ARROYO LOS BAÑOS	ARROYO CHARI LEHUE
Auquilico Fm. About 80 m of gypsiferous limestones.			
La Manga Fm. 8-10 m, dark gray and bluish-gray marls; shales in the lower part.	**DM-4**	Beds G 206: *Passendorferia* sp. [MLP 16949-16951]	
	DM-3	Bed G 203: *Euaspidoceras* cf. *tarapacaense* n. sp. [MLP 16946], *Perisphinctes* sp. [MLP 16947]	
	DM-2	Bed G 202: *Subvinalesphinctes prophetae* [MLP 16942]	Bed G 193: *Subvinalesphinctes prophetae* [MLP 16912, 16914-16915]
Lotena Fm. 40 m siltstones with limestone banks. 30 m fine grayish-whitish sandstones. 30 m finely sandy, reddish to gray siltstones.	**DM-1**	*Hecticoceras (Sublunuloceras)* sp. (*in* Dellapé et al. 1979)	
Tábanos Fm. About 30 m of gypsiferous limestone.			

Figure 15. Sections and ammonite occurrences in the Domuyo Area. Arroyo Los Baños and Arroyo Chari Lehue, Northern Neuquén Province. Stratigraphy based on Dellapé et al. (1979), ammonites mainly of C. Gulisano collection. Biostratigraphy: DM-1: *Patagoniense* Biozone; DM-2: *Pseudokranaus* Biozone; DM-3: ?*Pseudokranaus* Biozone; DM-4: *Passendorferia* Biozone.

Tethyan forms. This is stressed under discussion and comparison of each species. This approach, although provisional, has two advantages: (1) it is useful for not hide the local species or morphotypes under European labels, (2) helps in to avoid circular arguments in time-correlation by similarity of nominal species.

Order Ammonoidea Zittel, 1884
Suborder Ammonitina Hyatt, 1889
Superfamily Haploceratoidea Zittel, 1884
Family Lissoceratidae Douvillé, 1885
Genus *Lissoceratoides* Spath, 1923
Type species: *Ammonites erato* d´Orbigny, 1850 by OD

***Lissoceratoides* cf. *erato* (d´Orbigny, 1850) [M]**

Material.- Two poorly preserved specimens from Arroyo Agua Fría (LO-1) and Arroyo Los Blancos (SE-5) [MLP 17336].
Remarks.- Smooth, moderately compressed and involute shells.
Distribution.- *Patagoniense* Bz. of Arroyo Agua Fría (associated with *Paralcidia*? sp.) and *Pressulus* Bz. of Arroyo Los Blancos (associated with *Peltoceratoides pressulus* and *P.* cf. *pressulus*).

Family Oppeliidae Douvillé, 1890
Subfamily Oppeliinae Douvillé, 1890
Genus *Oxycerites* Rollier, 1909
Type species: *Ammonites aspidoides* Oppel, 1862
Subgenus *Paroxycerites* Breistrofer, 1947
[= *Pseudoppelia* Leanza, 1946, subj. synonymy]
Type species: *Ammonites subdiscus* d´Orbigny, 1842

***Oxycerites (Paroxycerites) oxynotus* (Leanza, 1946) [M]**

*1946 *Streblites (Pseudoppelia) oxynotus* n. sp. - Leanza: 67, pl. 1: 1-2 (lectotype), *non* 3, 4, *non* 5.
1979 *Oxycerites oxynotus* (Leanza). - Dellapé et al.: 9 3 , pl. 1: 1-2, *non* 3-4, pl. 2: 1-2.
1984 *Oxycerites*. - Verma & Westermann: 36.

Remarks.- Leanza (1946) described the species from a type series composed by 12 specimens (sic) from Callovian beds of the lower part or the Lotena Fm. at Chacay Melehué. He figured five specimens but did not designate a type specimen. The specimen in the pl. 1, fig. 2 of Leanza (1946) is here designated lectotype; it is a phragmocone as the remaining figured specimens of the type series, but the best preserved one, showing slightly abraded flank preserving sculpture. Originally figured specimens of the type series seem to belong to two different species, and also the material figured by Dellapé et al. (1979). There is a group (A) of specimens to which belongs the lectotype, composed by involute oxyconic ammonites with blunt falcoid ribs, mostly undivided and extended through the flank with no changes in strength (Oppeliinae: *Oxycerites*); the other group (B) is composed by

BARDAS BLANCAS – ARROYO DE LA VAINA			Faunal level	**CAJÓN TRONCOSO**	
Auquilco Fm.	> 150 m gypsum.	Unfossiliferous		Unfossiliferous	
La Manga Fm.	14 m of limestone and marls.	Perisphinctidae (material comparable to that of Arroyo de La Manga	**BB-5**	Bed LI-I: *Cubasphinctes durangensis*, Perisphinctidae indet.	**Nacientes del Teno Fm.**, > 300 m: Upper 80 m (Estratos del Toro, upper part): gray limestones with some levels of sandstone. Fossils come from the upper half.
Lotena Fm.	30 m of bluish and greenish siltstones and marls; passing to fine sandstones near the base.	Bed G 1237: *Peltoceratoides* cf. *intercissus*	**BB-4**	Bed LI-II – LI-IV: *Trimarginites* cf. *eucaris*, *Neocampylites* cf. *delmontanus*, *Neoprionoceras* cf. *henrici*, *Peltoceratoides pressulus*, *Peltoceratoides ballenaensis*, *Euaspidoceras* cf. *ajax*, *Tenuisphinctes* cf. *herreroduclouxi*, *Per. (Prososph.)* cf. *mazuricus/matheyi*, *Retroceramus* aff. *galoi*.	
		Bed G 1083: *Pseudopelteras* cf. *chauvinianum*, *Hecticoceras* sp., *Rehmannia* cf. *patagoniense*	**BB-3**		
			BB-2	Bed L-II: *Eurycephalites* aff. *extremus*, *Araucanites* n. sp. A.	Middle 245 m (Estratos del Toro, middle part): violet to greenish limestones and calcareous sandstones and shales.
Tábanos Fm.	29 m gypsum and limestone	Unfossiliferous		Unfossiliferous	
			BB-1	Bed L-III: *Perisphinctes* aff. *hillebrandti* n. sp., *Eurycephalites* cf. *rotundus*,	
		Eurycephalites rotundus			

Figure 16. Sections and ammonite successions of the Bardas Blancas area (based on Stipanicic 1966, Cornejo et al. 1982, Riccardi & Westermann 1991 and Beresi 2003). Biostratigraphy: BB-3: *Patagoniense* Biozone; BB-4: *Pressulus* Biozone; BB-5: *Pseudokranaus* Biozone.

platyconic ammonites with falcoid ribbing, primaries divide at mid-flank in finer secondaries (ribblets) which, with the intercalars, make a densely ribbed upper half of flank. Thus *Oxycerites oxynotus* (Leanza) must be interpreted after the lectotype and remaining syntypes of group A. Dellapé et al. (1979: 93) and Verma & Westermann (1984: 36) assigned the species to *Oxycerites* (*Paroxycerites*). The group A clearly belongs to this subgenus. Specimens of group B compare closely with, for instance, some *Hecticoceras* figured by Zeiss [1956: pl. 1: 8, *Hecticoceras (Lunuloceras)* aff. *compressum* (Quenstedt, 1888), and pl. 1: 10, *H. (L.) michailowense* Zeiss, 1956: holotype].

Scarce and fragmentary new material was recently collected in Chacay Melehué and Rahuecó, from faunal level CM-2 (Fig. 11), few meters above the supposed type horizon (see Fig. 10A present report and discussion *in* Dellapé et al. 1979: 91). These ammonites match the lectotype in any respect. Suture line of the largest specimen seems typical of *Oxycerites*; the whorl section is higher than wide in phragmocone and the venter is rather acute with a single, undifferentiated keel; at beginning of the bodychamber whorl section becomes wider and rounded. Ornamentation consists of stout ribs on the upper half of the flank.

Distribution.- *Patagoniense* Bz. of Chacay Melehué, Rahuecó and probably Paso del Espinacito (associated with *R. patagoniense*).

Subfamily Hecticoceratinae Hyatt, 1900
Genus *Hecticoceras* Bonarelli, 1893
Type species: *Nautilus hecticus* Reinecke, 1818
Subgenus *Sublunuloceras* Spath, 1928
Type species: *Harpoceras lairense* Waagen, 1875

***Hecticoceras (Sublunuloceras)* cf. *lairense* (Waagen, 1875)**
[M&m]
Fig. 20A-D, App. 1

?1966 *Sublunuloceras* aff. *discoides* Spath.- Stipanicic:

Auquilco Fm. (200 m)	White, massive gypsum; laminar in the lower 30 m, with thin levels of limestone; unfossiliferous.	
La Manga Fm. (100-120 m)	Black marl with thin levels of white gypsum and greenish sandstone in the lower part.	**SE-6**: (G997, RMG895): *Cubasphinctes durangensis* (MLP 17343, 17233).
Lotena Fm. (10-100 m)	Greenish-gray and bluish marls and shales or mudstones, brown weathered. In the lower third sandy marl.	**SE-5**: (G295, RMG887, RMG934, G1056, G966-968): *Peltoceratoides pressulus* [M&m] (MLP 17666, 17672), *P.* cf. *pressulus* [M&m] (MLP 17298, 17322, 17324-25, 17233, 17337), *Lissoceratoides* cf. *erato* (MLP 17336). **SE-4**: (G910, RMG894): *Cubasphinctes* aff. *durangensis* (MLP 17114, 17348). **SE-3**: (G1055): *Perisphinctes* cf. *picteti* (MLP 17335).
(Tabanos Fm.)		
Calabozo Fm. / Tres Esquinas Fm.	Top: greenish sandstones with lenses of limestone with ammonites.	**SE-2**: (G951, M908): *Reineckeia stehni*, *Reineckeia*? sp., *Indosphinctes*? sp. **SE-1**: *Eurycephalites*? aff. *extremus*, *Hecticoceras (Putealiceras?)* sp., *Neuqueniceras* cf. *bodenbenderi*.

Figure 17. Generalized section and ammonite succession in the Santa Elena area: Arroyo Santa Elena, Cerro Las Yeseras, Arroyo La Bajada, Subida Mojón, Río del Cobre, Subida del Cobre and Arroyo Los Blancos (based on Stipanicic 1966 and Riccardi & Westermann 1991). Biostratigraphy: SE-2?: *Patagoniense* Biozone; SE-3 - SE-5: *Pressulus* Biozone; SE-6: *Pseudokranaus* Biozone.

420.
?1979 *?Sublunuloceras* sp.- Dellapé et al.: 96

Material.- Several variably preserved specimens from Manzano Escondido (VM-2 - VM-3) [LPB 710-711, 717-718, 745, and material seen in the field], one from Vega de la Veranada (VV-1) and one from Campana Mahuida (LO-1).
Description.- Innermost whorls ($1.5 < D < 3.5$ mm) evolute, widely umbilicate, rounded in whorl section. There are four to five rounded ribs on the flanks per half whorl. Whorls at $5<D<9$ mm platycone: moderately involute, subrectangular, higher than wide whorl section bearing a single ventral keel. Ornamentation consists of wide, coarse flexuous paired lateral ribs, inflated on the umbilical and ventrolateral shoulders.

Macroconch: largest available D = 140 mm at peristome and D = 65 mm at last septum. The bodychamber is strongly uncoiled and very short (L_{Bc} = 100°); venter narrow with a keel that fades gradually towards the end of phragmocone, where the venter becomes rounded; umbilicus moderately wide with rounded shoulder. Ribbing consist of wide, flexuous primaries, some of them bifurcated just above the umbilical shoulder; there are some intercalars. All ribs reach regularly the ventro-lateral shoulder, in some specimens with a slight tuberculation, and die out before crossing the venter. Peristome border flexuous and slightly expanded.

Microconch: smaller than macroconch, about 70 mm at base of peristome with longer bodychamber (L_{Bc} = 180°). Differs from the macroconch for a mid-lateral interruption of ribs at last whorl of phragmocone, and for the bodychamber which is periumbilically smooth, but strongly uncoiled too as in macroconch. Unfortunately there are no specimens with the complete peristome preserved.
Remarks.- The shell large, moderately involute, compressed with high flanks and a single keel, not tuberculated, covered by strong flexuous ribs, paired on the umbilical shoulder and bullate on the ventro-lateral shoulder, indicates inclusion of described specimens in the subgenus *Sublunuloceras*, close, in the morphotypic gradation, to *Putealiceras* Buckman, 1922 (Type species: *Ammonites putealis* Leckenby, 1859). Best resemblance is with *H. (S.) lairense* (Waagen), especially with the type specimen from the upper Callovian of Cutch (Arkell et al. 1957: fig. 324-4) and with that figured by Gill et al. (1985: pl. 5: 12) from the upper Callovian of Southern Israel. The microconch shows the typical features of *Paroecotraustes* Spath, 1928 (Type species: *Oecotraustes serrigerus* Waagen, 1869). The microconch of *H. lairense* is not known precluding comparisons. A similar, but smaller and less ornamented microconch specimen was figured by Haas (1955: pl. 5: 1-3) as *Hecticoceras kersteni* (Noetling, 1887), but this is an early Oxfordian (Mariae Zone) species.

In the bed ME(1)-3 of the Manzano Escondido section (Fig. 8) occurs distinctive evolute specimens with strong and wide, undivided, distant ribs and a single acute keel; largest specimens (not yet collected) are 70-80 mm in diameter at bodychamber. They match completely with *Hecticoceras (Eochetoceras) hersilia* (d'Orbigny, 1850, *sensu* Maire 1928: pl. 1: 7-10; Lamberti to Mariae Zones of Franche-Comté, France), the type species of *Eochetoceras* Spath, 1928. Other specimens are more compressed and finely ribbed (Fig. 21B, App. 1), being comparable with *H. discoides* (Spath, 1928) *sensu* Gill et al. (1985: 719-720).
Distribution.- *Patagoniense* Bz. of Manzano Escondido (VM-2 - VM-3), Campana Mahuida (LO-1), Vega de la Veranada (VV-1), Arroyo Los Baños [DM-1, as *Hecticoceras (Sublunuloceras)* sp.], Arroyo de La Vaina (BB-3). Stipanicic (1966: 420) cited *Sublunuloceras* aff. *discoides* Spath from Vega de la Veranada. Dellapé et al. (1979: 96) cited *Sublunuloceras* from Campana Mahuida, Arroyo Agua Fría and Arroyo Los Menucos. *H. (Sublunuloceras)* cf. *pseudopunctatum* was cited from Rahuecó (CM-4?) by Gulisano & Gutierrez (1995: fig. 41).

Hecticoceras (Sublunuloceras) cf. _virguloides_ (Gerard &

	Faunal level	ARROYO DE LA MANGA	ARROYO BLANCO
Auquilico Fm. 180 - 200 m. Marine evaporitic gypsum and limestones.			
La Manga Fm. 25 - 45 m. Bluish-gray limestones, marls and shales.	**LM-5**	*Perisphinctes (Kranaosphintes)* gr. *promiscuus-decurrens, Passendorferia* n. sp. A.	*Perisphinctes (Kranaosphintes)* gr. *promiscuus-decurrens, Passendorferia* n. sp. A.
	LM-4	(bed G1369): *Euaspidoceras ajax.*	
	LM-3	(bed G1368): *Peltoceratoides pressulus.*	*Peltoceratoides pressulus.*
Lotena Fm. 100 – 170 m. Yellowish and reddish sandstones and conglomerates.	**LM-2**	*Rehmannia (Loczyceras) patagoniense.*	
Tábanos Fm. 30 - 50 m. Marine evaporitic gypsum and limestone.			
Calabozo Fm. 5 – 25 m. Limestones and claystones.	**LM-1**		*Grossouvria*? sp.

Figure 18. Arroyo de La Manga area. Lithostratigraphy, ammonite fauna and faunal levels (LM-1 - LM-5) in Arroyo de La Manga and Arroyo Blanco sections. Lithostratigraphic features after Stipanicic (1966), Riccardi & Westermann (1991) and Gulisano & Gutierrez (1995). Biostratigraphy: LM-2: *Patagoniense* Bz.; LM-3 - LM-4: *Pressulus* Bz.; LM-5: *Pseudokranaus* Bz.

Contaut, 1936) [M]
Fig. 21A, App. 1

Material.- A single incomplete macroconch phragmocone (MOZP 6815/2) from Manzano Escondido (VM-3).
Description.- Large platycone, moderately involute. Umbilicus moderately narrow (U/D = 0.25), shallow with marked shoulder. Whorl section subrectangular, higher than wide (W/H_1 = 0.54), flat flanks, venter rather narrow, tectiform with a single keel. Lower half of flanks smooth, upper half covered with wide, straight ribs which end on the ventro-lateral shoulder slightly inflated.
Distribution.- *Hecticoceras* Horizon, *Patagoniense* Biozone of Manzano Escondido.

Subfamily Taramelliceratinae Spath, 1928 (1925)
Genus *Taramelliceras* Del Campana, 1904

Type species: *Ammonites trachynotus* Oppel, 1863; SD by H. Douvillé (1879)

Taramelliceras? sp. A [M]
Fig. 22A

Material.- Two specimens from Manzano Escondido, VM-3 [LPB 713, 715], one cf.-specimen, VM-4 [746/4]; two specimens from Rahuecó (CM-4).
Description.- Discoidal, compressed and involute phragmocone. Flanks flat, venter narrow and smooth with a median keel. Ribbing is relatively strong and dense, flexuous or falcoid, with lateral nodes on the diverging points of falcoid ribs.
Remarks.- The specimens could likely represent an early form of *Taramelliceras* (accorded by G. Schweigert, *pers. comm.*, 23/09/2004), but material now available is still too poor for more accurate determination.
Distribution.- *Patagoniense* Bz. of Manzano Escondido and *Pressulus* Bz. of Rahuecó.

Subfamily Glochiceratinae Hyatt, 1900
Genus *Trimarginites* Rollier, 1909

Type species: *Ammonites arolicus* Oppel, 1863; SD Arkell (1943)

Trimarginites cf. *eucharis* (d'Orbigny, 1850) [M]
Fig. 22D

Material.- One specimen from Vega de la Veranada (VV-2), one from Cajón Troncoso (BB-4).
Remarks.- Typical macroconch, compressed, discoidal with very complex suture. Presumed geological age, but mainly smooth whorls suggest comparison with *T. eucharis* better than *Trimarginites arolicus* (Oppel. 1862) [M] / *Trimarginites stenorhynchus* (Oppel, 1862) [m]. *T. eucharis* occurs in the lower Oxfordian of Europe (Enay & Gauthier *in* Fischer: 171), whilst *T. arolicus* / *stenorhynchus* (regarded as sexual dimorphic pair, see D'Arpa & Meléndez 2002) in the middle

QUEBRADA DE LOS BURROS	AGUADA DEL CARRETÓN	AGUADA DE ORO	Chronostratigraphy	
	Ochetoceras mexicanum, Orthosphinctes cf. *tiziani, Wegelea gredingense, Lithacosphinctes desertorum, Geyssantia geyssanti* *Euaspidoceras* spp. [M&m]		Desertorum Zone	Late Oxfordian
	Perisphinctes n. sp., *P. (Dichotomoceras) andium, Euaspidoceras tarapacaense* n. sp., *Gregoryceras perplanatum*		Tarapacaense Zone	Middle Oxfordian
Perisphinctes s.l.		*Perisphinctes* s. l. spp.	?Passendorferia Zone	
		Gregoryceras cf. *chongi*	Pseudokranaus Zone	
	Caracoliceras dunkeri	*Caracoliceras dunkeri*	Dunkeri Zone	
<6m unfossiliferous>	<120 m unfossiliferous>	*Perisphinctes* s. l., *Euaspidoceras* gr. *freii, Rehmannia* n. sp. A (aff. *patagoniense*), *Reineckeia* n.sp. B	Eugenii Zone	Early Oxfordian
		Perisphinctes s. l.	?Dimorphosus Zone	
Araucanites prereyesi n. sp., *Perisphinctes hillebrandti* n. sp. (holotype), *Euaspidoceras* sp. B [m]	*A. prereyesi* n. sp. [m], *P. hillebrandti* n. sp., *Peltoceras (Rursiceras) convexum, Peltoceras (Peltomorphites) primus, Peltoceratoides*? sp.	*P. hillebrandti* n. sp., *P. (R.) convexum, P. (P.) primus*	Primus Zone	Late Callovian
<10 m unfossiliferous> *Reineckeia nodosa, Reineckeia* s.l. spp., *Hubertoceras* sp.		*Rehmanni stehni, Hecticoceras (Zieteniceras)* cf. *atacamense*	"Athleta" Zone	
		Reineckeia s.l. sp., *Neuqueniceras*? sp.		Middle Callovian

Figure 19. Ammonite succession of selected localities of the southern part of the Tarapacá Basin. Ammonite successions and biostratigraphy after Gygi & Hillebrandt (1991), Hillebrandt & Gröschke (1995) and present report; taxonomy as used in present report.

Oxfordian (Transversarium Zone, Callomon 1988, Callomon et al. 1987, Meléndez 1989, Jeannet 1951: pl. 24: 4-5; Bifurcatus Zone, D'Arpa & Meléndez 2002: 215).
Distribution.- *Pressulus* Bz. of Vega de la Veranada and Cajón Troncoso.

Genus *Neoprionoceras* Spath, 1928
Type species: *Oppelia girardoti* de Loriol, 1902

Neoprionoceras cf. *henrici* (d'Orbigny, 1840) [M]
Fig. 22C

Material.- One fragment of an adult bodychamber (SNGM 7558/1) from Cajón Troncoso (BB-4).
Remarks.- The fragment is identical to the last part of the bodychamber of the lectotype (see Christ 1961: pl. 18: 1, Enay & Gauthier *in* Fischer 1994: pl. 73: 5).
Distribution.- *Pressulus* Bz. of Cajón Troncoso.

Genus *Neocampylites* Callomon, 1973
[pro *Campylites* Rollier, 1922]
Type species: *Ammonites delmontanus* Oppel, 1863; by OD

Neocampylites cf. *delmontanus* (Oppel, 1863) [M]
Fig. 22B

Material.- One specimen from Cajón Troncoso (BB-4), one from Arroyo Milno (MLP 16890), bed G314 (Gulisano col., 1982).
Distribution.- *Pressulus* Bz. of Cajón Troncoso and Arroyo Milno.

Superfamily Perisphinctoidea Steinmann, 1890
Family Reineckeiidae Hyatt, 1900
Subfamily Reinceckeiinae Cariou, 1984
Genus *Rehmannia* Schirardin, 1956
Type species: *Ammonites rehmanni* Oppel, 1857
Subgenus *Loczyceras* Bourquin, 1968
Type species: *Loczyceras sequanicum* Bourquin, 1968

Rehmannia (Loczyceras) patagoniense (Weaver, 1931) [M&m]
Figs. 23A-C, 24, 25A-B, App. 1

Synonymy.- See the recent review by Riccardi & Westermann (1991).
Material.- Several specimens, [M] and [m]: Picún Leufú (PL-1), Manzano Escondido (VM-1 - VM-2), Mallín Quemado (VM-1), Vega de la Veranada (VV-1), Q. Remoredo (VV-1), A. de la Mula (VV-1), Bardas Blancas (BB-3), Arroyo de La Manga (LM-2), Paso del Espinacito (PI-1).
Remarks.- It is notorious the mode of occurrence in Picún

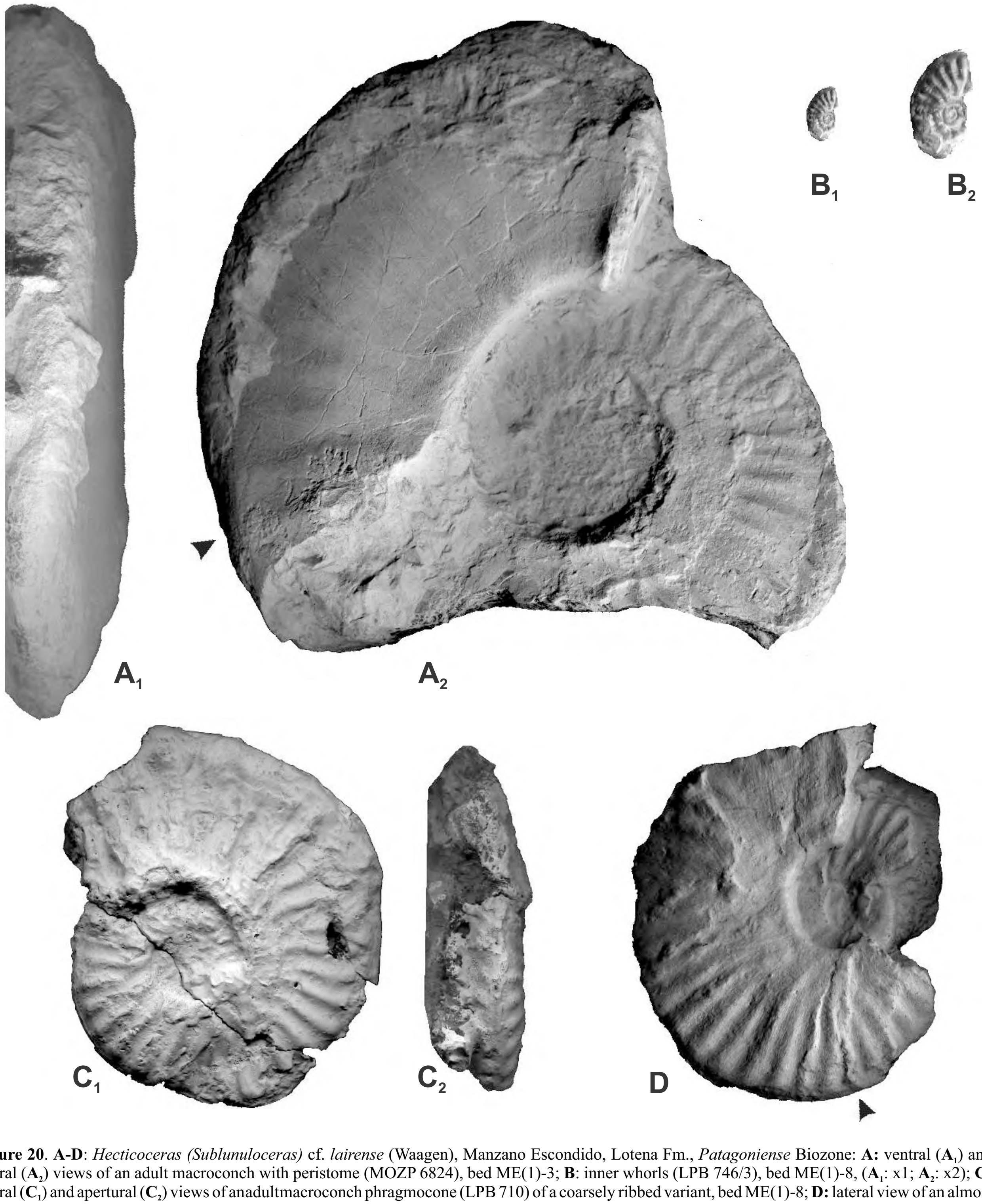


Figure 20. **A-D**: *Hecticoceras (Sublunuloceras)* cf. *lairense* (Waagen), Manzano Escondido, Lotena Fm., *Patagoniense* Biozone: **A:** ventral (**A_1**) and lateral (**A_2**) views of an adult macroconch with peristome (MOZP 6824), bed ME(1)-3; **B**: inner whorls (LPB 746/3), bed ME(1)-8, (**A_1**: x1; **A_2**: x2); **C:** lateral (**C_1**) and apertural (**C_2**) views of an adult macroconch phragmocone (LPB 710) of a coarsely ribbed variant, bed ME(1)-8; **D:** lateral view of an almost complete adult microconch (MOZP 6806) with incomplete peristome, bed ME(1)-3. All natural size (x1) except **B_2** (x2). Arrowhead at last septum.

Leufú, very abundant, with both sexual dimorphs commonly associated in beds of the Lotena Fm., complete or almost complete adults as the only ammonite through several meters of claystones and fine sandstones (Fig. 6). There may be differentiated two macroconch morphotypes in succession:

(1) Transient α (the oldest; Fig. 24): inflated, with large and conical tubercles. It occurs in the lower and middle parts of the stratigraphic range of the species in Picún Leufú, in beds of red fine sandstones and upwards claystones.

(2) Transient β (Fig. 23A-B): slender and more finely ribbed than transient α, apparently confined to the upper part of the range of the species in Picún Leufú, in beds of grey to greenish-grey siltstones, up to just below the green sandstones which conform the top of the Lotena Fm., passing abruptly to the yellowish conglomerate of the Tordillo Fm. (= Quebrada del

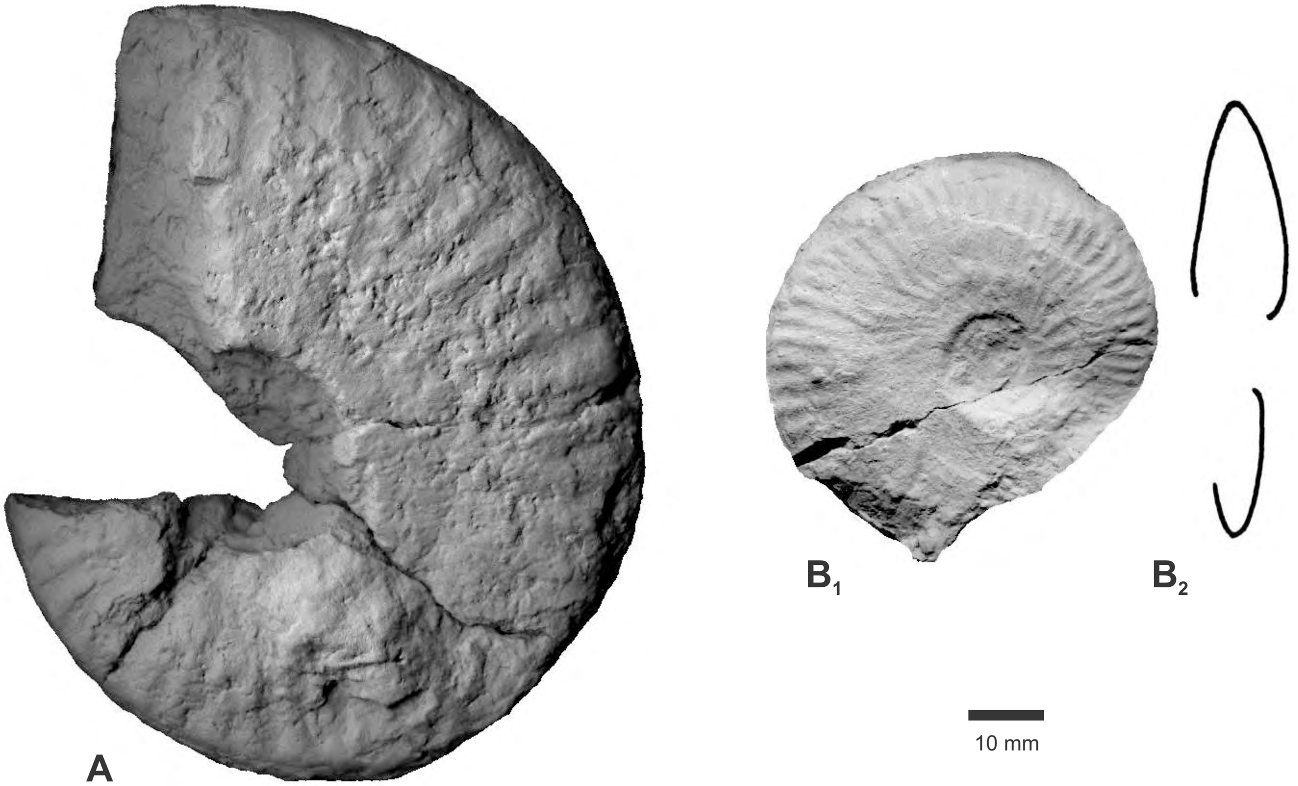


Figure 21. **A**: *Hecticoceras (Sublunuloceras)* cf. *virguloides* (Gerard & Contaut), lateral view of the phragmocone of an adult macroconch (MOZP 6815/2), bed ME(1)-8, Manzano Escondido, *Patagoniense* Biozone, *Hecticoceras* Horizon. **B:** *Hecticoceras (Sublunuloceras)* cf. *discoides* (*sensu* Gill et al. 1985), lateral view (**B**$_1$) and whorl section (**B**$_2$) of a finely ribbed ?macroconch phragmocone (MOZP 6806), bed ME(1)-3, Manzano Escondido, *Patagoniense* Biozone, *Choffatia* Horizon. All natural size (x1).

Sapo, see Fig. 5). Microconchs (Fig. 25A-B) of both transients are identical, indicating their shells have not changed during the phyletic evolution of the species in the time interval represented by their range in Picún Leufú. Differences between the older and the younger transients are confined to the adult whorls of the macroconch, in a morphological stage non developed by the microconchs. The microconch differs from the macroconch by a smaller size and the bodychamber being more compressed with tabulate venter, there are no tubercles, only dense polyfurcated ribs which fade away on the ventrolateral shoulder, resulting a wide smooth band on the venter.

Distribution.- *Patagoniense* Bz. through almost every locality of the NMB. In the TB occurs in the form of *Rehmannia* cf./aff. *patagoniense*, in the Primus Zone of Cerro La Ballena and Cerro Paisaje (see Hillebrandt & Gröschke 1995).

Family Aspidoceratidae Zittel, 1895
Subfamily Peltoceratinae Spath, 1924

Remarks.- The classification of the late Callovian - early Oxfordian Peltoceratinae (excl. *Gregoryceras* Spath, 1924; Type species: *Ammonites transversarius* Quenstedt, 1847) adopted in this paper consists of two genera of sexually dimorphic species: (1) *Peltoceras* Waagen, 1871 [M&m] (Athleta - Lamberti zones), whose microconchs are currently classified in the genus or subgenus *Rursiceras* Buckman, 1919 (Type species: *Ammonites reversus* Leckenby, 1859), and (2) *Peltoceratoides* Spath, 1924 [M&m] (Mariae - Cordatum zones) whose microconchs are currently classified in the genera or subgenera *Rursiceras* and *Parawedekindia* Schindewolf, 1925 (Type species: *Ammonites arduennensis* d'Orbigny, 1848). *Peltomorphites* Buckman, 1925 (Type species: *P. hoplophorus* Buckman, 1925) should be a synonym of *Peltoceratoides*, including trituberculate morphospecies (mostly of the "*eugenii*-group", see Arkell et al. 1957: p. L333), confined to the Cordatum Zone. Species content of each of the two genera is rather complex by well-known reasons (see Bonnot 1995), and each basin seems to have its own specialties (morphotypes or local species). The best known successions are those of Europe (see Bonnot et al. 2002 for a recent review).

Genus *Peltoceras* Waagen, 1871
Type species: *Ammonites athleta* Phillips, 1829. Late Callovian

Peltoceras cf. *athleta* (Phillips, 1829) [M]

non 1900 *Peltoceras athleta* Phill.- Burckhardt: 39, pl. 23: 4, pl. 29: 8.
1998a *Peltoceras (Peltoceras)* cf. *athleta* (Phillips).- Parent: 265.

Material.- A single specimen (MLP 15655) from Chacay Melehué (CM-3).

Remarks.- This specimen closely matches *Peltoceras athleta* (Phillips) morph baylei [M] as described by Bonnot (1993: pl. 3: fig. 3), but small differences and insufficient preservation prevents a closer identification with the index-species of the Athleta Zone (Parent 1998a). Within Andean faunas the present specimen is almost identical to *Peltoceratoides?* sp. figured by

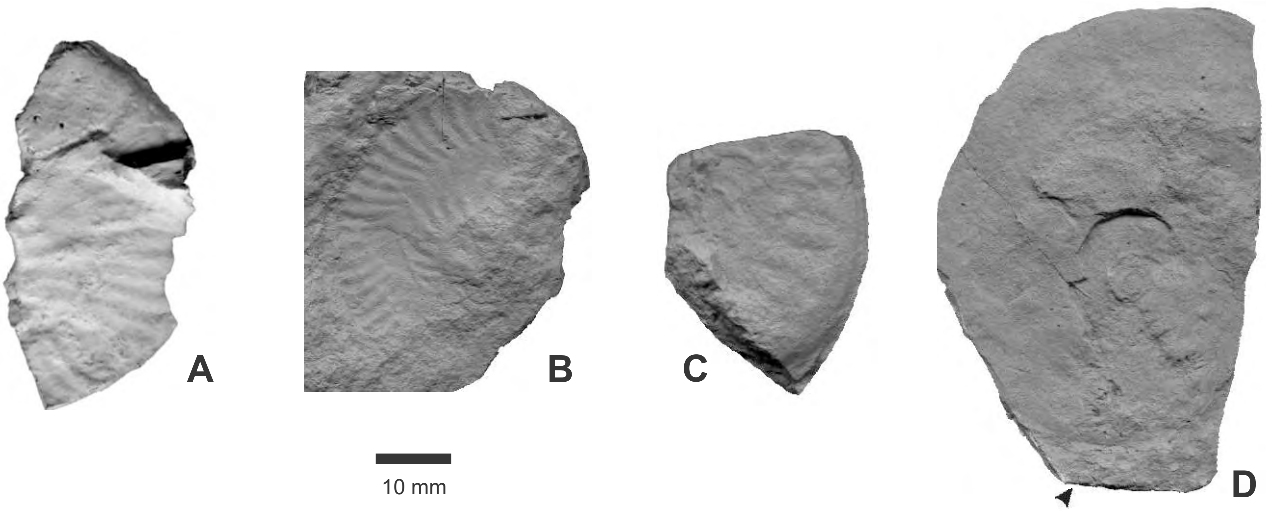


Figure 22. **A:** *Taramelliceras*? sp. A, lateral view (LPB 713), Manzano Escondido, bed ME(1)-3, Lotena Fm., *Patagoniense* Bz. **B:** *Neocampylites* cf. *delmontanus* (Oppel), Cajón Troncoso, Nacientes del Teno Fm., bed LI-II - LI-IV, *Pressulus* Bz.; last whorl of an adult macroconch phragmocone (SNGM 7597). **C**: *Neoprionoceras* cf. *henrici* (d'Orbigny), Cajón Troncoso, Nacientes del Teno Fm., bed LI-II - LI-IV, *Pressulus* Bz.; portion macroconch bodychamber (SNGM 7558/1). **D**: *Trimarginites* cf. *eucharis* (d'Orbigny), Cajón Troncoso, Nacientes del Teno Fm., bed LI-II LI-IV, *Pressulus* Bz.; phragmocone and bodychamber of an adult macroconch (SNGM 7624). All natural size (x1). Arrowhead at last septum.

Hillebrandt & Gröschke (1995: pl. 2, fig. 2) from the late Callovian Primus Zone of Aguada del Carretón (TB). The only apparent difference, which is significant for classification, is that the specimen of Chacay Melehué has radial ribbing on phragmocone, not rursiradiate like in the specimen of Aguada del Carretón.

Burckhardt (1900b: pl. 23: 4) described from Laguna del Fierro, near Santa Elena (see Fig. 3) *Peltoceras athleta*, but the specimen consists of inner whorls of an ammonite which does not show features of the Peltoceratinae.

Distribution.- *Patagoniense* Bz. of Chacay Melehué. ?Primus Zone of Aguada del Carretón (TB).

Peltoceras cf. *convexum* (Hillebrandt *in* Hillebrandt & Gröschke, 1995) [m]

Fig. 26

Material.- Fragmentary specimens: M. Escondido (LPB 744).

Description.- Although some of the specimens could be somewhat crushed it can be seen that whorl section is compressed, subrectangular with flat flanks and venter; umbilicus wide. The ribbing is strong and acute. Primaries bifurcate on the upper half of flank and secondaries cross the venter orthogonally and with no change in strength.

Remarks.- Present specimens may belong to any of many morphospecies in literature, but closer comparisons should be useless because the fragmentary state of the material. There is strong resemblance with the *Rursiceras*-like microconch *P. convexum* (Hillebrandt *in* Hillebrandt & Gröschke).

Distribution.- *Hecticoceras* Horizon, *Patagoniense* Biozone of Manzano Escondido. *P. convexum* is widely distributed in the Primus Zone of the TB (see Hillebrandt & Gröschke 1995).

Genus *Peltoceratoides* Spath, 1924

Type species: *Peltoceras semirugosum* Waagen, 1875. Early Oxfordian.

Peltoceratoides pressulus (Leanza, 1947) [M&m]

Figs. 27A-E, App. 1

*1947a *Nebrodites pressulus* n. sp. - Leanza: 4, pl. 2: 1 [holotype], 2-3.
1951 *Peltoceras (Peltoceratoides)* cf. *constantii*. - Stipanicic: 225. pl. 2: 1.
1966 *Peltoceras (Peltoceratoides)* cf. *constantii*. - Stipanicic: 441.
1982 *Parawedekindia* sp. 1. - Cornejo et al.: pl. 2: 1-2.
1982 *Peltoceratoides* sp. - Cornejo et al.: pl. 2: 4.
1984 *Parawedekindia* sp. - Muñoz & Niemeyer: pl. 2: 1-3.
1984 *Peltoceratoides* sp. - Muñoz & Niemeyer: pl. 2: 6.
1984 *Nebrodites pressulus*. - Riccardi: 92 (Cuadro 3).
1998a *Peltoceras constantii* [M] / *arduennense* [m]. - Parent: 265-266.

Holotype.- Originally designated by Leanza (1947a: 5, pl. 2: 1), herein refigured (Fig. 27A). It consists of a somewhat crushed, moderately well preserved adult macroconch with half whorl of bodychamber.

Type locality and section.- Section of the Lotena Fm. at Chacay Melehué. Leanza (1947a: 7) stated: "Lomas Bayas Bajas, en la ladera derecha del arroyo Chacay-Melehué. Calizas gris-azuladas ligeramente dolomíticas. Kimmeridgiano, Horizonte con *Nebrodites pressulus* n. sp.". The bed from which was collected the holotype seems to be bed L, faunal level CM-4 (Fig. 11).

Material.- Abundant material from several localities: Chacay Melehué (CM-4), Rahuecó (CM-4), Campana Mahuida (LO-2) [MLP 16906, several (m) and one (M)], Vega de la Veranada (VV-2), Cajón Troncoso (BB-4), Santa Elena area (SE-5), Arroyo de la Manga (LM-3), and cf.-specimens from Arroyo Blanco (LM-3).

Description.- Macroconch: Maximum preserved diameter about 100 mm at ?subadult bodychamber (holotype) and could have been more than 150 mm at peristome. Inner whorls have rounded whorl section; ribbing consists of fine and dense primaries, slightly convex but flexuous on last whorl of phragmocone; bifurcation is seen in some primaries on the umbilical shoulder forming a lamellar elevation, then at the end of the phragmoconce bifurcation is sporadic, at middle or upper third of flank. Whorl section of bodychamber compressed

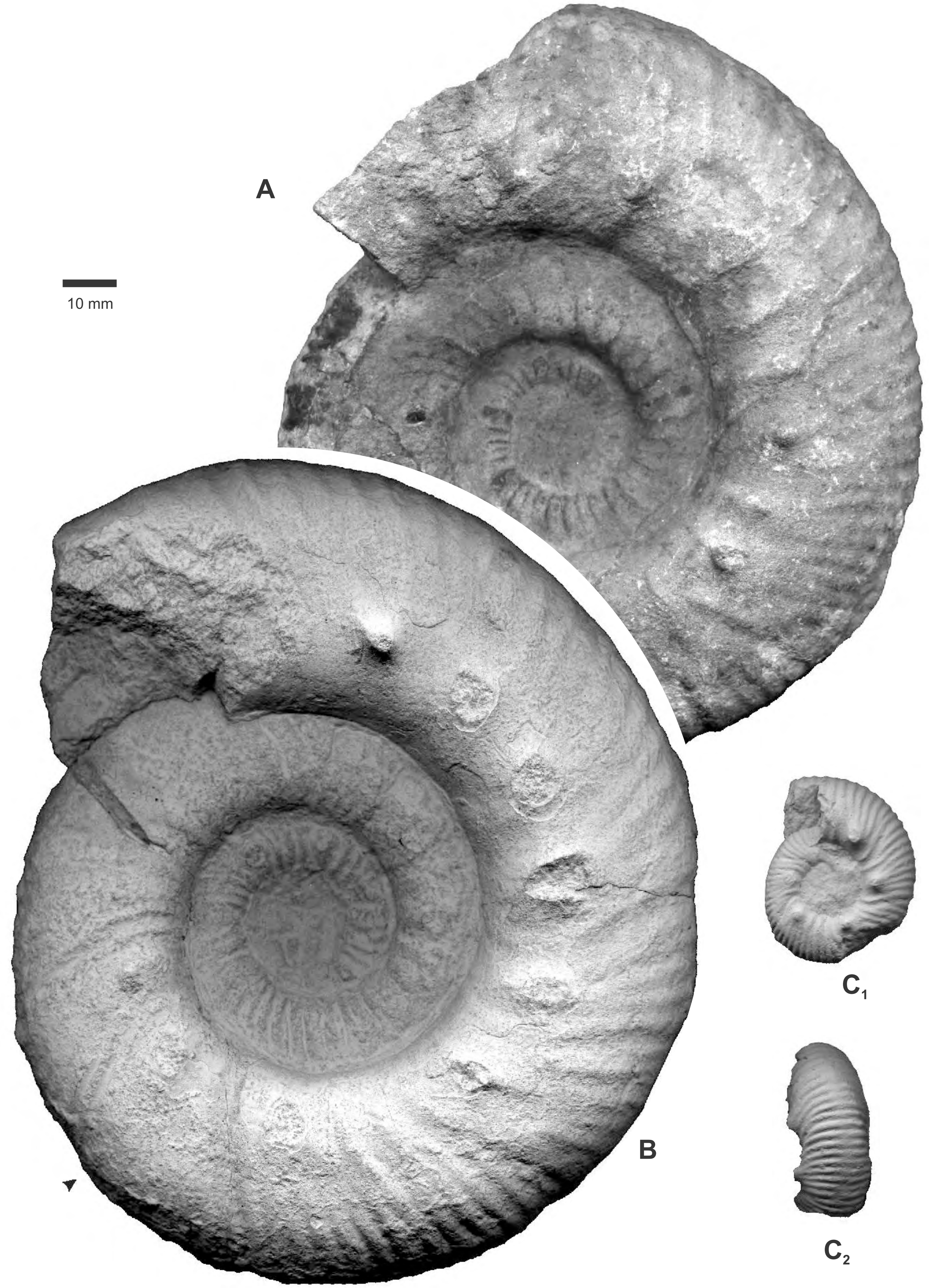


Figure 23. **A-C:***Rehmannia (Loczyceras) patagoniense* (Weaver, 1931) [M], Picún Leufú, Lotena Fm., *Patagoniense* Bz., *Patagoniense* Hz. **A-B:** Almost complete adults of the late transient beta; **C:** inner whorls of a macroconch showing the early lateral tuberculation (**C$_1$**) and weakening of ventral ribbing (**C$_2$**). Arrowhead at last septum. All natural size (x1).

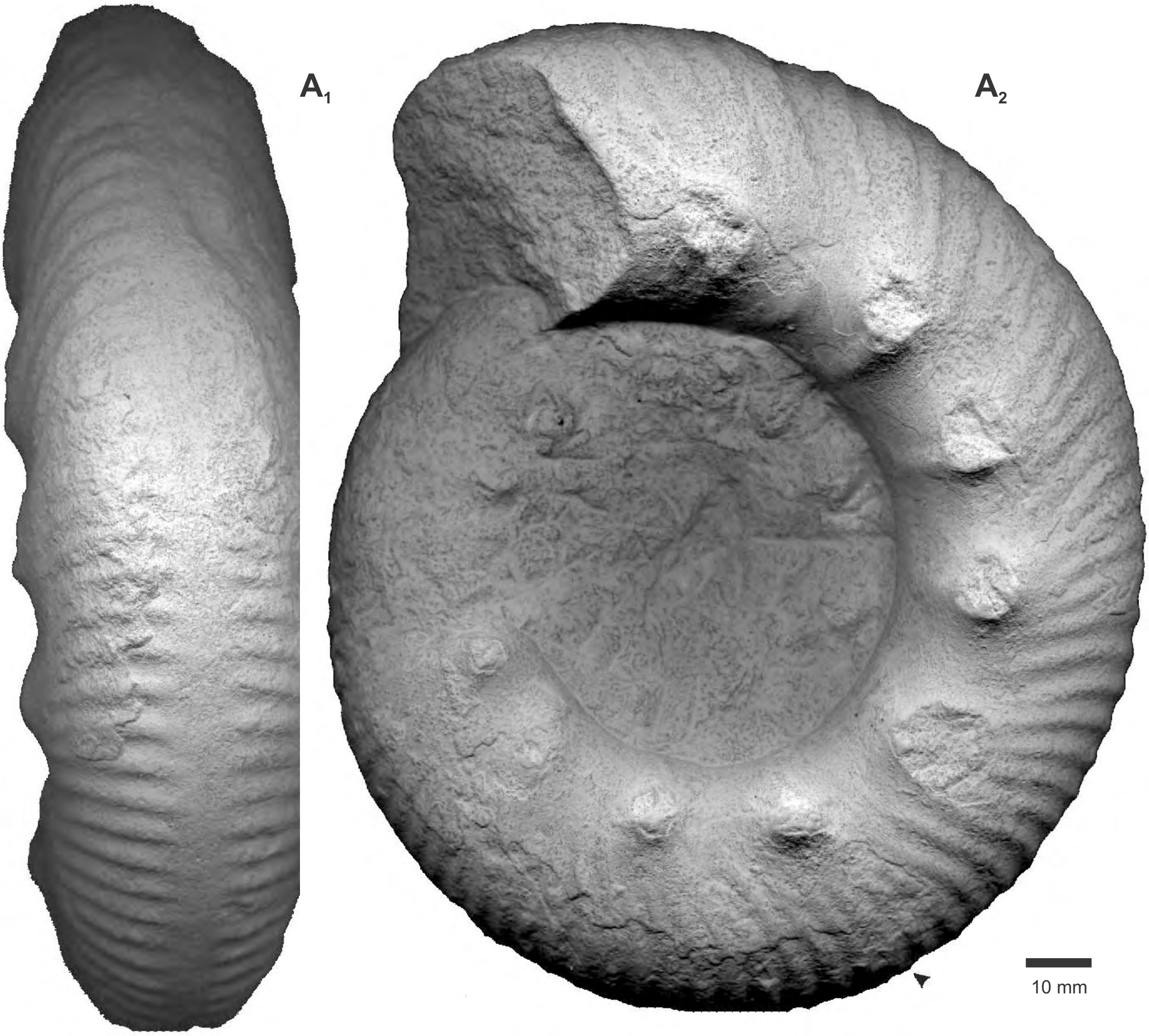


Figure 24. *Rehmannia (Loczyceras) patagoniense* (Weaver, 1931), Picún Leufú, *Patagoniense* Biozone, *Patagoniense* Horizon. Ventral (**A**$_1$) and lateral (**A**$_2$) views of a large, almost complete macroconch of the early transient alfa, lower part or the Lotena Fm.Natural size (x1), arrowhead at last septum.

subrectangular, higher than wide, with flat flanks and narrow, rounded venter. Bodychamber is covered by stronger sculpture, primaries born on the umbilical wall, cross the umbilical shoulder forming a lamellar tubercle and run radially or slightly flexuously on the flank, forming a rounded, radially elongated tubercle at the ventro-lateral shoulder. Some few primaries divide in two secondaries which are joined on the ventro-lateral shoulder, forming a loop-structure very common in many of the studied adult macroconchs. Venter is crossed orthogonally by moderately wide ribs. The holotype has $P = 24$ and $V = 33$ at $D = 98$ mm (Bc) and $P = 21$ at $D = 45$ mm (last whorl of phragmocone).

Microconch: Maximum diameter about 60 mm. Phragmocone indistinguishable from that of the macroconch at comparable diameters. Bodychamber about 0.5 whorl long, with compressed, subrectangular whorl section. Ribbing formed by simple, convex primaries, engrossed on the upper half of flanks; there can occur one or two bifurcations on the umbilical shoulder. All ribs cross the venter orthogonally, with, in some specimens, an interruption or weakening forming a groove. Peristome with moderately long, slender lappets.

Remarks.- Within the abundant Peltoceratinae described by Hillebrandt & Gröschke (1995) from the TB there is no any specimen comparable with *P. pressulus*; moreover A. Hillebrandt (*pers. comm.* 12/01/01) has never found any specimen comparable with *Peltoceratoides constantii-williamsoni - arduennense - choffati* in northern Chile. This situation suggests paleobiogeographic differences with the NMB, but could also be reflecting differences in age of the stratigraphic levels sampled. Closely comparable morphotypes of the Tethys belong to *Peltoceratoides constantii* (d'Orbigny, 1847) [M] and *P. arduennense* (d'Orbigny, 1847) [m], profusely ilustrated by Malinowska (1963), Bonnot (1995), Arkell (1935-1948), Matyja (1977), and Tarkowski (1983) among others. These species are included by Bonnot (1995) in synonymy with *Peltoceratoides williamsoni* (Phillips, 1829)

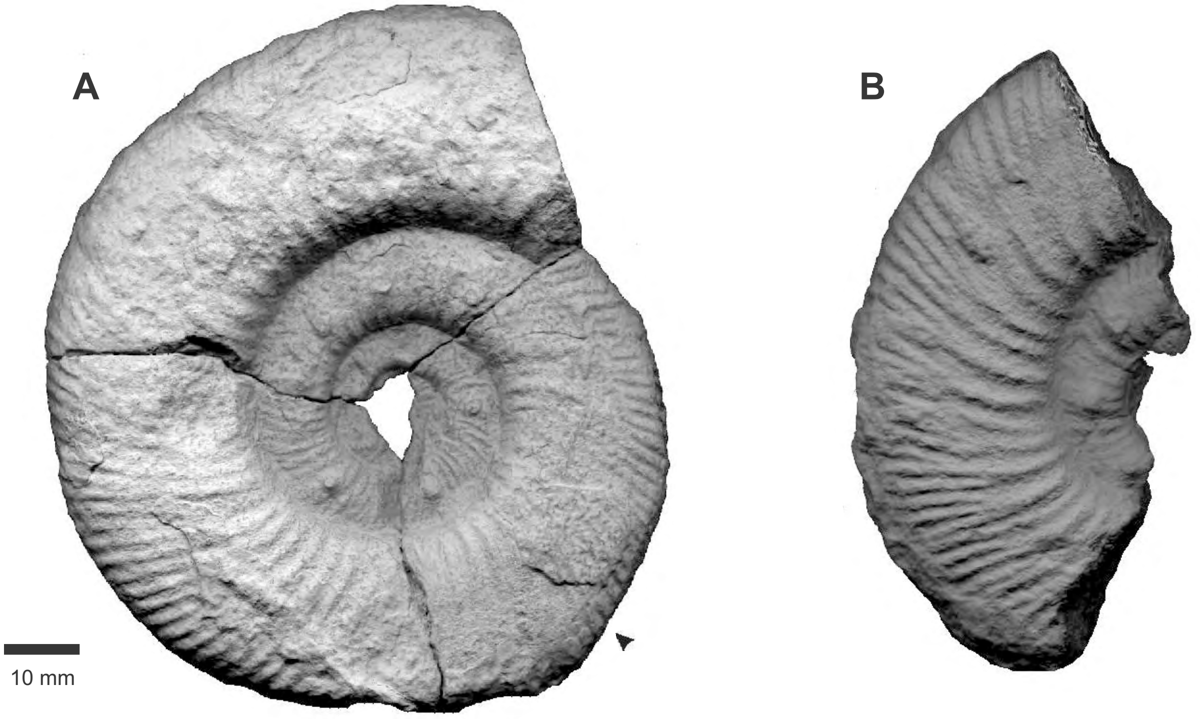


Figure 25. **A-B:** *Rehmannia (Loczyceras) patagoniense* (Weaver, 1931), Picún Leufú, Lotena Fm., *Patagoniense* Biozone, *Patagoniense* Horizon. Lateral views of adut microconchs. All natural size (x1). Arrowhead at last septum.

[M]. The holotype of this latter is a wholly septate nucleus. *Peltoceratoides pressulus* is most likely conspecific with *Peltoceratoides constantii / arduennense* as suggested by Bonnot (*pers. comm.* 27/12/2002); but for the time being the Andean form is retained as a different species. *P. constantii, P. williamsoni* and *P. arduennense* are characteristic of the Bukowskii and Costicardia Subzones of the Cordatum Zone (Matyja 1977, 1994) and may begin in the late Mariae Zone (Bonnot 1995). Based on the strong resemblance of these morphospecies with *P. pressulus* (probably a synonym) a similar age is assumed.

Distribution.- *Pressulus* Bz. throughout the Neuquén-Mendoza Basin. In the section of Río del Cobre there were collected comparable specimens from three successive beds (faunal level SE-5) of yellowish fine sandy limestones but the material now available is scarce and poorly preserved for trying to find differences that should allow the subdivision of this faunal level.

Peltoceratoides ballenaensis (Hillebrandt *in* Hillebrandt & Gröschke, 1995) [m]

Fig. 27F, App. 1

1982 *Parawedekindia*? sp. 2. - Cornejo et al.: A95, pl. 2: 3.

Material.- A single specimen [SNGM 7604] from Cajón Troncoso (BB-4).

Description.- Medium size microconch (*D* = 75 mm), very evolute throughout juvenile and adult ontogeny. Phragmocone with rounded flanks, covered by distant primaries which tend to bifurcate, one each two or three, in the upper half of flank. The style of ribbing is characterized by sets of two parallel and closely spaced primaries of which from the posterior one is detached a retrocline secondary. Bodychamber subrectangular in whorl section, higher than wide. It begins with a moderate variocostation, primaries are strong, prosocline and convex adaperturally. Bifurcation point migrates to the umbilical shoulder, but bifurcated ribs only occur in the first third of bodychamber. All ribs reach slightly engrossed the ventro-lateral shoulder. The venter is not observable, the peristome is not preserved and less than half whorl of bodychamber is preserved.

Remarks.- The studied specimen was already figured as *Parawedekindia*? sp. 2 by Cornejo et al. (1982: pl. 2, fig. 3). The ontogeny of the whorl section, the style of ribbing and ornamentation on bodychamber, all match perfectly with *Peltoceratoides ballenaensis* (Hillebrandt *in* Hillebrandt & Gröschke, 1995) and, especially, *P.* cf. *ballenaensis* (Hillebrandt *in* Hillebrandt & Gröschke, 1995: pl. 4: 3-5). There is also strong similarity with *Peltoceratoides bodeni* Prieser, 1937 as figured by Tarkowski (1983: pl. 18: 3, pl. 19: 2-3) from the Cordatum Zone of Poland, but is here used the local name for reasons explained above. Present specimen differs significantly from the microconch of *P. pressulus* in the style of ribbing of the phragmocone: in this later it is more densely ribbed and bifurcation is more irregular and at a lower point on the flank, and its bodychamber is slightly more densely ribbed.

Distribution.- *Pressulus* Bz. of Cajón Troncoso.

Peltoceratoides cf. *intercissus* (Uhlig, 1881)

Material.- One incomplete adult? specimen from Bardas Blancas (BB-4).

Remarks.- The specimen consists of a bodychamber with remains of the last whorl of phragmocone, matching in any detail with *P. intercissus* (Uhlig, 1881) as figured by Malinowska (1963: pl. 30: 144). It may be compared with *Peltoceratoides dimorphosus* (Hillebrandt *in* Hillebrandt & Gröschke 1995: pl. 3: 3) from the lower Oxfordian Dimorphosus Zone (roughly equivalent to the Mariae Zone of Europe) of Cerro Amarillo (TB), but ribs of the present

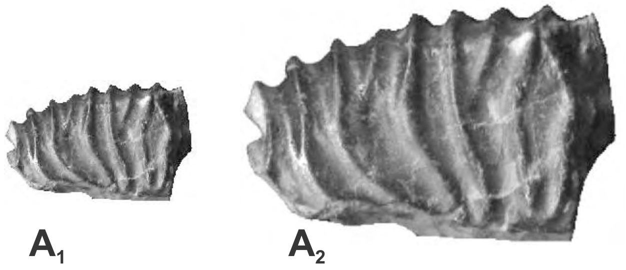


Figure 26. *Peltoceras* cf. *convexum* (Hillebrandt, 1995) [m], fragment of bodychamber (LPB 744), Manzano Escondido, bed ME(1)-8, *Patagoniense* Biozone, *Hecticoceras* Horizon. $\mathbf{A}_1$: natural size, $\mathbf{A}_2$: enlarged (x2).

specimen are always straighter and radial.
Distribution.- *Pressulus* Bz. of Bardas Blancas.

Subfamily Aspidoceratinae Zittel, 1895
Genus *Euaspidoceras* Spath, 1930

Type species: *Ammonites perarmatus* Sowerby, 1822

Euaspidoceras n. sp. aff. *raynaudi* (Bonnot, 1996) [M]

Fig. 28

1998a *Euaspidoceras*? sp..- Parent: 266.

Material.- A single macroconch specimen [MLP 15662] from Vega de la Veranada (VV-1).
Description and remarks.- An adult macroconch (D = 105 mm), very evolute, rounded to subrounded in whorl section throughout the ontogeny. Inner whorls at about D < 30 mm are smooth. The last whorl shows a single row of ventro-lateral, conical-punctiform tubercles but no ribs are visible.

The general aspect of the shell and the stratigraphic position suggest that this specimen belongs to an early Upper Callovian species of *Euaspidoceras*, especially by the late tuberculation and the smooth inner whorls. In this last feature it is comparable with *Euaspidoceras veranadaense* n. sp. (described below), but the latter is larger in adult size and its bodychamber exhibits a subrectangular whorl section with, in addition, robust, rounded tubercles. It could likely be an early transient or chronospecies of this latter species.

Euaspidoceras first appears in Europe in the latest Athleta Zone, and in Kutchch probably in the middle Athleta Zone. Recently Bonnot (1996) has described *E. raynaudi* from the late Athleta Zone of France. This species is strongly ornamented through outer whorls by two rows of tubercles, but inner whorls are more finely ornamented and moreover some specimens (Bonnot 1996: pl. 3: 1-3) show only a ventro-lateral row of small tubercles and very weak or no umbilical tubercles at diameters comparable with the specimen described.

The present specimen also resembles *Euaspidoceras ovale* (Neumann) figured by Collot (1917: pl. 1, fig. 4) and the specimens illustrated by Bonnot & Gygi (1998: pl. 2, figs. 13-14) from the Cordatum Zone of Herznach, Switzerland. Main difference lies in that our specimen has not the row of feeble and irregular tubercles which the Herznach's specimens show near the umbilical shoulder of the last whorl of the phragmocone.
Distribution.- *Patagoniense* Bz. of Vega de la Veranada and Manzano Escondido. Specimens from Manzano Escondido (VM-2) were seen in the field, but not yet collected.

Euaspidoceras ajax (Leanza, 1947) [M&m]

Figs. 22B-K, App. 1

*1947a *Aspidoceras (Euaspidoceras) ajax* n. sp.- Leanza: 10, pl. 1: 2-3 (lectotype), 4-5, pl. 3: 3-4.
1979 *Euaspidoceras ajax*.- Dellapé et al.: 83, 91, 93.
1976 *Euaspidoceras ajax*.- Stipanicic et al.: 287.
?1976 *Euaspidoceras* aff. *waageni* (Spath).- Stipanicic et al.: 287.
1998a *Euaspidoceras* cf. *babeanum* (d'Orbigny).- Parent: 265.
1998a *Euaspidoceras* cf. *kobyi* (de Loriol).- Parent: 265.
1998a *Euaspidoceras* cf. *catena* (Sowerby).- Parent: 266.

Lectotype- Leanza (1947a) did not designate type specimen, therefore, here is designated as lectotype the specimen in his pl. 1: 2-3 (herein refigured in Fig. 29B), a juvenile phragmocone. Remaining material originally figured consists of fragments or inner whorls, and moreover, it is not possible to assign them to different ontogenetic stages of a single specimen. The specimen in his pl. 1: 5 is unidentifiable; that in his pl. 1: 4 could be any of several microconchs in literature (although identical to specimens from Rahuecó and Vega de la Veranada as shown in Fig. 29H); the specimen in his pl. 2: 3-4 is a macroconch which could belong to any of several species in literature. The lectotype is the most informative specimen of those originally figured. It is a nucleus (D = 20 mm) showing a complete whorl which is moderately involute, rounded then subrectangular in whorl section, with rounded flanks covered by well spaced, lamellar primary ribs; in the later half of the whorl, primary ribbing is somewhat denser, and at the end are visible signs of minute ventro-lateral tubercles (merely as elevation of primary ribs).
Type horizon and locality: Lotena Fm., *Pressulus* Bz. of Rahuecó, Neuquén (Figs. 2, 12). Leanza (1947a: 11) stated: "Arroyo Rahuecó, Cerro Caicayén [Rahuecó], Neuquén. Arcillas y calizas azuladas. Horizonte con *Idoceras herrero-ducloux*i n. sp. Kimmeridgiano".
Material.- Several macro- and microconch specimens: from Rahuecó [type locality, bed RA(1)-9, faunal level CM-4: LPB 737-739], Vega de la Veranada (VV-3), C. Troncoso (BB-4), and A. de la Manga (LM-4); a cf.-specimen from Cajón Chico (Bed G 983, MLP 17199).
Description.- The adult macroconchs are preserved with incomplete bodychamber at D = 78-80 mm. They are stout and evolute, with a moderately narrow umbilicus and a rounded to subquadrate whorl section. The innermost whorls are rounded in whorl section and the ribbing is composed by fine, radial, simple ribs which do not cross the smooth and wide venter. On the last whorl of the phragmocone the whorl section is subrectangular and the ribbing consists of widely spaced, parabolic primaries, which on the ventro-lateral shoulder develop a minute, rounded tubercle. The primary ribs cross the venter somewhat attenuated. The adult bodychamber may extend along 0.5 - 0.8 whorl. Whorl section is subrectangular to subquadratic, with flattish flanks and convex venter. There are about 17 wide and rounded primary ribs on the last half of bodychamber (D = 80 mm); each primary has a very feeble tubercle situated at the base of the flanks and one other, somewhat bigger and spatulated with elliptical base, at the ventro-lateral shoulder; later develop two rows of rounded tubercles, one of them at umbilical shoulder and the other close to the ventro-lateral shoulder.

The microconch is smaller and differentiated by the body chamber at the diameter of the last whorl of the macroconch phragmocone. At about D = 10 mm, the whorl section is subquadrate to subcircular (about $W = H_1$) with

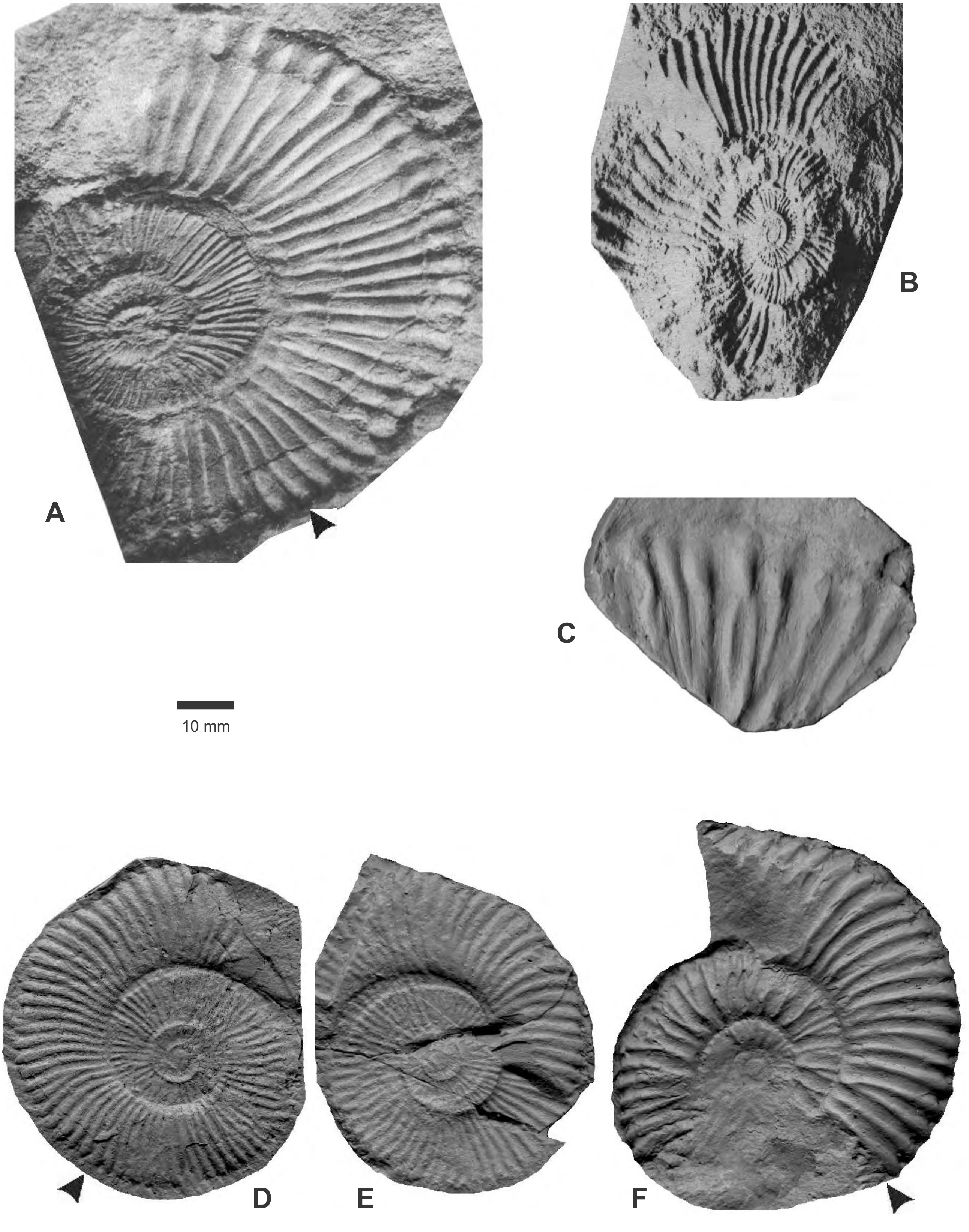


Figure 27. **A-E**: *Peltoceratoides pressulus* (Leanza, 1947) [M&m]. **A**: holotype, ?sub-adult macroconch from Chacay Melehué, bed L, *Pressulus* Biozone (refigured after Leanza 1947b: pl. 2: 1); **B**: incomplete microconch from Chacay Melehué, bed L, *Pressulus* Biozone (refigured from Leanza 1947b: pl. 2: 2); **C**: cast of a fragment of an adult macroconch (SNGM 7606) from Cajón Troncoso, Nacientes del Teno Fm., bed LI-II - LI-IV, *Pressulus* Biozone; **D**-**E**: casts of almost complete microconchs (**D**: specimen with lappet, SNGM 7602, **E**: SNGM 7603) from Cajón Troncoso, Nacientes del Teno Fm., bed LI-II - LI-IV, *Pressulus* Biozone. **F**: *Peltoceratoides ballenaensis* (Hillebrandt), cast of a virtually complete microconch (SNGM 7604) from Cajón Troncoso, Nacientes del Teno Fm., bed LI-II - LI-IV, *Pressulus* Biozone. Arrowhead at last septum. All natural size (x1).

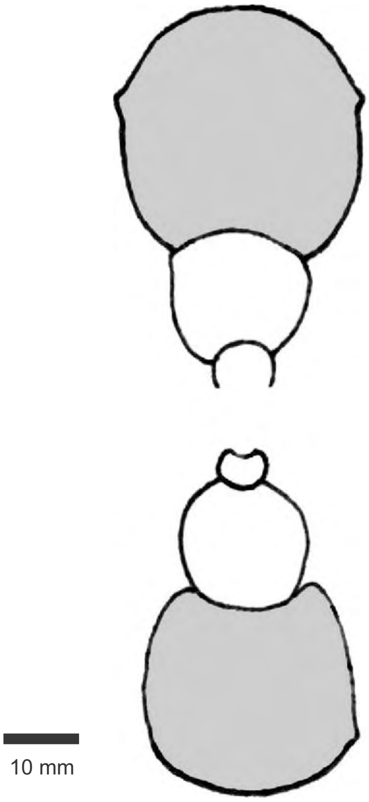


Figure 28. *Euaspidoceras* n. sp. aff. *raynaudi* (Bonnot, 1996) [M] (MLP 15662), Vega de la Veranada (VV-1), *Patagoniense* Biozone; cross section of an adult with complete bodychamber, natural size (x1).

rounded shoulders. Ribs are wide and rounded, low and close to each other, they appear as radial bullae. Moderately evolute with narrow umbilicus. At $D > 20$ mm, whorl section becomes higher than wider and the umbilicus notoriously wider. Bodychamber shows dense, fine ribbing crossing, unchanged, orthogonally the venter. There is visible a wide pre-peristomatic constriction followed by a rostrum. Lappets are not preserved.

Remarks.- The present material shows strong resemblance with the dimorphic pair recently described by Bonnot & Gygi (1998) as *Euaspidoceras freii* Jeannet, 1951 [M] / *Mirosphinctes niedzwiedzkii* (Siemiradzki, 1891) [m] from the late Cordatum Zone of Switzerland. It is especially significant that one of the specimens from Herznach conforms simultaneously the anatomically unconnected specimens of the original type series of *E. ajax*. That is the specimen figured as *E.* cf. *perarmatum* (Sowerby, 1822) by Jeannet (1951: pl. 97: 3), which has been reallocated in *E. freii* by Bonnot & Gygi (1998: 497). *E.* ex gr. *freii* was cited by Hillebrandt et al. (2000) from the lower Oxfordian of Chile, in a stratigraphic position similar to that of the type series of *E. ajax* (see Fig. 19).

The material described was cited with varied names in Parent (1998a), see synonymy, before the discovery of sexual dimorphic correspondence between them. Nevertheless some additional material available after new collections leads to the conclusion that all these forms belong to a single, sexually dimorphic species.

Distribution.- *Pressulus* Bz. of Rahuecó, V. Veranada, Cajón Chico, C. Troncoso and A. de la Manga. In this last locality *E. ajax* could range up into the *Pseudokranaus* Bz.

Euaspidoceras veranadaense **n. sp. [M & ?m]**

Fig. 30A-B, App. 1

1998a	*Euaspidoceras* cf. *paucituberculatum* Arkell.- Parent: 266.
1998a	*Mirosphinctes* gr. *syriacus-regularis* (Noetling).- Parent: 265.
1998a	*Euaspidoceras* cf. *douvillei* (Collot).- Parent: 265.

Material.- An adult macroconch bodychamber with remains of phragmocone from Vega de la Veranada (holotype, MLP 15664, VV-2), another one from Quebrada Remoredo (MLP 17016); a cf.-specimen (macroconch) from Rahuecó (CM-5); one adult microconch? (LPB 737) from Rahuecó (CM-4).

Holotype.- The specimen (MLP 15664) illustrated by a cast in Fig. 30A.

Type horizon and locality.- Lotena Fm., faunal level VV-2 (G_1 287, Fig. 14) of Vega de la Veranada, Neuquén.

Derivatio nominis.- After the type locality.

Diagnosis.- Macroconch evolute with smooth phragmocone; bodychamber with subquadrate whorl section, strong, distant and rounded primaries, undivided and with a single row of rounded tubercles on the ventro-lateral shoulder.

Remarks.- The ?microconch is moderately small, evolute, inner whorls rounded in whorl section, with blunt primary ribs and no tubercles; the last whorl preserved is subrectangular in whorl section with finely and densely ribbed, flat venter and is uncoiled. In the macroconch the tubercles (internal mold) have been the base of hollow spines of the shell, as described by Gygi & Hillebrandt (1991: 162). The specimen form Rahuecó is tentatively included in this species; it consists of a compressed, subadult phragmocone ($D = 60$ mm) with compressed subrectangular whorl section, flat flanks and rounded venter; 7-8 primary ribs per half whorl connecting two rows of small tubercles.

Distribution.- *Pressulus* and *Pseudokranaus* Biozones of V. Veranada and Rahuecó.

Euaspidoceras **cf.** ***chilense*** **Leanza, 1947 [M]**

Remarks.- There are several specimens of *Euaspidoceras* from different localities consisting of adult macroconchs with depressed subrectangular to subquadrate phragmocone and bodychamber with high umbilical wall and two rows of strong, rounded tubercles located at the base and the top of the flanks. This morphology suggests comparison with *E. hypselum* (Oppel, 1863) as seen in literature; nevertheless the holotype (by monotypy) of this species is somewhat different, with a dense tuberculation on the flanks from the inner whorls onwards. It appears that the holotype of Oppel has never been figured photographically, thus the opportunity is taken here to figure a cast of the specimen (Fig. 31B, App. 1) kindly prepared by Gerhard Schairer (München). *Euaspidoceras chilense* (Leanza 1947b: pl. 1: 2holotype, and 3) from Caracoles, Chile, is a species hard to interpret not only because it is based on a poorly preserved holotype but mainly by its resemblance with some of the many morphospecies of Europe. A list of some of these specimens which can be attributed to *E. chilense* is as follows: a macroconch from Portada Covunco, VM-8 (cited by Groeber 1953); an adult phragmocone of a macroconch from Cañadón Alazanes (MLP 19617), VM-8 (colected by C. Gulisano in his level G-377); an almost complete adult macroconch from Aguada de la Mula, beds M 227-229, VV-6; an adult phragmocone from Arroyo Malal Vaca, bed G 1220; a large macroconch from Paso del Inca (MLP 3328), PI-2. Most of these specimens seem to belong to the *Tarapacaense* Bz.

***Euaspidoceras tarapacaense* n. sp. [M&m]**

Fig. 31A, App. 1

?1881 *Euaspidoceras perarmatum* Sowerby.- Steinmann: 282, pl. 11: 2
1947b *Euaspidoceras* cf. *perarmatum*.- Leanza: 291, pl. 1: 4.
1976 *Euaspidoceras* aff. *waageni* Spath.- Stipanicic et al.: 287.
1976 *Euaspidoceras* sp. (*?E. vignalense*).- Wierzbowski: 235, pl. 8: 12.
*1991 *Euaspidoceras* sp.- Gygi & Hillebrandt: 162, pl. 9: 5 (holotype)
1991 *Mirosphinctes* sp. B.- Gygi & Hillebrandt: 157, pl. 3: 6.
1991 *Euaspidoceras* aff. *waageni* Spath.- Riccardi & Westermann: 13.
1998a *Euaspidoceras* cf. *costatum* (Oppel).- Parent: 266.

Material.- A well preserved macroconch adult phragmocone (NMB J31172) and a complete microconch (NMB J31169) from bed 671208/3 of Agua[da] del Carretón; an adult macroconch specimen from Aguada de la Mula (VV-6); and a cf.-specimen adult bodychamber from Arroyo Los Baños (DM-3, MLP 16946).

Holotype.- The specimen figured by Gygi & Hillebrandt (1991: pl. 9: 5).

Type horizon and locality.- Bed 671208/3 (assemblage 3), *Tarapacaense* Bz. of Agua[da] del Carretón, east of Quebrada Incaguasi, Chile (Gygi & Hillebrandt 1991: fig. 11).

Derivatio nominis.- After the type locality located in the Tarapacá Basin.

Diagnosis.- Macroconch of medium adult size, very evolute, subrectangular compressed to subquadrate whorl section with flat flanks and gently rounded venter. Inner whorls with flexuous ribs; tubercles arise firstly on the ventrolateral shoulder, then after $D = 30$ mm two rows are well developed, rather spatulate and connected by rounded ribs, frequently looped; density of tubercles tend to be increase in outer whorl of phragmocone. Microconch smaller, compressed, densely ribbed on bodychamber, primaries bifurcate on the upper half of flanks; innermost whorls identical to macroconch up to about 15 mm in diameter; peristome with a rostrum and long, slender lappets preceded by a wide constriction.

Description.- The holotype is a rather complete specimen with a quarter whorl of living chamber whorl (maximum $D = 89$ mm), probably adult considering the slight uncoiling of the half last whorl. Inner whorls higher than wide, loosely ribbed on flanks without umbilical tubercles. From $D = 58$ mm (phragmocone) ribbing density is higher, the whorl section becomes subrectangular, wider than high, with flat flanks and rounded venter. Each periumbilical tubercle is connected with a ventro-lateral one by means of a strong radial primary rib. Few ribs near the end of the phragmocone are looped. The ventro-lateral tubercles are spatulated and elongated transversally. On the venter the tubercles are connected by straight ventral ribs as wide as the primaries, somewhat weaker in the bodychamber.

Remarks and comparison.- The holotype was found associated with *Mirosphinctes* sp. B (Gygi & Hillebrandt 1991: pl. 3, figs. 6), the corresponding microconch to judge by the identity of their inner whorls. Close inspection of the inner whorls (casts kindly contributed by R. Gygi and R. Panchaud, Natural Museum Basel) shows they are identical up to $D = 15$ mm, after which each specimen develops its own dimorphic morphology. Other specimen of *Mirosphinctes* sp. B from upper beds in the same section shows an aspect closer to the *Epipeltoceras*-morphology, suggesting a phyletic succession exactly like in Europe (the important macroconch cited in association with this latter remains to be described).

The new species has some resemblance with *Euaspidoceras chilense* Leanza and *E.* cf. *perarmatum* (Sowerby) described by Leanza (1947b) from Caracoles. As noted by Chong et al. (1984) these two forms are actually close to *E. hypselum* (Oppel) and *E. costatum* (Dorn, 1931) of the latest Bifurcatus Zone and early Bimammatum Zone. *E. tarapacaense* n. sp. is very close to *E. costatum* [M] / *Epipeltoceras berrense* [m] (middle Bimammatum Subzone), the macroconch as figured by Dorn (1931: pl. 6: 7). However the macroconch of the Tethyan species exhibits tuberculate innermost whorls tuberculate earlier than in the Andean species; looped ribs are irregularly seen in both species (cf. Dorn 1931: pl. 7: 6). The most significant difference is in the microconchs: a true *Epipeltoceras* in *E. costatum* but a typical *Mirosphinctes* in *E. tarapacaense* n. sp.

The morphogenera *Mirosphinctes* and *Epipeltoceras* are receptacles for the small lappeted microconchs of *Euaspidoceras* (cf. Bonnot et al. 1994). The morphological transition from *Mirosphinctes* to *Epipeltoceras* is seen at the late Bifurcatus to early Bimammatum zones (Enay 1966, Enay et al. 1982, Schweigert 1995, 1997, Gygi & Hillebrandt 1991), when appears the first *E. hypselum* (Rozak & Brochwicz-Lewinski 1978, see Parent 1998a) as the modal morphotype within the *Euaspidoceras* of this age, then passing to *E. costatum*. These late Oxfordian *Euaspidoceras* are included in *Clambites* Rollier, 1922 (Type species: *Ammonites clambus* Oppel, 1863; SD by Roman 1938) by some authors, e.g. Schweigert (1995, 1997). This evolutionary pattern of the sexual dimorphism may be used for reliable estimation of the age of this Andean level of *Euaspidoceras* in terms of morphological correspondence between sexual dimorphic pairs with Tethyan forms, since homoeomorphies should be much lesser probable in this complex set of characters. *Mirosphinctes* sp. B in Gygi & Hillebrandt (1991) was considered by these authors as a very late representative of the genus, intermediate to *Epipeltoceras*. In conclusion a late Bifurcatus Zone age is indicated, what is additionally supported by the associated fauna at Agua del Carretón (see Fig. 19), described by these authors as *Perisphinctes (Dichotomoceras) andium* Steinmann, *Perisphinctes (P.)* n. sp. and *Gregoryceras perplanatum* Gygi & Hillebrandt, 1991.

E. ajax is more involute but very similar in whorl section and ornamentation of the inner whorls with *E. tarapacaense* n. sp. The bodychamber of *E. ajax* is poorly known but seems to differ only in being more involute and less strongly ribbed by flexuous ribs arising on the umbilical shoulder. It may be assumed that both species are closely related.

Distribution.- *Tarapacaense* Bz. of Aguada de la Mula, Arroyo Los Baños and Agua del Carretón.

Wierzbowski (1976: pl. 8: 12) has described under "*Euaspidoceras* sp. (?*E. vignalense*)" a specimen from Cuba which clearly belongs to *E. tarapacaense* n. sp. This identification indicates a wide biogeographic distribution of the new species.

Genus *Cubaspidoceras* Myczynski, 1976

Type species: *Cubaspidoceras kuteki* Myczynski, 1976

***Cubaspidoceras* n. sp. aff. *carribeanum* (Myczynski, 1976) [M]**

Fig. 29A, App. 1

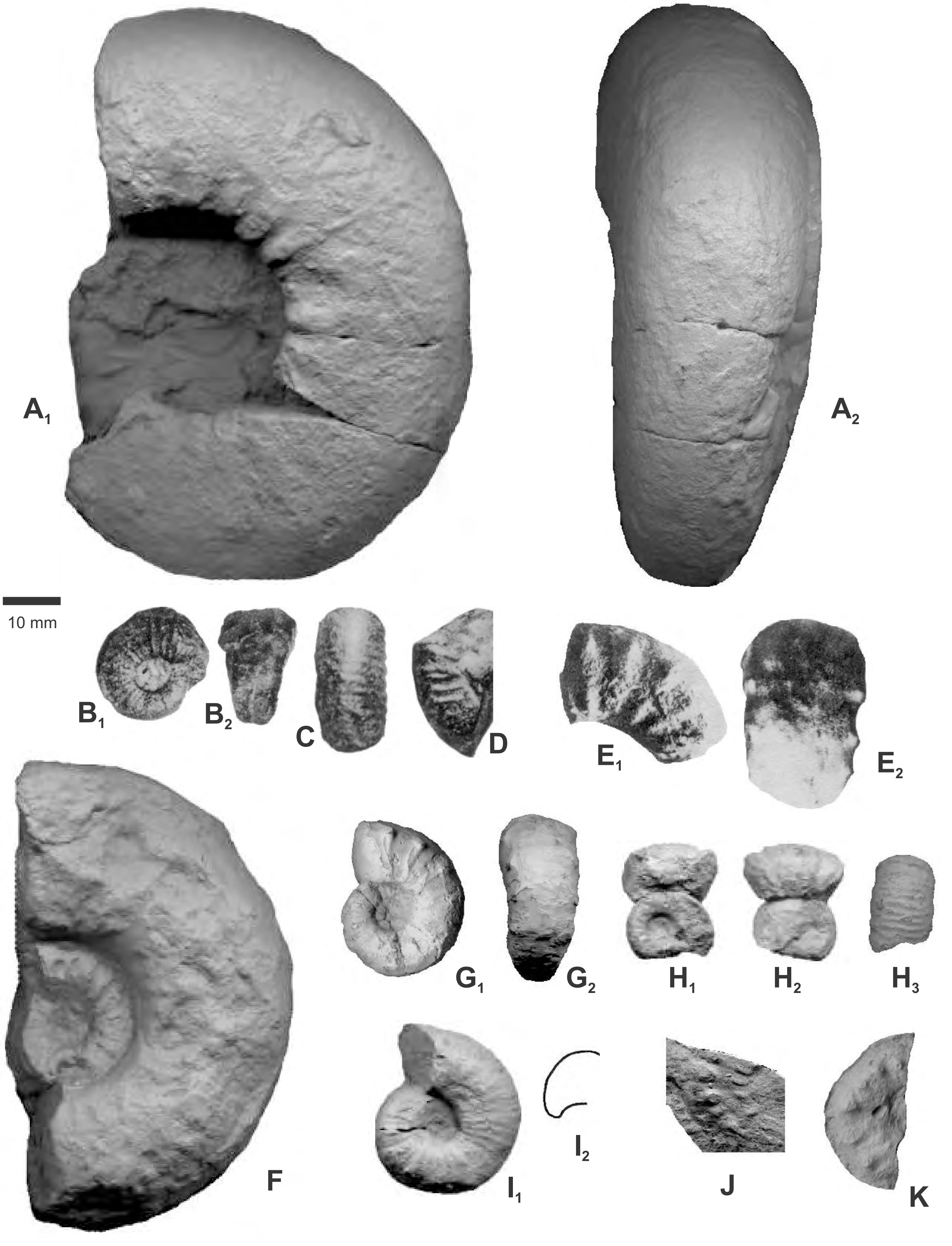


Figure 29. A: *Cubaspidoceras* n. sp. aff. *carribeanum* Myczynski, Vega de la Veranada, La Manga Fm., *Pressulus* Biozone, lateral (**A**$_1$) and ventral (**A**$_2$) views of a cast of an adult macroconch bodychamber (MLP 15670). **B-K**: *Euaspidoceras ajax* (Leanza). **B**: lateral (**B**$_1$) and ventral (**B**$_2$) views of the lectotype, phragmocone (reproduction of Leanza 1947a: pl. 1: 2-3), Rahuecó, Lotena Fm., faunal level CM-4, *Pressulus* Biozone, *Pressulus* Horizon. **C-D**: Microconch syntypes (reproduction of Leanza 1947a: pl. 1: 4-5), Rahuecó, Lotena Fm., faunal level CM-4, *Pressulus* Biozone, *Pressulus* Horizon. **E**: Syntype, macroconch (reproduction of Leanza 1947a: pl. 3: 3-4), Rahuecó, Lotena Fm., faunal level CM-4, *Pressulus* Biozone, *Pressulus* Horizon. **F-H**: Macroconchs (**F**: cast of an adult with bodychamber, MLP 15661; **G**: inner whorls LPB s/n) and microconch (**H**: LPBs/n) from Vega de la Veranada (faunal level VV-2), Lotena Fm., *Pressulus* Biozone. **I**: *Euaspidoceras* aff. *ajax* (Leanza), microconch from Rahuecó, faunal level CM-4, Lotena Fm., *Pressulus* Biozone, *Pressulus* Horizon; lateral view (**I**$_1$) and cross section of the last whorl (**I**$_2$). **J:** lateral view of a juvenil macroconch (LPB 1000), Rahuecó-C. Caicayén, Lotena Fm., faunal level CM-4, *Pressulus* Biozone. **K**: lateral view of a cast of a juvenil macroconch (SNGM 7558/2) from Cajón Troncoso, Nacientes del Teno Fm., bed LI-II LI-IV, *Pressulus* Biozone. All natural size (x1). Arrowhead at last septum.

Material.- An adult macroconch (MLP 15670) from Vega de la Veranada (VV-2).
Description.- Bodychamber involute, narrowly umbilicate with rounded subtrapezoidal whorl section, higher than wide, flat and smooth flanks converging to a rounded moderately narrow and smooth venter. The only ornamentation consists of a single row of periumbilical tubercles. These tubercles are very closely spaced, elongated radially and projected into the umbilicus.
Remarks.- This specimen was cited as *?Cubaspidoceras carribeanum* Myczynski by Parent (1998a) and recently (R. Myczynski, *pers. comm* 03/11/99) interpreted as a morphologically intermediate form between *C. carribeanum* and *C. kuteki* (Myczynski, 1976). Nevertheless the stratigraphic position of the present record, well below the Cuban species, and the morphological differences indicate it is a different undescribed, older species (chronospecies?) which could have given origin to the species of Cuba.

On the other hand, diagnostic features of *Cubaspidoceras* overlap with those of *Pseudowaagenia* Spath, 1931 (Type species: *Ammonites haynaldi* Neumayr, 1873) what has been already suggested by Cariou et al. (1985). Recent colections from Swabia in the last years have gathered isolated records of single specimens of *Pseudowaagenia* from middle Oxfordian beds upwards. In this way *Cubaspidoceras* could very likely represent a junior synonym of *Pseudowaagenia*. The record of scattered *Pseudowaagenia*-like specimens through the Oxfordian along the Tethys leads to consider them as merely extreme morphotypes occasionally developed in some species of *Euaspidoceras* with typical morphology dominating in their populations (see Myczynski & Br.-Lewinski 1981 for discussion and different interpretation).
Biostratigraphy.- *Pressulus* Bz. of Vega de la Veranada.

Family Perisphinctidae Steinmann, 1890
Subfamily Pseudoperisphinctinae Schindewolf, 1925
Genus *Choffatia* Siemiradzki, 1898
Type species: *Perisphinctes cobra* (Waagen, 1875) by SD Buckman (1920: 29)

Choffatia sp. A [M]
Figs. 32C, 33A-B, 34A-B, App. 1

Material.- Several macroconch specimens, more or less complete from Manzano Escondido (VM-2, in collection of MOZP).
Remarks.- Differs from *Choffatia* sp. B in being more inflated, somewhat more involute and with primary ribbing stronger, prosocline and variocostation more slowly progressive. Some specimens are similar to *Perisphinctes hillebrandti* n. sp.
Distribution.- *Patagoniense* Biozone of Manzano Escondido, mainly *Choffatia* Horizon.

Choffatia sp. B
Figs. 32C, 35A-B, App. 1

Material.- Macroconch specimens, more or less complete from Manzano Escondido (VM-2, in collection MOZP), ?one poorly preserved from Picún Leufú (PL-1), ?one from Chacay Melehué (CM-2), one from Rahuecó (CM-2), fragmentary material from Santa Elena (SE-4), Estación Rajapalo (Bed G246), and Vega de la Veranada (VV-2).
Descritpion.- Moderately large adult macroconchs (D = 110 130 mm close to peristome); evolute and widely umbilicate throughout the ontogeny. In the last whorl of the phragmocone and bodychamber the whorl section is subrectangular, higher than wide with flattish flanks, although in some specimens is as high as wide. Phragmocone densely ribbed with radial to subradial primaries bifurcating on the upper third of the flank. Bodychamber is strongly variocostate passing to strong primaries which trifurcate near the ventro-lateral shoulder or in the upper third of flank. Constrictions wide and shallow, about three per whorl from the inner whorls. Peristome simple.
Remarks.- This species is very close to *Alligaticeras*? aff. *raguini* (Gerard & Contatut, 1936) described below, differing in the more depressed whorls, the occurrence of strong constrictions and the stronger primary ribs. The closest resemblance is with late Callovian forms of the Tethys characterized by their rounded to subrectangular phragmocone whorls, radially ribbed with wide shallow constrictions and variocostate bodychambers with ventral ribs abundant and weaker than primaries. These forms are intermediate between *Choffatia* and *Alligaticeras* Buckman, 1923, *e.g.* the specimen from the Athleta Zone of Lupien, France figured by Mangold (1971: pl. 16: 2). This strong resemblance suggests a late Callovian age for the material described, and most likely conspecificity.

There is a large number of perisphinctids collected by C. Gulisano (collections at Museo de La Plata), labelled as *Perisphinctes*? sp., *Arisphinctes*? sp., and other similar names. Most of them are poorly preserved, coming from siltstone and mudstone beds of the Lotena Fm. and many of them are in almost all respects assignable to *Choffatia* sp. A or *Choffatia* sp. B.
Distribution.- *Patagoniense* Bz. of Manzano Escondido, mainly *Choffatia* Hz.; ?Picún Leufú, ?Chacay Melehué, Rahuecó, Santa Elena, ?Estación Rajapalo, and Vega de la Veranada.

Genus *Pseudopeltoceras* Spath, 1928
Type species: *Ammonites chauvinianus* d'Orbigny, 1847

Pseudopeltoceras cf. *chauvinianum* (d'Orbigny, 1847) [M]

Remarks.- Two incomplete bodychambers with remains of phragmocone from Vega de la Veranada (MLP 15669, VV-1) and Arroyo de la Vaina (BB-3) are indistinguishable from the lectotype of *P. chauvinianum* (d'Orbigny, 1847) from the Athleta Zone of France figured by Ruget-Perrot et al. (1961: pl. 2: 2). Also is very similar with the specimen figured by Bonnot et al. (1992: pl. 1: 1) as *P. leckenby* from the late Callovian Athleta Zone of Coté d'Or, France.
Distribution.- *Patagoniense* Bz. of Vega de la Veranada and Arroyo de la Vaina.

Subfamily Perisphinctinae Steinmann, 1890

Genus *Alligaticeras* Buckman, 1923
Type species: *Ammonites alligatus* Leckenby, 1859

Alligaticeras? aff. *raguini* (Gerard & Contaut, 1936) [M]
Fig. 32C, 36A-D, App. 1

Material.- Several specimens, mostly phragmocones from Manzano Escondido (VM-2, collection MOZP).
Description.- Evolute throughout all the ontogeny. Inner whorls rounded in whorl section and densely ribbed by fine prosocline primaries. Outer whorls of phragmocone become subrectangular in whorl section, higher than wide, and covered by densely spaced, fine prosocline primary ribs. On the last whorl of phragmocone and the beginning of the bodychamber the primary ribs are reinforced and bifurcate or trifurcate on the

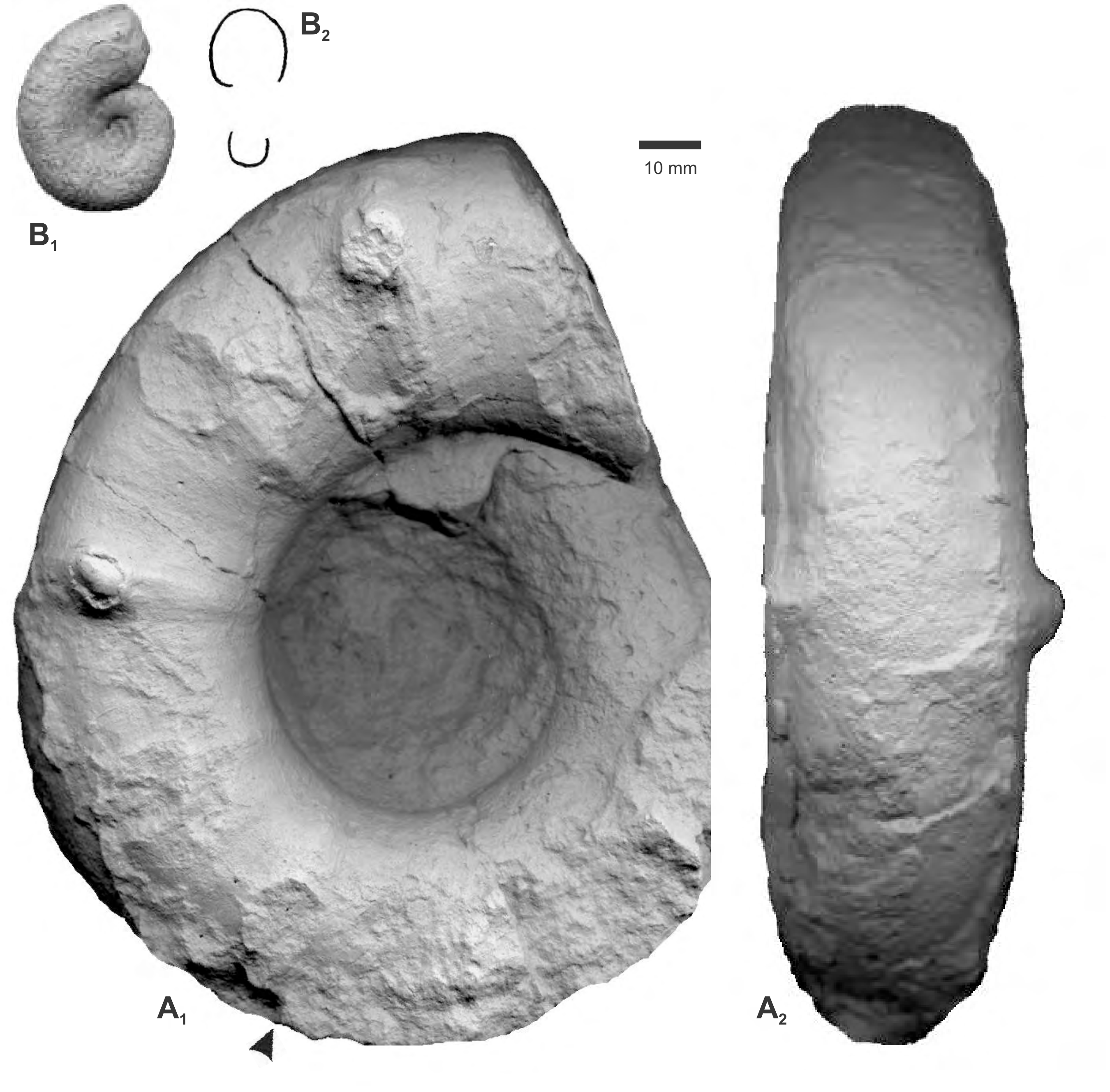


Figure 30. *Euaspidoceras veranadaense* n. sp. **A**. Lateral (**A**$_1$) and ventral (**A**$_2$) views of a cast of the holotype MLP 15664, a macroconch bodychamber with remains of phragmocone from Vega de La Veranada, Lotena Fm., Bed G287, faunal level VV-2, *Pressulus* Biozone. **B**. Lateral view (**B**$_1$) and whorl section (**B**$_2$) of an adult ?microconch phragmocone (LPB 737) from Rahuecó, faunal level CM-4, Lotena Fm., *Pressulus* Biozone. All natural size (x1). Arrowhead at last septum.

upper third of the flanks in finner secondaries which cross orthogonally the venter with some intercalars which occur irregularly distributed. Some primaries are polyschizotome, they bifurcate first near the umbilical shoulder remaining strong, then again on the upper third of the flanks. Constrictions not well marked, narrow and shallow, commonly associated with the polyschyzotomic primaries.

Remarks.- The described material differs from *A. raguini* only by showing some double furcation in the last whorl of phragmocone and at the beginning of the bodychamber. The transference of *O. raguini*, from the original classification in *Orionoides* Spath, 1931 (Type species: *Perisphinctes pseudorion* Waagen, 1875), into *Alligaticeras* was adopted by Lewy (1983), and later supported by Cox (1988: 50). The type species of *Orionoides* consists of an involute perisphinctid with flexuous and fasciculate primary ribs with low furcation point (cf. Arkell et al. 1957: Fig. 405, 11), nothing comparable with *A. raguini* which responds to the diagnosis of the genus *Alligaticeras* and show affinities with *Alligaticeras rotifer* (Brown, 1849; see Cox 1988: pl. 22: 1-8).

Some poorly preserved specimens (Fig. 36B) show subrectangular whorl section (wider than high) with prosocline

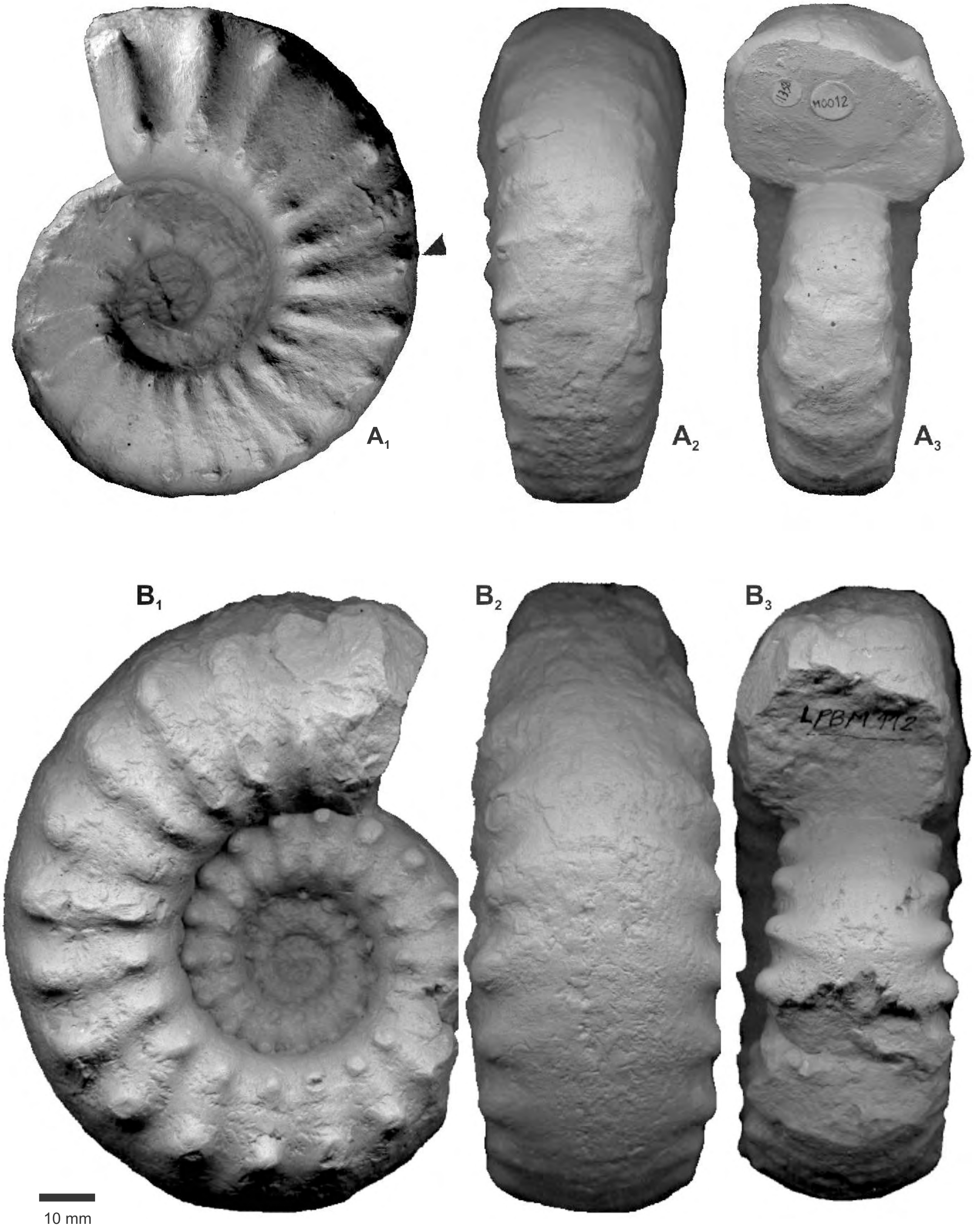


Figure 31. A. *Euaspidoceras tarapacaense* n. sp.: lateral (**A**$_1$), ventral (**A**$_2$) and apertural (**A**$_3$) views of a cast (LPB M012) of an almost complete adult macroconch (MLP 15662) from Aguada de la Mula, La Manga Fm., faunal level VV-5, *Tarapacaense* Biozone. **B.** *Euaspidoceras hypselum* (Oppel, 1863): Lateral (**B**$_1$), ventral (**B**$_2$), and apertural (**B**$_3$) views of a cast (LPB M112) of the holotype (Bayerishe Staatssammlung für Paläontologie un Historische Geologie AS VIII 61), adult phragmocone probably complete, from Umgebungen von Balingen (Württemberg) figured by Oppel (1862-1865: pl. 64: 2) with a hand drawing. Bimammatum Zone, Upper Oxfordian. Cast loaned by G. Schairer (München). Arrowhead at last septum. All natural size (x1).

primaries bifurcating or trifurcating on the ventro-lateral shoulder and with, at least, a well marked constriction per half whorl. Parabolic structures occur on the venter. Ventral ribbing is very distinctive, finer than the primary and crossing venter forming a gentle arch convex towards the aperture and with a slight depression on mid-venter. These specimens are very close to those of *Alligaticeras rotifer* (Brown, 1849) figured by Cox [1988: pl. 22: 1 (holotype), 3-5] from the Athleta Zone of different localities in England.

It is important to note that there are many features in common between *Choffatia* sp. A, *Choffatia* sp. B, and *Alligaticeras*? aff. *raguini*, which in Manzano Escondido occur associated in the same horizon. Moreover, they could be assimilated in a continuum spectrum of variation. Nevertheless they are described in morphotypic terms as separate morphospecies, and the possibility that all of them could belong to a single, very variable species is open to evaluation after more material from different localities is available. On the other hand some specimens are very close to *Cubasphinctes* aff. *durangensis* (Burckhardt), described below (cf. Fig. 36A, D and Fig. 40D), suggesting phyletic relationships.

Distribution.- *Choffatia* Hz., *Patagoniense* Biozone of Manzano Escondido.

Genus *Perisphinctes* Waagen, 1869

Type species: *Ammonites variocostatus* Buckland, 1836; SD Arkell (1951)

Perisphinctes cf. *picteti* De Loriol, 1898

Material.- Three specimens, one from Rahuecó (CM-4), and one from Arroyo Los Blancos, Santa Elena area (SE-3), collection MLP.

Remarks.- Small adults, rather involute, narrowly umbilicate, with wide whorl section and strong blade-like primaries which bifurcate near the ventro-lateral shoulder. On the last whorl the primaries are strong and acute, the interspaces wider than the rib. This form is unique through the basin and matches with the form figured as *Perisphinctes picteti* by Tarkowski (1983: pl. 14: 2). Resemblance is evident with Perisphinctids from the Primus Zone of Agua del Carreton and Aguada del Oro, Chile illustrated by Hillebrandt & Groschke (1995: pl. 6: 8, pl. 6: 7) as *Subgrossouvria* sp. and *Binatisphinctes* sp.

These specimens, in the collection of the Museo de La Plata, are labelled as *Obtusicostites*? sp. Nevertheless the type species of *Obtusicostites* Buckman, 1921 (*Perisphinctes obtusicosta* Waagen, 1875) is a Callovian Indo-Madagascan form characterized by a whorl section higher than wide, involute, and with primary ribs inflated at the umbilical shoulder, then divided in sheaves of two or three secondaries at mid-flank (cf. Arkell et al. 1957: fig. 402; see Callomon 1993: 238).

Distribution.- *Pressulus* Bz. of Rahuecó and Arroyo Los Blancos (NMB).

Perisphinctes hillebrandti n. sp. [M]

Fig. 37A-C

1991 *Perisphinctes* s.l.- Gygi & Hillebrandt: 145 (pars).
*1995 *Perisphinctes (Otosphinctes)* sp.- Hillebrandt & Gröschke, p. 17, pl. 6: 6 [holotype].

Holotype.- The specimen figured by Hillebrandt & Groschke (1995: pl. 6: 6).

Additional material.- An almost complete specimen (J 32824) from Quebrada del Medio, Chile; an aff.-specimen from Cajón Troncoso (BB-1); a fragmentary specimen from Chacay Melehué (LPB 382) from faunal level CM-3.

Derivatio nominis.- After Axel v. Hillebrandt (Berlin), a pioneer in modern systematic studies of the Andean Jurassic and collector of the holotype.

Type locality and horizon.- Quebrada Los Burros, Chile; Primus Zone. Associated with the holotype occur *Araucanites prereyesi* n. sp. and *Miroshinctes* sp. B (*in* Hillebrandt & Gröschke 1995). This fauna belongs to the upper Callovian (see Fig. 19 and discussion below).

Diagnosis.- Inner whorls evolute with dense prosocline primary ribs and deep prosocline constrictions. End of phragmocone and bodychamber compressed suboval; primary ribs strong, acute and prosocline, slightly concave, bi- or trifurcated at the upper third of flank; some secondaries remain unconnected with its respective primary, resembling intercalary ribs; ventral ribbing finer, interrupted after vanishing in mid-venter near peristome and forming an adapical arch.

Remarks.- *P. hillebrandti* n. sp. differs from *T. herreroduclouxi* (Leanza) by the following significant features: (a) Regular occurrence of deep and wide constrictions preceded by a polyfurcated-polyschizotome rib followed by a strong single primary curved forward, (b) stronger ribbing, especially on the phragmocone, where primaries bifurcate lower in the flank, typically below the umbilical seam, and (c) narrower umbilicus and higher whorl section.

Comparable specimens were collected from deeper levels than the type material at Santa Elena (SE-6), Chacay Melehué (CM-2), and Cajón Troncoso (BB-1). The last one, figured as *P.* aff. *hillebrandti* n. sp. (Fig. 37C), differs from *P. hillebrandti* n. sp. in its ventral ribbing finer and denser, and primaries are more rectiradiate.

Distribution.- *Patagoniense* Bz. of Chacay Melehué (NMB), and Primus Zone of Quebrada Los Burros, Aguada del Carretón and Aguada de Oro (TB).

Subgenus *Kranaosphinctes* Buckman, 1921

Type species: *Kranaosphinctes kranaus* Buckman, 1921

Perisphinctes (Kranaosphinctes) cf./aff. *promiscuus* Bukowski, 1887 [M]

Remarks.- The specimen figured by Stipanicic (1951: pl. 1: 1) is practically identical to *P. (Kranaosphinctes?)* n. sp. gr. *promiscuus* (*in* Enay & Boullier 1981: pl. 3: 2) of the late Cordatum Zone, and to *P. (K.) promiscuus* (*in* Glowniak 2002: pl. 1: 2), only differing by the primary ribs slightly concave in the European specimens but rectiradiate to slightly prosocline in the Andean specimen. Very close resemblance is seen between the Andean specimen and *P. (K.) decurrens* (*in* Glowniak 2002: pl. 3: 2). Similar material from Chacay Melehué was recently described as *P.* aff. *promiscuus* from the *Pseudokranaus* Biozone (Parent et al. 2006 *in print*).

Distribution.- *Pseudokranaus* Bz. of Arroyo de La Manga and Chacay Melehué.

Subgenus *Subdiscosphinctes* Malinowska, 1972

Type species: *Perisphinctes kreutzi* Siemiradzki, 1891, by OD

Perisphinctes (*Subdiscosphinctes*) cf. *mindowe* Siemiradzki, 1891

Fig. 37H

Material.- Several well preserved specimens from Mallín

Quemado (VM-7; MLP 16874), Agua Fría (LO-4), Rahuecó (CM-7) and Quebrada Remoredo (VV-4).
Description.- The largest specimen (Mallín Quemado) is a medium-sized (D = 70 mm) phragmacone with part of the bodychamber; involute and compressed, with flat, densely ribbed flanks. Inner whorls are more rounded in whorl section with dense, slightly prosocline ribbing. The specimens from Rahuecó and Arroyo Agua Fría are discoidal, more or less involute; finely ribbed with prosocline primary ribs on the inner whorls and slightly flexuous on the last preserved whorl (40 - 50 mm in diameter) with the bifurcation point at about the lower third of the flanks. Whorl section is higher than wide with flat flanks.
Remarks.- The specimens closely match *P. mindowe* as figured by, *e.g.*, Fischer & Gygi (1989: fig. 6E), Enay (1966: pl. 37, fig. 1, 4), and *P.* (*S.*) *lucingae* Favre, 1876, *e.g.*, Fischer & Gygi (1989: fig. 6A), Enay (1966: pl. 37, fig. 10) of the early Transversarium Zone, Parandieri Subzone (sensu Cariou et al. 1971) of Switzerland.

There is resemblance with some Cuban Oxfordian ammonites described by Wierzbowski (1976) under *Discosphinctes* Dacqué, 1914 (Type species: *Perisphinctes arussiorum* Dacqué, 1905) but the Cuban forms show typical polyzchizotomy combined with irregular ribbing and are currently considered as involute *Cubasphinctes* (see below and Parent et al. 2006, *in print* for an updated revision of these ammonites).
Distribution.- *Passendorferia* Bz. of Mallín Quemado, Agua Fría, Rahuecó and Quebrada Remoredo.

Perisphinctes (Subdiscosphinctes) cf. *lucingae* (Favre, 1875)

Fig. 37I

1991 *Perisphinctes (Subdiscosphinctes)* cf. *lucingae* (Favre).- Gygi & Hillebrandt: fig. 10.
1998 *Perisphinctes (Pseudodiscosphinctes) lucingae* (Favre).- Myczynski et al.: 188.

Material.- One adult specimen with incomplete bodychamber (NMB-J32823) from Quebrada del Medio (TB).
Description.- Small, evolute and compressed platyconic perisphinctid. Maximun diameter preserved (estimated) 47 mm at beginning of the bodychamber. The uncoiling from last septum indicates adulthood. Inner whorls evolute with rounded to flat flanks; umbilicus moderately wide (U/D = 0.35) with vertical wall and rounded shoulder. Ribbing very fine and dense (P = 33 at D = 24 mm; P = 34 at D = 37 mm), almost radial. Last whorl of phragmocone evolute (U/D = 0.35) and compressed. Whorl section subrectangular with slightly convex flanks and narrow venter. Ribbing compossed of fine and dense primaries which born on the umbilical wall and cross the flank almost radially. Some few primaries are bifurcated, divided on the upper third of flank or on the umbilical shoulder. There is one constriction on last whorl. All ribs reach the ventro lateral shoulder forming an acute elevation. In the beginning of the bodychamber ribbing remains dense and radial; flanks are flat and the umbilical shoulder is rectangular.
Remarks.- The costulation regular with no flared ribs and the absence of polyschizotomy, suggests inclusion in *Perisphinctes (Subdiscosphinctes)* of the Perisphinctinae rather than in *Cubasphinctes* Judoley & Furrazola, 1968 of the Vinalesphinctinae. The present specimen is indistinguishable from *Perisphinctes (Subdiscosphinctes) acandai* Judoley & Furrazola, 1968 (in Gygi & Hillebrandt 1991: pl. 3: 4), which is considered here, as suggested by Gygi & Hillebrandt 1991: 153), a form closely allied to *P. (S.) kreutzi-mindowe* Siemiradzki, 1891. The specimen described has less dense lateral ribbing than *P. (S.)* cf. *mindowe* described above. Having no more than a single incomplete specimen, discussion on its specific identity seems not useful; the name used by Gygi & Hillebrandt (1991) is herein retained for the time being, and a very likely Transversarium Zone age is assumed.
Distribution.- "Transversarium" Zone of Quebrada del Medio, partially equivalent to the Passendorferia Zone of the Neuquén-Mendoza Basin.

Subgenus *Prososphinctes* Schindewolf, 1925

Type species: *Perisphinctes mazuricus* Bukowski, 1887

Perisphinctes (Prososphinctes) cf. *mazuricus* Bukowski, 1887 [M] / *matheyi* de Loriol, 1898 [m]

Fig. 37D-G

Material.- Several macro- and microconchs (LPB 791-792, 803; MLP 16861, 16865, 16870: several specimens) from Rahuecó (CM-4); inner whorls from Cajón Troncoso (BB-4) (SNGM 7612).
Description.- Macroconch: Largest adult specimen with part or its bodychamber (D = 120 mm) subovate to subrectangular in whorl section, higher than wide; ribbing compossed by prosocline to slightly flexuous primaries which divide at the upper half of the flank, ventral ribs fine and not interrupted. Last whorl of the phragmocone densely ribbed and indistinguishable from the microconchs at comparable diameters. Microconch: Several small adults, very evolute with incomplete peristome, one of them with lappets partially preserved; whorl section compressed, subrectangular with flat flanks, venter narrow, rounded and rather smooth; umbilicus shallow and wide. There are about four shallow, prosocline constrictions per whorl through $10 < D < 30$ mm, all of them delimited adapically by a lip. The largest and best preserved specimen presents the following dimensions: maximum D = 45 mm, U/D = 0.48, W/D = 0.22, H_1/D = 0.28, P = 21, V = 37.
Remarks.- This sample matches partially with many forms described throughout Europe, but, importantly, as assemblage with that studied by Scouflaire et al. (1997) of the Cordatum Zone of Chaignay (France), and Brochwicz-Lewinski (1981) from the Bukowski-Cordatum subzones (Cordatum Zone) of the Czestochowa Area, Poland. *Perisphinctes (Prososphinctes) mazuricus* [M] / *matheyi* [m], here interpreted as a sexual dimorphic pair, is attributed everywhere to the early Oxfordian (*e.g.* Atrops & Meléndez 1993, Bourseau 1977, Enay 1966, Gygi 1990, Matyja 1977, Meléndez 1989, Sapunov 1979, Tarkowski 1983).
Distribution.- Upper part of the *Pressulus* Bz. of Rahuecó and Cajón Troncoso.

Subfamily Vinalesphinctinae Meléndez & Myczynski, 1987

Remarks.- This subfamily includes two groups of forms rather well differentiated, the genus *Cubasphinctes* and the genera *Subvinalesphinctes* and *Vinalesphinctes* (see Parent et al. 2006, *in print*).

Genus *Subvinalesphinctes* Wierzbowski, 1976 [M&m]

Type species: *Perisphinctes corrali* Judoley & Furrazola, 1968, by OD

Subvinalesphinctes pseudokranaus Parent, Schweigert & Meléndez, 2006

Fig. 38A-D

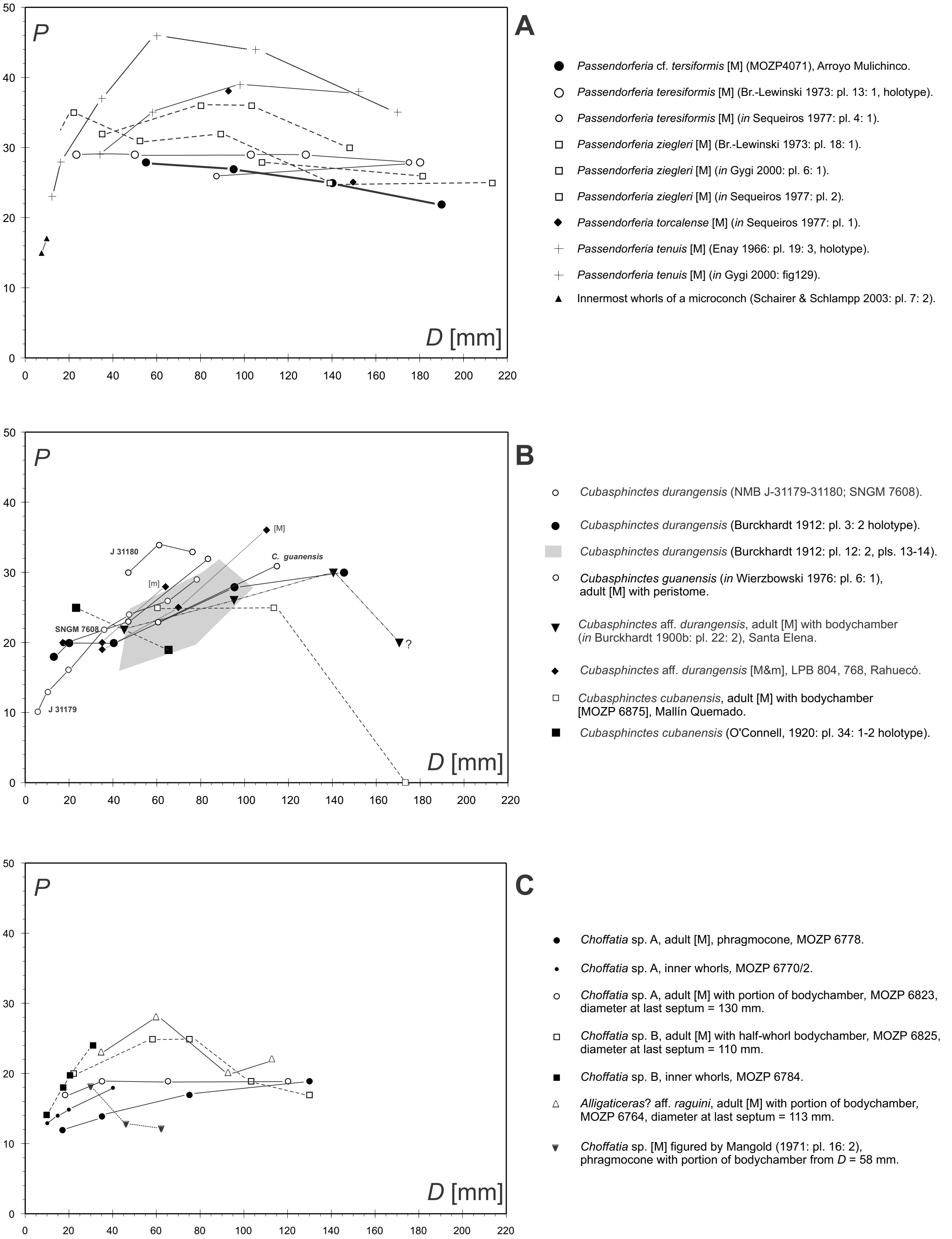


Figure 32. Number of primary ribs per half whorl. **A:** *Passendorferia* cf. *teresiformis* (Brochwicz-Lewinski, 1973) [M] compared with representative material of Europe and type specimens. **B:** Andean *Cubasphinctes* compared with Caribbean species and type specimens. **C:** *Choffatia* sp. A, *Choffatia* sp. B and *Alligaticeras*? aff. *raguini* (Gerard & Contaut, 1936), and comparative material of France.

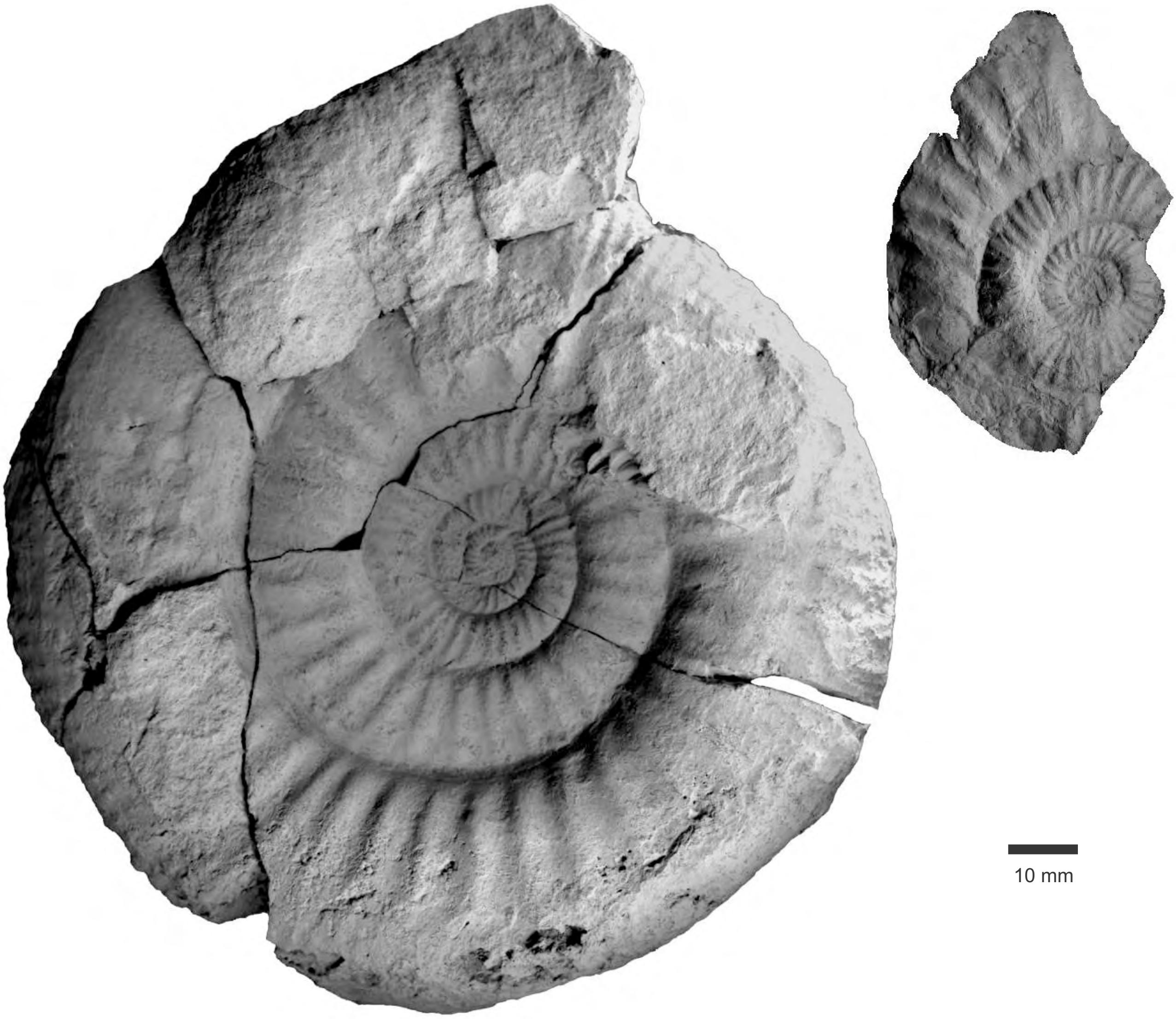


Figure 33. A-B: *Choffatia* sp. A**,** Manzano Escondido, bed ME(1)-3, Lotena Fm., faunal level VM-2, *Patagoniense* Biozone. **A:** lateral view of an adult macroconch phragmocone (MOZP 6778). **B:** inner whorls (MOZP 6770/2). Arrowhead at last septum. All natural size (x1).

Synonymy.- See Parent et al. 2006 *in print*.

Material.- An adult phragmocone (cast LPB-M 121) from Chacay Melehué (CM-5), several specimens (LPB 769, 773, 794, ?802) from Rahuecó (CM-5).

Remarks.- The specimen shown in Fig. 38A from Chacay Melehué, comes from a stratigraphic position slightly lower in the section than the type material. However, the specimens from Rahuecó come from the base of the *Pseudokranaus* Biozone, less than a meter above the faunal level CM-4 which is included in the *Pressulus* Biozone. In those specimens the inner whorls differ from those of the co-ocurring material of *Cubasphinctes* aff. *durangensis* (early transient of the species) in that they have stronger ribbing and there are no bifurcations. It seems probable that both genera have a common origin, and these early forms differentiate mainly in the preadult and adult whorls, reflecting incipient phylognetic divergence.

Distribution.- *Pseudokranaus* Biozone of Chacay Melehué (type locality), Rahuecó, and Arroyo Agua Fría (cf.-specimens).

Subvinalesphinctes prophetae (Gygi & Hillebrandt, 1991)

Fig. 38E

Synonymy.- See Parent et al. (2006 *in print*).

Material.- Some specimens matching the type material of Chile coming from Chacay Melehué (LPB 351/3), Arroyo Los Baños (MLP 16942) and Arroyo Chari Lehue (MLP 16914-16915) faunal level DM-2.

Remarks.- *S. prophetae* was originally allocated to *Perisphinctes (Antilloceras)* but later (Parent et al. 2006 *in print*) was transferred to *Subvinalesphinctes*.

Distribution.- *Pseudokranaus* Bz. of Chacay Melehué, Arroyo Los Baños and Arroyo Chari Lehue. These localities are in a relatively small area corresponding to the depocentre of the NMB (see Fig. 3).

Genus *Cubasphinctes* Chudoley & Furrazola, 1968 [M&m]

Type species: *Perisphinctes (Cubasphinctes) jaworskii*
Chudoley & Furrazola, 1968

Cubasphinctes durangensis (Burckhardt, 1912)

Figs. 32B, 39A-E, 40A-D, App. 1

1900b *Perisphinctes funatus* Oppel.- Burckhardt: 38, pl.

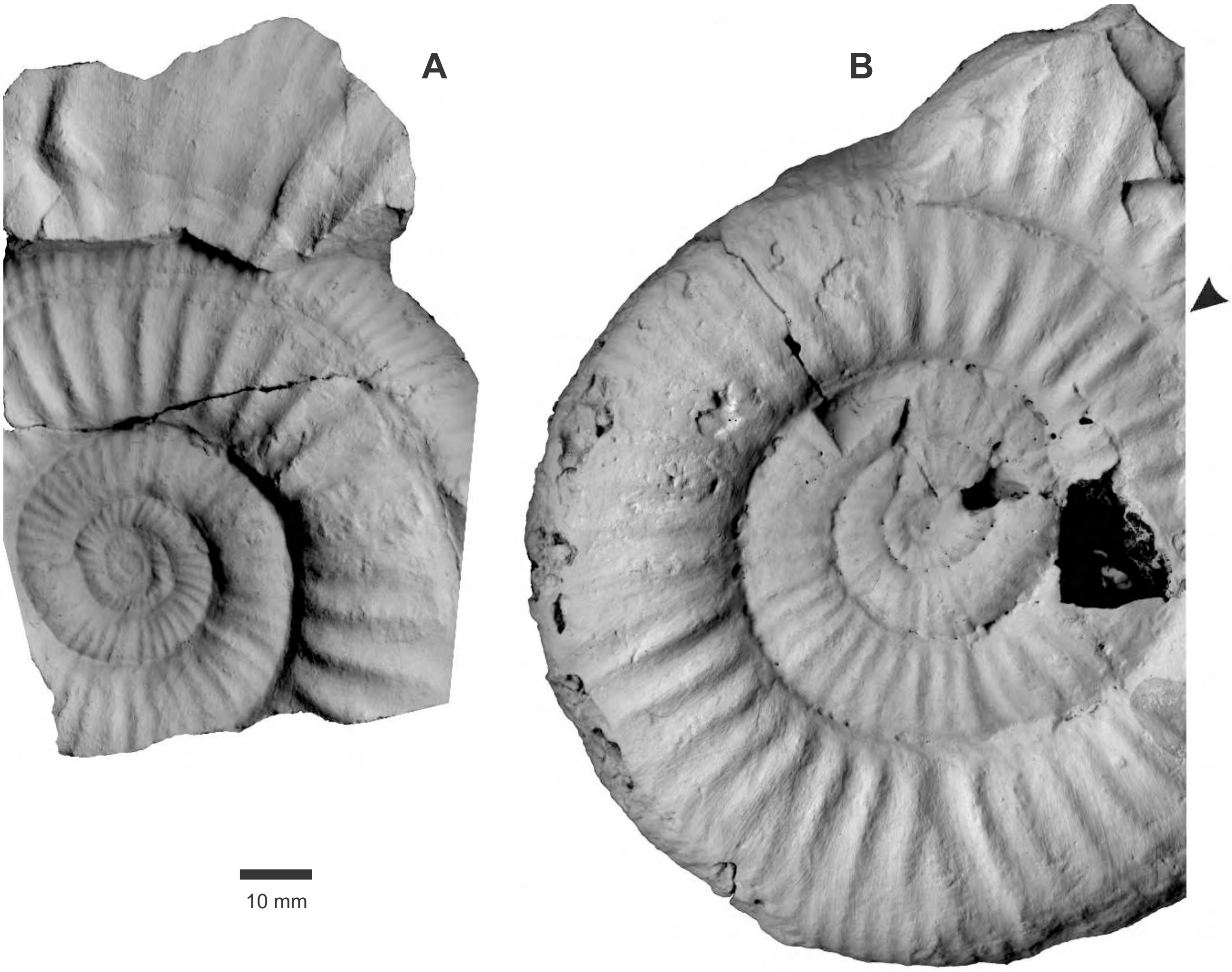


Figure 34. A-B: *Choffatia* sp. A**,** Manzano Escondido, bed ME(1)-3, Lotena Fm., faunal level VM-2, *Patagoniense* Biozone. **A:** lateral view of an adult macroconch with portion of bodychamber (MOZP 6808/1). **B:** lateral view of an adult macroconch with portion of bodychamber (MOZP 6823). Arrowhead at last septum. All natural size (x1).

23: 2.
*1912 *Perisphinctes durangensis* n. sp.- Burckhardt: 16, pl. 3: 1-2, pl. 4: 6.
1912 *Perisphinctes lagunitasensis* n. sp.- Burckhardt: 18, pl. 2: 13-15, 17.
1912 *Perisphinctes* cf. *rota* Sinzow.- Burckhardt: 21, pl. 3: 3.
1912 *Perisphinctes* cf. *promiscuus* Bukowski.- Burckhardt: 20, pl. 3: 4-6.
1912 *Perisphinctes* aff. *plicatilis* d'Orbigny.- Burckhardt: 22, pl. 4: 2-4.
1912 *Perisphinctes* cf. *plicatilis* De Riaz.- Burckhardt: 24, pl. 4: 1, 5, 10.
1912 *Perisphinctes* cf. *chloroolithicus* Nikitin.- Burckhardt: 27, pl. 4: 7-9, pl. 5: 7-10.
1968 *Perisphinctes (Arisphinctes) albeari intermedius* sp. et subsp. nov.- Judoley & Furrazola: pl. 29: 1a-d, pl. 27: 1a-b, pl. 28: 1a-b.
1976 *Perisphinctes (Cubasphinctes)* aff. *guanensis* Sánchez Roig.- Wierzbowski: 211, pl. 5: 7.
1976 *Perisphinctes (Cubasphinctes) guanensis* Sánchez Roig.- Wierzbowski: 211, pl. 6: 1.
?1976 *Perisphinctes (?Antilloceras)* aff. *plicatoides* O'Connell.- Wierzbowski: 221, pl. 7: 4.
1982 *Perisphinctes* s.s. sp. 1 (= *Dichotomosphinctes*? sp.).- Cornejo et al.: pl. 2: 5-6.
1984 *Perisphinctes* (*Dichotomosphinctes*?) sp.- Muñoz & Niemeyer: pl. 2: 5.
1988 *Dichotomosphinctes wartaeformis* (Burckhardt).- Contreras et al.: 9, pl. 1: 3.
1988 *Dichotomosphinctes lagunitasensis* (Burckhardt).- Contreras et al.: 9, pl. 1: 1.
1991 *Perisphinctes (Dichotomosphinctes)* cf. *wartae* Bukowski.- Gygi & Hillebrandt: 144. [NMB-J31180; Fig. 39C of present paper].
1991 *Perisphinctes (Arisphinctes)* aff. *helenae* de Riaz.- Gygi & Hillebrandt: 144. [NMB-J31179; Fig. 39A of present paper].
1992 *Perisphinctes (Dichotomosphinctes) durangensis* Burckhard. - Callomon *in* Hillebrandt et al.: 265.

Material.- Several specimens, mostly phragmocones. Tarapacá Basin: Sandón (col. A. Hillebrandt: level 660726/6, NMB-J31179 and level 660726/2, NMB-J31180). Neuquén-Mendoza Basin: Arroyo Agua Fría (LO-3), Chacay Melehué (CM-6), Cajón Troncoso (BB-5; SNGM 7608-7609, 7613), Santa Elena (MLP 17343, faunal levels SE-4 and SE-6), Aguada de la Mula (VV-3). Aff.-specimens form Rahuecó

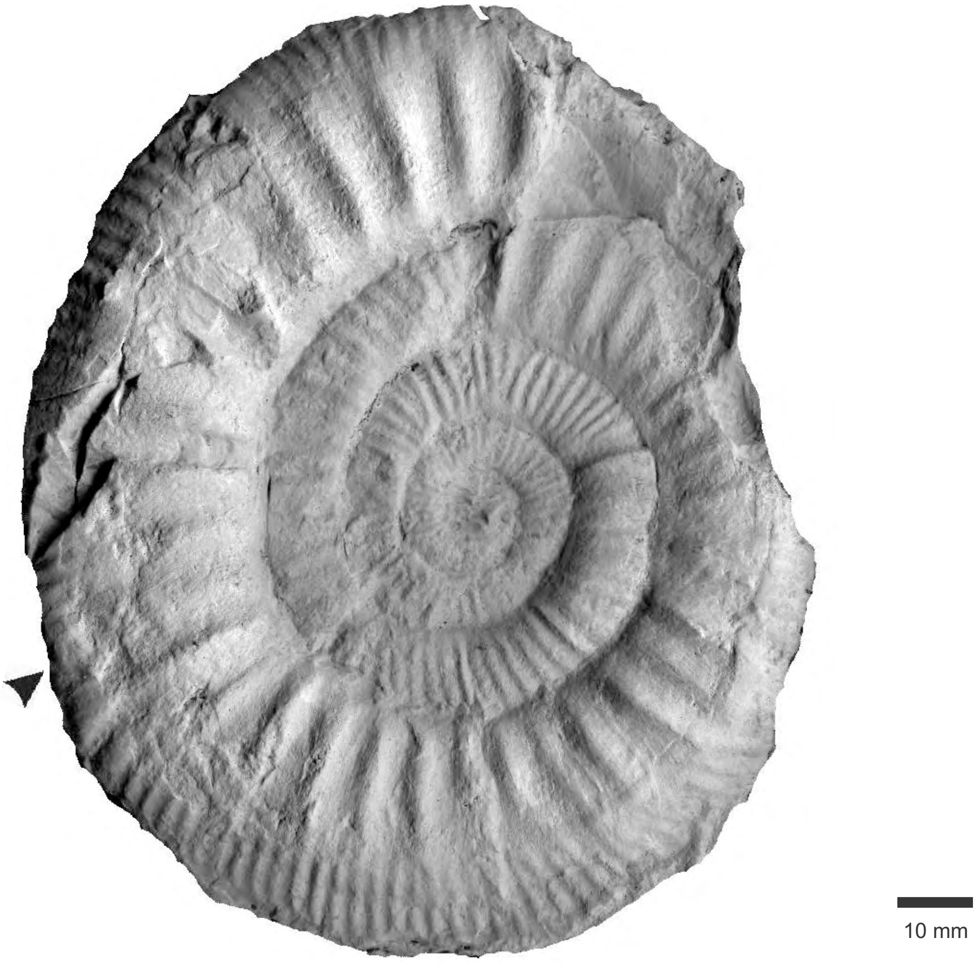


Figure 35. *Choffatia* sp. B**,** Manzano Escondido, bed ME(1)-3, Lotena Fm., faunal level VM-2, *Patagoniense* Biozone, *Choffatia* Horizon, lateral view of an almost complete adult macroconch (MOZP 6825). Arrowhead at last septum. Natural size (x1).

(CM-4).

Holotype.- The only specimen studied by Burckhardt (1912: pl. 3: 2, pl. 4: 6) is the holotype by monotypy.

Description.- Innerwhorls ($6 < D < 20$ mm) evolute with rounded whorl section. Flanks densely ribbed with 12 to 20 fine prosocline primaries per half whorl. Outer whorls ($D > 20$ mm) evolute with subrounded whorl section, then subquadrate with flattish flanks and rounded venter. Primary ribs fine, wiry, slightly flexuous to rectiradiate, bifurcating on the ventrol-lateral shoulder; there are some simple undivided primaries. Secondaries are slightly projected towards aperture, and cross the ventral region together with the undivided primaries, with no change of strenght and evenly spaced. Two or three constrictions per whorl, moderately wide and deep. On outer whorls constrictions are preceeded by a polyfurcated or polyschyzotomic rib and followed by a flared undivided primary. Angular length of bodychamber between 270° and 360°.

Remarks.- This species could be assigned to *Perisphinctes (Dichotomosphinctes)* (cf. Callomon *in* Hillebrandt et al. 1992: 265) or better, as pointed out by Wierzbowski (1976: 192), to *Cubasphinctes*. Indeed, the somewhat irregular ribbing with several simple primaries and constrictions associated with polyschizotome-polyfurcated and flared ribs, clearly point to an evolute representative of *Cubasphinctes* after the current interpretation of the subfamily Vinalesphinctinae. Additional evidence for the inclusion of the present species in *Cubasphinctes* comes from the corresponding microconch, recognized in an early transient of the species, which exhibits the characteristic lappeted peristome of the genus (described below). At specific level most of the present specimens agree with the holotype of *Perisphinctes durangensis*. The specimens figured by Burckhardt (1912, see list in synonymy) may be considered as part of a single, moderately variable species following a pattern very similar to that seen in the Plicatilis Zone *Perisphinctes* of Europe (cf. Callomon 1988, Callomon *in* Hillebrandt et al. 1992: 265). Present sample includes specimens which fit with the variation attributed to the Mexican specimens of Burckhardt (1912; *e.g*., our Fig. 39A with his pl. 4: 1-2 and our Fig. 39C with his pl. 5: 1-3). Moreover this latter specimen (Fig. 39C) is very close to *Cubasphinctes*? *elizabethaeformis* (Burckhardt, 1912, including the specimen figured as *P. alterneplicatus* Waagen in his pl. 7: 1-3) of upper levels (early Transversarium Zone, Callomon *in* Hillebrandt et al. 1992: 265), although less densely ribbed. This parallelism in morphologic evolution between Perisphinctinae and Vinalesphinctinae may be attributed to a common root (genetic relationships), but for the present author this remains not a completely satisfactory explanation.

Within Cuban Perisphinctids the most similar one is the specimen figured by Wierzbowski (1976: pl. 6: 1) as *Cubasphinctes guanensis* (Judoley & Furrazola, 1968) from the lower part of the Jagua Fm. *C. guanensis* is most probably a

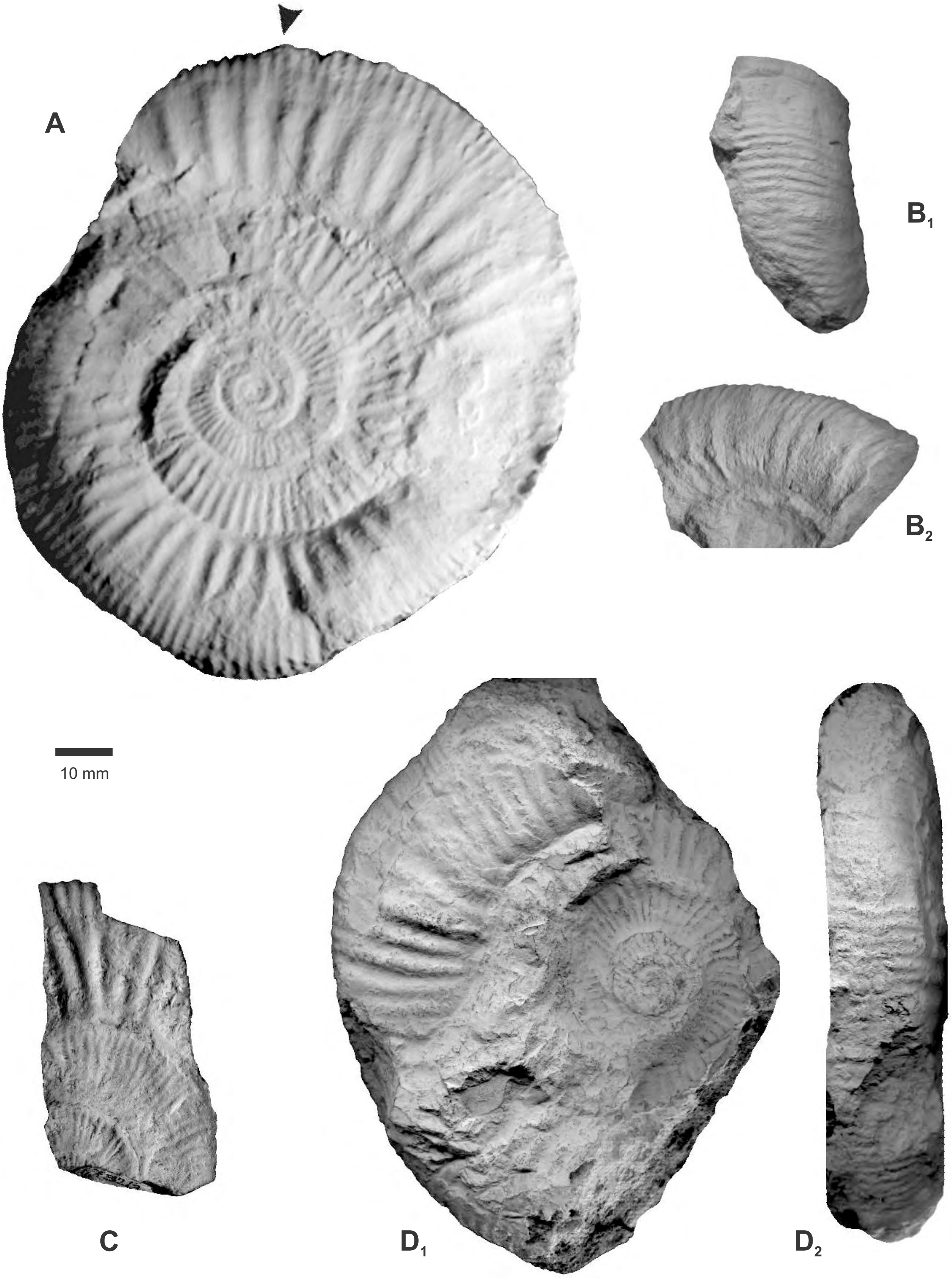


Figure 36. A-D: *Alligaticeras*? aff. *raguini* (Gerard & Contaut, 1936), Manzano Escondido, bed ME(1)-3, Lotena Fm., faunal level VM-2, *Patagoniense* Biozone, *Choffatia* Horizon. **A:** lateral view of an adult ?macroconch phragmocone with beginning of bodychamber (MOZP 6764). **B:** ventral (**B**$_1$) and lateral (**B**$_2$) views of the inner whorls of a ?macroconch (MOZP 6800). **C:** inner whorls of a ?macroconch (MOZP 6792/3) showing details of ribbing. **D**: lateral (**D**$_1$) and ventral (**D**$_2$) views of an adult ?macrococnch phragmocone (MOZP 6796) of a compressed and finely ribbed individual. Arrowhead at last septum. All natural size (x1).

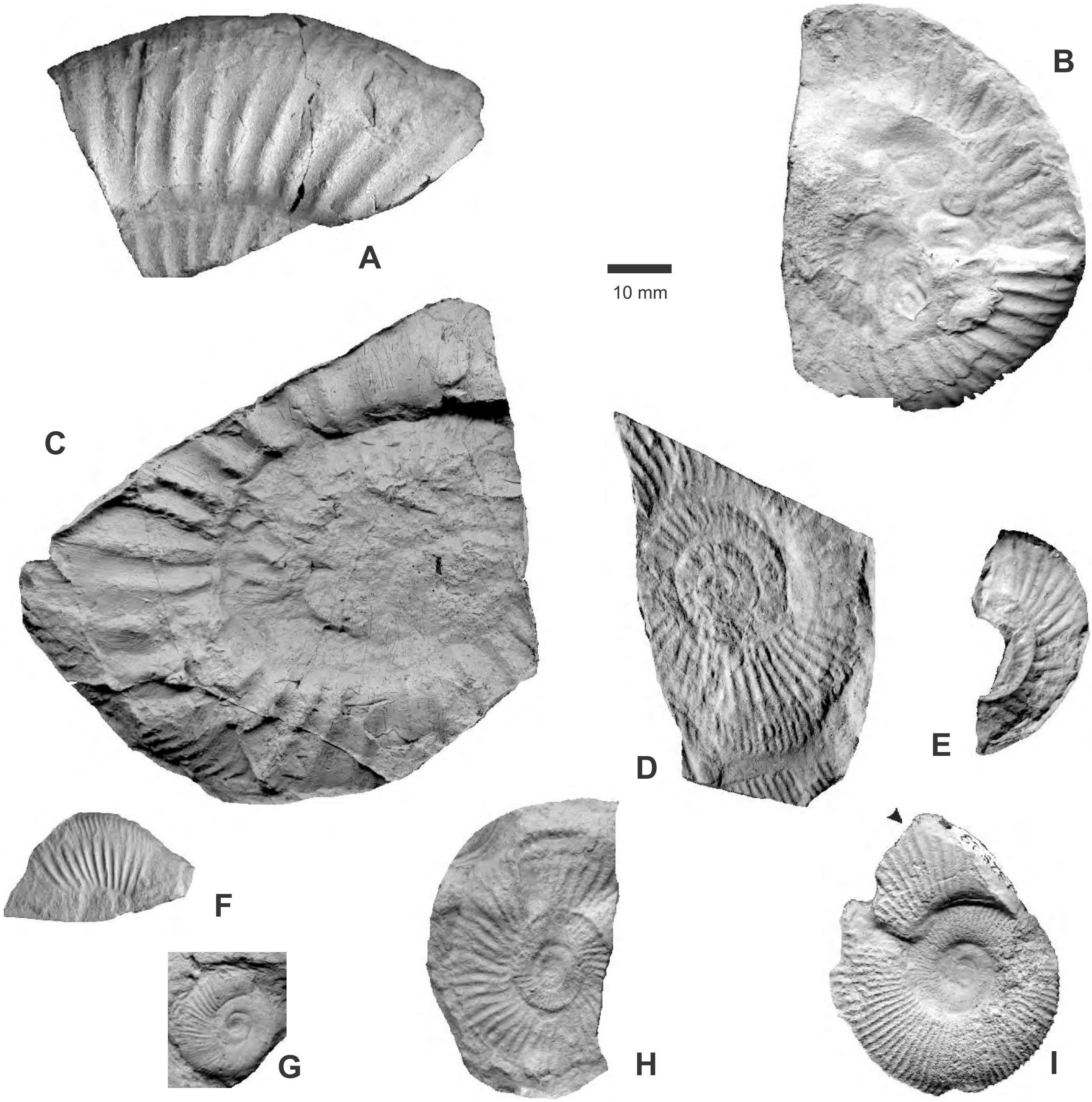


Figure 37. A-B: *Perisphinctes hillebrandti* n. sp. **A**: lateral view of a fragmentary adult macroconch (LPB 382) from Chacay Melehué, Lotena Fm., faunal level CM-3, *Patagoniense* Biozone; **B:** lateral view of a ?microconch with incomplete bodychamber (NMB-J 32824) from Quebrada del Medio (TB), Primus Zone. **C**: *Perisphinctes* aff. *hillebrandti* n. sp., lateral view of a cast of a macroconch bodychamber with remains of phragmocone (SNGM unnumbered), Cajón Troncoso, Nacientes del Teno Fm., faunal level BB-1, middle-upper Callovian. **D-F:** *Perisphinctes (Prososphinctes)* cf. *mazuricus / matheyi* from Rahuecó - C. Caicayén, Lotena Fm., bed RA(1)-9, faunal level CM-4, *Pressulus* Biozone: **D:** phragmocone of an adult macroconch (LPB 792); **E:** incomplete adult microconch (LPB 803); **F:** inner whorls of a macroconch (LPB 791). **G:** *Perisphinctes (Prososphinctes)* cf. *mazuricus / matheyi*, inner whorls (SNGM 7612), Cajón Troncoso, faunal level BB-4, *Pressulus* Biozone. **H**: *Perisphinctes (Subdiscosphinctes)* cf. *mindowe* Siemiradzki, phragmocone (LPB 757) from Rahuecó - C. Caicayén, bed RA(1)-13 (upper part), base of La Manga Fm., faunal level CM-7, *Passendorferia* Biozone. **I:** *Perisphinctes (Subdiscosphinctes)* cf. *lucingae*, adult specimen with beginning of bodychamber (NMB-J32823) from Quebrada del Medio (TB), *Passendorferia* Zone. Arrowhead at last septum. All natural size (x1).

junior synomyn of *C. durangensis* and occurs associated with *Subvinalesphinctes corrali* (Judoley & Furrazola, 1968) in Cuba, what is very significant for it is very close to *Subvinalesphinctes pseudokranaus* Parent et al. (2006 *in print*) from the *Pseudokranaus* Bz. (roughly Plicatilis Zone) of Chacay Melehué. *Perisphinctes (Arisphinctes) albeari intermedius* Judoley & Furrazola (1968: pl. 29: 1a-d, pl. 27: 1a-b, pl. 28: 1a-b) seems also indistinguishable but its stratigraphic position is uncertain.

Material from the *Pressulus* Biozone of Rahuecó (Fig. 12: CM-4) may belong to a different, directly related species or an early transient of *C. durangensis*, including macro- and microconchs, with some small differences respect the described material. In this form labeled as *C.* aff. *durangensis* (Fig. 40A-D), the primary ribs are somewhat reinforced or elevated towards the point of furcation at the

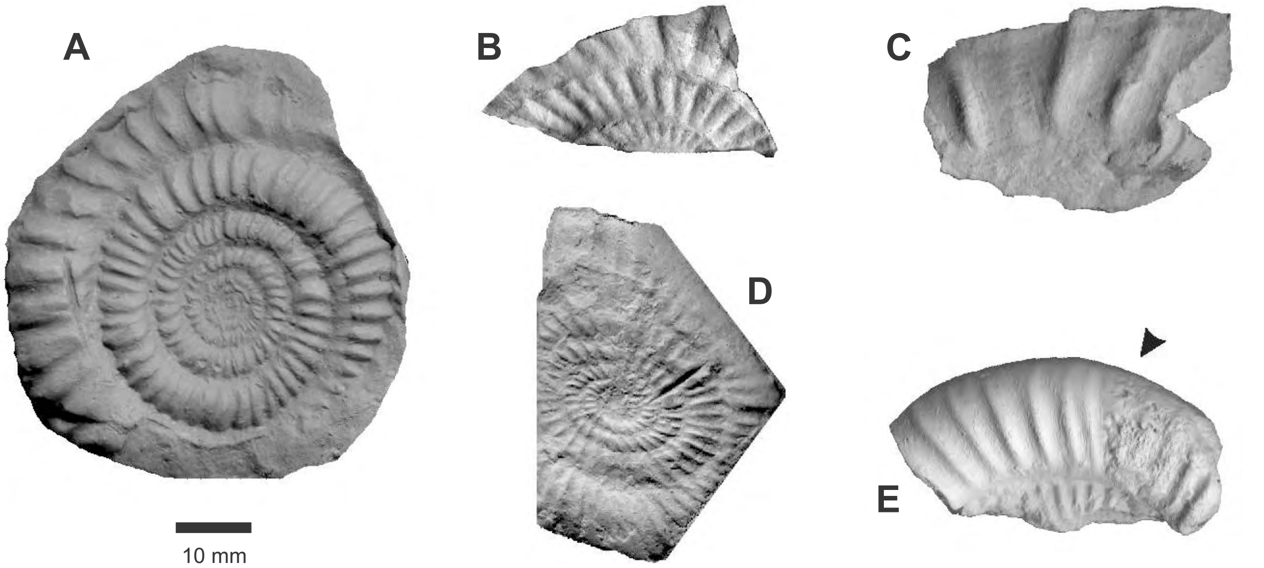


Figure 38. A-D: *Subvinalesphinctes pseudokranaus* Parent, Schweigert & Meléndez. **A**: Plastercast (LPB-M 121) of an incomplete specimen from Chacay Melehué, La Manga Fm., bed P_1, faunal level CM-5, *Pseudokranaus* Bz. **B-D**: fragmentary specimens (LPB 769, 794, 802) from Rahuecó (C. Caicayén), Lotena Fm., bed RA(1)-10, faunal level CM-5, *Pseudokranaus* Bz. **E:** *Subvinalesphintes prophetae* (Gygi & Hillebrandt): portion of phragmocone and beginning of bodychamber, probably adult specimen (LPB 351/3), Chacay Melehué, base of La Manga Fm., bed P_1, faunal level CM-5, *Pseudokranaus* Bz. All natural size (x1). Arrowhead at last septum.

ventro-lateral shoulder, not flexuous, and the secondaries and intercalars are weaker. These features of ribbing are seen in the lower Oxfordian genus *Tenuisphinctes* Gygi, 1998 (Type species: *Tenuisphinctes kruegeri* Gygi, 1998), and especially in the Andean *Tenuisphinctes herreroduclouxi* (Leanza, 1947) (see Parent et al. 2006 *in print*), but in this species the whorl section is oval and ribbing generally less dense on the phragmocone. The microconch of *C.* aff. *durangensis* (D_p = 45 mm) is less than half as large as of the macroconch (max preserved D = 110 mm but some fragments indicate larger sizes); the peristome is a smooth segment of whorl, with a short rostrum and two broad and short lappets, typical of the subfamily (cf. Parent et al. 2006 *in print*; Wierzbowski 1976: pl. 6: 6). The macroconch from Santa Elena figured by Burckhardt (1900b: pl. 23: 2) belongs to *C.* aff. *durangensis*, being identical with material from Rahuecó (Fig. 40A). This specimen preserves its bodychamber up to the peristome, showing strong and widely spaced primary ribs in the last fourth.

Distribution.- *Pseudokranaus* Bz. of Rahuecó, Chacay Melehué, Arroyo Agua Fría, Cajón Troncoso, Santa Elena and Aguada de la Mula. In Sandón, Chile (TB) it occurs in beds included in the lower “Transversarium” Zone (= Plicatilis Zone) of Hillebrandt & Gröschke (1995). Type material from México (San Pedro de Gallo) comes from beds correlated with the Plicatilis Zone of Europe. In Cuba the age of the lower part of the Jagua Fm. should be Plicatilis Zone in age (cf. Wierzbowski 1976). The early transient *C.* aff. *durangensis* is known to occur in the upper part of the *Pressulus* Biozone of Rahuecó and Chacay Melehué (CM-4).

Cubasphinctes cubanensis (O'Connell, 1920) [M]

Figs. 32B, 41A-B

Material.- Seven adult macroconchs (MOZP 6874-6875; MLP 16875, 16877-16879) from Arroyo Agua Fría (LO-4) and Mallín Quemado (VM-7) with more or less complete bodychamber; a poorly preserved macroconch bodychamber from Riscos Bajos (MOZP 6873), poorly preserved juvenil and macroconch specimens (LPB 754-756, 771) from Rahuecó (CM-7).

Description.- Macroconchs: Diameter 110 - 180 mm close to the peristome, the largest could have been even larger than 200 mm in max diameter (MOZP 6874). Evolute platycones with compressed bodychamber, smooth or covered by wide vestigial prosocline primaries which in the last half tend to fade away. Phragmocone is rather compressed with rounded-subrectangular whorl section, higher than wide. It is covered by primaries slightly inclined forward, not very dense (P = 25 at D_{ls} = 113 mm) and trifurcating on the ventro-lateral shoulder. Ventral ribs are evenly spaced, crossing the venter orthogonally with no interruption.

Remarks.- The described specimens can be considered local evolute morphotypes of the species. The largest one is practically smooth in the last half of its bodychamber with the ribs on the phragmocone inflated on the umbilical shoulder; moreover it is more narrowly umbilicate and strongly ribbed in phragmocone, closely resembling the specimen figured by Wierzbowski (1976: pl. 4: 3).

The smooth bodychamber of *C. cubanensis* (see also Wierzbowski 1976: pl. 4: 6) gives evidence that this feature may be diagnostic, thus useful for distinguishing between adult macroconchs of the Vinalesphinctinae and Perisphinctinae.

Distribution.- *Passendorferia* Bz. of Riscos Bajos, Mallín Quemado, Rahuecó and Arroyo Agua Fría.

Subfamily Passendorferiinae Meléndez, 1989 [1984]

Passendorferiinae gen. et sp. indet.

Fig. 42D

Remarks.- In the bed ME(1)-3 of the Manzano Escondido section (*Patagoniense* Biozone, *Choffatia* Horizon) it was collected a well preserved specimen consisting of the inner whorls of a very evolute ammonite, with rounded whorl section and dense, slightly prosocline to radial primary ribbing,

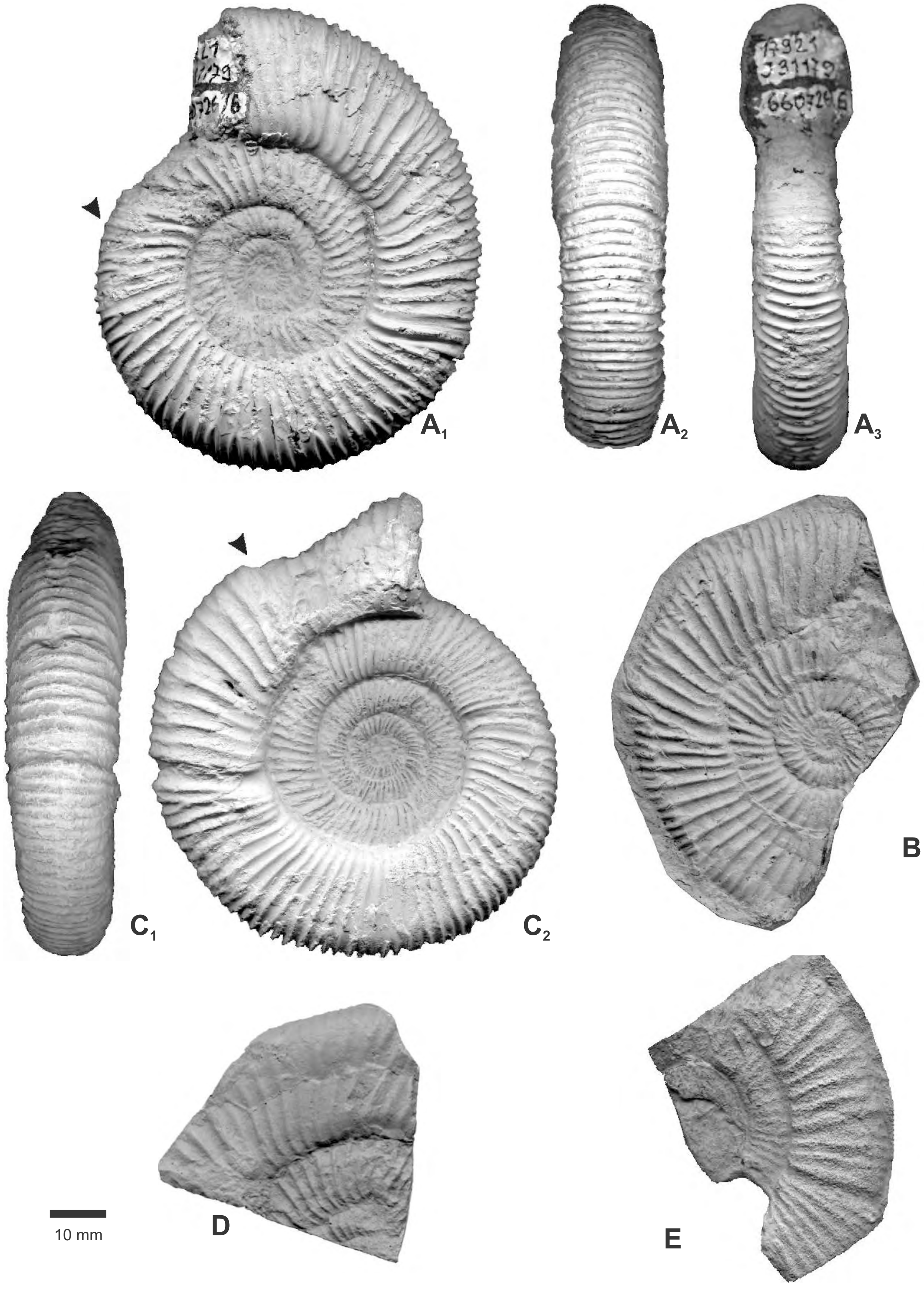


Figure 39. *Cubasphinctes durangensis* (Burckhardt, 1912), all specimens from beds of the *Pseudokranaus* Bz. **A**: ?macroconch phragmocone with beginnig of bodychamber (NMB-J31179), Sandón (level 660726/6). **B**: Cast of phragmocone (SNGM 7608), Cajón Troncoso, faunal level BB-5, upper part of the Nacientes del Teno Fm. **C**: Adult phragmocone with beginning of bodychamber (NMB-J31180), Sandón (level 660726/2). **D**: Cast of phragmocone (SNGM 7609), Cajón Troncoso, faunal level BB-5. **E**: Specimen with portion of bodychamber (LPB 765) from Chacay Melehué, faunal level CM-6, *Pseudokranaus* Biozone. All specimens natural size (x1) otherwise indicated.

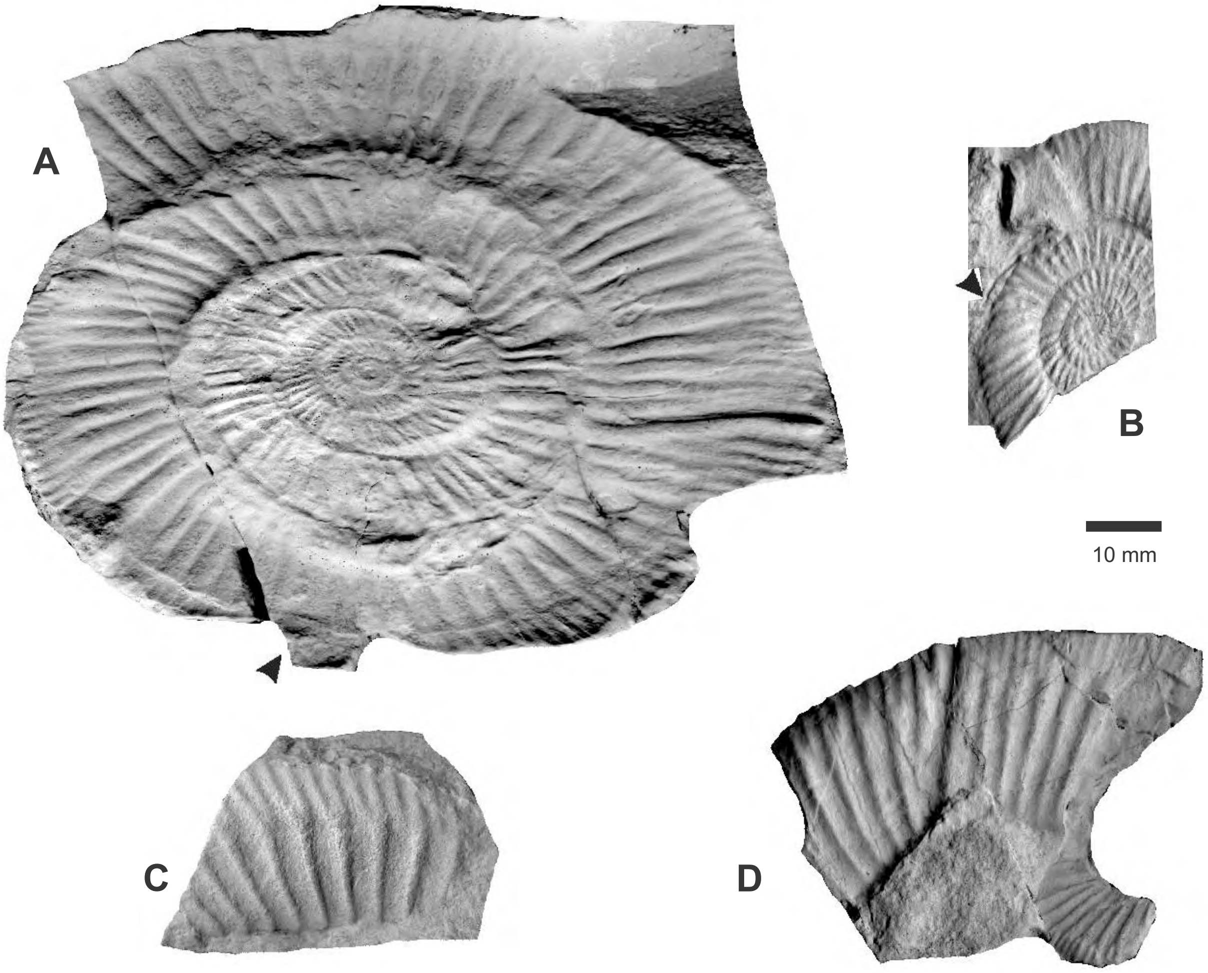


Figure 40. *Cubasphinctes* aff. *durangensis* (Burckhardt), Rahuecó (C. Caicayén), Lotena Fm., bed RA(1)-9, faunal level CM-4, *Pressulus* Bz. **A:** almost complete adult macroconch (LPB 804); **B:** complete microconch with lappets (LPB 768); **C:** fragment of terminal adult macroconch bodychamber (LPB 796) showing details of ribbing at the ventro-lateral shoulder; **D:** portion of adult macroconch (LPB 779) showing details of the constriction in adult phragmocone and ribbing of inner whorls (cf. **B**). All natural size (x1). Arrowhead at last septum.

showing three wide, well marked constrictions per whorl. This record is interesting since it could be the earliest one (late Callovian, see below) for the subfamily.

Genus *Passendorferia* Brochwicz-Lewinski, 1973

Type species: *Nebrodites (Passendorferia) teresiformis* Brochwicz-Lewinski, 1973

Remarks.- The representatives of this genus are mainly distinguished from those of the Perisphinctinae by ribbing and whorl section (see Brochwicz-Lewinski 1973 and Melendez 1989). There is a very good example of the differential features in the specimen of *Passendorferia ziegleri* figured by Gygi (2000: pl. 6: 1). It shows inner whorls ($D < 75$ mm) densely ribbed with radial, fine, undivided primaries on flattish flanks. The shell is very evolute with slowly growing whorl section area relative to the diameter, and a constriction each 0.75 whorl. For $D > 75$ mm ribs become wider and more distant but remain recti-radiate and with almost no bifurcations, only bifurcations seem to coincide with constrictions, as described by Meléndez (1989). The innermost whorls are well ilustrated by Schairer & Schlampp (2003). The innermost whorls figured by Wittmann (2001: pl. 1: 10) as *Passendorferia* sp., coming from beds of the late Middle to early Late Oxfordian of Quebrada Los Tarros (TB), does not belong to this genus. It is ornamented in a style unknown in *Passendorferia*: strongly ribbed by well spaced primaries which bifurcate on the ventro-lateral shoulder in two strong and divergent secondaries.

The most densely ribbed species seems to be *Passendorferia tenuis* (Enay, 1966) which can reach almost twice the number of primaries per half whorl than the type species of the genus (Fig. 32A). *Passendorferia ziegleri* (Br.-Lewinski, 1973) and *P. torcalense* (Kilian, 1889) tend to have a denser ribbing than the type species, especially in the phragmocone, but converging to this latter through the bodychamber.

Passendorferia cf. *teresiformis* (Brochwicz-Lewinski, 1973) [M]

Figs. 32A, 42A-C

1998a ?*Passendorferia* gr. *torcalense* (Kilian).- Parent: 266.

Material.- Several adult macroconchs from Arroyo Mulichinco (MOZP 5771; LO-4), Arroyo Agua Fría (LO-4), V. Veranada (VV-4), Mallín Quemado (VM-6), Chacay Melehué (CM-7) and Rahuecó (CM-7).

Description.- Adult macroconchs with maximum diameter about 190-200 mm at peristome; the phragmocone begins at *D*

= 100 to 140 mm; angular length of bodychamber 300°. Very evolute from the innermost whorls with very shallow umbilicus. Rounded whorl section that becomes subrectangular, higher than wide, with flat flanks in the three last whorls of phragmocone and bodychamber. Inner whorls covered by fine, dense, slightly prosocline primaries not divided, then in middle whorls primary ribbing is dense and radial. Last whorl of phragmocone and bodychamber with stronger and widely spaced radial primaries which do not divide. Shallow, slightly prosocline constrictions from the inner whorls throughout the ontogeny (in specimen MOZP 4071 they are preserved at D = 32, 36, and 80 mm); they are preceeded by a pair of primaries united on the umbilical shoulder with the anterior one more inclined, parallel to the constriction. A well preserved fragment of bodychamber from Rahuecó shows the characteristic compressed whorl section with primary ribs undivided, reaching the ventro-lateral shoulder radially, where they become more elevated, crest-shaped, and die out leaving the narrow venter smooth.

Remarks.- The described specimens closely match with the type species of the genus in whorl section, rib density ontogeny and adult size. However they do not differ significantly from morphotypes figured by Sequeiros (1977) from the Transversarium Zone at Málaga, Spain (Meléndez 1989, Cariou & Meléndez 1990: 141), especially from *P. torcalense* (Kilian, 1889) [M]. *P. ziegleri* (Br.-Lewinski, 1973) [M] is more densely ribbed (see Fig. 32A), rounded in whorl section and larger in adult size than *P. teresiformis* and than the Andean species. Nevertheless specific identity is not fully indicated because of the profusion of names for co-ocurring morphotypes with only small morphological differences through Europe and the yet unclear significance for biogeography in this time interval between the eastern Pacific and the Tethys. In the region Huasteca (Mexico) and Louisiana (U.S.A.) the genus has been recorded (López-Palomino et al. 2006, Young & Olóriz 1993) from Middle Oxfordian beds, but only based on poorly preserved material which precludes closer comparisons.

Distribution.- *Passendorferia* Bz. of Arroyo Mulichinco, Arroyo Agua Fría, Vega de la Veranada, Quebrada Remoredo, Mallín Quemado, Chacay Melehué and Rahuecó.

Passendorferia n. sp. A

Fig. 42E

1951 *Perisphinctes (Arisphinctes)* sp. I. Stipanicic: 233, pl. 1: 2, pl. 2: 2.
1951 *Perisphinctes (Arisphinctes)* sp. II. Stipanicic: 234, pl. 1: 3, pl. 3: 2.

Material.- Poorly preserved specimens from Arroyo de la Manga and Arroyo Blanco (LM-5); a phragmocone from Quebrada del Medio, North Quebrada Incahuasi, Chile, bed 671207/4 (collected by A. Hillebrandt, NMB-J32825).

Description.- Innermost whorls ($3 < D < 6$ mm) smooth, strongly constricted, evolute, rounded whorl section with flat or slightly convex flanks. At D = 10 mm first visible primaries, wide and acute, prosocline and simple. At $D > 26$ mm the ribbing becomes stronger and looser, almost radial; whorl section is subrectangular then rounded, and very evolute. There are two broad constrictions per whorl. Primaries cross the venter weakened.

Remarks.- The new material well matches with the bulk of the Perisphinctid fauna of Arroyo de La Manga described by Stipanicic (1951), on which could be based the new species. Except the specimen in his pl. 1: 1 (described as *P.* cf. *promiscuus-decurrens*), the specimens in pl. 1: 2, 3, pl. 2: 2 and pl. 3: 2 have a ribbing of the same style on inner whorls: moderately dense, slightly prosocline, with no clear bifurcation, then becoming subradial and coarser towards the bodychamber. There are some well spaced constrictions from the inner whorls. They share a conspicuous pattern of ribs bifurcated on the umbilical shoulder, followed by a pair of closely spaced simple primaries. All these ammonites seem to conform to a single, moderately variable species, very evolute with the whorl section being subrectangular with almost flat flanks. This fauna was discussed briefly by Parent (1998a), but now supported by new material it becomes clear that these ammonites belong to Passendorferiinae.

The specimen of Quebrada del Medio was cited by Gygi & Hillebrandt (1991: 145) indicating its stratigraphic position as middle Oxfordian (Plicatilis Zone), below *Gregoryceras transversarium gemmellaroi* Gygi & Hillebrandt, 1991.

Distribution.- *Pseudokranaus* Bz. of Arroyo de la Manga, Arroyo Blanco (NMB), and Quebrada del Medio (TB).

Family Ataxioceratidae Buckman, 1921
Subfamily Ataxioceratinae Buckman, 1921

Genus *Lithacosphinctes* Olóriz, 1978

Type species: *Ammonites lictor evolutus* Quenstedt, 1888; renamed *Lithacosphinctes siemiradzkii* Zeiss, see Kiessling & Zeiss (1992)

Remarks.- *Lithacosphinctes* aff. *janus* (Choffat, 1893) described in Parent et al. (2006 *in print*) from material of Chacay Melehué (Fig. 11: faunal level CM-8), has now been recorded from Rahuecó (Fig. 12, faunal level CM-8).

Lithacosphinctes desertorum (Stehn, 1923) [M&m]

Fig. 43A

*1923 *Perisphinctes desertorum* n. sp. - Stehn: 129, pl. 5: 3.
*1930 Granulaptychus (?) f_1 in *Perisphinctes desertorum* Stehn.- Trauth: pl. 5: 1.
1987 *Decipia desertorum* (Stein [*recte*: Stehn]).- Aguirre-Urreta *in* Sanguinetti: 281.
1989 *Decipia desertorum* (Stehn).- Aguirre-Urreta *in* Sanguinetti: 384.
1991 *Lithacosphinctes* aff. *desertorum* (Stehn, 1923).- Gygi & Hillebrandt: 155, pl. 4: 1-2.
2006 *Lithacosphinctes desertorum* (Stehn, 1923).- Parent et al.

Remarks.- The specimen figured by Stehn (1923: pl. 5: 3) is the holotype by monotypy (herein refigured by photographs in Fig. 43A). The type section is at Caracoles (Fig. 4), but the type horizon is unknown. The specimen is a rather small microconch ammonite in respect of this genus, preserving the phragmocone and the bodychamber complete (L_{BC} = 300°). The peristome is not perfectly preserved but the base of one of the lappets is preserved (Fig. 43A$_2$). Within the bodychamber the lower jaws are preserved in the form of a Praestriaptychus (Fig. 43A$_2$, A$_5$); the contour of these jaws perfectly fits the whorl section of the aperture (Fig. 43A$_3$) as expected for the accessory function as operculum. The ornamentation of the last whorl is in the inner mold as strong as in the test. The typical features of the species are the strong primaries trifurcated on the upper third of flank through the last whorl of phragmocone, passing to fasciculate or fascipartite units on the beginning or the

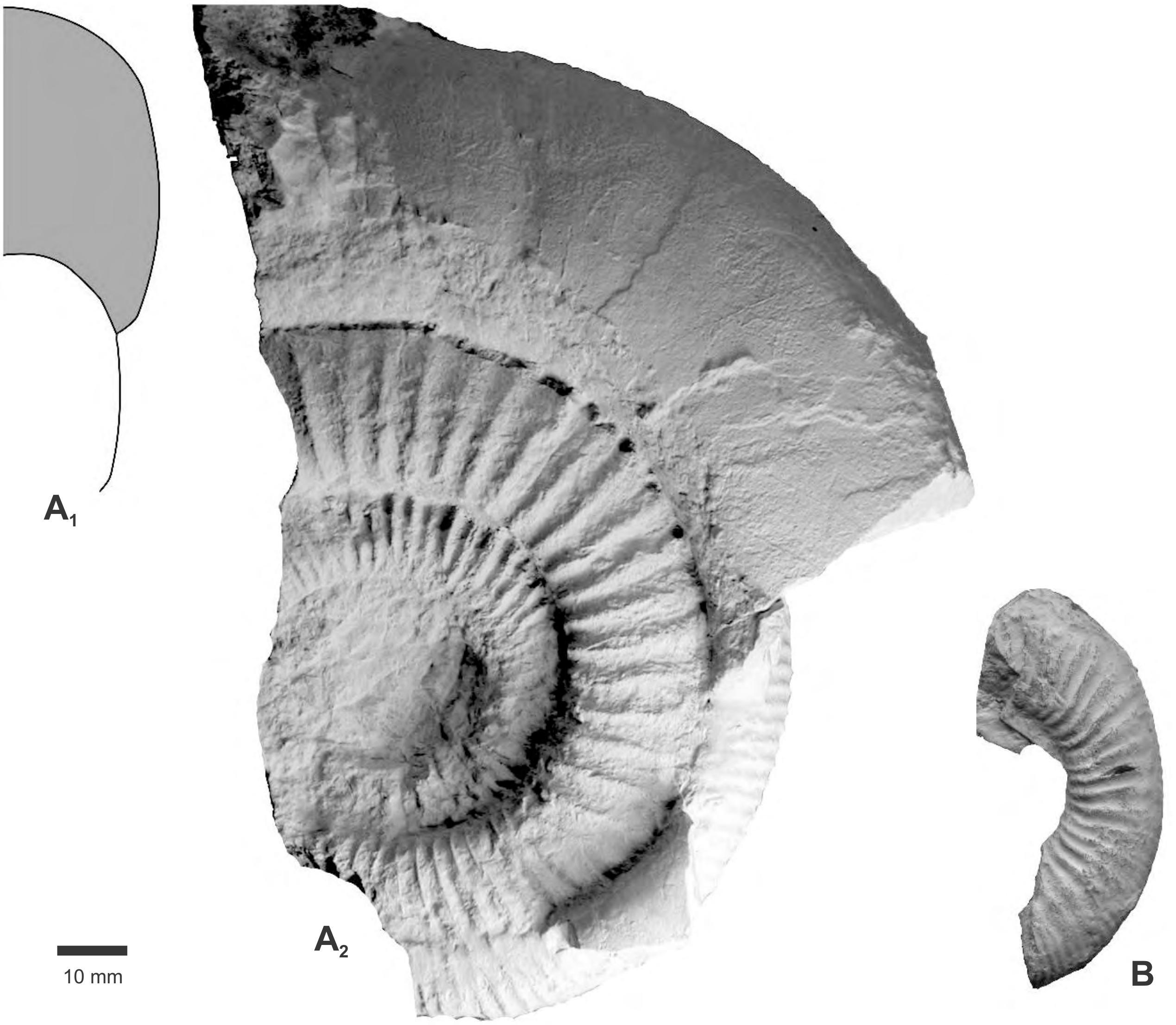


Figure 41. A-B: *Cubasphinctes cubanensis* (O'Connell). **A**: adult macroconch ($\mathbf{A}_1$: transverse section, stippled bodychamber; $\mathbf{A}_2$: lateral view) with incomplete bodychamber (MOZP 6875) from Mallín Quemado, bed MQ(1)-3, La Manga Fm., faunal level VM-7, *Passendorferia* Biozone. **B**: incomplete phragmocone (LPB 754) from Rahuecó-C. Caicayén, bed RA(1)-14a, base of La Manga Fm., faunal level CM-7, *Passendorferia* Biozone. All specimens natural size (x1).

bodychamber; whorl section subrectangular to subtrapezoidal, tending to be slightly higher than wide on the bodychamber, and compressing towards the aperture.

The large macroconchs figured by Gygi & Hillebrandt (1991: pl. 4: 1-2), see also Parent et al. (2006 *in print*: Fig. 7, whorl section), match closely the holotype at comparable diameters, so that they can be referred confidently to the Stehn's species. *L. desertorum* differs from *L.* aff. *janus* (in Parent 2006 *in print*) by its more depressed whorl section and the stronger and widely spaced primary ribs on phragmoconce; bodychamber cannot be compared safely since it is poorly known in *L.* aff. *janus*.

Genus ***Orthosphinctes*** **Schindewolf, 1925**

Type species: *Ammonites tiziani* Oppel, 1863

***Orthosphinctes*? sp. A [m]**

Fig. 43B, App. 1

Material.- A well preserved adult microconch (MOZP 2704/1) and a juvenil specimen (MOZP 2704/2) from Vega de la Veranada, VV-6, base of the Auquilco Fm.

Description.- Adult microconch preserving half whorl of bodychamber without peristome. Very evolute throughout the ontogeny from at least $D = 5$ mm. Whorl section of innermost whorls rounded, then subrectangular ($W/H_1 = 0.95$), and contracting in the preserved portion of bodychamber which is higher than wide ($W/H_1 = 0.65$). Innermost whorls with delicate prosocline primary ribbing. Outer whorls of phragmoconce covered by subradial primaries which arise on the umbilical wall and cross the flank subradially, bifurcating on the upper third of the flank. There are few ribs which remain simple (undivided). All ribs interrupted on venter by a well defined groove. On the bodychamber the primary ribs bifurcate or trifurcate on the upper third of the flank, few ribs remain simple.

Remarks.- The triplicate ribs on bodychamber and the moderately prosocline lateral ribbing on inner whorls suggest a late form of *Othosphinctes*; rib density of the inner whorls is lower than in the species of the genus *Ardescia* Atrops, 1982

(Type species: *Ataxioceras desmoides* Wegele, 1929). Nevertheless the ventral groove and the rather irregular ribbing are unusual of *Orthosphinctes*.

Distribution.- ?*Desertorum* Biozone of Vega de la Veranada (VV-6).

Superfamily Stephanoceratoidea Neumayr, 1875
Family Sphaeroceratidae Buckman, 1920
Subfamily Eurycephalitinae Thierry, 1976
Genus *Araucanites* Westermann & Riccardi, 1976

Type species: *Mayaites (Araucanites) stipanicici*
Westermann & Riccardi, 1976 by OD

Remarks.- *Araucanites* was originally proposed as a subgenus of the Indo-Madagascan genus *Mayaites* Spath, 1924 (Type species: *Ammonites maya* Sowerby, 1840). Later it was recognized as a typical Eurycephalitinae (Westermann & Riccardi 1985, see Westermann *in* Westermann et al. 2002 for discussion), and most probably originated from *Eurycephalites* Spath, 1928 (see Parent 1998b). As Westermann (*in* Westermann et al. 2002) pointed out, the clue to the distinction of *Araucanites* from the most closely similar morphologic taxon, *Lilloettia* Crickmay, 1930 (Type species: *Lilloettia lilloetensis* Crickmay, 1930), lies in the microconchs, commonly included in the morphogenus *Xenocephalites* Spath, 1928 (Type species: *Macrocephalites neuquensis* Stehn, 1923). It must be noted that this approach is supported by the fact that early microconch *Araucanites* from Chile and New Zealand show a slight but conspicuous subtabulation of the venter of the bodychamber, mostly due to a ventrolateral elevation of ribs before running on venter (see Hillebrandt & Gröschke 1995: pl. 6: 2-3, Westermann *in* Westermann et al. 2002: figs. 6H, 8J, 9D, 9L). Microconch *Eurycephalites* and *Lilloettia* have well rounded whorl section without any sign of local elevation of ribs throughout the complete ontogeny.

Westermann (*in* Westermann et al. 2002) described a rich fauna of early to middle Callovian *Araucanites* of New Zealand for the first time outside the Andean Province. Hillebrandt & Groschke (1995) described several samples of late Callovian to early Oxfordian Eurycephalitines, including *Araucanites* and *Eurycephalites*, from northern Chile. The earliest *Araucanites* of the NMB and TB are *Araucanites* n. sp. A (material yet undescribed from the middle Callovian faunal level CM-1 of Chacay Melehué, see Fig. 11) and *A. prereyesi* n. sp. (late Callovian). The most probable phyletic succession accounting records of both basins is shown in Fig. 44. *Eurycephalites* n. sp. D (*in* Hillebrandt & Gröschke 1995), Primus Zone of the upper Callovian of the TB, is almost identical to the widely distributed *E. extremus* from the early Callovian (Riccardi & Westermann 1991, Parent 1998b), suggesting that *Eurycephalites* persisted as an independent lineage to *Araucanites* or, well, that early *Araucanites* developed extreme (atavic?) variants with the morphology of their ancestors. There are two possible origins of the Andean *Araucanites* lineage. The first, a modification of that already proposed (Parent 1998b) after new evidence, is that late populations of *E. extremus* should had evolved to *Araucanites* n. sp. A (middle Callovian), *A. prereyesi* n. sp. (late Callovian - ?early Oxfordian), and then to the group of *A. stipanicici-reyesi-mulai* (middle Oxfordian). This hypothesis has received additional support in the last years after the observation that *E. extremus* exhibits a subtriangular whorl section in its inner whorls, and the discovery of a new species (*Araucanites* n. sp. A) in the middle Callovian of Chacay Melehué (work in progress). The second hypothesis (Westermann in Westermann et al. 2002) suggests an origin in the early? or middle Callovian of New Zealand in the form of *Araucanites awakino* Westermann, 2002. Nevertheless, most likely the ancestors of *Araucanites* lived in the Pacific platforms of western South America and southwards up, at least, to New Zealand, belonging to a common genetic pool with rather free exchange during the early and middle Callovian.

Araucanites prereyesi n. sp. [M&m]

Figs. 44, 45A-B, App. 1

*1995 *Eurycephalites* n. sp. B.- Hillebrandt & Gröschke: 15, pl. 6: 1 (holotype). [Macroconch].
1995 *Eurycephalites*? n. sp. E.- Hillebrandt & Gröschke: 16, pl. 6: 4.[Macroconch].
1995 *Eurycephalites*? n. sp. F.- Hillebrandt & Gröschke: 16, pl. 6: 2-3. [Microconch].

Holotype.- The adult macroconch figured by Hillebrandt & Gröschke (1995: pl. 6: 1a-b) in lateral views; the apertural view is shown herein as Fig. 45B.

Additional material.- One adult macroconch bodychamber with remains of phragmocone (LPB 012) from Chacay Melehué (faunal level CM-2); three poorly preserved macroconch specimens (LPB 732-734) from bed ME(1)-3 and several probable conspecific nuclei from Manzano Escondido (all from faunal level VM-4); ?one adult from Vega de la Veranada, VV-1.

Type locality and horizon.- Cerro Amarillo, horizont 3 (*in* Hillebrandt & Gröschke 1995).

Description.- Macroconch: phragmocone and bodychamber very involute, sphaeroconic, slightly uncoiled near peristome. Whorl section subtriangular, higher than wide ($W/H_1 = 0.89$ at $D = 50$ mm), more depressed near peristome. $L_{Bc} = 240 - 270°$. Peristome simple, prosocline, preceded by a constriction. Ribbing formed by prosocline primaries which divide at mid-flank in two or three prosocline secondaries. Primaries fade out gradually on the periumbilical area from the end of the phragmocone. Intercalatory ribs arise at middle third. All ribs cross the venter orthogonally very regularly spaced. Phragmocone whorl section is sub-oval, rather compressed with venter and flanks more rounded than in bodychamber. Microconch: Represented by the *Xenocephalites*-like specimens figured as *Eurycephalites*? sp. F by Hillebrandt & Gröschke (1995: pl. 6: 2-3). They are characterized by strong ribs with a ventro-lateral elevation and crossing perpendicularly the subtabulate venter.

Remarks and comparison.- The distinctiveness of this species lies in the well-marked primaries on flanks through first 2/3 of the bodychamber. It is very close to some forms of *Lilloettia*, but the stratigraphic position and the short bodychamber point to an inclusion in *Araucanites*, very close to *A. reyesi* Westermann & Riccardi, 1976 but older and enough different to be considered a separate species. Differences are not only the deeper stratigraphic position of *A. prereyesi* but its narrower umbilicus and more persistent lateral ribbing; whorl sections are almost identical at the end of phragmocone (cf. Westermann & Riccardi 1976: fig. 4b). The earliest forms could be present in the fauna from Cajón Troncoso, illustrated by Cornejo et al. (1982) and Muñoz & Niemeyer (1984), *Eurycephalites* aff. *extremus* and *Araucanites* n. sp. A, likely late Callovian (Fig. 16: faunal level BB-2), *Patagoniense* Bz.

A. prereyesi n. sp. closely resembles *A. spellmani* Westermann [M&m], this is very significant for phylogeny, for they should represent be direct derivatives, transients, in the lineage described above during the middle to early late Callovian.

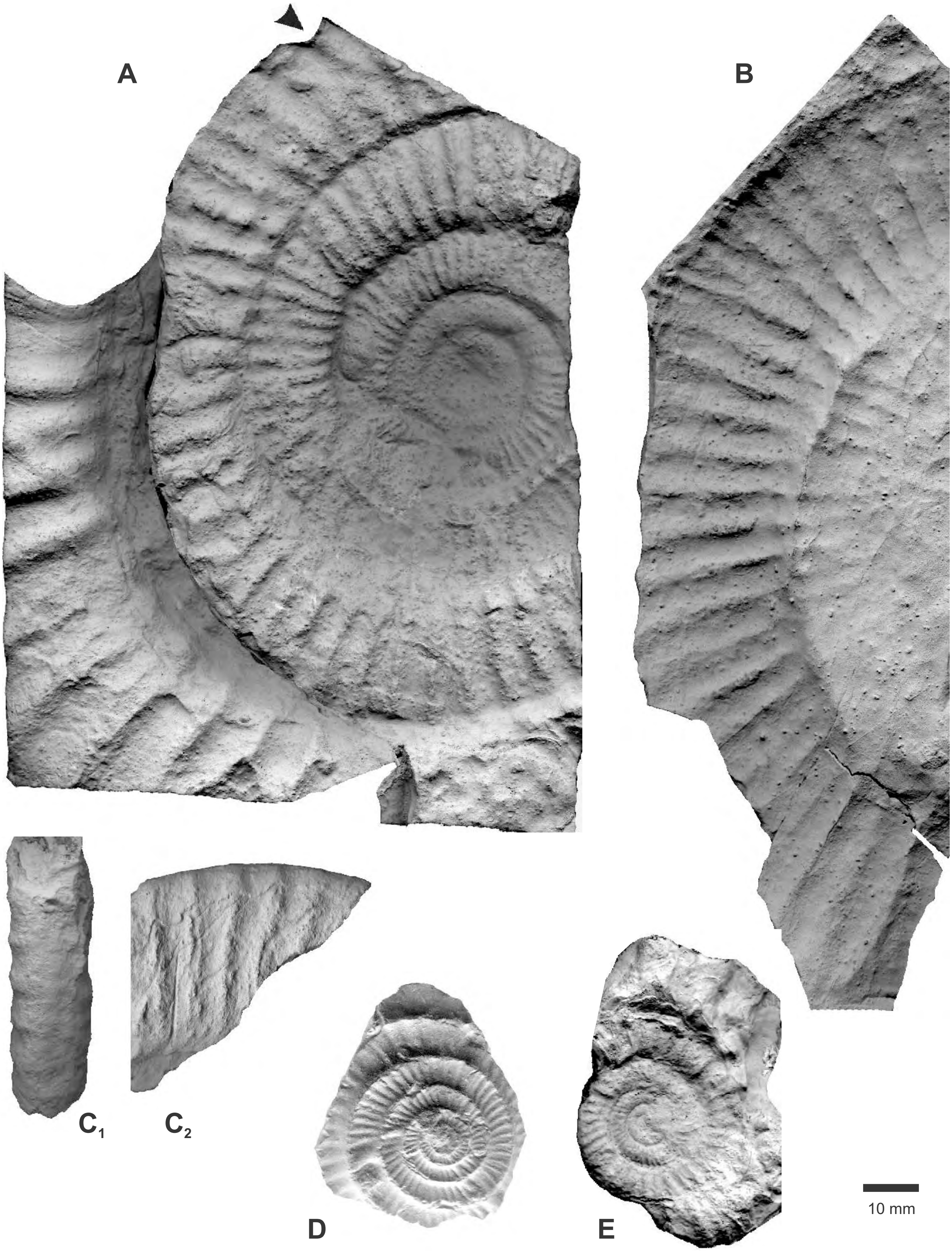


Figure 42. A-C: *Passendorferia* cf. *teresiformis* (Br.-Lewinski, 1973); **A:** adult macroconch with peristome (MOZP 5771) from Arroyo Mulichinco, La Manga Fm., faunal level LO-4, *Passendorferia* Bz. **B**: Adult macroconch bodychamber (LPB 758) from Rahuecó (C. Caicayén), La Manga Fm., bed RA(1)-14b, faunal level CM-7, *Passendorferia* Bz. **C:** fragment of adult bodychamber (LPB 753) in ventral (**C**$_1$) and lateral (**C**$_2$) views showing the characteristic ending of the lateral ribbing at the ventro-lateral shoulder, Rahuecó **(**C. Caicayén**)**, bed RA(1)-14a, faunal level CM-7**,** La Manga Fm., *Passendorferia* Bz. **D**: Passendorferiinae gen. et sp. indet., inner whorls (MOZP 6784) from M. Escondido, bed ME(1)-3, *Patagoniense* Biozone, *Choffatia* Horizon. **E**: *Passendorferia* n. sp. A, phragmocone from Quebrada del Medio, ?*Pseudokranaus* Biozone. All natural size (x1). Arrowhead at last septum.

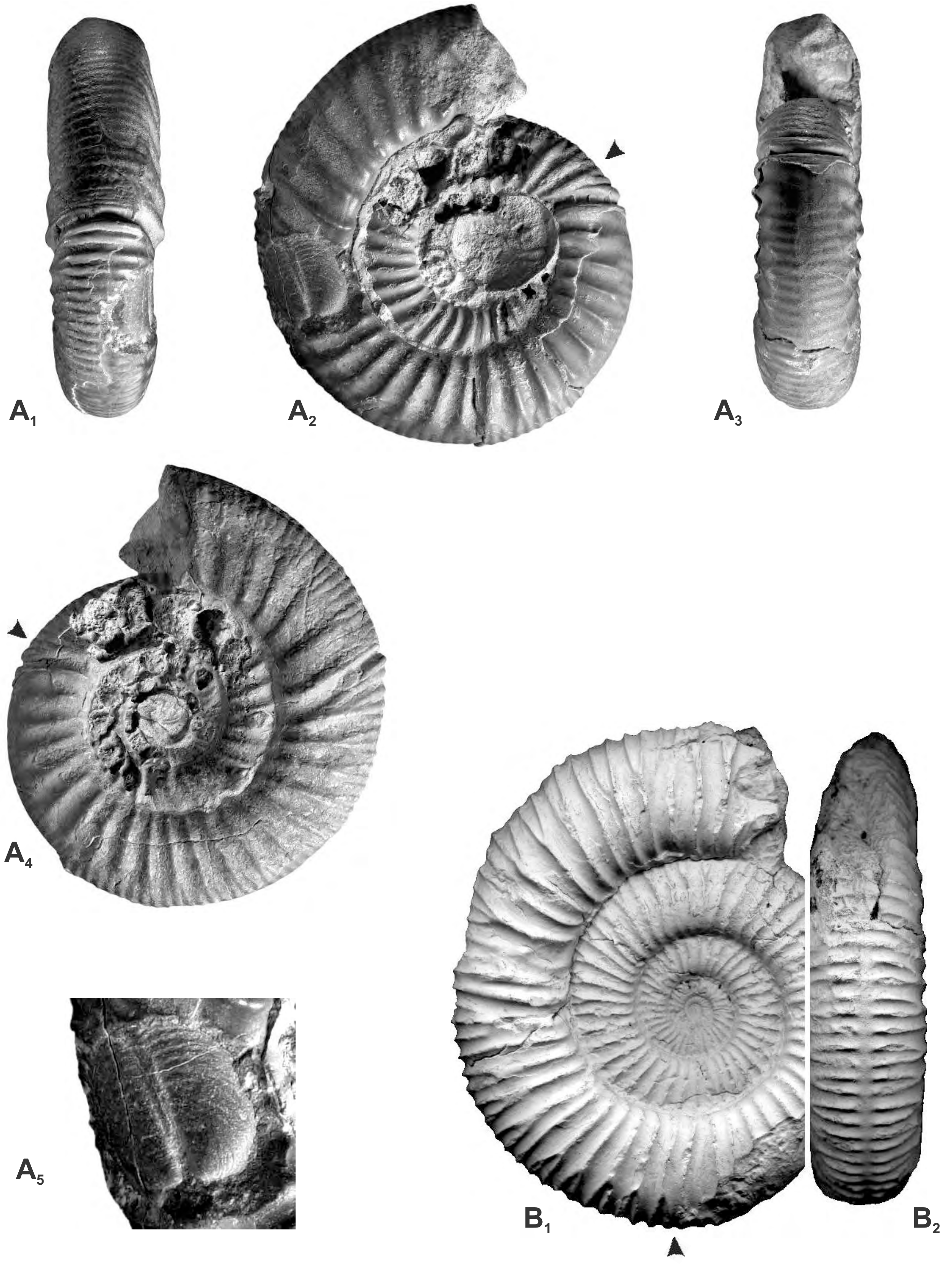


Figure 43. A: *Lithacosphinctes desertorum* (Stehn, 1923), ventral (**A**$_1$), left side (**A**$_2$), apertural (**A**$_3$), and rigth side (**A**$_4$) views and ampliation (**A**$_5$) of the mandibles in the form of Praestriaptychus (x2) of the holotype from Caracoles, upper Oxfordian, *Desertorum* Biozone. Specimen figured by Stehn (1923: pl. 5: 3), housed in the Bonn University (IPB-STEHN-7), photographs loaned by Georg Heumann and Martin Sander. **B:** *Orthosphinctes*? sp. A, lateral (**B**$_1$) and ventral (**B**$_2$) views of an almost complete, adult microconch (MOZP 2704) from Vega de la Veranada, lower part of the Auquilco Fm., faunal level VV-6, ?*Desertorum* Biozone. All natural size (x1) except **A**$_5$ (x2). Arrowhead at last septum.

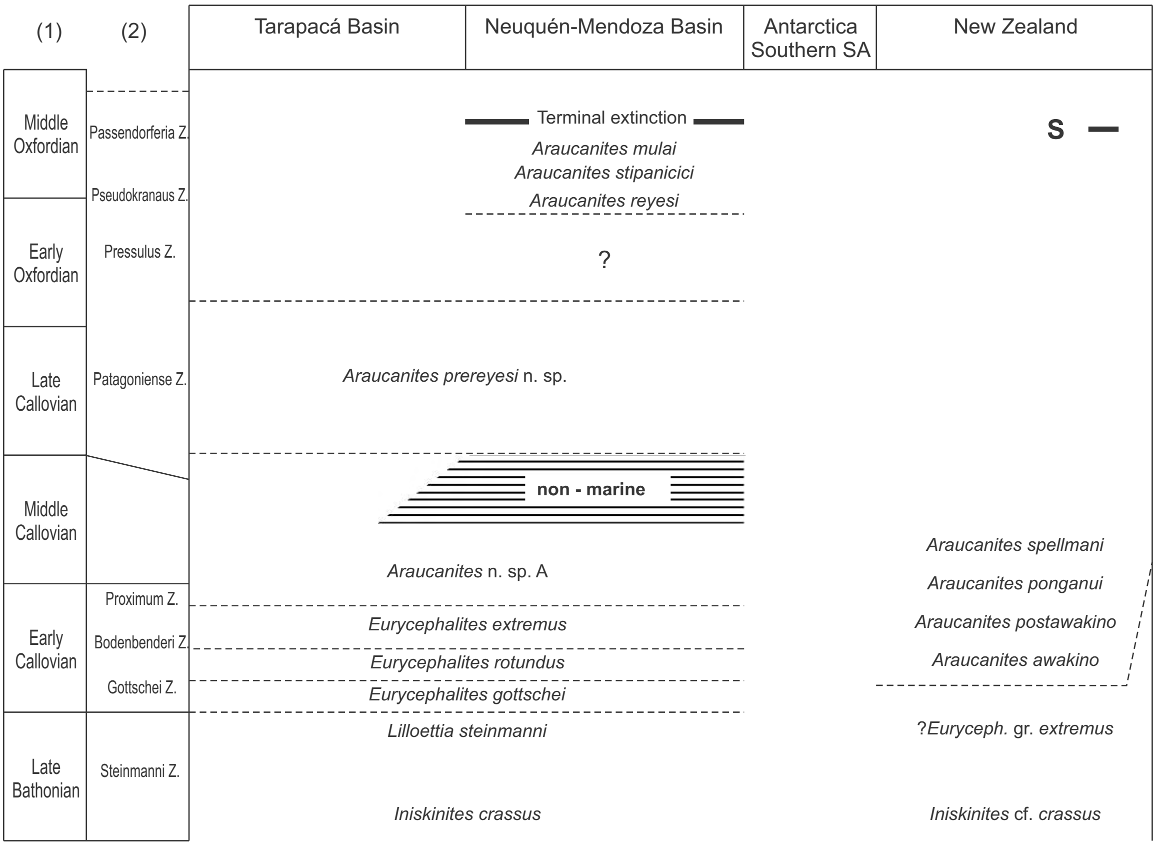


Figure 44. A. Phylogeny of the Eurycephalitinae in south and western Gondwana (Tarapacá and Neuquén-Mendoza Basins and New Zealand). Stratigraphic succession and ages as indicated by Hillebrandt & Gröschke (1995), Riccardi & Westermann (1991), Parent (1998b), Westermann et al. (2002) and this report, referred to: (1) the international standard chronostratigraphic subdivision, and (2) the Andean chronozones introduced in present report and the standard chronozonation of Riccardi & Westermann (1991) for the Late Bathonian - Early (?Middle) Callovian. There is a gap in the record for the Antarctica and southern South America (SA).

Comparable specimens from Manzano Escondido are slightly more compressed; they seem to be juveniles with a densely ribbed venter; the flanks become smooth at smaller sizes than in the type material and than in the specimen from Chacay Melehué. The two specimens from Cerro La Ballena (Tarapacá Basin) figured by Hillebrandt & Gröschke (1995: pl. 5: 5-6) are microconch *Araucanites* close to *A. prereyesi* n. sp., likely belonging to a new species.

Distribution.- The holotype was collected in beds assigned to the Primus Zone (Late Callovian) of the Tarapacá Basin; in the Neuquén-Mendoza Basin it occurs in the upper *Patagoniense* Bz. of Chacay Melehué, Vega de la Veranada, and ?Cajón Troncoso. In Manzano Escondido *Araucanites* cf. *prereyesi* n. sp. occurs in beds of the *Patagoniense* Bz..

Araucanites reyesi Westermann & Riccardi, 1975 [M]

Fig. 45C

*1976 *Mayaites* (*Araucanites*) *reyesi* n. sp.- Stipanicic et al.: 296, pl. 3: 1-2 (holotype), pl. 4: 1, pl. 5: 1-2.

Remarks..- A single macroconch bodychamber with remains of phragmocone (MOZP unnumbered) from faunal level VM-6, Riscos Bajos.

Distribution.- *Pseudokranaus* Bz. of Riscos Bajos (Sierra Vaca Muerta). Most of the material of the genus described by Westermann & Riccardi (in Stipanicic et al. 1976) comes from equivalent beds.

BIOSTRATIGRAPHY

Definitions and procedure

In biostratigraphy fossils are used for subdivision and correlation of rocks, that is, a classification by their fossil content independently of lithology and time. Time, although not interveining in the definition, is always indirectly implied as transformation of the vertical range of fossils in the succession. The definition of biostratigraphic unit adopted in this paper is a body of rock characterized by its fossil content, bounded in space by the known limits of biogeographic distribution and vertical ranges of fossil taxa [see, e.g., Callomon 1984: 3; cf. CAE (Comité Argentino de Estratigrafía) 1992].

The basic unit of biostratigraphic classification is the biozone. There are several kinds of biozones resulting from the different forms and combinations in which are used the biostratigraphic data, e.i. the spatial and vertical ranges of species in sequences of rocks. The most widely used kinds of biozones fall in one of two categories (Fig. 46A): (1) Assemblage biozone: body or sheet of rocks characterizaed by the occurrence of an association of taxa different to that of adjacent rocks; (2) Range or interval biozone: body or sheet of rocks defined by the spatial (vertical-stratigraphic and horizontal-geographic) range of one or two taxa of an assemblage. The interval biozones may be divided in (cf. CAE 1992): a) single taxon range biozone, b) concurrent range

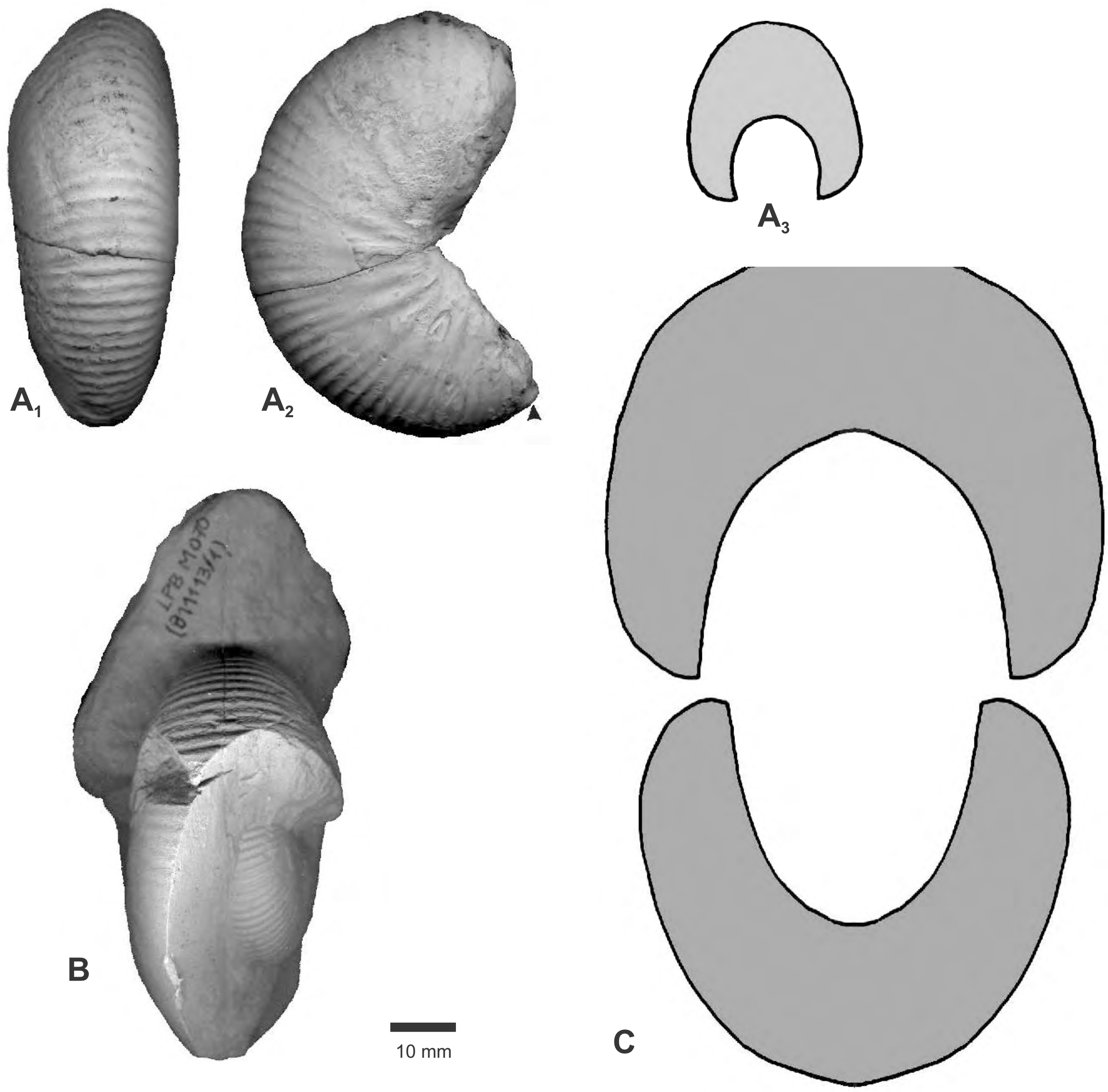


Figure 45. A-B: *Araucanites prereyesi* n. sp. **A:** ventral (A_1) and lateral **(**A_2**)** views and whorl sectionat half bodychamber **(**A_3**)** of a macroconch specimen (LPB 012) from the lower part of Lotena Fm., Chacay Melehué, *Patagoniense* Biozone. **B**: apertural view of a cast of the holotype. **C**: *Araucanites reyesi* Westermann & Riccardi, whorl section of the bodychamber of an adult macroconch (MOZP unnumbered), Riscos Bajos, bed RB(1)-2, La Manga Fm., *Pseudokranaus* Bz. All naltural size (x1). Arrow at last septum.

biozone, c) first occurrences biozone, d) last occurrences biozone, e) first and last occurrences of two taxa. The assemblage biozone has problems in definition and recognition out of the type section or locality, by which is convenient to restrict it as concurrent-range assemblage biozone. This last converges to the concept of *faunal horizon* or *biohorizon* (see Gabilly 1971, Callomon 1985, Page 1995, Dommergues et al. 1994: 63) and to that of *association unitaire* of Guex (1979, 1991).

In early times of knowledge the subjectivity of the biozones is not clearly manisfested. Nevertheless when knowledge grows up, the vertical ranges of species are extended and/or the taxonomic interpretation changed, and then subjectivity could become notorious (Fig. 46B-C). There is no any kind of biozone inmune to these effects of advance of knowledge because of the nature of this kind of stratigraphic unit. However, the concurrent-range-biozone may be the most robust (in statistical sense) in front of these changes. Each biozone defines a conjugate chronostratigraphic unit, a biostratigraphical chronozone, consisting of all the rocks lying between two time-planes (Callomon 2003). Typically exist overlaps and/or gaps between these non-standard zones, so that the necessary continuity for the establishmen of a standard chronostratigraphical classification is obtained by defining standard chronostratigraphic units by its base only. Throughout text we refer the chronostratigraphic zones (chronozones) as *zones* and the biostratigraphic zones as *biozones*, following a widely accepted convention (cf. Callomon 1984). If the zones

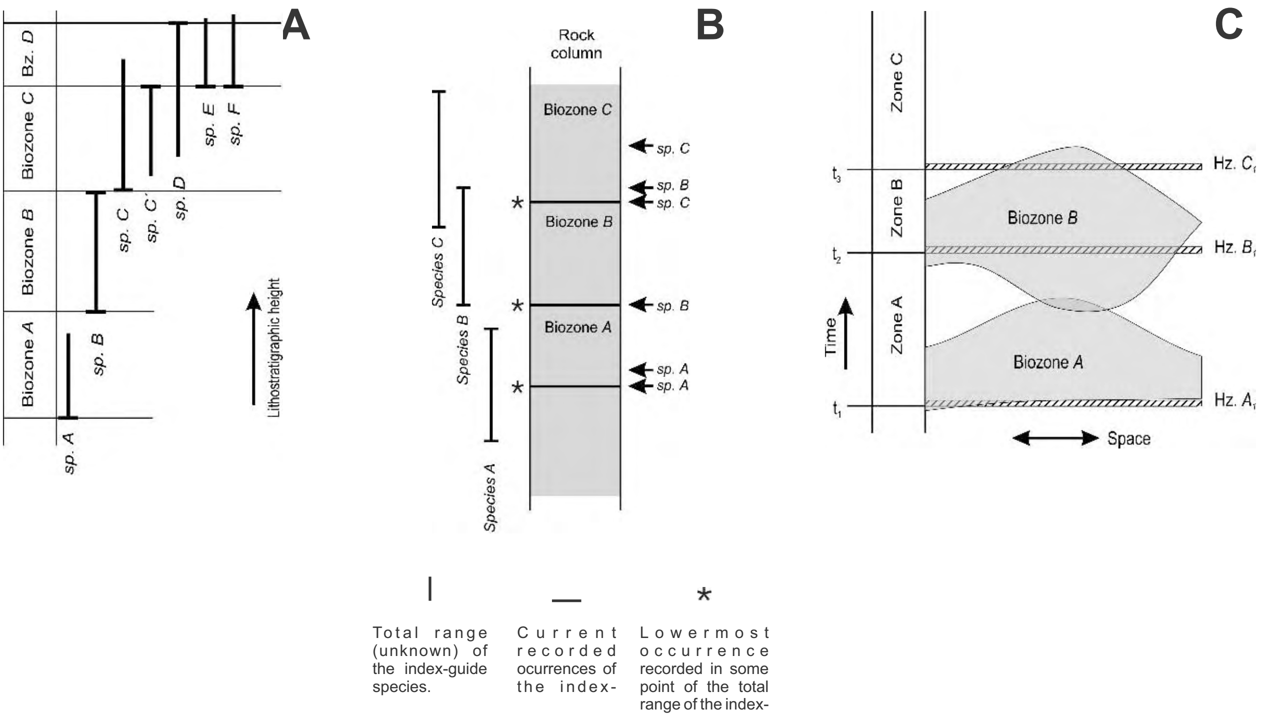


Figure 46. A. Theoretical biostratigraphic classification based on different kinds of biozones: first occurrence biozone *A*; total-range Biozone *B*; first and last occurrence Biozone *C*; concurrent-range Biozone *D*. **B.** Procedure followed in this report for obtaining a succession of first occurrence biozones (FOB), though useful for future chronostratigraphic standarization. Such these FOB are of unknown total range, and the base of any of them could be moved downwards after new findings of the index-guide species in the type locality. This classification is not perturbated by such new lower records of the index-guide species. The case which could introduce incompatibilities is that consisting of finding of the index-guide species occurring below the base of the underlying FOB. Each one of these biozones has a conjugated chronostratigraphic zone. **C**. Typical relationship between biozones and standard chronostratigraphic zones. The base of each zone is determined by a faunal horizon or time-plane (t_1-t_3, the "golden spikes"); the time intervals between faunal horizons are not equal.

are standard zones or not, is in the context.

The recognition of faunal horizons gives much more stability in biostratigraphic classificatons, like biostratigraphic points fixed in the conjugated time scale. Faunal levels defined in this paper are not at all suitable for defining faunal horizons because most of them have the following limitating features: (1) small samples, and/or (2) poor preservation of significant specimens for accurate identification and future comparison. However many of them have a wide geographic distribution through the NMB and, in part, through the TB, thus potentially useful for biostratigraphic correlation.

The biostratigraphic classification presented below is based on the relative position or vertical arrangement, the spatial sequence, of faunal levels obtained following the "natural" procedure of sequence composition well summarized by Remane (1991: fig. 1) and Callomon (1995). The composite sequence of faunal levels, now independent of the rock succession, is then divided in first-occurrence-biozones (FOB) on the base of the vertical ranges of selected species (*guide species*), then labeled with the name of any of the species of the biozone (*index species*), preferently the guide species (Fig. 46B). Then these biozones may be recognized by the occurrence of the guide species and/or by species of the characteristic assemblage (e.i., the species which are known to be confined to the biozone). For time-correlation are used the homonymous zones conjugated to each biozone.

Biozonation of the upper Callovian - upper Oxfordian of the Neuquén-Mendoza Basin

Since early studies of the Andean Upper Jurassic it was evident a coarse succesion of Callovian-Oxfordian Reineckeiids, Peltoceratids, Perisphinctids and, at top, Aspidoceratids (see Chapter Antecedents). More recently Hillebrandt (1970) described similar succesions through northern Chile (Tarapacá Basin) and, later, C. Gulisano during 1980-1982 made a extensive stratigraphic survey of Jurassic sections along the Neuquén-Mendoza Basin, obtaining important colections of ammonites which again showed the same coarse succesion. These colections were the base for the biostratigraphc classification proposed by Riccardi (1984), later reviewed by Riccardi et al. (1990) and summarized by Riccardi & Damborenea (1993) as follows, from below:

1) *Peltoceratoides-Parawedekindia* Assemblage [= Fáunula de *Peltoceras* (Riccardi 1984); ?= Zone a *Peltoceras athleta* (Burckhardt 1900b)]: "Undoubtely lower Oxfordian ammonite faunas seem to be rare, but appear to be represented by peltoceratids comparable to the dimorphic pair *Peltoceratoides* and *Parawedekindia* (Stipanicic 1966, Hillebrandt 1970, Cornejo et al. 1982, Chong et al. 1984). This fauna however, could possibly be latest Callovian. Observation: bajo esta denominación se hizo referencia a las faunas de amonites

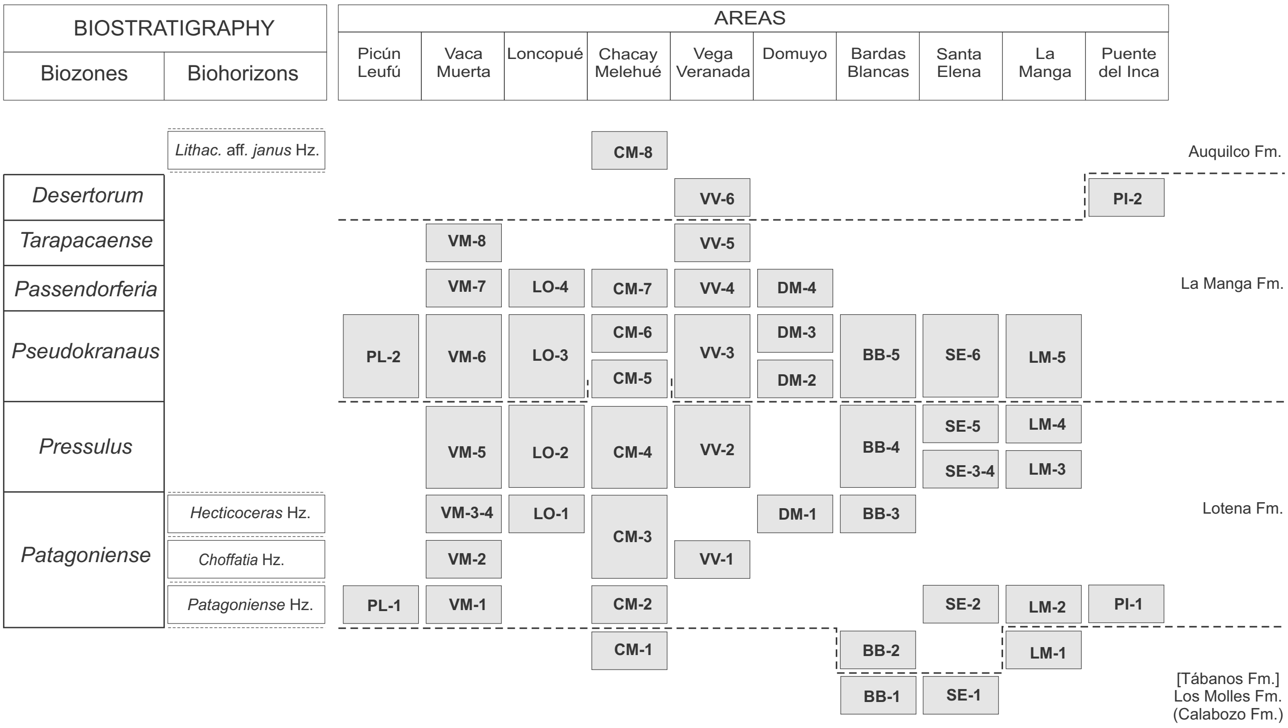


Figure 47. Spatial sequence of faunal levels composed by biostratigraphic correlation (*i.e.* by faunal resemblance) and the biozonation (first occurrence biozones) for the late Callovian to late Oxfordian of the Neuquén-Mendoza Basin proposed in this paper. Each area is a group of localities as used in text as indicated in Fig. 2. Height of each of the biozones is determined in the picture by the number of discrete faunal levels included, implying neither rock-thickness nor time magnitud. Right column indicates the biostratigraphic range of the lithostratigraphic units (as indicated in Fig. 5), not implying directly the age.

citadas en al literatura que corresponderían al Caloviano mas alto o al Oxfordiano inferior, pero de las cuales existe un conocimiento muy limitado" [Riccardi et al. 1990].

2) Zona de Asociación de *Perisphinctes* (Riccardi 1984): "La casi totalidad de los amonites discutidos de Argentina y Chile pertenecen a una asociación abundantemente representada en numerosas localidades. Este conjunto que usualmente ha sido estudiado en forma puntual, incluye: *Perisphinctes (Kranaosphinctes)* spp., *P. (Prososphinctes)* sp., *Mayaites (Araucanites)* spp., *Euaspidoceras* aff. *waageni* Spath, *Peltoceras* spp., *Gregoryceras* cf. *transversarium* (Quenstedt) (véase Stipanicic 1951, Hillebrandt 1970, Stipanicic et al. 1976). Es considerada equivalente aproximado del Oxfordiano medio, i.e., parte superior de la Zona Cordatum a Zona Transversarium. En Argentina esta fauna se encuentra bien representada en la Fm. La Manga en el Arroyo Blanco, A. Santa Elena, Río del Cobre, Malargüe, P. Malal, Sierra de Reyes (Mendoza), Vega de la Veranada, Chacay Melehué, Rahuecó y Sierra de la Vaca Muerta (Neuquén). Por encima de esta asociación faunística Hillebrandt (1970) ha reconocido otros dos niveles con amonites del Oxfordiano superior. El nivel inferior con *Discosphinctes* cf. *lucingae* (Favre) y el superior con *Campylites* cf. *mexicanum* (Burckhardt). Es posible que estos niveles también estén representados (presentes) en la Argentina, aunque hasta la fecha no han sido claramente diferenciados de la fauna infrayacente mencionada mas arriba (Riccardi 1984: 570). A esta Zona de Asociación posiblemente pertenezca la fauna supuestamente Kimmeridgiana descripta por Leanza (1947) de Rahuecó y Chacay Melehué (Dellapé et al. 1979)" [Riccardi 1984: 569].

3) *Euaspidoceras* Assemblage: "The youngest representatives of the previous fauna [Zona de Asociación de *Perisphinctes*] include several species of *Euaspidoceras* indicating correlation with the Bifurcatus-Bimammatum standard zones. Material from northern Chile indentified with *Cubaspidoceras* cf. *carribeanum* Myczynski has been considered as representative of the Bifurcatus Zone (Förster & Hillebrandt 1984)" [Riccardi et al. 1990: 131]. This assemblage was not considered in a later paper (Riccardi et al. 2000).

Recently it has been shown that the marine Oxfordian is more completely represented than previously suspected (Parent 1998a), moreover, from central sections of the basin (Chacay Melehué and Vega de la Veranda-Sierra de Reyes areas) may be composed the greatest part of the Oxfordian stage and the late Callovian. This extension of the record is herein supported and expanded to other positions of the basin. Based on the characterization and description of the successive faunas presented above along the basins has been possible to compose a relatively dense sequence of ammonite faunal levels for the interval upper Callovian - upper Oxfordian, and to work out a new, formal biostratigraphical classification for the Neuquén-Mendoza Basin (Fig. 47). Formal because of designation of type localities and sections and index species previously described. The biostratigraphic classification proposed is in agreement with the coarser subdivision of Riccardi (1984) and Riccardi et al. (1990), but it was now possible: (1) to make a finer subdivision, and (2), more important, to describe the ammonites on which the new formal biozonation and the conjugate chronozonation are proposed:

Patagoniense **Biozone**

Index: *Rehmannia (Lozczyceras) patagoniense* (Weaver, 1931).

Definition: First occurrence biozone of the index, comprising bedrocks up to the base of the subsequent biozone (e.i., first occurrence of *Peltoceratoides pressulus*).

Type locality and section: Manzano Escondido, Neuquén, NMB, lower part of the Lotena Fm. (Fig. 8).

Characteristic fauna and horizons (Figs. 47-50): The stratigraphic position and relationships, and faunal content and ranges are clearly defined in the type section where three biohorizons can be distinguished:

(1) the lower, *Patagoniense* Horizon. Defined by Riccardi &Westermann 1991. It contains *R. patagoniense* practically monospecific. The type locality and section were not defined originally, herein the section of the top of the Lotena Fm. at Picún Leufú (Fig. 6: PL-1) is designated, where profusely both sexual dimorphs of the index occur.

(2) the middle, *Choffatia* Horizon. Type locality and section at Manzano Escondido [Fig. 8: bed ME(1)-3] containing an abundant and diverse fauna: *Choffatia* sp. A, *Choffatia* sp. B, *Alligaticeras*? aff. *raguini*, *R. patagoniense*, *Araucanites* cf. *prereyesi* n. sp., *H.* cf. *lairense* [M&m], *H.* cf. *discoides*, *H. hersilia* (*sensu* Maire), *Taramelliceras*? sp. A.

(3) the upper, *Hecticoceras* Horizon. Type locality and section at Manzano Escondido [Fig. 8: bed ME(1)-8] containing abundant *H.* cf. *lairense*, *H.* cf. *virguloides* and *Peltoceras* cf. *convexum*.

Distribution: The *Patagoniense* Bz. has been recognized in almost every studied locality of the basin (see Fig. 47), lower Lotena Fm., typically represented by reddish to greenish siltstones and fine sandstones, and by dark gray limestones in central parts of the basin.

Age: There is no conclusive evidence about the age of the *Patagoniense* Hz., as redefined above, because of the absence of any other time-diagnostic ammonites than *R. patagoniense*. It could be latest Coronatum Zone or, most probably, early Athleta Zone as discussed in Parent (1998a: 269). The *Choffatia* Hz. yields a fauna in the type locality which can be clearly correlated with the Athleta Zone as discussed under the corresponding species of the typical assemblage. The *Hecticoceras* Hz. yields ammonites which can be correlated with the Athleta Zone or with some part of the Lamberti Zone because of the occurrence of *Peltoceras* cf. *convexum*. The biozonal index *R. patagoniense* does not range up into this later biohorizon.

Pressulus **Biozone**

Index: *Peltoceratoides pressulus* (Leanza, 1947).

Definition: First occurrence biozone of the index, comprising bedrocks up to the base of the subsequent biozone (e.i., first occurrence of *Subvinalesphinctes pseudokranaus*).

Type locality and section: Chacay Melehué, Neuquén, NMB, upper part of the Lotena Fm. (Fig. 11).

Distribution: Rocks with *P. pressulus* are widely distributed through almost all the basin (Fig. 47), typically as grey to greenish or yellowish limestones, marls or fine sandstones depending on the position in the basin. The maximun thickness is known in Santa Elena (Fig. 17).

Fauna (Figs. 48-50): In the type locality the index is associated with *Tenuisphinctes herreroduclouxi*. Most diverse fauna in Rahuecó, faunal level CM-4 including the index, *Cubasphinctes* aff. *durangensis*, *Tenuisphinctes herreroduclouxi*, *Perisphinctes* cf. *mazuricus*/*matheyi*, *Perisphinctes* cf. *picteti*, *Euaspidoceras ajax* and *E. veranadaense*.

Age: Early Oxfordian. Correlation with the late Mariae to Cordatum zones is unambiguously indicated by the index which shows features typical of *Peltoceratoides* from the Cordatum Zone, almost indistinguishable from *Peltoceratoides constantii* [M] / *arduennese* [m].

Remarks: This new biozone is approximately equivalent to the *Peltoceratoides* - *Parawedekindia* Assemblage of Riccardi (1984). In the Santa Elena area the biozone comprises three levels with *Peltoceratoides*, thus potentially a good section for finer subdivision. In Bardas Blancas the index occurs associated with *Peltoceratoides ballenaensis* and *Peltoceratoides* cf. *intercissus*.

Pseudokranaus **Biozone**

Index: *Subvinalesphinctes pseudokranaus* Parent, Schweigert & Meléndez, 2006.

Definition: First occurrence biozone of the index, comprising bedrocks up to the base of the subsequent biozone (e.i., first occurrence of *Passendorferia* cf. *teresiformis*).

Type locality and section: Chacay Melehué, NMB, lower part of the La Manga Fm. (Fig. 11), typically the "bluish marls with Oysters" (CAG in Fig. 5).

Distribution: Besides the type locality it has been recognized by some of the species of the guide assemblage in every locality of the basin (and with similar lithology) except of Puente del Inca area, northermost portion of the basin (see Fig. 47).

Fauna (Figs. 48-50): Characterized by the assemblage of the index with *Subvinalesphinctes prophetae, Cubasphinctes durangensis* or *Perisphinctes (Kranaosphinctes)* cf./aff. *promiscuus*. In the Tarapacá Basin the association of *Cubasphinctes durangensis*, *Subvinalesphinctes prophetae* and *Perisphinctes parvulus* Gygi & Hillebrandt, 1991 indicates this biozone.

Age: Plicatilis Zone, Middle Oxfordian. Time correlation based on the ammonites from Chacay Melehué was discussed in Parent et al. (2006 *in print*). Moreover, this biozone is bracketed by the well dated *Pressulus* and *Passendorferia* biozones.

Remarks: The *Pseudokranaus* Bz. is best represented in the type locality and Arroyo Agua Fría as dark-gray to bluish marls with small oysters. The index represents one of the oldest known Vinalesphinctinae (as discussed above).

Passendorferia **Biozone**

Index: *Passendorferia* cf. *teresiformis* (Brochwicz-Lewinski, 1973) as described above.

Definition: First occurrence biozone of the index, comprising bedrocks up to the base of the subsequent biozone (e.i., first occurrence of *Euaspidoceras tarapacaense* n. sp.).

Type locality and section: Arroyo Mulichinco, Neuquén, NMB, beds of bluish marly limestone of the La Manga Fm. (Fig. 9).

Fauna (Figs. 48-50): Characterized by the assemblage of the index associated with *Cubasphinctes cubanensis*; in Mallín Quemado, Rahuecó, Quebrada Remoredo and Vega de la Veranada occur also *Perisphinctes (Subdiscosphinctes)* cf. *mindowe*.

Distribution (Fig. 47): Recognized in Rahuecó, M. Quemado and M. Rubio by means of the characteristic assemblage; in Vega de la Veranada and Q. Remoredo by the index and *Perisphinctes (Subdiscosphinctes)* cf. *mindowe*; in Chacay Melehué by the index.

Age: Transversarium (and early Bifurcatus?) Zone, middle Oxfordian, as discussed under *P.* cf. *teresiformis* and *P.* cf. *mindowe*.

Remarks: The informal unit *Perisphinctes* - *Araucanites* Assemblage of Riccardi (1984) appears to comprise the *Pseudokranaus* and *Passendorferia* biozones.

***Tarapacaense* Biozone**

Index: *Euaspidoceras tarapacaense* n. sp.
Definition: First occurrence biozone of the index, comprising bedrocks up to the base of the subsequent biozone (e.i., first occurrence of *Lithacosphinctes desertorum*).
Fauna (Figs. 48-50): Characterized in the Tarapacá Basin by the association of the index with *Perisphinctes (Dichotomoceras) andium*, *Perisphinctes* n. sp. (in Gygi & Hillebrandt 1991) and *Gregoryceras perplanatum* in the type section.
Type locality and section: Aguada del Carretón, Chile (Fig. 19), TB, levels 3-4 of the section described by Gygi & Hillebrandt (1991: fig. 11).
Distribution (Fig. 47): Represented in Caracoles, Quebrada del Medio, and Q. Profeta (Tarapacá Basin) by the index, or by forms of the characteristic assemblage (see Gygi & Hillebrandt 1991). In Aguada de la Mula (Neuquén-Mendoza Basin) by the association of the index with *E.* cf. *chilense* and in Sierra Vaca Muerta (Fig. 8) it may be represented by beds with *Euaspidoceras* cf. *chilense* Leanza, in the upper part of the La Manga Fm.
Age: Bifurcatus to lower Bimammatum zones as discussed under *E. tarapacense* and below.

***Desertorum* Biozone**

Index: *Lithacosphinctes desertorum* (Stehn, 1923).
Definition: First occurrence biozone of *Lithacosphinctes desertorum*. The top lies below the *Lithacosphinctes* aff. *janus* Hz. in Chacay Melehué and Rahuecó (Figs. 47-48).
Type locality and section: Aguada del Carretón (Fig. 19), level 5 of the section described by Gygi & Hillebrandt (1991: fig. 11).
Fauna (Figs. 48-50): Characterized in the type section by a conspicuous assemblage (Gygi & Hillebrandt 1991) composed of the index, *Ochetoceras mexicanum* (Burckhardt, 1912), *Orthosphinctes* cf. *tiziani* (Oppel, 1863), *Pseudorthosphinctes gredingenis* (Wegele, 1929), and *Geyssantia* cf. *geyssanti* Meléndez, 1989 [1984].
Distribution (Fig. 47): Besides the type locality it is represented in Caracoles (type locality of the index), Quebrada del Medio and Q. Profeta (TB), and Puente del Inca (NMB) by the index. In Vega de la Veranada it could be represented in beds overlying the *Tarapacaense* Bz. containing *Orthosphinctes*? sp. A (described above) at the base of the Auquilco Fm.
Age: The characteristic assemblage in the type locality and especially the index directly indicate the Bimammatum Zone, late Oxfordian (discussion below) and ranging up into equivalentes of the Planula Zone.

***Lithacosphinctes* aff. *janus* Horizon (Fig. 47).**

In Chacay Melehué, type locality and section (Fig. 11), occur younger ammonites in the form of *Lithacosphinctes* aff. *janus* (Choffat, 1893) originally described from equivalents of the Planula - Platynota zones (see Parent et al. 2006, *in print*), in basal beds of the Auquilco Fm., bed P_2, faunal level CM-8. The horizon has been recognized recently in Rahuecó and Chacay Melehué by means of the index species.

Biostratigraphical time-correlation of the Neuquén-Mendoza and Tarapacá basins

The interval upper Callovian - middle Oxfordian of northern Chile (TB), has been subdivided in zones by Hillebrandt & Gröschke (1995), later reviewed by Hillebrandt et al. (2000). This classification was mainly based on the Peltoceratinae, and the zones were defined as chronostratigraphic units (A. Hillebrandt, *pers. comm.* 12/01/01). Biostratigraphic correlation between both basins and the most reliable time-correlation obtained are shown in Fig. 48. Complete lists of species and their distribution in both basins are given in Figs. 49-50. Species recorded in both basins are the base of the following discussion. At some horizons or levels there are no common ammonites, therefore it is very hard to make comparisons.

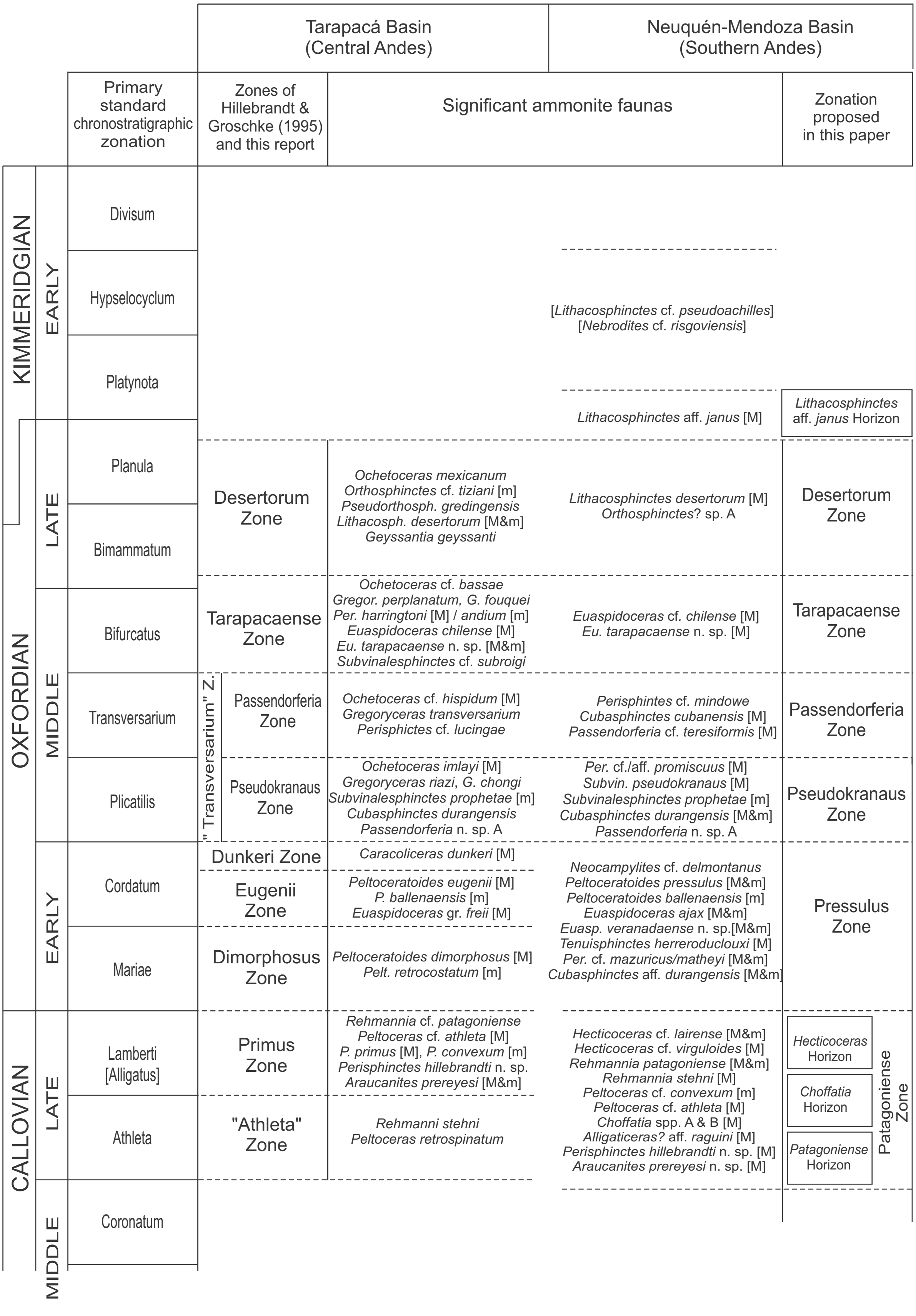
Rehmannia patagoniense and *Araucanites prereyesi* n. sp., and, slightly upper, *Peltoceras* cf. *convexum* and *P.* cf. *athleta* (= *Peltoceratoides*? sp. *in* Hillebrandt & Gröschke 1995: pl. 2: 2) indicate the partial equivalence between the Patagoniense Zone with the “Athleta” and Primus zones (late Callovian). In Quebrada Asientos the fauna containing *Pseudopeltoceras*, *Peltoceras*? and “*Reineckeia*” may be assigned to the Patagoniense Zone.

The Peltoceratid species of the Dimorphosus and Eugenii zones described by Hillebrandt & Gröschke (1995) for the TB are known in the NMB only by *Peltoceratoides ballenaensis* recorded from the *Pressulus* Biozone of Cajón Troncoso. The Pressulus Zone and the Dimorphosus-Eugenii zones are bracketed between horizons which can be correlated by common species (Fig. 48). They are considered, at least, partially time-equivalents, early Oxfordian in age. It is discussed under *P. pressulus* and by Hillebrandt & Gröschke (1995). The Peltoceratinae are reliable indicators of early Oxfordian in Magadascar, Cutch, Indonesia (cf. Callomon 1990; see Bonnot & Cariou 1999 and Bonnot et al. 2002 for a recent aplication in parallel zonations of the Submediterranean Province of the Tethys).

Caracoliceras dunkeri Hillebrandt et al., 2000 is only known from the TB. In Quebrada Profeta and Cerro Amarillo occurs just below *Subvinalesphinctes prophetae*, *Gregoryceras chongi* and *Ochetoceras imlayi*. *S. prophetae* occurs in the Pseudokranaus Zone of the NMB, by which the Dunkeri Zone of Hillebrandt et al. (2000) could be in part equivalent to the upper part of the Pressulus Zone and, less probably, earliest part of the Pseudokranaus Zone. Supporting this correlation is the time-correlation provided by the assemblage occurring just above the Dunkeri Zone. *S. prophetae* was dated as Plicatilis Zone in Chacay Melehué (Parent et al. 2006 *in print*); *G. chongi* shows features seen in *Gregoryceras* species of the Plicatilis Zone of Europe (Gygi & Hillebrandt 1991: 158); *O. imlayi* seems to be an early *Ochetoceras* close to *Neocampylites*, thus not younger than the Plicatilis Zone in Europe. The late Cordatum age for the Dunkeri Zone is well supported by this independent evidence and on the other hand is constrained by the Peltoceratinid fauna of Hillebrandt & Gröschke (1995) described for horizons inmediately below.

The “Transversarium” Zone of Gygi & Hillebrandt (1991, see also Hillebrandt et al., 2000) includes all the Transversarium and the upper part of the Plicatilis zones of the international chronostratigraphic scale. The Pseudokranaus Zone may be used in the TB as equivalent of the lower part of this “Transversarium” Zone.

The assemblage of the Passendorferia Zone in the NMB includes *Perisphinctes* cf. *mindowe* and *Cubasphinctes cubanensis*. In the TB there are some closely comparable ammonites occurring in the upper “Transversarium” Zone, they are *P. mindowe-kreutzi* and *P.* cf. *lucingae*. Although the guide species of the Passendorferia Zone is not known in that



			Tarapacá Basin (Central Andes)		Neuquén-Mendoza Basin (Southern Andes)	
		Primary standard chronostratigraphic zonation	Zones of Hillebrandt & Groschke (1995) and this report	Significant ammonite faunas		Zonation proposed in this paper
KIMMERIDGIAN	EARLY	Divisum				
		Hypselocyclum			[*Lithacosphinctes* cf. *pseudoachilles*] [*Nebrodites* cf. *risgoviensis*]	
		Platynota			*Lithacosphinctes* aff. *janus* [M]	*Lithacosphinctes* aff. *janus* Horizon
OXFORDIAN	LATE	Planula	Desertorum Zone	*Ochetoceras mexicanum* *Orthosphinctes* cf. *tiziani* [m] *Pseudorthosph. gredingensis* *Lithacosph. desertorum* [M&m] *Geyssantia geyssanti*	*Lithacosphinctes desertorum* [M] *Orthosphinctes*? sp. A	Desertorum Zone
		Bimammatum				
	MIDDLE	Bifurcatus	Tarapacaense Zone	*Ochetoceras* cf. *bassae* *Gregor. perplanatum, G. fouquei* *Per. harringtoni* [M] / *andium* [m] *Euaspidoceras chilense* [M] *Eu. tarapacaense* n. sp. [M&m] *Subvinalesphinctes* cf. *subroigi*	*Euaspidoceras* cf. *chilense* [M] *Eu. tarapacaense* n. sp. [M]	Tarapacaense Zone
		Transversarium	" Transversarium" Z.: Passendorferia Zone	*Ochetoceras* cf. *hispidum* [M] *Gregoryceras transversarium* *Perisphictes* cf. *lucingae*	*Perisphintes* cf. *mindowe* *Cubasphinctes cubanensis* [M] *Passendorferia* cf. *teresiformis* [M]	Passendorferia Zone
		Plicatilis	Pseudokranaus Zone	*Ochetoceras imlayi* [M] *Gregoryceras riazi*, *G. chongi* *Subvinalesphinctes prophetae* [m] *Cubasphinctes durangensis* *Passendorferia* n. sp. A	*Per.* cf./aff. *promiscuus* [M] *Subvin. pseudokranaus* [M] *Subvinalesphinctes prophetae* [m] *Cubasphinctes durangensis* [M&m] *Passendorferia* n. sp. A	Pseudokranaus Zone
	EARLY	Cordatum	Dunkeri Zone Eugenii Zone	*Caracoliceras dunkeri* [M] *Peltoceratoides eugenii* [M] *P. ballenaensis* [m] *Euaspidoceras* gr. *freii* [M]	*Neocampylites* cf. *delmontanus* *Peltoceratoides pressulus* [M&m] *Peltoceratoides ballenaensis* [m] *Euaspidoceras ajax* [M&m] *Euasp. veranadaense* n. sp.[M&m] *Tenuisphinctes herreroduclouxi* [M] *Per.* cf. *mazuricus/matheyi* [M&m] *Cubasphinctes* aff. *durangensis* [M&m]	Pressulus Zone
		Mariae	Dimorphosus Zone	*Peltoceratoides dimorphosus* [M] *Pelt. retrocostatum* [m]		
CALLOVIAN	LATE	Lamberti [Alligatus]	Primus Zone	*Rehmannia* cf. *patagoniense* *Peltoceras* cf. *athleta* [M] *P. primus* [M], *P. convexum* [m] *Perisphinctes hillebrandti* n. sp. *Araucanites prereyesi* [M&m]	*Hecticoceras* cf. *lairense* [M&m] *Hecticoceras* cf. *virguloides* [M] *Rehmannia patagoniense* [M&m] *Rehmannia stehni* [M] *Peltoceras* cf. *convexum* [m] *Peltoceras* cf. *athleta* [M] *Choffatia* spp. A & B [M] *Alligaticeras?* aff. *raguini* [M] *Perisphinctes hillebrandti* n. sp. [M] *Araucanites prereyesi* n. sp. [M]	Patagoniense Zone: *Hecticoceras* Horizon *Choffatia* Horizon
		Athleta	"Athleta" Zone	*Rehmanni stehni* *Peltoceras retrospinatum*		*Patagoniense* Horizon
	MIDDLE	Coronatum				

Figure 48. Chart of biostratigraphic correlation between the NMB and the TB, and tentative time-correlation respect the Primary standard chronostratigraphic zonation (based on Cariou et al. 1971). Ammonites listed are mainly those co-occurring in both basins and those time-diagnostic species (full lists are shown in Figs. 49-50). Vertical order in each list is normative only, not implying relative stratigraphic position between species of each assemblage. The new placement of the Oxfordian/Kimmeridgian boundary is indicated. Dotted lines indicate tentative correlations. *Nebrodites* cf. *risgoviensis* and *Lithacosphinctes* cf. *pseudoachilles* figured by Burckhardt (1900a: pl. 26: figs. 1 and 2 respectively) from west-central Mendoza (NMB).

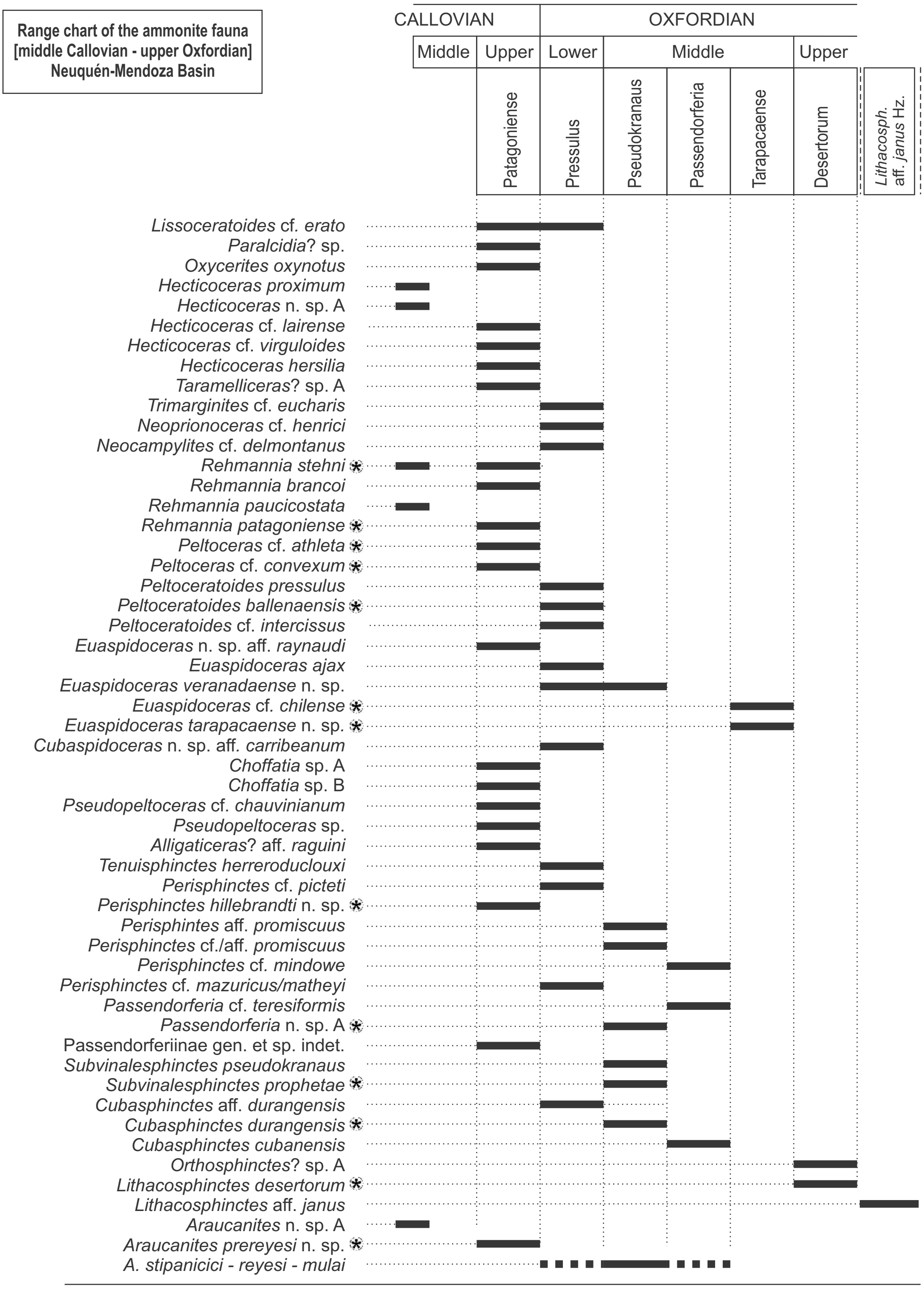


Figure 49. Chronostratigraphic ranges of the Upper Callovian to Upper Oxfordian ammonite fauna of the Neuqúen-Mendoza Basin as obtained in present study. Encircled asterisks indicate the species is co-ocurring in the Tarapacá Basin. The apparent clear-cut-ranges of the species may be an artifact of the morphotypic classification here adopted and of the non-standard chronozonation which includes gaps and overlaps between the (chrono-) zones derived from the biozones defined in text.

basin, the ammonites mentioned suggest correlation with the upper part of the “Transversarium” Zone. Moreover both assemblages occur below the Tarapacaense Zone recognized in both basins.

Euaspidoceras tarapacaense n. sp. is known from both basins, thus the *Tarapacaense* Biozone defined in northern Chile is recognized also in the NMB. The fauna associated with the guide species in the type section gives

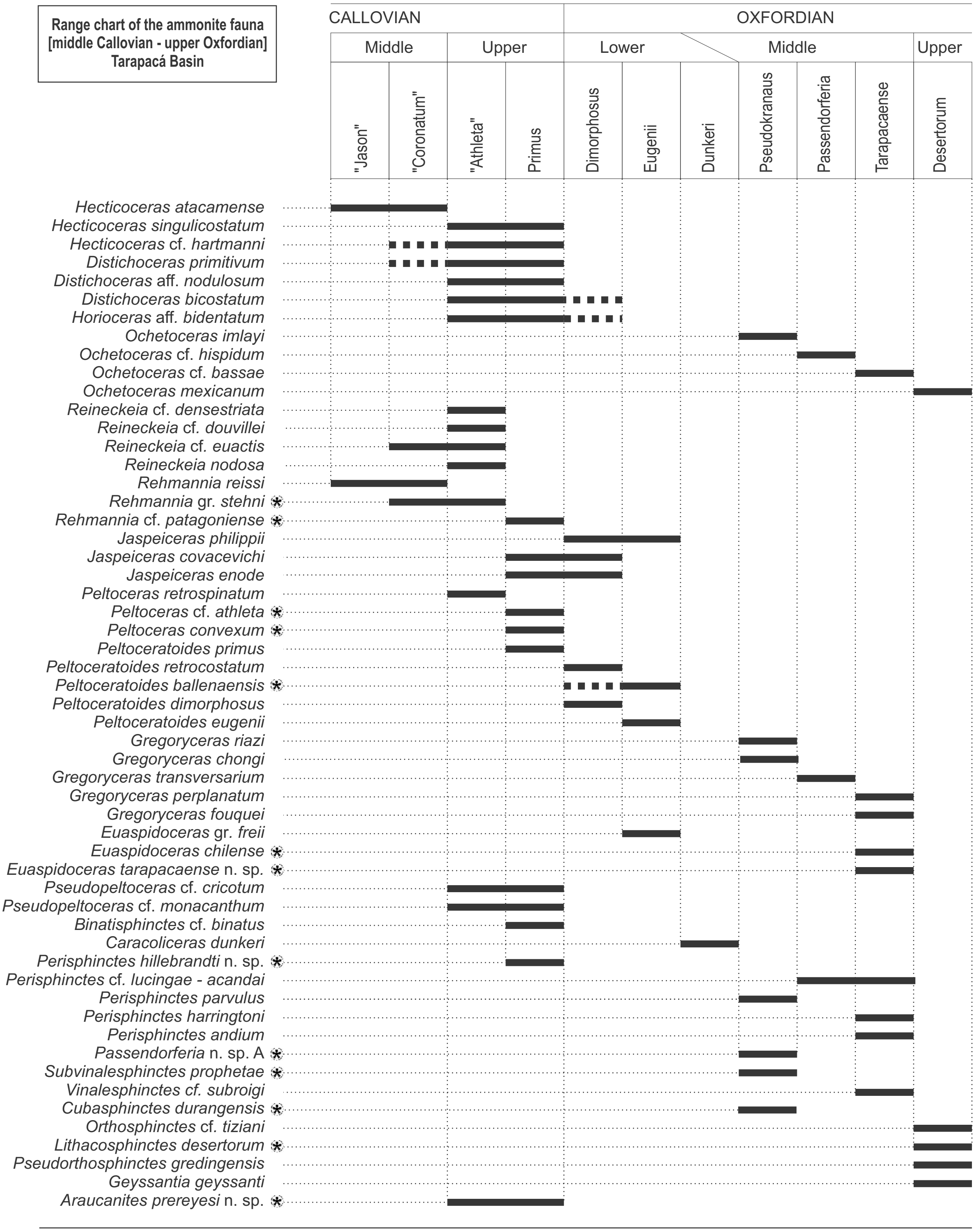


Figure 50. Chronostratigraphic ranges of the Upper Callovian to Upper Oxfordian ammonite fauna of the Tarapacá Basin. Based on Gröschke & Zeiss (1990), Gygi & Hillebrandt (1991), Hillebrandt & Gröschke (1995), Gröschke & Kossler (1999), Hillebrandt et al. (2000), Pérez (1982) and present paper. Encircled asterisks indicate the species is co-ocurring in the Neuquén-Mendoza Basin. Chronostratigraphy: "Jason" to Dunkeri Zones after Hillebrandt et al. (2002); Pseudokranaus to Desertorum Zones defined in present paper. The apparent clear-cut-ranges of the species may be an artifact of the morphotypic classification here adopted and of the non-standard chronozonation which includes gaps and overlaps between the (chrono-) zones.

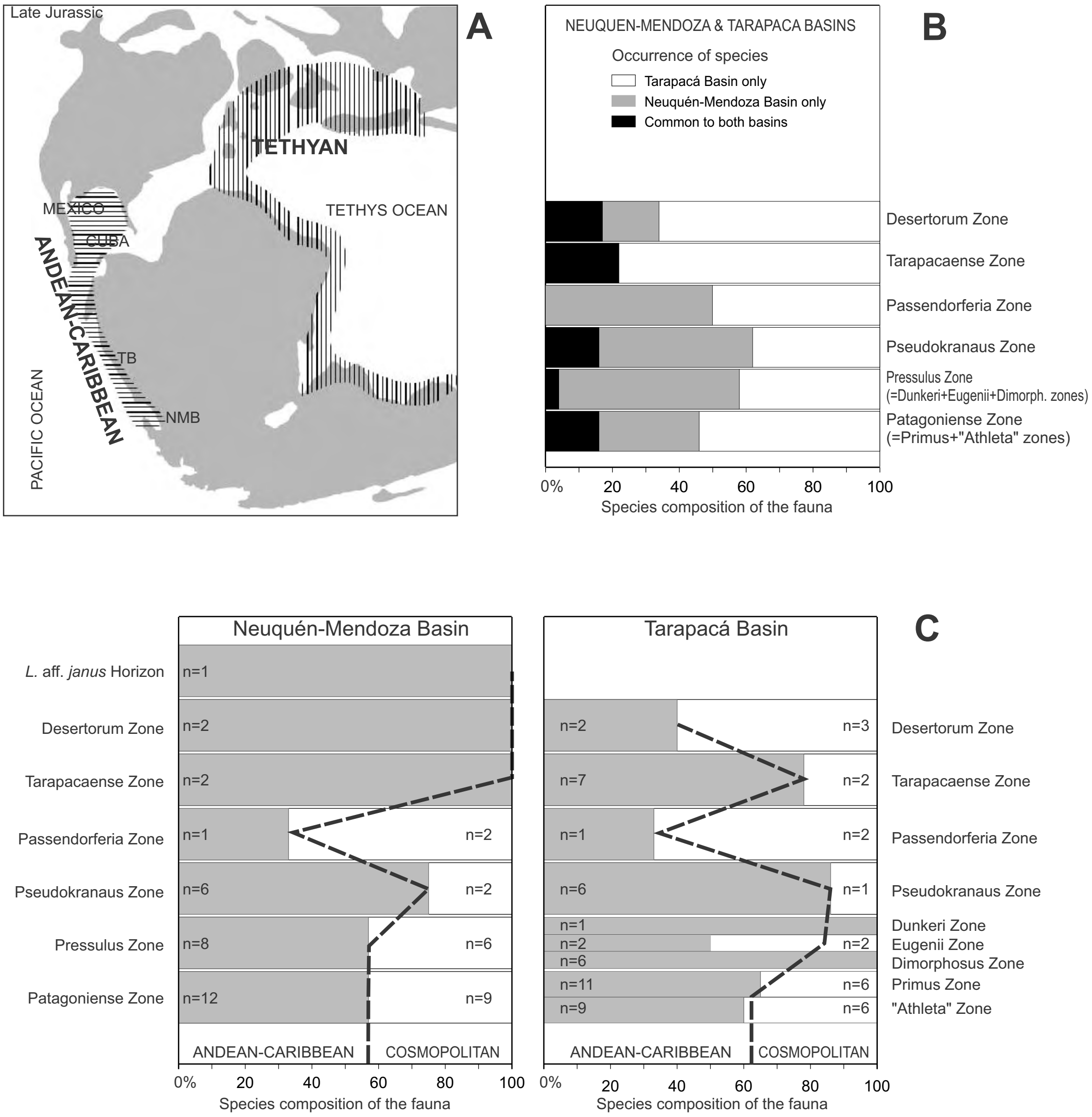


Figure 51. Biogeographic patterns and affinities (species level) of the late Callovian - late Oxfordian ammonite faunas of the Neuquén-Mendoza and Tarapacá basins based on paleogeography adopted (Fig. 1) and results of present study as summarized in Figs. 49-50. **A:** Paleogeographic domains considered for biogeographic analysis. **B:** Proportional percentual composition of the ammonite faunas of both basins. **C:** Biogeographic composition of the ammonite faunas of each basin. Species known to occur in both the Andean - Caribbean region and Tethyan regions are called cosmopolitan. Composition expressed as percent of the total number of recorded nominal species in each zone. Broken lines showing the trend in each basin. In order to obtain uniform comparisons the trend of the Tarapacá Basin is traced through the mean values of the "Athleta" - Primus zones (equivalents of the Patagoniense Zone of the NMB) and Dimorphosus - Eugenii - Dunkeri zones (equivalents of the Pressulus Zone of the NMB).

strong evidence of the age of the biozone. *Perisphinctes harringtoni* Leanza, 1947b shows inner whorls typical of species of the Bifurcatus Zone of the Tethys (e.g., *P. panthieri* Enay, 1966), almost identical to those of *Perisphinctes andium* Steinmann, 1881 (*in* Gygi & Hillebrandt 1991) which closely resembles *Perisphinctes stenocycloides* Siemiradzki, 1898. Chong et al. (1984) have discussed this and other similar assemblages suggesting convincingly a Bifurcatus Zone age. *Euaspidoceras chilense* Leanza, 1947b is known from poor material (see discussion under *E.* cf. *chilense*), resembling the morphotypes of the early transients of *E. hypselum* of the latest Bifurcatus Zone (as explained under *E. tarapacaense*); the same age is proposed above for *E. tarapacaense* n. sp. (cf. Leanza 1947b: pl. 1: 4).

The Desertorum Zone, also with type locality in the TB, is recognized in the northern part of the NMB by the index only, and more to the South in Vega de la Veranada probably by the occurrence of *Orthosphinctes*? sp. A (Fig. 14). The age at the type locality is strongly supported by the conspicuous characteristic assemblage indicating the Bimammatum Zone of the late Oxfordian.

PALEOBIOGEOGRAPHY

The virtual absence of phylloceratids and lytoceratids (only a single fragment of a lytoceratid in the *Patagoniense* Bz. of Manzano Escondido) in the faunas of the NMB and TB can be clearly attributted to isolation from the oceanic influence. This isolation is also clearly manifested in the sediment filling of the basins as described by Legarreta & Uliana (1996), see Fig. 5. The wide platforms and dense volcanic arches, as shown in Fig.

2, have generated conditions for fluctuant confinement of the Araucanian and Tarapacá seas, leading to the development of faunas with a mixture of endemic, Caribbean and Tethyan elements, and a moderate differentiation between the faunas of each of these seas.

The composition at species level, of the successive faunas of both basins is depicted in Fig. 51. The following discussion is based on trends that may be biased by the small number of recorded or known species, or taxonomic judgement, but they are considered representative of broad general patterns. The geographic domains for comparison have been defined as Andean-Caribbean (including Mexico, Cuba, the TB and NMB) and Tethyan (including almost all the Tethys as shown in Fig. 51A); species co-occurring in both domains are called cosmopolitan. The biogeographic affinity between both basins, measured as the proportion of common species respect to the total number, is very low (Fig. 51B; mean value 12.5%) considering the adjacence between the Araucanian and Tarapacá seas. Lowest values are recorded in the Pressulus Zone (4%) and, extremely, in the Passendorferia Zone (0%) whereas the highest value is recorded from the Tarapacaense Zone (22%) making the most marked shift in the trend. The most notable feature of the affinities between basins is the complete differentiation in the Passendorferia Zone which is consistent even at the genus level (see Figs. 49-50): disjunct occurrence of *Gregoryceras* and *Ochetoceras* (TB) versus *Passendorferia* and *Cubasphinctes* (NMB) and the genus *Perisphinctes* probably co-occurring by means of different morphospecies of the subgenus *Subdiscosphinctes*. On the other hand the composition of faunas (Andean-Caribbean versus Cosmopolitan) show very similar patterns and trends in both basins (Fig. 51C): A maximun of Andean-Caribbean species in the Pseudokranaus Zone shifting to a maximun of cosmopolitan species in the Passendorferia Zone, and a shift to predominance of Andean-Caribbean species in the subsequent Tarapacaense Zone. In the Desertorum Zone the trends differentiate clearly, a new dominance of cosmopolitan species in the TB but a complete dominance of Andean-Caribbean species in the NMB. The trend of the NMB correlates with the geographic extension of the record of each biozone (see Fig. 47).

A first conclusion is that faunal exchange between the Andean-Caribbean regions and the Tethys was fluid during the late Callovian to the middle Oxfordian, and during late Oxfordian the exchange was mantained but not for the NMB. Nevertheless this conclusion must remain preliminary for the possibility of limited exchange between the Tethys and the Caribbean region which was not analyzed separately from the Andean basins. Gygi & Hillebrandt (1991) concluded that faunal exchange between South American Pacific basins and the Tethys was limited to *Gregoryceras* and *Mirosphinctes* in the Transversarium and Bifurcatus Zones, but new evidence indicates it has been much wider, not only taxonomically but also in the time.

Several papers have been published in last years about Oxfordian paleobiogeography of ammonites of the Caribbean and Andean basins (see chapter Antecedents). They were mainly based on described or undescribed material of Cuba and the TB, and references to the NMB were rather indirect and conforming to the same biogeographic domain, especially because of the scarce systematic descriptions which could provide the only concrete evidence. There is a general agreement in that faunal exchange between Andean regions and the Tethys was fluctuant during late Callovian to late Oxfordian, accounting for the presence/absence of certain genera (*Peltoceratoides, Gregoryceras, Euaspidoceras, Taramelliceras, Rehmannia, Perisphinctes*). Present results also indicate a fluctuant pattern as indicated by trends of similarity of composition of faunas in both basins (Fig. 51C).

Some of the ammonites described above suggest that important changes in the current views could surely arise after further studies:

(1) The occurrence of *Passendorferia* in the Passendorferia Zone of the NMB enlarges the biogeographic distribution of the genus. López-Palomino et al. (2006) have cited the occurrence of *Passendorferia* in Mexico, in beds also containing *Cubasphinctes* cf. *cubanensis*. Moreover, Passendorferiinae gen. et sp. indet. in the late Callovian Patagoniense Zone could even indicate the origin of the subfamily in this basin.

(2) The early occurrence of *Subvinalesphinctes* and *Cubasphinctes*, the bulk of the subfamily Vinalesphinctinae (see Parent et al. 2006 *in print*), in the Pseudokranaus Zone of the NMB, could point to an origin of the subfamily in this basin, followed by instalation in the Caribbean region where they seem to have florished and dominated the local Perisphinctid fauna.

(3) The occurrence of *Choffatia* sp. A - *Choffatia* sp. B - *Alligaticeras*? aff. *raguini* in the late Callovian Patagoniense Zone of the NMB shows a morphologic spectrum closely similar to that seen in the Tethyan late *Choffatia* evolving into *Alligaticeras*.

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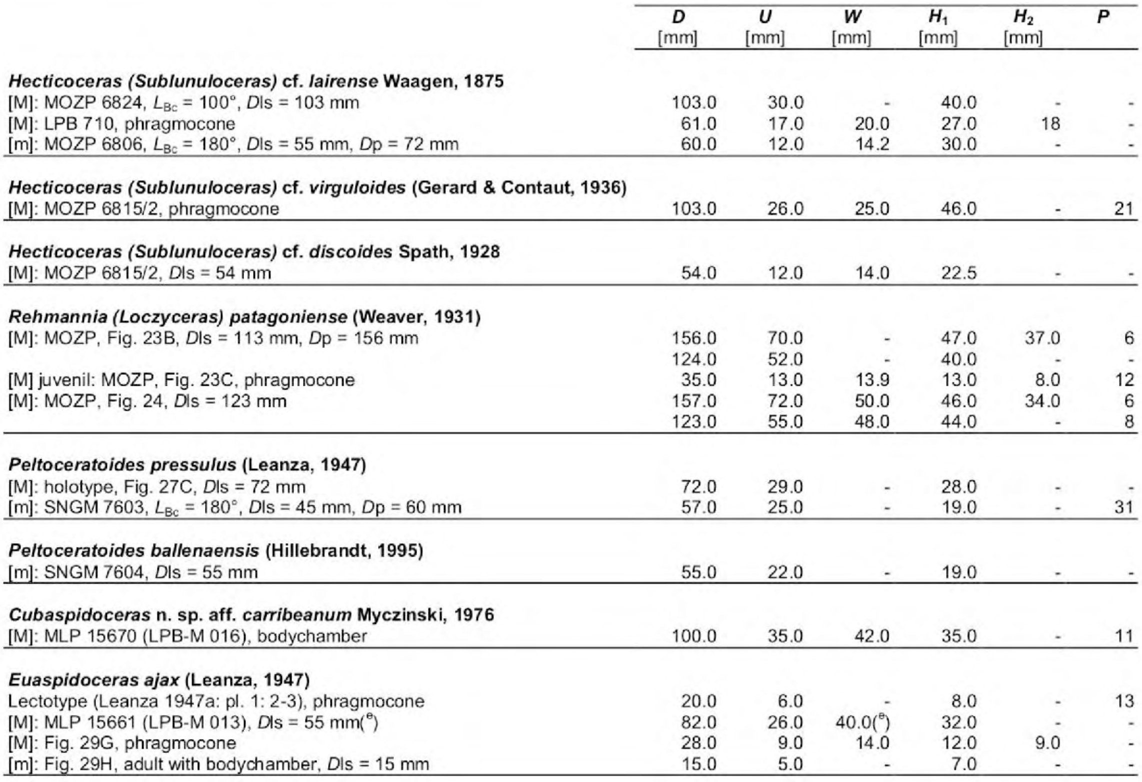
Appendix 1. Dimensions of figured ammonites. Symbols and abbreviations as in text.



	D [mm]	*U* [mm]	*W* [mm]	H_1 [mm]	H_2 [mm]	*P*
***Hecticoceras (Sublunuloceras)* cf. *lairense* Waagen, 1875**						
[M]: MOZP 6824, L_{Bc} = 100°, *D*ls = 103 mm	103.0	30.0	-	40.0	-	-
[M]: LPB 710, phragmocone	61.0	17.0	20.0	27.0	18	-
[m]: MOZP 6806, L_{Bc} = 180°, *D*ls = 55 mm, *D*p = 72 mm	60.0	12.0	14.2	30.0	-	-
***Hecticoceras (Sublunuloceras)* cf. *virguloides* (Gerard & Contaut, 1936)**						
[M]: MOZP 6815/2, phragmocone	103.0	26.0	25.0	46.0	-	21
***Hecticoceras (Sublunuloceras)* cf. *discoides* Spath, 1928**						
[M]: MOZP 6815/2, *D*ls = 54 mm	54.0	12.0	14.0	22.5	-	-
***Rehmannia (Loczyceras) patagoniense* (Weaver, 1931)**						
[M]: MOZP, Fig. 23B, *D*ls = 113 mm, *D*p = 156 mm	156.0	70.0	-	47.0	37.0	6
	124.0	52.0	-	40.0	-	-
[M] juvenil: MOZP, Fig. 23C, phragmocone	35.0	13.0	13.9	13.0	8.0	12
[M]: MOZP, Fig. 24, *D*ls = 123 mm	157.0	72.0	50.0	46.0	34.0	6
	123.0	55.0	48.0	44.0	-	8
***Peltoceratoides pressulus* (Leanza, 1947)**						
[M]: holotype, Fig. 27C, *D*ls = 72 mm	72.0	29.0	-	28.0	-	-
[m]: SNGM 7603, L_{Bc} = 180°, *D*ls = 45 mm, *D*p = 60 mm	57.0	25.0	-	19.0	-	31
***Peltoceratoides ballenaensis* (Hillebrandt, 1995)**						
[m]: SNGM 7604, *D*ls = 55 mm	55.0	22.0	-	19.0	-	-
***Cubaspidoceras* n. sp. aff. *carribeanum* Myczinski, 1976**						
[M]: MLP 15670 (LPB-M 016), bodychamber	100.0	35.0	42.0	35.0	-	11
***Euaspidoceras ajax* (Leanza, 1947)**						
Lectotype (Leanza 1947a: pl. 1: 2-3), phragmocone	20.0	6.0	-	8.0	-	13
[M]: MLP 15661 (LPB-M 013), *D*ls = 55 mm(^{e})	82.0	26.0	40.0(^{e})	32.0	-	-
[M]: Fig. 29G, phragmocone	28.0	9.0	14.0	12.0	9.0	-
[m]: Fig. 29H, adult with bodychamber, *D*ls = 15 mm	15.0	5.0	-	7.0	-	-

Appendix 1 (continued). Dimensions of figured ammonites. Symbols and abbreviations as in text.

	D [mm]	***U*** [mm]	***W*** [mm]	H_1 [mm]	H_2 [mm]	***P***
***Euaspidoceras veranadaense* n. sp.**						
[M]: holotype, MLP 15664 (LPB-M 015), *D*ls = 113 mm	149.0	62.0	34.0	49.0	36.0	5
[m]: LPB 737, phragmocone	34.0	11.0	12.0	14.0	12.0	-
***Euaspidoceras tarapacaense* n. sp.**						
[M]: MLP 11356 (LPB-m 012), *D*ls = 76 mm	88.0	33.8	38.0	33.0	28.0	12
	76.0	28.5	31.4	27.0	-	12
***Euaspidoceras hypselum* (Oppel, 1863)**						
[M]: holotype, AS VIII 61 (LPB-M 112), phragmocone	111.0	41.8	48.0	37.9	36.0	10
	80.3	31.0	41.0	30.1	-	10
***Choffatia* sp. A**						
[M] : MOZP 6778, phragmocone	130.0	63.0	-	33.0	-	19
[M] : MOZP 6823, *D*ls = 130 mm	115.0	56.0	-	31.0	-	19
***Choffatia* sp. B**						
[M] : MOZP 6825, *D*ls = 110 mm	130.0	66.0	-	33.0	-	17
***Alligaticeras* ? aff. *raguini* (Gerard & Contaut, 1936)**						
[M] : MOZP 6764, *D*ls = 113 mm	113.0	60.0	-	28.0	-	22
***Perisphinctes (Subdiscosphinctes)* cf. *lucingae* (Favre, 1875)**						
NMB-J32823, *D*ls = 47 mm (^{e})	37.0	12.9	11.7	15.0	-	34
***Cubasphinctes durangensis* (Burckhardt, 1912)**						
[?M]: NMB-J31179, phragmocone	81.3	40.3	21.3	22.7	-	32
	64.6	28.7	16.5	17.4	-	26
[?M]: NMB-J31180, *D*ls = 76.3	76.3	35.6	20.5	21.6	-	36
***Cubasphinctes cubanensis* (O'Connell, 1920)**						
[M]: MOZP 6875, *D*ls = 130 mm (^{e})	119.0	52.8	26.8	36.5	22.5	24
***Orthosphinctes* ? sp. A**						
[m] : MOZP 2704, *D*ls = 69 mm	88.0	45.0	17.0	26.0	20.0	25
	69.0	32.0	19.0	20.0	-	24