N. Jb. Geol. Paläont. Abh. 275/2 (2015), 163–217 **Article**
Stuttgart, February 2015

The ammonite fauna of the La Manga Formation (Late Callovian-Early Oxfordian) of Vega de la Veranada, Neuquén Basin, Argentina

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With 39 figures and 1 table

To the memory of Bernhard Ziegler (1929-2013)
and Gerd E.G. Westermann (1927-2014)

Abstract: A well exposed section of the La Manga Formation in the locality Vega de la Veranada (north of the Neuquén Province, Argentina), sampled bed-by-bed, has provided a diverse ammonite fauna. This fauna indicates an age range comprising the Lamberti to Cordatum zones, older than concluded in previous studies by different authors. There have been identified 20 species belonging to 14 genera (*Hecticoceras*, *Choffatia*, *Collotia*, *Rehmannia*, *Araucanites*, *Euaspidoceras*, "*Perisphinctes*", *Vinalesphinctes*, *Peltoceratoides*, *Neoprionoceras*, *Lissoceratoides*, *Veranadaites* n. gen., *Subvinalesphinctes*, and *Cubasphinctes*). It is introduced *Veranadaites* n. gen. (Type species: *Veranadaites palmicostatus* n. gen. et n. sp.) for small Early Oxfordian sphaeroceratids closely related to the Late Callovian-Early Oxfordian *Araucanites*. *Choffatia schilleri* n. sp. (Upper Callovian), as part of the guide assemblage, is taken as the index of the *schilleri* Horizon (new). *Peltoceratoides pressulus* Leanza (Lower Oxfordian), as part of the guide assemblage, is taken as the index species of the *pressulus* Horizon (new). A chronostratigraphic zonation for the Callovian-Oxfordian interval in the Andean Neuquén and Tarapacá basins is proposed based on the two existing quasi-independent scales. After revision of the age of the guide ammonites, the Primus, Dimorphosus, and Eugenii zones are inserted between the Patagoniensis and Pressulus zones. The Pressulus Zone is standardized by designation of the *pressulus* Horizon as its base.

Key words: Neuquén Basin, Vega de la Veranada, La Manga Formation, Oxfordian, Ammonites, Chronostratigraphic zonation.

1. Introduction

Vega de la Veranada is a locality situated in the northern part of the Neuquén Province (Fig. 1A), on the eastern side of the Tromen volcano. In this locality the La Manga Fm is more fossiliferous compared to many other outcrops of the Neuquén Basin, allowing to sample the Upper Callovian-Lower Oxfordian ammonite fauna with fine stratigraphic control.

The La Manga Fm in Vega de la Veranada (VV) consists of a succession of few metres of sandstones, marls and micritic limestones attributed to the Lower?-Middle Oxfordian (Cordatum?-Plicatilis zones) by Stipanicic (1965) and Stipanicic et al. (1976), and to the Pressulus and ?Passendorferia zones by Parent (2006). These studies were based on more or less gross samplings, pending a survey under fine stratigraphic control.

In this paper we present the results of the study of the ammonite fauna of the La Manga Fm in Vega de la Veranada, which was sampled bed-by-bed.

Independent chronostratigrahic ammonite zonations for the Callovian-Oxfordian interval are currently available for the Neuquén Basin (Parent 2006; Garrido & Parent 2013) and Tarapacá Basin (Hillebrandt & Gröschke 1995; Hillebrandt et al. 2000). Several

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DOI: 10.1127/njgpa/2015/0461
0077-7749/2015/0461 $ 13.75

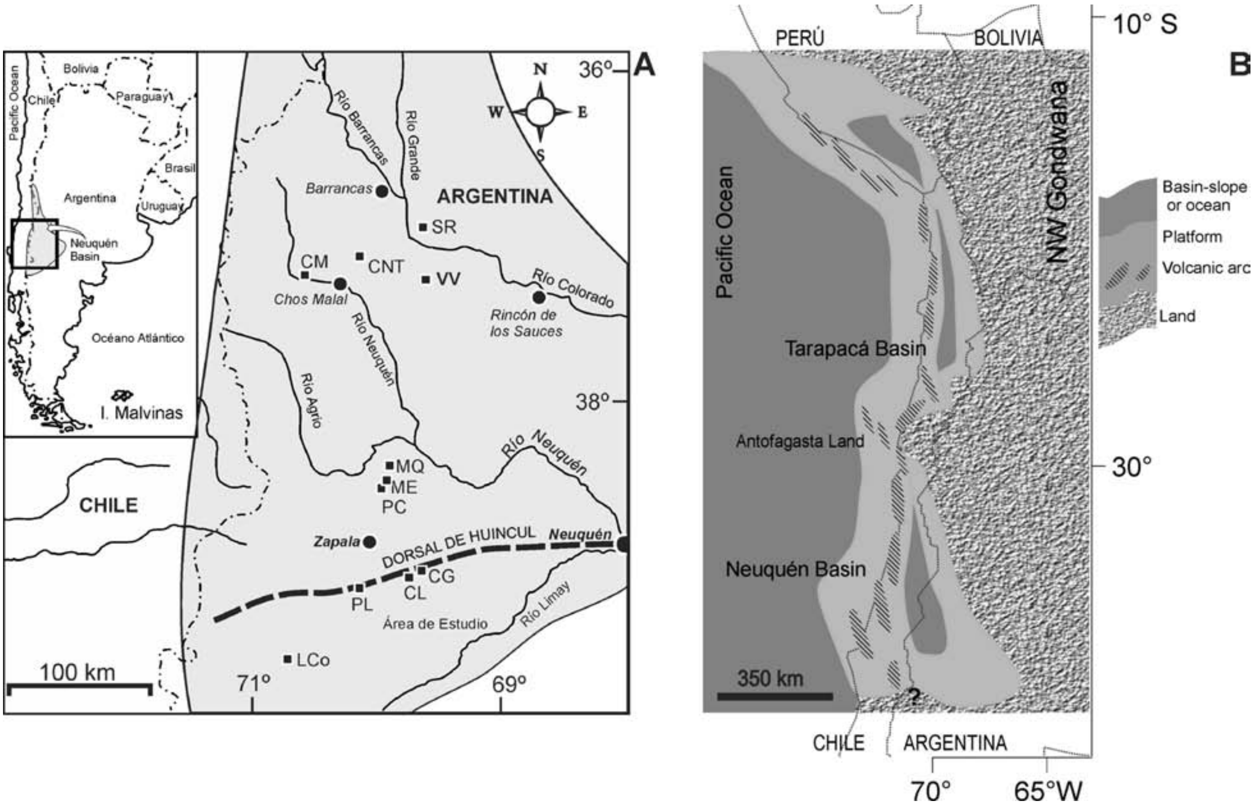


Fig. 1. A – Southern Neuquén Basin (grey area), west-central Argentina, with indication of Vega de la Veranada (VV) and other localities mentioned in text: PL (Picún Leufú), PC (Portada Covunco), ME (Manzano Escondido), MQ (Mallín Quemado), CM (Chacay Melehué), and SR (Sierra de Reyes). **B** – Oxfordian geography of SW South America superimposed on the Recent geography showing the Tarapacá and Neuquén basins (after Parent 2006).

of the described species in this paper are new for the Neuquén Basin, few of them are closely comparable with species described by Hillebrandt & Gröschke (1995), and others can be assigned to Tethyan species. After a revision of the time-correlation of the available zonations and the similarities of some of their ammonites, an ammonite zonation scale common to both basins is proposed.

The regional palaeogeographic framework of the Neuquén (or Neuquén-Mendoza) Basin and the Tarapacá Basin in the western border of South America follows Parent (2006) as shown in Fig. 1B.

We distinguish: (a) biozone as a body of rock characterized by their fossil content, (b) chronostratigraphic zone as a sheet of rock (one or more strata) bounded by two time-planes, and (c) standard chronostratigraphic zone as a chronostratigraphic zone defined only by a faunal horizon at its base, then conforming a succession of standard zones without gaps or overlaps. These definitions and the corresponding nomenclature of the units are widely discussed by Callomon (1995, 2001), Parent (2006) and Garrido & Parent (2013). Abbreviations are used for chronostratigraphic zone, or Zone for short (Z.) and ammonite horizon or biohorizon (Hz.).

2. Stratigraphic framework

The outcrops of the study area (Fig. 2) comprise a Lower to Middle Jurassic succession of marine deposits, included in the Cuyo and Lotena groups of the Neuquén Basin (Gulisano & Gutiérrez-Pleimling 1995). The lithostratigraphic units are represented by the Los Molles (Upper Bajocian?-Upper Bathonian), Lajas (Lower-Middle Callovian), Lotena (upper Middle?-Upper Callovian), and La Manga (Upper Callovian-Oxfordian) formations (e.g., Stipanicic 1965; Gulisano & Gutiérrez-Pleimling 1995; Howell et al. 2005; Parent 2006; Veiga et al. 2011). The Auquilco Fm, resting on the La Manga Fm, is mainly

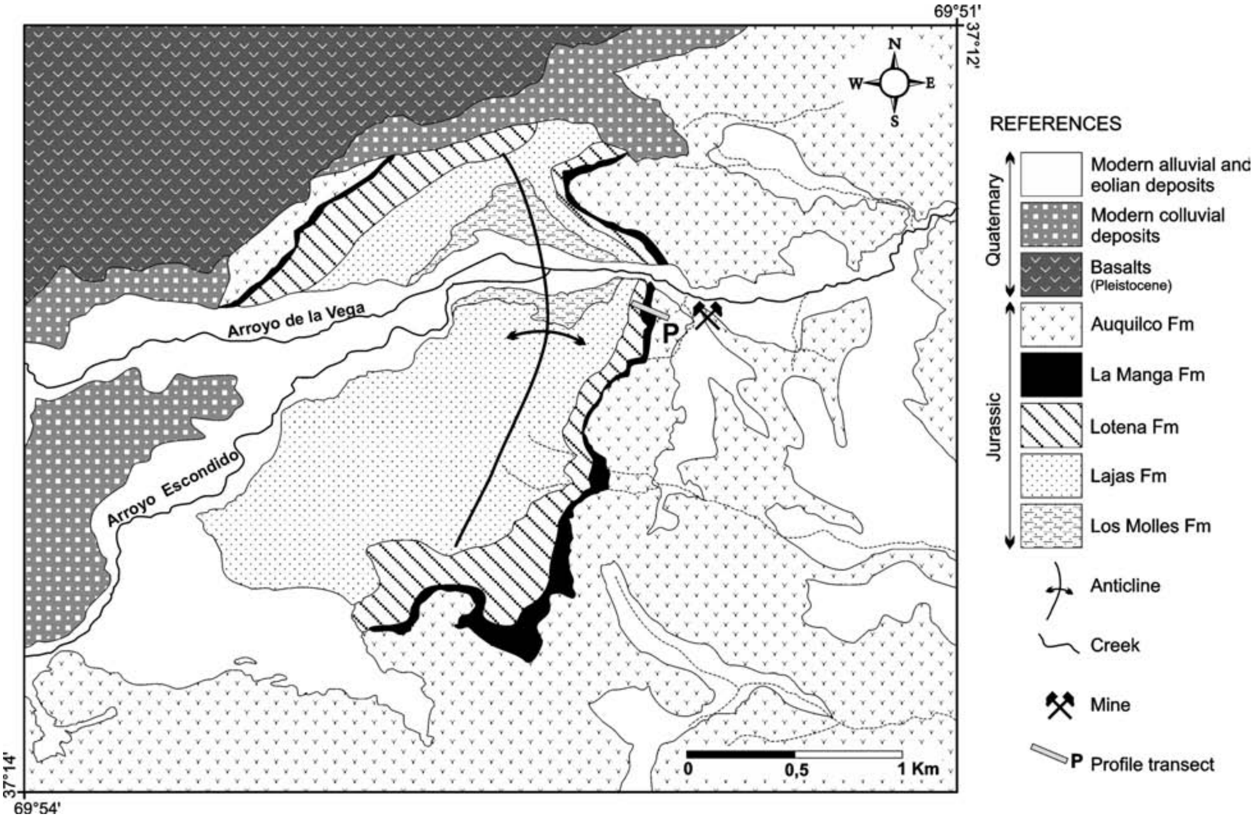


Fig. 2. Geologic map of the Vega de la Veranada area composed from the results of the present study with indication of the studied section (P).

evaporitic (gypsiferous) and Oxfordian in age. This interesting geologic setting of the study area was described by Groeber (1953) and in detail by Stipanicic (1965). According to Gulisano (1992) the Upper Callovian to Oxfordian rocks in the area would have been deposited in a distal platform setting.

In the studied section (Fig. 3) the total measured thickness of the La Manga Fm is 8.7 m. It comprises a succession of micritic limestones, sandy limestones, marls and calcareous sandstones, conforming a transitional setting between the "Facies de La Manga" and "Facies de la Vaca Muerta" of Stipanicic (1965). In general our lithostratigraphic profile can be correlated with the section of Stipanicic (1965: fig. 5), but with the following remarks:

(1) Our level VV-M-2 corresponds to the top level of the Lotena Fm in the scheme of Stipanicic (1965: 417, pl. 3: 2). In this sense, the presence of an underlying thin bed of micritic limestones (our level VV-M-1) and the petrologic affinity of our level VV-M-2 with the upper levels lead us to consider both of them as part of the La Manga Fm.

(2) Our levels VV-M-3 to VV-M-20 are compatible with the unit "La Manga inferior" (Mi) of Stipanicic (1965), while our levels VV-M-21 to VV-M-25 are correlated with his unit "La Manga superior" (Ms).

A rich invertebrate fauna was collected from this succession, including some 200 ammonites. Ostreid bivalves are abundant in few beds (levels VV-M-12 and VV-M-20); additionally there were collected three belemnites and a specimen of *Retroceramus* (level VV-M-17; Fig. 4B). A detailed stratigraphic study of the Lotena, La Manga and Auquilco formations is to be published elsewhere.

3. Systematic palaeontology

The material described was collected by the authors and housed at the Museo Provincial de Ciencias Naturales "Prof. Dr. Juna A. Olsacher", Zapala, Neuquén, Argentina (MOZ-PI). Bodychamber is abbreviated with Bc and phragmocone

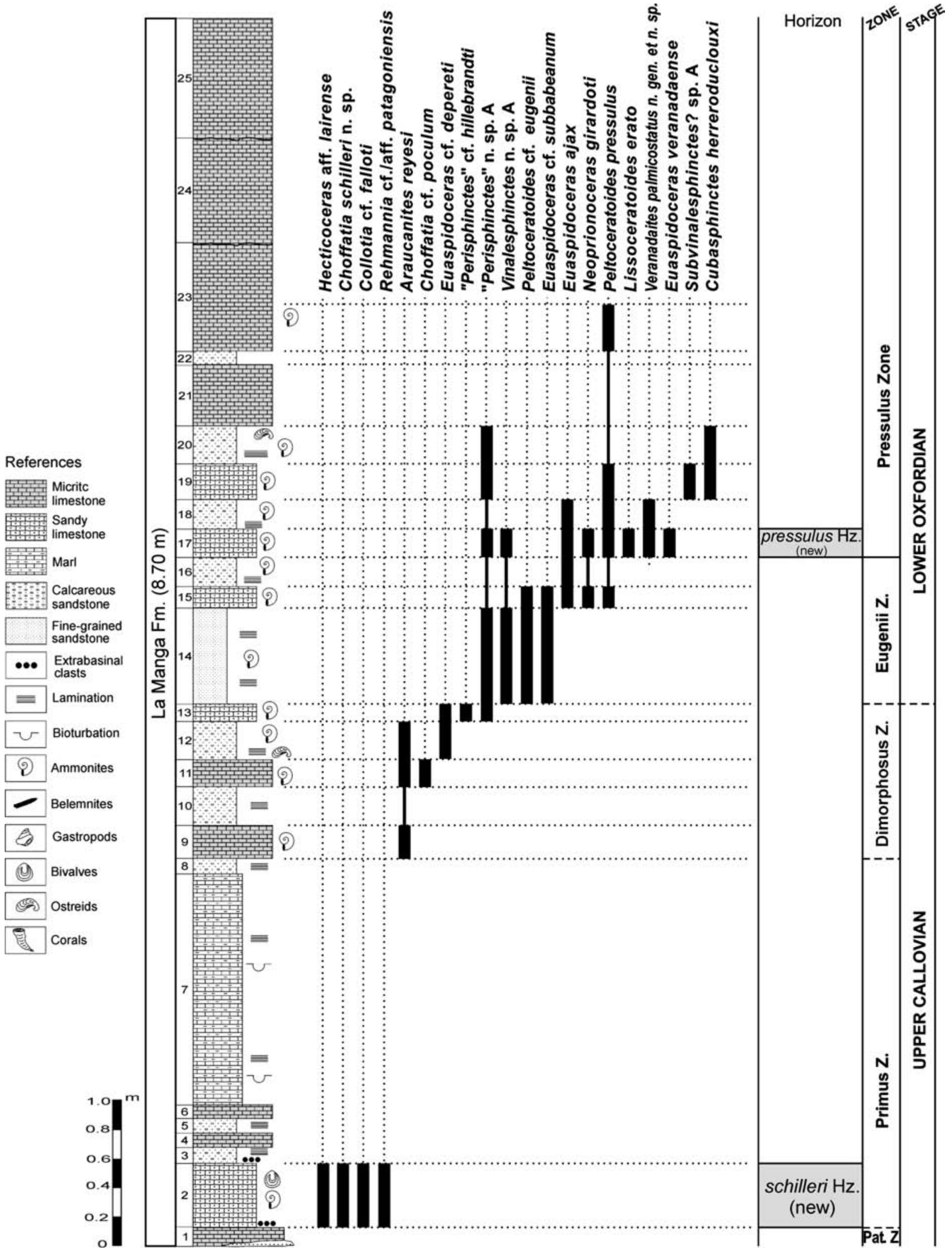


Fig. 3. Stratigraphic chart of the studied section of the La Manga Fm in Vega de la Veranada showing the log-section, the ammonite fauna, and the chronostratigraphic classification. The ammonite zonation and the new biohorizons (*schilleri* Hz. and *pressulus* Hz.) introduced in this paper are explained in text. Bed numbers used throughout the text as VV-M-1 to VV-M-25 (VV for Vega de la Veranada, M for La Manga Fm) are illustrated. Zonal boundaries indicated by solid lines for standard zones, while broken lines are used for tentative correlation or non-standard zones. Pat. Z indicates the Patagoniensis standard Zone.

with Ph; [M]: macroconch (female), [m]: microconch (male). Measurements are indicated as follows (see Parent et al. 2010: fig. 2): 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 millimetres [mm]; length of body chamber (L_{Bc}) in degrees [°]. Number of primary (P) and ventral (V) ribs and periumbilical (T_U), lateral (T_L) and ventro-lateral (T_V) tubercles per half whorl. Report of biometric features of shell-shape is given in the form of dimensionless numbers or "indexes", mainly relative to the size (D) which allow comparisons in a range of sizes. Lists of synonyms are mainly referred to lists already published; the synonyms are listed only for some revised species.

Sexual dimorphism and intraspecific variation: We generally assume that macroconch ammonites were the females and the microconchs the males. It remains, however, useful to add the former terms mainly because of some complex cases reported which seem to involve some form of hermaphroditism or sex change (Parent et al. 2008).

It is widely accepted that most ammonites were widely variable intraspecifically in morphology and adult size (e.g., Sturani 1971; Callomon 1985; Bonnot 1993; Parent 1998a; Bonnot et al. 2008; Landman et al. 2010). However, the sequence of sculptural stages (sculpture ontogeny) is rather stable. Variation in shell shape and sculpture, between individuals from a single stratigraphic horizon, arises mainly because of size variation at which the ontogenetic changes occur, in sequences which are otherwise very constant (cf. Hantzpergue 1989: 80). This variation in timing may be considered as generated by developmental heterochronies, the processes modelling the phenotypic variation through a range of more or less paedo- or peramorphic variants (see Meister 1989 for a clear example). This phenotypic variation should be, at least in part, a response to different environmental conditions during development (Mitta 1990; Wilmsen & Mosavinia 2010; Parent et al. 2013). These changes in the timing of expression of the successive morpho/ornamental stages generate the gradual variation and the more or less discrete different morphotypes usually described in ammonite species.

Frequently in palaeontology, the occurrence of two or more morphotypes within a single species is referred as polymorphism. Nevertheless, the term *polymorphism* s.s. refers to genetic variation, whether or not this has recognizable phenotypic effects (e.g., Fusco & Minelli 2010) – not detectable in fossils, save sexual dimorphism. This latter includes both, genetic and genetic-based phenotypic differences between sexes. To refer to different eco-phenotypes the term *polyphenism* should be used which refers to different phenotypes produced by a single genotype in response to different environmental signals (e.g., Stearns 1989), again not discriminable in fossils. We have pointed out the frequent misuse of these terms (e.g., Parent 1998a; Parent et al. 2011) but no proposed a solution. In order to avoid confusions by the misuse of the terms, we propose the term *polymorphotypism* for the cases where more or less discrete morphotypes are considered to belong to a single or same species, i.e., a polymorphotypic species. For the cases of different morphotypic-composition of stratigraphically different samples belonging to a single species, we use the common term *transient* which refers to evolutionary changes (mainly in the ranges and/or patterns of variation) within a lineage (see Callomon 1985; Dietze et al. 2005).

Order Ammonitida Fischer, 1882
Suborder Ammonitina Fischer, 1882
Superfamily Haploceratoidea Zittel, 1884
Family Lissoceratidae Douvillé, 1885
Genus *Lissoceratoides* Spath, 1923

Type species: *Ammonites erato* d'Orbigny, 1850, by original designation.

Lissoceratoides erato (d'Orbigny, 1850)
Fig. 4A

Material: 1 phragmocone (MOZ-PI 9474) from bed VV-M-17.

Description and remarks: Smooth, involute platycone with compressed suboval, higher than wide whorl section. Umbilical shoulder rounded, umbilical wall vertical. Maximum D = 53 mm, U/D = 0.11.

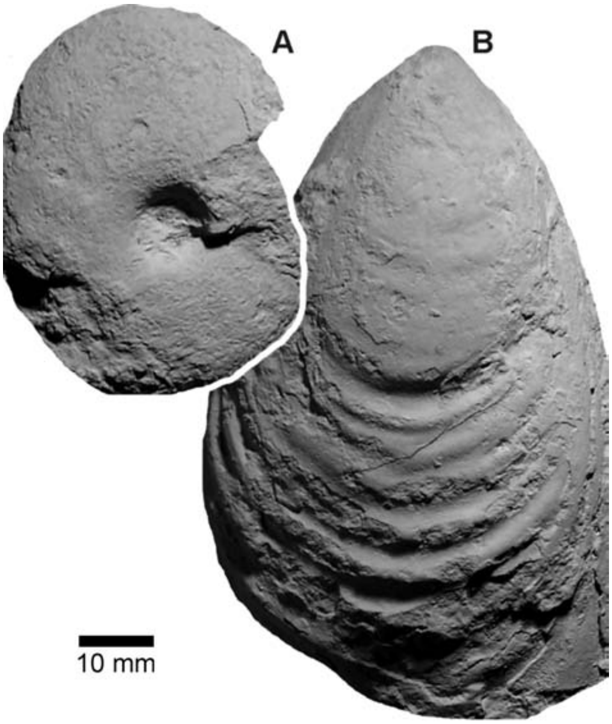


Fig. 4. **A** – *Lissoceratoides erato* (D'Orbigny, 1850), juvenil? [M] phragmocone (MOZ-PI 9474), bed VV-M-17, *pressulus* Hz., Pressulus Z. **B** – *Retroceramus galoi* (Boehm, 1907), complete specimen from bed VV-M-17, *pressulus* Hz., Pressulus Z. – All natural size (x1).

Species of the genus differ mainly in shell shape, because sculpture is either absent or weakly restricted to flanks, varying intraspecifically. The present specimen closely resembles the phragmocone of the lectotype (Enay et al. 1994: pl. 74, fig. 2). It does, however, show no signs of uncoiling, suggesting that it was larger in adult size. A similar specimen figured by Matyja (1977: pl. 1: 10) is also an adult phragmocone beginning to uncoil. *L. erato* ranges in the Tethys at least through the Lower and Middle Oxfordian (e.g., Matyja 1977; Enay et al. 1994).

Occurrence: Vega de la Veranada section level VV-M-17, *pressulus* Hz., Pressulus Z., Lower Oxfordian. Similar but poorly preserved specimens have been described from the Patagoniensis Z. (Upper Callovian) of Arroyo Agua Fría (central Neuquén Basin) and the Pressulus Z. of Arroyo Los Blancos, northern Neuquén Basin (Parent 2006: 18).

Family Oppeliidae Douvillé, 1890
Subfamily Hecticoceratinae Hyatt, 1900

Remarks: The many nominal genera and subgenera of the subfamily were summarized by Arkell et al. (1957). The number of species described is so large that it seems impossible to find a rationale for the determination of new material. Most previously described taxa were based on morphotypes with minute differences in their phragmocones, and usually collected without stratigraphic information. Moreover, the differences between specimens are frequently originated from the comparison of different growth stages. The framework becomes even worse considering that sexual dimorphic pairs are almost unknown, even when there have been early attempts (e.g., d'Orbigny 1842-1849: 441, pls. 152, 157).

A sexually dimorphic species with relatively high intraspecific variability and collected under close stratigraphic control, was convincingly described by Bonnot et al. (1999) as *Sublunuloceras* gr. *virguloides* Gérard & Contaut, 1936. The assemblage described by these latter authors is an acceptable representation of the species with the variability-range of both sexual dimorphs well represented. The many morphotypes illustrated (Bonnot et al. 1999: pl. 2, figs. 1-8 and pl. 3, figs. 1-4) intergrade in size, shell-shape and prominence of ornamentation. The prominence of the ribbing shows, as usual, negative covariation with its density. Each one of these morphotypes could have been assigned to one or more of the several nominal morpho-genera and/or morpho-subgenera available, at least *Paroecotraustes*, *Hecticoceras, Lunuloceras, Sublunuloceras, Putealiceras*, *Kheraites*, and *Brightia*.

The broad classification of the Hecticoceratinae proposed by Elmi (1964, see also Elmi 1967) as two genera, e.i. *Hecticoceras* and *Lunuloceras* Bonarelli, 1893, seems well balanced and, interestingly, goes back to the original classification of Bonarelli (1893). Nevertheless, the study of Bonnot et al. (1999) shows that both genera – as also most of the remaining ones– would merely consist of different parts of the range of variation of assemblages which may be considered belonging to a single lineage.

We conclude that most of the Hecticoceratinae could likely conform to a single lineage, of widely variable chronospecies (or transients) for which can be used the name *Hecticoceras* Bonarelli, 1893.

This classification in a single genus would not obscure the potential stratigraphic utility of these ammonites. The stratigraphic ranges attributed to each morphogenera/subgenera is variable among the different wide revisions (cf. Elmi 1964, 1967; Arkell et al. 1957), and some other authors (e.g., Zeiss 1959) range all the morphogenera/subgenera throughout all the interval Early to Late Callovian. However, the stratigraphic utility of the Hecticoceratinae might appear from descriptions of assemblages collected under fine stratigraphic control and based on adult macro- and microconchs.

Genus *Hecticoceras* Bonarelli, 1893

Type species: *Nautilus hecticus* Reinecke, 1818 by original designation.

Hecticoceras aff. *lairense* (Waagen, 1875)
Fig. 5A-D; Table 1

Material: 1 poorly preserved adult [M] (MOZ-PI 9419), 2 adult [M] phragmocones, 3 fragmentary phragmocones and 1 cast of phragmocone (not collected). All from bed VV-M-2.

Description: *Macroconch* (Fig. 5A-C): the two last whorls of the adult phragmocone (D = 60-150 mm) are compressed and involute; whorl section suboval to rounded subtriangular, higher than wide with narrowly rounded smooth venter, low vertical umbilical wall and sharp umbilical shoulder. At $D < 70$ mm the sculpture consists of falcoid primary ribs originating at the umbilical shoulder and bifurcating on the middle of the flank; secondary and intercalatory ribs are short and projected forwardly before fading near the venter. From about $D = 70$ mm the lower and middle flank are smooth, but the distinctive ribbing of the uppermost flank remains unchanged, disappearing before reaching the smooth and rounded venter. Slightly above the mid-flank there is a weak spiral ridge. One specimen (Fig. 5B) shows that since the beginning of the bodychamber the whorl section widens, especially on the overlapping part of the whorl.

The largest of the studied specimens (not figured MOZ-PI 9419, D_{ls} c. 180 mm, D_p c. 270 mm) has a smooth bodychamber, which is uncoiled and more inflated than the phragmocone with an angular length of about half a whorl. The poorly preserved peristome is sigmoidal. Septal suture line is very poorly preserved.

Microconch? (Fig. 5D): a septate whorl fragment is highly evolute, suggesting it is adult at a much smaller size. The whorl section is suboval to subrectangular with smooth and widely rounded venter. Ribbing consists, as in the macroconchs, of short ribs confined to the upper part of the flank.

Remarks and comparison: The present specimens differ

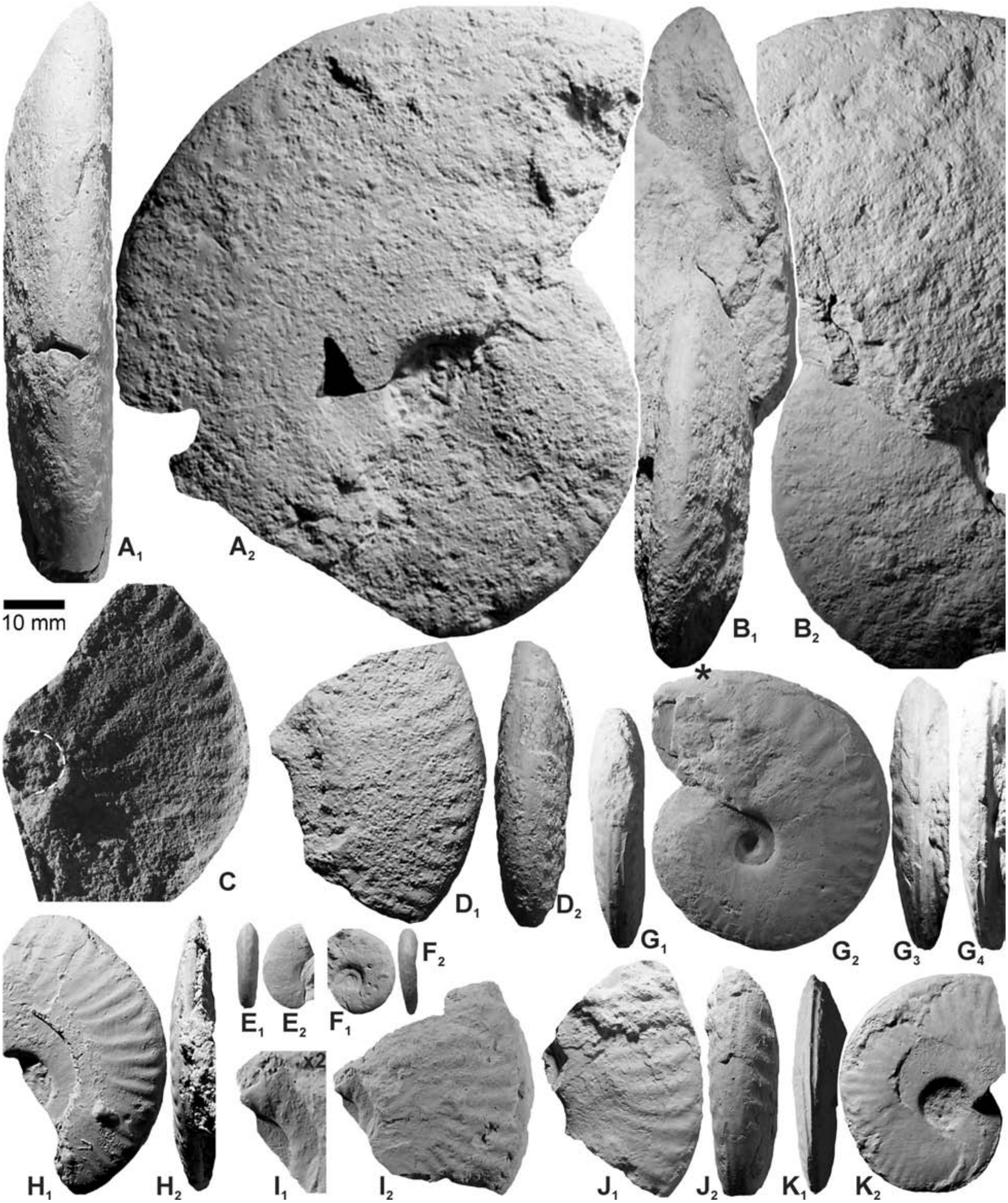


Fig. 5. **A-D**: *Hecticoceras* aff. *lairense* (Waagen, 1875), bed VV-M-2, *schilleri* Hz., Primus Z. **A** – Adult [M] phragmocone (MOZ-PI 9400). **B** – Adult [M] phragmocone (MOZ-PI 9396). **C** – Portion of [M] phragmocone of an individual with strong lateral ribbing (negative photograph of an impression in the surface of the bed). **D** – [m?] hragmocone (MOZ-PI 9397). **E-K** – *Neoprionoceras girardoti* (De Loriol, 1902), Eugenii (bed VV-M-15) and Pressulus (bed VV-17, *pressulus* Hz.) zones. **E** – Iinner whorls (MOZ-PI 9448), bed VV-M-15. **F** – Inner whorls (MOZ-PI 9454/3), bed VV-M-15. **G** – Complete adult [M] phragmocone (MOZ-PI 9448/11), bed VV-M-15; apertural (G_1), lateral (G_2) and two ventral (G_3-G_4, with different ilumination) views. **H** – Adult [m?] phragmocone (MOZ-PI 9462), bed VV-M-15. **I** – Portion of adult [M] phragmocone (MOZ-PI 9448/12), bed VV-M-15**;** I_2: enlarged (x2) view of the umbilical shoulder showing mild bullae. **J** – Portion of adult [M] phragmocone (MOZ-PI 9496), bed VV-M-17. **K** – Adult [m?] ?phragmocone (MOZ-PI 9489), bed VV-M-17. – All natural size except I_1 (x2), asterisk indicating the last septum.

Table 1. Biometric features of type and figured specimens. Abbreviations and symbols explained in text. Ph-Bc indicates observations at the last adult septum.

	D [mm]	U/D	W/D	H_1/D	H_2/D	P	V	T_U	T_V	Ph/Bc	
***Hecticoceras* aff. *lairense* (Waagen, 1875)**											
MOZ-PI 9400 (VV-M-2) [M]	100.00	0.10	0.16	0.54	0.30	–	–	–	–	Ph	Fig. 5A
	71.00	–	0.17	0.48	–	–	–	–	–	Ph	
***Neoprionoceras girardoti* (De Loriol, 1902)**											
MOZ-PI 9448/11 (VV-M-15) [M]	50.00	0.18	0.20	0.48	0.30	–	21	–	–	Ph-Bc	Fig. 5G
	36.00	0.14	0.24	0.44	–	–	24	–	–	Ph	
MOZ-PI 9454 (VV-M-15)	14.00	0.28	0.21	0.43	–	–	–	–	–	Ph	Fig. 5F
MOZ-PI 9489 (VV-M-17) [m?]	37.00	0.19	0.21	0.46	–	–	27	–	–	Ph	Fig. 5K
***Choffatia schilleri* n. sp.**											
MOZ-PI 9418 (VV-M-2). HT [M]	180.00	0.57	0.19	0.23	0.17	–	–	–	–	Bc	Fig. 8
(D_{ls} = 129 mm, L_{BC} = 315°)	155.00	0.54	0.24	0.25	–	22	–	–	–	Bc	
	83.00	–	–	–	–	11	–	–	–	Ph	
MOZ-PI 9414 (VV-M-2). PT [M]	111.00	0.50	0.27	0.29	–	13	–	–	–	Ph-Bc	Fig. 10A
„*Perisphinctes*” n. sp. A											
MOZ-PI 9435 (VV-M-14) [M]	118.00	0.59	0.19	0.22	–	30	–	–	–	Ph	Fig. 13B
	86.00	0.53	0.20	0.22	–	26	–	–	–	Ph	
	51.00	–	–	–	–	27	–	–	–	Ph	
	25.00	–	–	–	–	22	–	–	–	Ph	
MOZ-PI 9524 (VV-M-19) [M]	144.00	0.56	0.21	0.24	0.18	27	50	–	–	Ph	Fig. 14
	119.00	0.53	0.24	0.24	–	–	–	–	–	Ph	
	93.00	0.52	–	–	–	25	–	–	–	Ph	
MOZ-PI 9532 (VV-M-19) [M]	115.00	0.56	0.19	0.23	–	25	–	–	–	Ph	Fig. 15A
	72.00	0.55	–	–	–	20	–	–	–	Ph	
MOZ-PI 9533 (VV-M-19) [M]	105.00	0.52	0.25	0.25	–	22	–	–	–	Ph	Fig. 16C
	65.00	–	–	–	–	20	–	–	–	Ph	
MOZ-PI 9537 (VV-M-19) [M]	55.00	0.55	–	–	–	22	–	–	–	Ph	Fig. 17A
MOZ-PI 9540 (VV-M-20) [M]	108.00	0.48	0.35	0.30	–	17	–	–	–	Ph	Fig. 17B
***Peltoceratoides pressulus* (Leanza, 1947)**											
MOZ-PI 9476 (VV-M-17)	22.00	0.41	0.20	0.41	–	12	–	–	–	Ph	Fig. 20A
MOZ-PI 9504 (VV-M-17) [M]	102.00	0.43	0.23	0.34	–	18	18	–	–	Ph	Fig. 20D
MOZ-PI 9501 (VV-M-17) [M]	93.00	0.39	0.20	0.37	–	21	26	–	–	Ph	Fig. 20E
MOZ-PI 9505 (VV-M-17) [M]	134.00	0.40	0.25	0.34	–	16	16	–	–	Ph	Fig. 21
MOZ-PI 9502 (VV-M-17) [m]	75.00	0.47	0.20	0.32	–	22	–	–	–	Bc	Fig. 22C
***Euaspidoceras ajax* (Leanza, 1947)**											
MOZ-PI 9449/2 (VV-M-15) [M]	16.00	0.38	0.38	0.38	–	–	–	–	–	Ph	Fig. 27B
MOZ-PI 9449/4 (VV-M-15) [M]	27.00	0.33	0.52	0.41	–	10	0	3	10	Ph	Fig. 27D
MOZ-PI 9449/3 (VV-M-17) [M]	24.00	0.29	0.42	0.42	–	10	0	–	10	Ph	Fig. 27E
MOZ-PI 9454/1 (VV-M-15) [m]	40.00	0.38	0.33	0.35	–	19	35	–	–	Ph-Bc	Fig. 27J
	36.00	0.39	0.36	0.36	–	19	29	–	–	Ph	
MOZ-PI 9449/8 (VV-M-15) [M]	55.00	0.33	0.40	0.44	–	–	–	10	15	Ph	Fig. 28C
MOZ-PI 9465 (VV-M-16) [M]	117.00	0.35	0.38	0.38	–	11	–	11	0	Ph	Fig. 28D
MOZ-PI 9478 (VV-M-17) [M]	102.00	0.31	0.34	0.41	–	10	–	10	0	Ph	Fig. 31A
	75.00	0.29	0.40	0.49	–	10	–	10	5	Ph	
MOZ-PI 9513 (VV-M-18) [M]	180.00	0.43	0.33	0.34	–	9	–	9	0	Ph-Bc	Fig. 33
***Araucanites reyesi* (Westermann & Riccardi, 1976)**											
MOZ-PI 9423 (VV-M-9) [M]	190.00	0.05	0.63	0.46	–	0	0	–	–	Ph-Bc	Fig. 35
	144.00	–	0.72	0.58	–	0	0	–	–	Ph	
***Veranadaites palmicostatus* n. gen. n. sp.**											
MOZ-PI 9521 (VV-M-18). HT [M],	62.00	0.21	0.42	0.40	0.23	10	54	–	–	Bc	Fig. 36C
[D_{ls} = 40 mm, L_{BC} = 270°]	49.00	0.20	0.38	0.43	–	11	–	–	–	Ph-Bc	
MOZ-PI 9475 (VV-M-17). PT [M]	57.00	0.19	0.37	0.43	–	9	45	–	–	Ph-Bc	Fig. 36B

from the widely recorded *H*. cf. *lairense* (in PARENT 2006, see also GARRIDO & PARENT 2013) of the *choffatia* Hz. and *hecticoceras* Hz. (Patagoniensis Zone) by the sculpture of the phragmocone, which in the latter consists of strong falcoid primaries that bifurcate at mid-flanks, as well as of secondaries and intercalatories reaching the ventro-lateral shoulder where they swell into small bullae. The adult [M] of *H*. cf. *lairense* is smaller and more evolute. The [m] of *H*. cf. *lairense* (in PARENT 2006: fig. 20D) is very similar to the present [m?] in Fig. 5D, with differences in the longer primary and secondary ribs which begin in the lower flank. *H*. cf. *lairense* is consistently recorded in a lower stratigraphic position.

The specimen of *H*. cf. *discoides* (SPATH, 1928) in PARENT (2006: fig. 21B) resemble the present specimens in shell shape, but the ribbing is finer and denser. It also occurs in a lower stratigraphic position, associated with *H*. cf. *lairense* in the *Choffatia* Hz. The specimen of *H*. cf. *virguloides* (GÉRARD & CONTAUT, 1936) in PARENT (2006: fig. 21A), from the *Hecticoceras* Hz., Patagoniensis Z. of Manzano Escondido, differs by the tectiform venter and by the stronger ribs and open umbilicus at comparable diameter.

The larger specimens (Fig. 5A-B) are similar to the large [M] figured as "*Hecticoceras*" *lairense* by COURVILLE & CRÔNIER (2004: pl. 2, fig. 3) from the upper Lamberti Z. of Haute-Marne. It is very similar in adult size and sculpture but more widely umbilicate at comparable diameter within D = 80-130 mm (phragmocones), "*H*." *lairense* has U/D = 0.25-0.30 but *H*. aff. *lairense* has U/D = 0.10-0.14. *Hecticoceras lairense* in BONNOT & MARCHAND (1996: pl. 3, fig. 6), Lamberti Z. (Lamberti Subzone) of Malain, is similar but the phragmocone is not observable for closer comparison.

The type specimens of *H*. *virguloides* (GÉRARD & CONTAUT 1936: pl. 7, figs. 2-3, holotype and paratype, respectively), upper Athleta-lower Lamberti zones of La Folie, France (CARIOU 1971), are similar in involution and confinement of the ribbing in the upper flank. Significant differences could be the considerably larger adult size and the finer and denser ribbing of our specimens with respect to *H*. *virguloides*. As discussed above, BONNOT et al. (1999) have described and illustrated a sample of *Hecticoceras* gr. *virguloides* (as *Sublunuloceras*) from the *collotiformis* Hz. (Athleta Z.) of Côte d'Or, which includes a wide range of intraspecific variants. Their largest macroconch (pl. 2, fig. 1) perfectly matches the holotye, which appears slightly smaller, but its bodychamber is incomplete. The more involute and weakly ribbed specimens (pl. 2, figs. 3, 8) closely resemble our specimens (cf. Fig. 5A, D) except by their smaller size. *H*. aff. *lairense* differs from *H*. *virguloides* by the larger size of the adult [M] with smooth bodychamber and the apparently smaller variability in involution and sculpture of the phragmocone. The [m?] in Fig. 5D is similar to the [m] of *H*. gr. *virguloides* in BONNOT et al. (1999: pl. 3, figs. 2-3).

The present material appears to belong to an undescribed species closely resembling *H*. *lairense* from the Upper Callovian of India.

Occurrence: Vega de la Veranada section level VV-M-2, *schilleri* Hz., Primus Z. STIPANICIC (1965) cited *Sublunuloceras* aff. *discoides* SPATH from the same locality and level, suggesting that it belongs to the present species. It has not been recorded from other localities.

Subfamily Glochiceratinae HYATT, 1900

Genus *Neoprionoceras* SPATH, 1928

Type species: *Oppelia girardoti* DE LORIOL, 1902, by original designation.

Remarks: Following CHRIST (1961) we consider *Neoprionoceras* to be a valid taxon at the genus level, independent from *Neocampylites* CALLOMON, 1973. The macroconchs of both genera have tricarinate venters and are more or less inflated suboxyconic to platyconic; they differ in the ontogeny of the umbilical width and sculpture. *Neoprionoceras* has a small umbilicus with a sharp shoulder and smooth inner halves of the flanks (cf. CHRIST 1961: 305), at least on the inner whorls. *Neocampylites* has more widely umbilicate inner whorls with prominent ribs on the upper part of the umbilical wall and usually rounded umbilical shoulders; the flanks of the phragmocone are covered by strong falcate ribs, but these tend to become smooth on the bodychamber (e.g., CHRIST 1961: pl. 17, fig. 1, COURVILLE et al. 2011: fig. 8C).

The lectotype of *Neoprionoceras henrici* (D'ORBIGNY, 1850) is a nearly complete adult [M] with the last half whorl belonging to the bodychamber (see CHRIST 1961: pl. 18, fig. 1; ENAY et al. 1994: pl. 73, fig. 5). It supposedly comes from the Cordatum Z. of Précy, France. The corresponding [m] may be the specimen figured by JEANNET (1951: pl. 19, fig. 6) as *Campylites inermis* JEANNET, 1951, from the Cordatum Z., which has a moderately involute phragmocone with a sharp umbilical shoulder and smooth lower flank, becomes uncoiled by maturity through the last whorl, and develops poorly known lateral lappets (see CHRIST 1961: pl. 18, fig. 3). *N*. *girardoti* is very similar in shell-shape to *N*. *henrici*, but there seem to be differences in sculpture ontogeny. DE LORIOL (1902: pl. 3, figs. 8 [lectotype], 9; lectotype designated by CHRIST 1961) illustrates *N*. *girardoti* with smooth inner whorls, developing primaries on the upper flank only on the adult phragmocone; *N*. *henrici* is ribbed throughout. *N*. *girardoti* occurs in the interval upper Mariae-lower Cordatum zones according to CHRIST (1961), *N*. *henrici* in the upper Cordatum-Plicatilis zones.

Neoprionoceras girardoti (DE LORIOL, 1902)

Fig. 5E-K, Table 1

* 1902	*Oppelia girardoti*, P. DE LORIOL. – DE LORIOL, p. 40, pl. 3, figs. 8 (lectotype), 9.
1961	*Campylites* (*Neoprionoceras*) *girardoti* (LORIOL 1902). – CHRISTI, p. 306, pl. 18, fig. 2.
1928	*Neoprionoceras girardoti* LORIOL. – SPATH, p. 128.
? 1951	*Neoprionoceras girardoti* LORIOL. – JEANNET, p. 85, pl. 27, fig. 6.
cf. 2006	*Trimarginites* cf. *eucharis* (D'ORBIGNY, 1850). – PARENT, p. 21 (pars).

Material: 1 complete adult [M] phragmocone (MOZ-PI 9448/1), 4 incomplete phragmocones (MOZ-PI 9448/2-3, 9454 and 9462) from level VV-M-15; 2 incomplete phragmocones (MOZ-PI 9489 and 9496) from level VV-M-17.

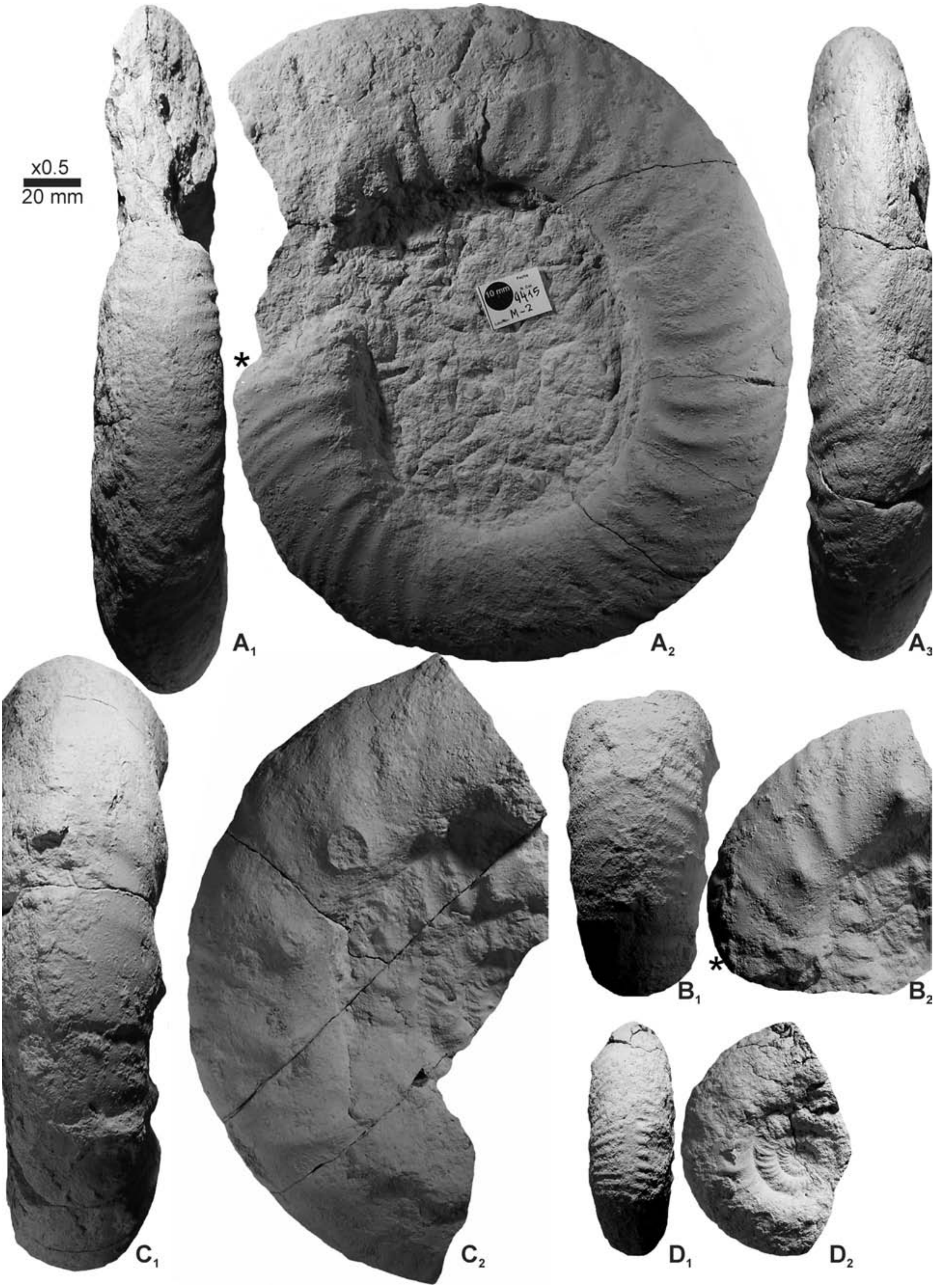


Fig. 6. A-B

Description: Material from level VV-M-15. *Macroconch* (Fig. 5E-G, I): Moderately preserved, wholly septate specimens with the following growth stages I to III, up to about $D = 70$ mm: the smooth platyconic inner whorls pass into inflated, tricarinate- suboxyconic whorls with strong ribs on the upper flanks at the following approximate diameters:

Stage I ($5 < D < 15$ mm): compressed and moderately evolute platycone with vertical umbilical wall, acute shoulder and flat flanks passing to the narrow rounded venter. Flanks and venter smooth.

Stage II ($15 < D < 35$ mm): involute, compressed platycone with vertical umbilical wall, well-developed mid-ventral keel and two weak lateral carinas. From about $D = 20$ mm weak falcoid ribs appear with short secondaries on the upper flank.

Stage III ($D > 35$ mm): involute platycone passing to inflate suboxycone with vertical umbilical wall and sharp shoulder, flanks slightly rounded, higher than wide and acute keels on venter. Ribbing falcoid with very weak primaries that bifurcate irregularly at mid-flank. Secondary and intercalatory ribs are prominent and regular on the upper half of flank and raised on the ventro-lateral shoulder, where they end in the lateral keels. A feeble ridge is present at mid-flank in some specimens.

Only one fragmentary phragmocone has short vestigial periumbilical ribs at $D = 25\text{-}30$ mm.

?*Microconch* (Fig. 5H): umbilicus relatively wide, apparently by incipient uncoiling; umbilical shoulder sharp, with lower half of the flanks smooth; compressed and tricarinate.

The specimens from level VV-M-17 (Fig. 5J-K) seem to be identical. Fig. 5J is a [M] phragmocone. Fig. 5K seems to be a [m], somewhat smaller than that in Fig. 5H but otherwise almost indistinguishable, especially in being more compressed than macroconchs.

Remarks and comparison: The assignment of the present specimens to *Neoprionoceras* is based on the tricarination and the sculpture ontogeny. The ribbing appears only at a diameter of 20-25 mm on the upper flank as in *N. girardoti*. The possible microconchs (Fig. 5H, K) are very similar to those of *N. henrici* (in Christ 1961: pl. 18: 3). *N. girardoti* occurs in the interval upper Mariae-lower Cordatum zones according to Christ (1961).

Occurrence: Vega de la Veranada section levels VV-M-15 (Eugenii Z.) and VV-M-17 (Pressulus Z.). A similar specimen assigned to *Neoprionoceras* cf. *henrici* came from the Pressulus Z. of Cajón Troncoso (Chile) and was found associated with *Neocampylites* (Parent 2006: fig. 22B-C). The specimen cited by Parent (2006: 21, fig. 14) as *Trimarginites* cf. *eucharis* is very similar to the larger specimens of *N. girardoti*.

Superfamily Perisphinctoidea Steinmann, 1890
Family Reineckeiidae Hyatt, 1900
Subfamily Reineckeiinae Cariou, 1984

Genus *Collotia* Grossouvre, 1917

Type species: *Ammonites fraasi* Oppel, 1857, by original designation.

Collotia cf. *falloti* (Gérard & Contaut, 1936)
Fig. 6A-B

Material: 1 complete, large [M] bodychamber (MOZ-PI 9415), 2 incomplete specimens (MOZ-PI 9407/1-2), from level VV-M-2. The material is abundant but mostly fragmentary.

Description: Adult [M] bodychamber begins at a diameter of about 150 mm, ending at $D_p = 240$ mm. Evolute ($U/D = 0.46$ to 0.48) and compressed, slightly uncoiled near peristome. Whorl section subrectangular to suboval, higher than wide. Ribbing rather irregular, strongly prosocline and moderately prominent on flanks and venter, which has a smooth band. Primary ribs originate on the umbilical shoulder and bi- or trifurcate on the lower third of the flank. There are small conical tubercles only at the beginning of the bodychamber, where the short primaries divide. After this tuberculate stage the ribbing consists of longer primaries ($P = 19$ at $D = 196$ mm), which irregularly bi- or trifurcate; some polyschizotomes occur. Secondary ribs are projected and most vanish before crossing the venter. Bodychamber length $L_{BC} = 320°$.

Remarks and comparison: Since all the available specimens are bodychambers, the typical inner whorls of the genus cannot be observed. But these bodychambers are very characteristic of the genus and very different from the other reineckeiids known in the Neuquén Basin and the Tarapacá Basin. Large size and evolute-compressed shell with few conical tubercles and projected ribbing, sometimes polyschizotomic (see Cariou 1984), appear to suffice to place the material in *Collotia*. Our largest [M] resembles the only specimen of *C. falloti* figured by Gérard & Contaut (1936: pl. 1, fig. 1) and is very similar to the large [M] figured by

Fig. 6. A-B – *Collotia* cf. *falloti* (Gerard & Contaut, 1936), bed VV-M-2, *schilleri* Hz., Primus Z. **A**: Complete adult [M] bodychamber (MOZ-PI 9415). **B**: Adult [M] with incomplete bodychamber (MOZ-PI 9407/1). **C-D** – *Rehmannia* cf./aff. *patagoniensis* (Weaver, 1931), bed VV-M-2, *schilleri* Hz., Primus Z. C: Adult [M] (MOZ-PI 9402), the last preserved whorl belongs to the bodychamber. D: Adult [M] phragmocone (MOZ-PI 9401). – All reduced x0.5, asterisk indicating the last septum.

Cariou (1984: pl. 64, fig. 3), but differs by its more marked, short stage of sculpture with periumbilical conical tubercles.

Cariou (1984: 370) considered the only figured specimen (i.e., Gerard & Contaut 1936: pl. 1: 1) as the holotype. Gerard & Contaut (1936: 51) mentioned different localities indicating they had more than a single specimen, but failed to designate a type specimen. We therefore designate the specimen illustrated by Gérard & Contaut (1936: pl. 1, fig. 1) as the lectotype of *Reineckeites falloti* Gérard & Contaut, 1936. The stratigraphic position is in the uppermost Athleta Zone, Collotiformis Subzone, *collotiformis* Hz. according to Cariou (1984), but could range somewhat higher according to the records of Gérard & Contaut (1936) in their "Subzone B" (upper Athleta Z. to lower Lamberti Z., Cariou 1971).

Occurrence: Vega de la Veranada section level VV-M-2, *schilleri* Hz. (new), Primus Z., Upper Callovian.

Genus *Rehmannia* Schirardin, 1956

Type species: *Ammonites rehmanni* Oppel, 1857, by original designation.

Rehmannia cf./aff. *patagoniensis* (Weaver, 1931)

Fig. 6C-D

Material: 1 adult, rather complete [M] (MOZ-PI 9402) and 1 adult [M] phragmocone (MOZ-PI 9401), from level VV-M-2. 10 adult [M], more or less complete, unnumbered.

Remarks: *R. patagoniensis* has been studied thoroughly by Riccardi & Westermann (1991), Parent (2006) and Garrido & Parent (2013). In the latter paper, the two transients α and β of the species (defined by Parent 2006) were characterized by the sculpture ontogeny of complete, adult macroconchs. The present material from the level VV-M-2 is similar to transient β, in which the tubercles arise later (at about $D = 60$-80 mm), similarly as observed in the material from Picún Leufú (Garrido & Parent 2013: figs. 7 and 14).

The later transient β seems to have given origin to *Jaspeiceras* Gröschke & Kossler, 1999, a genus known from the Upper Callovian-Lower Oxfordian of Chile (Garrido & Parent 2013). Fig. 6D is very similar to the specimen from the Primus Z. (Upper Callovian) of Cerro Paisaje figured by Hillebrandt & Gröschke (1995: pl. 6, fig. 11), which Gröschke & Kossler (1999) later included tentatively in *Jaspeiceras*. Very likely, these two specimens represent transitional forms between *R. patagoniensis* and the earliest *Jaspeiceras*.

Occurrence: Vega de la Veranada section level VV-M-2, *schilleri* Hz. (new), Primus Z., Upper Callovian. The close similarity of some of our specimens with forms of *Jaspeiceras* attests of the stratigraphic position of the *schilleri* Hz. (new) above the *Hecticoceras* Hz. of the upper Patagoniensis Z.

Family Perisphinctidae Steinmann, 1890

Subfamily Pseudoperisphinctinae Schindewolf, 1925

Genus *Choffatia* Siemiradzki, 1898

Type species: *Perisphinctes cobra* Waagen, 1875; subsequent designation by Buckman (1920).

Remarks: Diagnostic features of the genus, range and patterns of intraspecific variability of several of its species are stated in Cox (1988) and finely illustrated by Bonnot et al. (2008). The phyletic sequence *Choffatia-Alligaticeras-Properisphinctes-Perisphinctes* is a long-standing hypothesis already suggested by Arkell (1936) and supported by Cox (1988) and Page (1991), among others. The phyletic succession suggested by us (Fig. 7) is from the Late Callovian *Choffatia* and includes the *Alligaticeras-Properisphinctes* group. This phylogeny is supported mainly by stratigraphically controlled data from Gérard & Contaut (1936), Mangold (1971), Cox (1988), and Bonnot et al. (2008) among others.

Choffatia waageni (Teisseyre, 1889) – Coronatum Zone. The specimens figured under different names by Pfaehler-Erath (1938: pl. 1, figs. 1-2 [m] and pls. 2-3 [M]) can be clearly assigned to *C. waageni*, illustrating a narrow part of the range of variation of the species. The neotype (Corroy 1932: pl. 18, figs. 1-2) designated by Mangold (1971: 147; see also Enay et al. 1994: 138) illustrates an evolute, coarsely ribbed variant. These [M] and [m] specimens share the striking feature of a ventral groove or furrow on the adult phragmocone and, to some extent, the beginning of the bodychamber. The specimen from the Athleta Z. of Lupien (France) figured by Mangold (1971: pl. 16, fig. 2) as *C. waageni* is an ammonite closely allied to *C. isabellae* Bonnot et al., 2008. This is shown by one of the smaller macroconchs in Bonnot et al. (2008: pl. 2, fig. 3) which is almost identical to the specimen of Mangold.

Choffatia isabellae Bonnot et al., 2008 – lower Athleta Zone. Originally decribed from abundant adult specimens of both sexual dimorphs, with a wide spectrum of morphotypes. Most of the type material is typical for the genus, with the specific diagnostic features mainly consisting of the almost smooth innermost whorls, followed by consistently evolute, strongly constricted and finely ribbed inner-middle whorls with polyschizotomy (Fig. 7). The specimen of Bonnot et al. (2008: pl. 7) is very similar to the neotype of *C. waageni*; both specimens are serpenticonic thorughout and strongly ribbed, in contrast to most *Choffatia* species. The most notable difference is between the microconchs.

Some specimens (e.g., Bonnot et al. 2008: pl. 2, figs. 3, 5) have inner whorls indistinguishable from the holotype of *Alligaticeras rotifer* (Brown) at comparable diameter (cf. Bonnot et al. 2008: 12).

Choffatia crassa (Gérard & Contaut, 1936) – upper Athleta-lower Lamberti zones. In the wide sense this species would include the following [M] morphotypes described as distinct species by Gérard & Contaut (1936): *Subgrossou-*

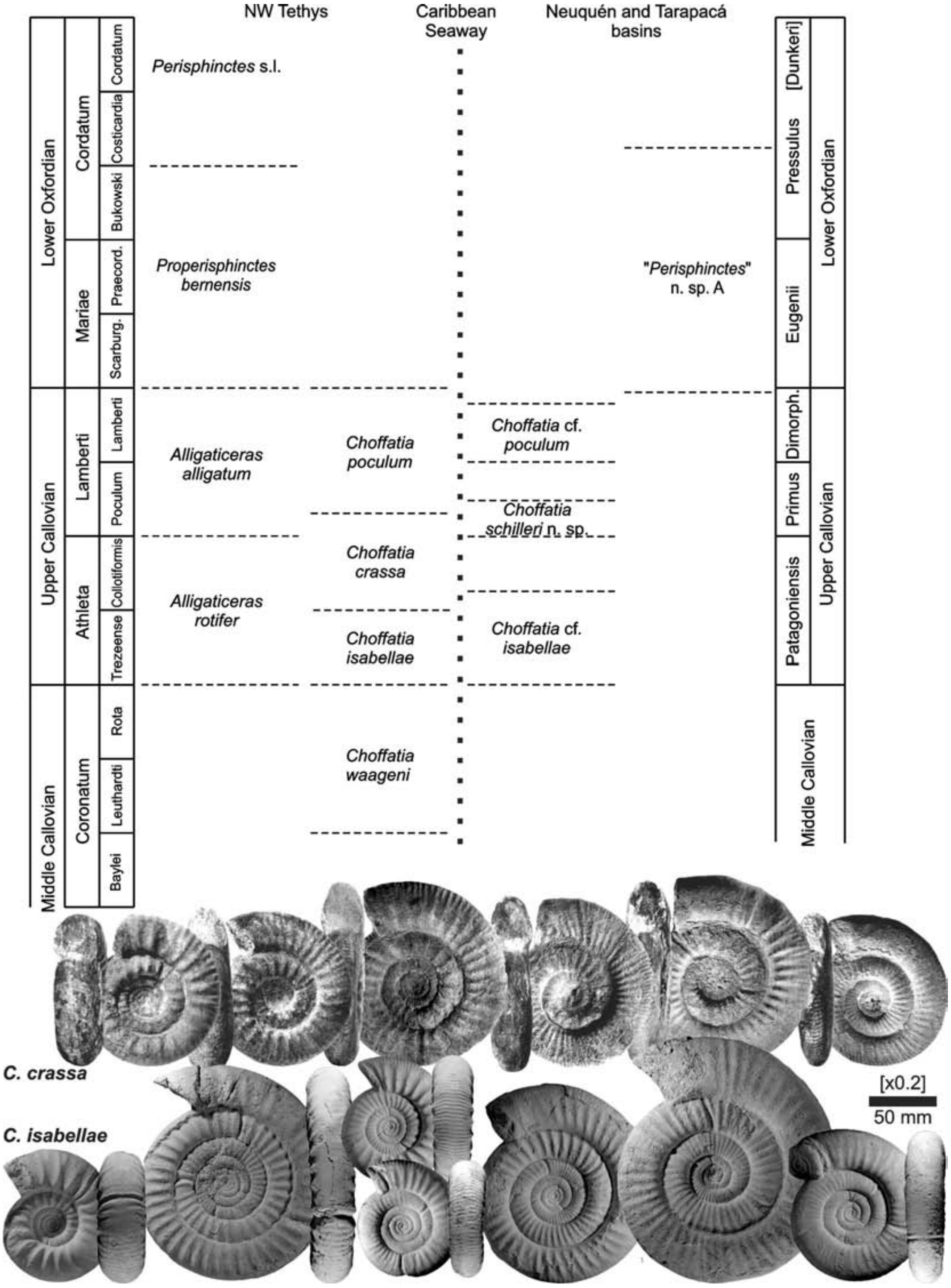


Fig. 7. Late Middle to Late Callovian succession of *Choffatia* and Late Callovian-Early Oxfordian *Alligaticeras-Properisphinctes-Perisphinctes* in Western Tethys (based on material from France and England discussed in text) as phylogenetic framework for comparison of the Andean relatives of the Neuquén Basin. The stratigraphic range of the species is arbitrary as nominal citations exist above and/or below the limits indicated. The morphologic variation of the species at the successive levels of its range produce the different morphotype-spectra (i.e. the transients) from which the nominal species are identified in different places and stratigraphic positions. The meaning of the species names is mainly the morphologic and stratigraphic typology indicated by the respective type specimens with a range of variation discussed in text. The spectrum and patterns of variation in macroconchs is illustrated by a selection of adult specimens (reduced x0.2) of *C. isabellae* (modified from Bonnot et al. 2008) and *C. crassa* (modified from Gerard & Contaut 1936). The arrangement of the specimens by gradual change of the sculpture (from coarse to fine) covariating with shell-shape (from stout to gracile), allows to compare morph-by-morph the two species. Zonation: Andean basins this report, NW Tethys after Thierry et al. (1997) and Cariou et al. (1997). The lack of data for the Caribbean area is represented by the vertical dot-line.

vria crassa, *Orionoides monestieri*, *O. termieri*, *O. cayeuxi*, *O. lanquinei*, *O. piveteaui*, and *O. raguini*. Following the order of citation, variation ranges from the inflated-involute and coarsely ribbed "*S. crassa*" to the opposite morph, i.e. the most compressed, evolute and finely ribbed morph represented by *O. raguini* (Fig. 7). The most significant common feature is the ontogeny of the sculpture consisting of more or less proverse primaries that bifurcate or, more rarely, trifurcate on the upper half of the flanks, accompanied by irregularly spaced, deep constrictions. The different morphotypes develop a conspicuous but short stage of prominent primary ribs towards the end of the adult phragmocone (e.g., Gérard & Contaut 1936: pl. 6, fig. 1, pl. 9, fig. 1, pl. 11, fig. 1). A similar rib sequence is present in *C. isabellae* Bonnot et al. (2008: pl. 2, fig. 3, pl. 3, fig. 1, pl. 7, fig. 1).

The innermost whorls are poorly illustrated by Gérard & Contaut (1936), but probably are as in the specimen figured by Bonnot et al. (2008: pl. 1, fig. 4) as *Subgrossouvria crassa*, and very similar to those of *C. isabellae* and *A. rotifer*. Bonnot et al. (2008: 13) already suggested similarly that these ammonites likely could have been originated from *C. isabellae*. Following the horizontal classification implied in the proposed phylogeny (Fig. 7), the specimen figured as *S. crassa* by Bonnot et al. (2008) would represent no more than the persistence of an inflated and coarsely ribbed morphotype or variant within the lineage, as interpreted in other well documented lineages of Jurassic ammonites (see e.g., Callomon 1985; Parent 2001 and references therein).

Choffatia poculum (Leckenby, 1859) – Lamberti Zone. Species definition sensu Cox (1988) and including *Poculisphinctes* cf. *poculum* of Fortwengler et al. (1997) and *P. poculum* of Fortwengler et al. (2012). *Choffatia trina* (Buckman, 1922) is hard to accommodate within a morphologic spectrum of a continuous, gradational variation including *C. poculum*. *Kepplerites peticlerci* De Loriol, 1898 seems to be an involute *Choffatia* (cf. Arkell 1939; Cox 1988) with strong primary ribs similar as in *C. poculum* and could likely be a terminal or residual development of the genus in the Mariae Z.

Alligaticeras rotifer (Brown, 1849) – Athleta Zone. This is the oldest species usually attributed to *Alligaticeras* (Cox 1988; Page 1991). Inner whorls with subtriangular coiling are sometimes indistinguishable from those of *C. isabellae* at comparable diameter. The adult whorls of *A. rotifer* retain the depressed, finely ribbed and strongly constricted aspect of the inner whorls. Under the hypothesis of direct phyletic relationships, this ontogenetic change can be interpreted as *A. rotifer* being a paedomorphic derivative of *C. isabellae*, in which the juvenil morphology is extended up to the sub-adult or adult stage by a developmental heterochronic process of neoteny (morphologic development slower for comparable sizes).

Alligaticeras alligatum (Leckenby, 1859) – Lamberti Zone. Well-known from the Lamberti Z. of England (Cox 1988) and France (Fortwengler et al. 1997, 2012; Courville & Crônier 2004).

In the Andes, the genus *Choffatia* has been recorded through the Upper Bathonian-lower Middle Callovian with species resembling Tethyan species, as well as others confined to the Neuquén and Tarapacá basins (see Riccardi et al. 1989; Parent 1998a). The record is lost in most of the Middle Callovian which is developed in the Neuquén Basin by the evaporitic Tábanos Fm. Starting in the early Late Callovian, the genus is known throughout the basin by *C.* cf. *isabellae* (see Parent 2006; Garrido & Parent 2013). The species described below add to the Upper Callovian record in the Neuquén Basin. It can be assumed that the genus has been established in the south-east Pacific from the late Bathonian onwards. Nevertheless, it is not yet clear whether a local lineage was developed due to the close resemblance that persists during the Callovian between the local representatives and those of the Tethys. Some differences can be observed in almost every Andean sample in comparison with the Tethyan ones, but these differences are usually small and could be due to some degree of infraspecific geographic differentiation.

This case as many others, including Andean ones, poses the extremely interesting and unsolved issue of the modes and geography of evolution of those ammonites which, along with a wide palaeogeographical distribution, show a synchronous morphologic evolution.

In the Upper Bathonian-Middle (Upper?) Callovian of the Caribbean the genus has been recorded mainly by Burckhardt (1927) and Sandoval et al. (1991), but there seems to be scarce Upper Callovian records.

Choffatia schilleri n. sp.
Figs. 8-9, 10A, Table 1

Etymology: After Walter Schiller (1879-1944).

Material: Holotype (Figs. 8 and 9A), a complete adult [M] (MOZ-PI 9418); paratype (Figs. 9B and 10A), an almost complete adult [M] (MOZ-PI 9414). Both from bed VV-M-2.

Type locality and section: Vega de la Veranada, Neuquén Province, Argentina (Figs. 1, 3).

Type horizon: Base of La Manga Fm, bed VV-M-2 (Fig. 3), Upper Callovian.

Diagnosis: Macroconch large and serpenticonic; flattish and smoothing flanks on the bodychamber with short ventro-lateral ribs that disappear towards the strongly projected peristome.

Description: The holotype and paratype are relatively large, serpenticonic macroconchs. The inner whorls are rounded, densely ribbed. The middle whorls are subrectangular with coarse primaries bifurcating on upper flank, constricted. Bodychamber evolute-oval, at first strongly ribbed like phragmocone, but gradually uncoiling with smoothing flanks and venter (holotype), retaining short ventro-lateral ribs. The peristome is strongly projected ventrally. L_{BC} = 330° (holotype).

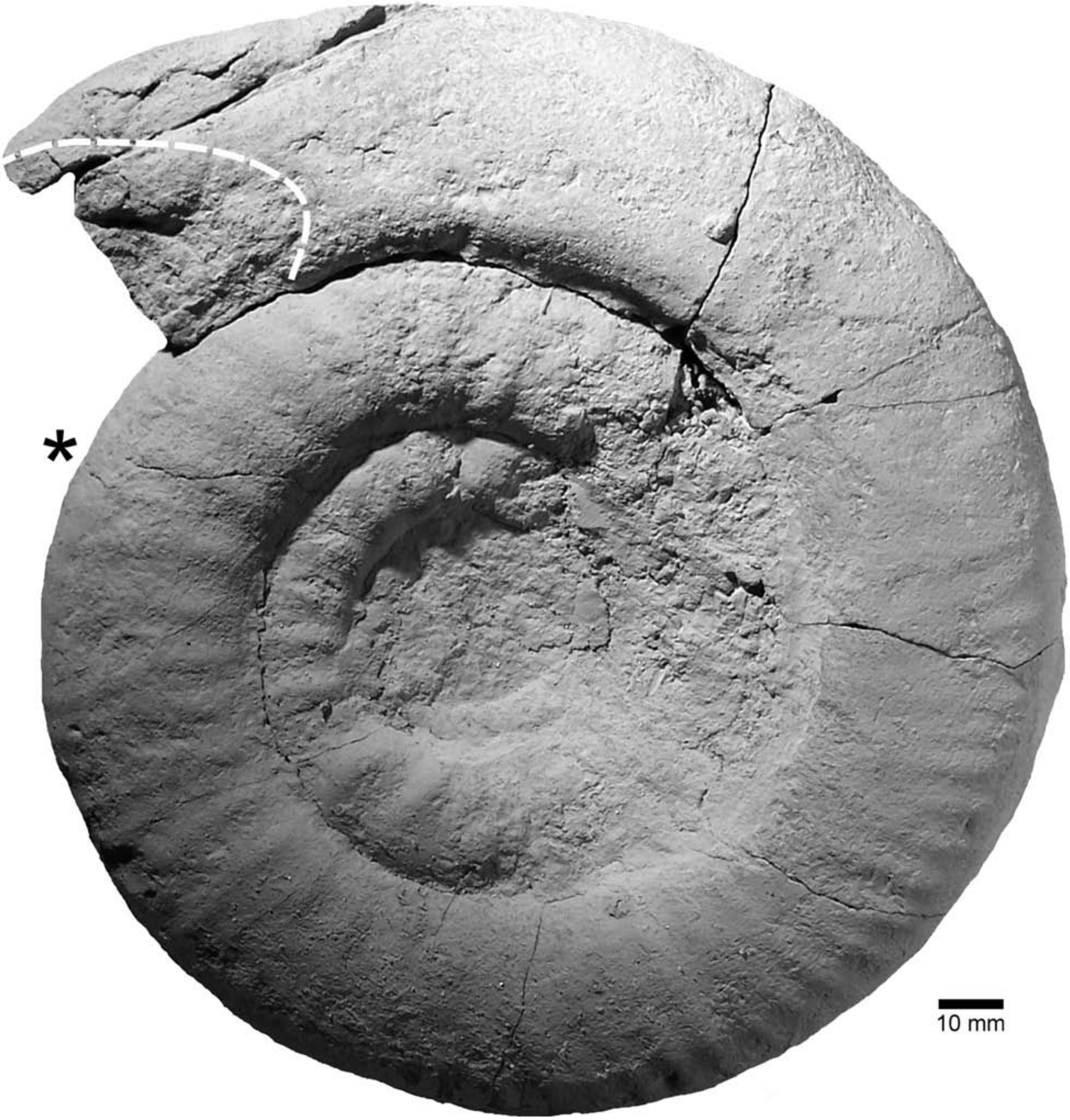


Fig. 8. *Choffatia schilleri* n. sp., bed VV-M-2, *schilleri* Hz., Primus Z. Holotype (MOZ-PI 9418), complete adult [M]. – Natural size (x1), asterisk indicating the last septum.

Remarks and comparison: *C*. cf. *isabellae* (in Garrido & Parent 2013, including *Choffatia* sp. A and *Choffatia* sp. B of Parent 2006) from the Patagoniensis Z. differs by the more finely and densely ribbed inner and middle whorls and the bodychamber that is strongly ribbed up to the peristome.

C. isabellae (lower Athleta Z. of Maine-et-Loire) shows a very interesting resemblance. The innermost whorls of some microconchs (Bonnot et al. 2008: fig. 9: 2-9; pl. 8: 5) have smooth flanks and short ventro-lateral ribs. These similarities at different growth stages are hard to interpret if not by strong developmental heterochronic processes. However, it indicates similar morphogenetic programs (see Checa & Westermann 1989), which in our opinion point to close relationships between *C. isabellae* and *C. schilleri* n. sp.

Fig. 9. *Choffatia schilleri* n. sp., bed VV-M-2, *schilleri* Hz., Primus Z. **A** – Holotype (MOZ-PI 9418), complete adult [M]; A_1: apertural view with the last part of bodychamber removed; A_2-A_3: ventral views of the beginning and end of the bodychamber. **B** – Ventral view of the Paratype (MOZ-PI 9414), lateral view in Fig. 10A. – All natural size (x1).

The most similar and apparently closely related Tethyan ammonites are the adult macroconchs figured by Gérard & Contaut (1936) as *Subgrossouvria crassa*, *Orionoides monestieri* and *Orionoides piveteaui*. All are from the upper Athleta Z. to lower Lamberti Z. (Cariou 1971) of West-central France and have partially identical sculpture to *C. schilleri* n. sp., but retain the strong sculpture of the middle whorls up to the bodychamber. We originally doubted

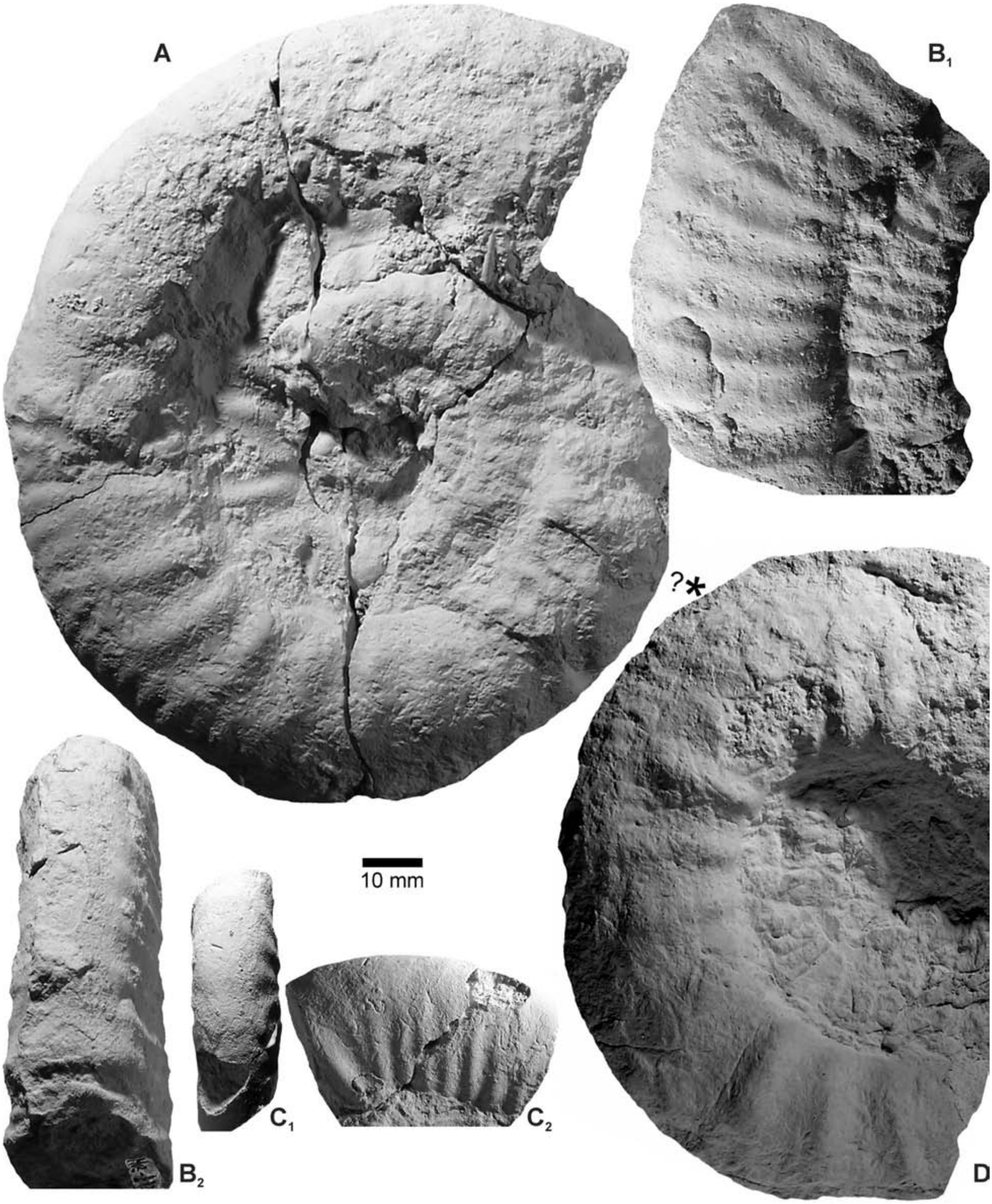


Fig. 10. A – *Choffatia schilleri* n. sp., bed VV-M-2, *schilleri* Hz., Primus Z. Paratype (MOZ-PI 9414), adult [M] with incomplete bodychamber. **B** – "*Perisphinctes*" cf. *hillebrandti* Parent, 2006, bed VV-M-13, Dimorphosus Z. (MOZ-PI 9429). **C** – *Subvinalesphinctes*? sp. A, bed VV-M-19, Pressulus Z. (MOZ-PI 9528). **D** – *Choffatia* cf. *poculum* (Leckenby, 1859), bed VV-M-11, Dimorphosus Z.; adult [M] with incomplete bodychamber (MOZ-PI 9420). – All natural size (x1), asterisk indicating the last septum.

to separate our material as a new species from these French forms (herein considered as variants of *C. crassa*, see above and Fig. 7) which also seems to be very similar in age. Finally, in the context of the palaeogeographic distance, we considered the different sequence of sculpture stages and the very different sculpture of the adult bodychamber as sufficient for specific differentiation.

Occurrence: Vega de la Veranada section level VV-M-2, *schilleri* Hz., Primus Z., Upper Callovian.

Choffatia cf. *poculum* (Leckenby, 1859)

Fig. 10D

Material: 1 specimen (MOZ-PI 9420) from level VV-M-11.

Description: Stout and narrowly umbilicate (*U*/*D* = 0.42) perisphinctid with part of the phragmocone and half whorl of bodychamber (maximum *D* = 112 mm). Whorl section suboval, higher than wide. Last whorl with widely spaced, prominent primaries (*P* = 11 at *D* = 112 mm) which trifurcate in the upper flank into finer secondaries which vanish towards the peristome.

Remarks and comparison: *C. poculum* is strongly sexually dimorphic: [M] large with blade-like to bullate primary ribs; [m] smaller, lappeted (Cox 1988). The best match of our [M] specimen is with the Lamberti Z. age specimen from Haute-Marne (France) figured by Courville & Crônier (2004: pl. 6, fig. 2). Also very similar are the specimens of the Lamberti Z. figured by Fortwengler et al. (1997, 2012).

The strong and widely spaced lateral ribs are similar in the adult phragmocone and beginning of bodychamber of *C. schilleri* n. sp. (cf. Fig. 10A with 10D) Unfortunately the inner whorls can not be compared, but the close stratigraphic position of these species suggest a close relationship.

C. poculum in the western Tethys ranges nearly the whole Lamberti Z. (Cox 1988; Fortwengler et al. 1997, 2002; see Fig. 7). Our specimen occurs in level VV-M-11 associated with a microconch of *Araucanites reyesi*, below the first occurrence of *Peltoceratoides pressulus* and above the *schilleri* Hz. This is coeval with some part of the Lamberti Z., suggesting that level VV-M-11 could belong to the upper Lamberti Z. (see discussion below in the chapter Biostratigraphy).

A similar association of late *Eurycephalites* and *C.* cf./aff. *poculum* (formerly figured as *P.* aff. *hillebrandti*) has been recorded from Cajón Troncoso (Parent 2006: figs. 16, 37C). However, this association is somewhat older as suggested by the specimens of a late form of *Eurycephalites*, likely Middle Callovian.

The holotype of *Orionoides sita* Spath (1931: pl. 61, fig. 6) is very similar to the present specimen but differs in its prominent, ventrally elevated, bifurcating ribs. However, this ribbing is observed in a specimen figured as *C. poculum* from the Lamberti Z. of Thuoux by Fortwengler et al. (2012: pl. 1, fig. 2).

Occurrence: Vega de la Veranada section level VV-M-11, Dimorphosus Z., Upper Callovian.

Subfamily Vinalesphinctinae Meléndez & Myczynski, 1987

Remarks: The classification adopted herein follows the recent revision by Parent et al. (2006), which distinguishes two Oxfordian sexually dimorphic lineages: (1) *Cubasphinctes* and (2) *Subvinalesphinctes*-*Vinalesphinctes*. The oldest record for the subfamily had been *Cubasphinctes* aff. *durangensis* (Burckhardt, 1912) in Parent (2006), i.e. Lower Oxfordian Pressulus Z. The Lower Oxfordian species described below, however, suggest a more diverse early development of the two main lineages of the subfamily in the Neuquén Basin. It is widely represented in western South America (Gygi & Hillebrandt 1991; Parent 2006; Parent et al. 2006), and in the Caribbean area the oldest records seem to be Plicatilis Z. in age (Wierzbowski 1976). It is very likely that both lineages of the subfamily originated in the Neuquén Basin and later expanded into the Caribbean area, ranging in both areas at least into the late Middle Oxfordian.

Genus *Vinalesphinctes* Spath, 1931

Type species: *Vinalesphinctes roigi* Spath, 1931, by original designation.

Vinalesphinctes n. sp. A

Fig. 11A-B

Material: 1 adult [M?] phragmocone (MOZ-PI 9440) from bed VV-M-14 and 1 fragmentary specimen (MOZ-PI 9482) from bed VV-M-17.

Description: Involute discoidal with suboval whorls higher than wide; ventrally narrow on inner whorls, but more rounded on the outermost whorl of phragmocone. Inner whorls (*D* = 30-45 mm) are finely ribbed with densely spaced fine primaries, but at *D* = 40-45 mm the shell becomes completely smooth. The largest, adult phragmocone is strongly uncoiled at *D* = 126 mm.

Remarks and comparison: The smooth, discoidal shape makes this ammonite a conspicuous element of the studied fauna and even within the Oxfordian Perisphinctidae. *Subvinalesphinctes*? sp. A (described below) differs by the strong lateral ribbing.

Our specimens closely resemble the Cuban *Vinalesphinctes roigi* Spath in Judoley & Furrazola (1968: pl. 54), but are larger and miss the widely spaced ridge-like ribs on the last whorl (bodychamber?). Other very similar forms are the two specimens of *Vinalesphinctes niger* Spath in Judoley & Furrazola (1968: pls. 52-53), but these are more evolute and show persistent coarse, lateral ribbing. These

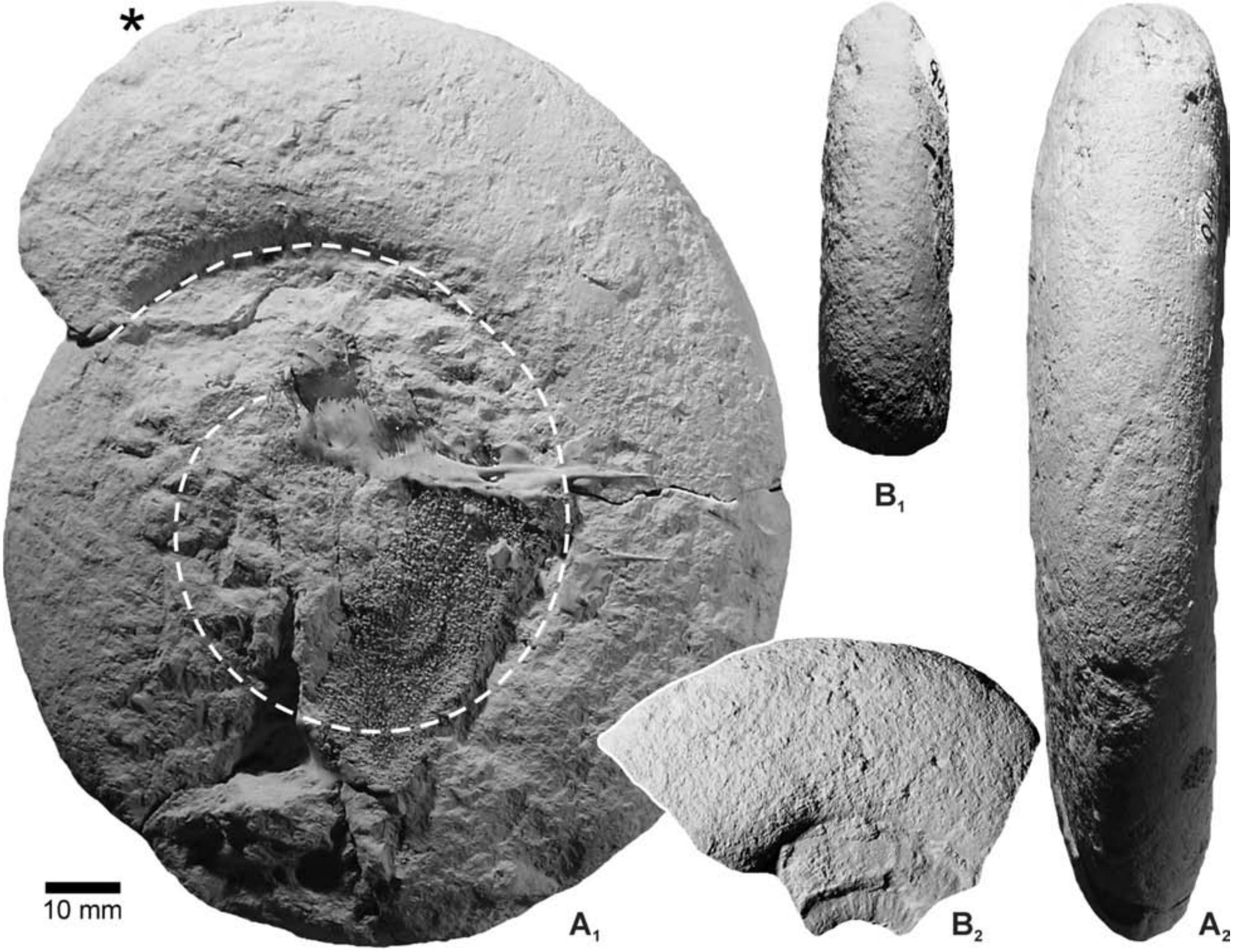


Fig. 11. *Vinalesphinctes* n. sp. A. **A** – Complete adult [M] phragmocone with the beginning of the bodychamber crushed (MOZ-PI 9440), bed VV-M-14, Eugenii Z. **B** – Portion of phragmocone (MOZ-PI 9482), bed VV-M-17, *pressulus* Hz., Pressulus Z. – All natural size (x1), asterisk indicanting the last septum.

differences and the lower stratigraphic position of our specimens are considered sufficient for a specific separation. Considering that there seems to be no other similar form, we suggest they belong to a species not yet described. More material is needed for a taxonomic conclusion.

Occurrence: Vega de la Veranada section levels VV-M-14 (Eugenii Z.) and VV-M-17 (*pressulus* Hz., Pressulus Z.), Lower Oxfordian.

Genus *Subvinalesphinctes* Wierzbowski, 1976

Type species: *Perisphinctes corrali* Judoley & Furrazola, 1968, by original designation.

Subvinalesphinctes? sp. A

Fig. 10C

Remarks: A fragmentary specimen (MOZ-PI 9528) from bed VV-M-19, Pressulus Z. Apparently a portion of the bodychamber of a very compressed ammonite with prominent subradial primary ribs, which occasionally bifurcate behind a constriction, and a smooth venter.

Genus *Cubasphinctes* Judoley & Furrazola, 1968

Type species: *Perisphinctes jaworskii* Judoley & Furrazola, 1968, by monotypy.

Fig. 12. *Cubasphinctes herreroduclouxi* (Leanza, 1947), bed VV-M-20, Pressulus Z. Adult? [M] phragmocone (MOZ-PI 9541). – Natural size (x1).

Cubasphinctes herreroduclouxi (Leanza, 1947)
Fig. 12

Synonymy: See Parent et al. (2006).

Material: 1 phragmocone (MOZ-PI 9443) from bed VV-M-19; 1 adult? phragmocone (MOZ-PI 9541) from bed VV-M-20.

Description: Compressed and evolute with suboval, higher than wide whorl section. Inner whorls densely ribbed; outermost whorl with straight primaries, radial to slightly prosocline, bi- or trifurcated on the ventro-lateral shoulder. Few primaries are joined (or bifurcated) on the umbilical shoulder.

Remarks: This species was assigned to *Tenuisphinctes* Gygi, 1998 by Parent et al. (2006), a genus known from the Cordatum Z. of Switzerland and most likely an evolute variant of *Prososphinctes* Schindewolf, 1925. Nevertheless, the cubasphinctes-like morphology and ribbing of the present species (see Wierzbowski 1976: 189; Parent et al. 2006) and the wide occurrence of representatives of the Vinalesphincinae in the Andean basins (Gygi & Hillebrandt 1991; Parent et al. 2006; Parent 2006 and material described in this report), strongly suggest it belongs to *Cubasphinctes* rather than to *Tenuisphinctes*.

Cubasphinctes aff. *durangensis* (Burckhardt, 1912 in Parent 2006: 44, fig. 40) from the Pressulus Z. of Rahuecó, differs by having wiry primaries and indistinct secondaries.

Occurrence and distribution: Vega de la Veranada section levels VV-M-19-20, Pressulus Z., Lower Oxfordian. Also recorded (Parent 2006) in Rahuecó, Chacay Melehué, and Cajón Troncoso (cf.-specimens).

Subfamily Perisphinctinae Steinmann, 1890
Genus *Perisphinctes* Waagen, 1869

Type species: *Ammonites variocostatus* Buckland, 1836 by subsequent designation of Arkell proposed in 1951, accepted by the ICZN in 1954.

"*Perisphinctes*" cf. *hillebrandti* Parent, 2006
Fig. 10B

Description and remarks: A single fragment (MOZ-PI 9429; bed VV-M-13, Dimorphosus Z.) of a very evolute and slender ammonite, with subrectangular higher than wide whorl section, and prominent subradial primaries that fade out on the ventro-lateral shoulder forming a mild swell. This specimen resembles the holotype of *P. hillebrandti* (Hillebrandt & Gröschke 1995: pl. 6, fig. 6) but in this latter the primary ribs tend to be concave.

The very compressed, suboval to subrectangular whorl section with strong subradial primaries on the flanks and almost smooth venter are not typical of the genus *Perisphinctes*, suggesting *P. hillebrandti* and the present specimen should belong to an undescribed genus.

"*Perisphinctes*" n. sp. A
Figs. 13-18; Table 1

Material: 16 specimens, more or less complete macroconch phragmocones, some with remains of bodychamber, from beds VV-M-13-15, 17 and 19-20.

Description: Mid-size macroconchs, maximum preserved diameter 144 mm (phragmocone). Phragmocone evolute and widely umbilicate (U/D = 0.50-0.60) all throughout from the inner whorls. Whorl section very variable, intergrading from suboval-subrectangular slightly higher than wide (W/H_1 c. 0.9) with rather flat flanks and rounded venter to depressed wider than high (W/H_1 c. 1.2) with low flanks and very widely rounded venter.

The ribbing style is very constant in all the specimens only with some variation in the strength of the primary ribs. The ribbing style is also regular through the individual ontogeny (phragmocone). From the inner whorls primary ribs are rod-like, radial to subradial, swollen on the ventro-lat-

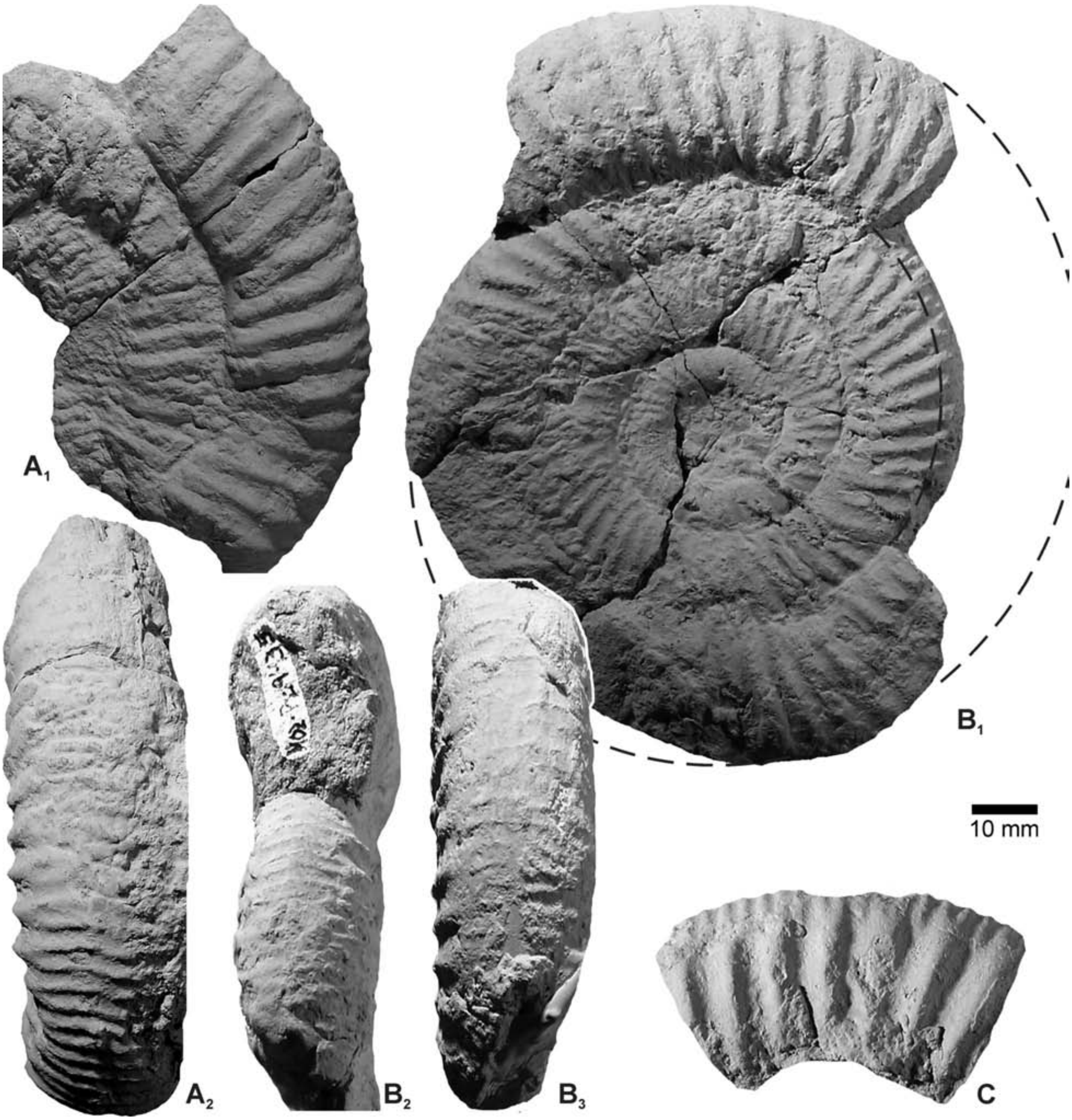


Fig. 13. "*Perisphinctes*" n. sp. A (morph A). **A** – Incomplete adult [M] phragmocone (MOZ-PI 9426), bed VV-M-13, Dimorphosus Z. **B** – Complete adult [M] phragmocone (MOZ-PI 9435), bed VV-M-14 (base), Eugenii Z. **C** – Fragment of adult phragmocone (MOZ-PI 9434) showing the primaries swollen on the ventro-lateral shoulder prior to furcation, bed VV-M-14 (base), Eugenii Z. – All natural size (x1).

eral shoulder; blade-like from the end of the phragmocone. They branch above the ventro-lateral shoulder in two or three weaker secondaries which cross the venter unchanged or weaken. Constrictions occur in most specimens preceeded by a trifurcate primary.

The bodychamber is very incompletely preserved in few specimens. The lateral ribbing becomes stronger, usually already from the end of the phragmocone, and widely spaced; the ventral ribbing fades leaving the venter smooth. Septal sutures not preserved.

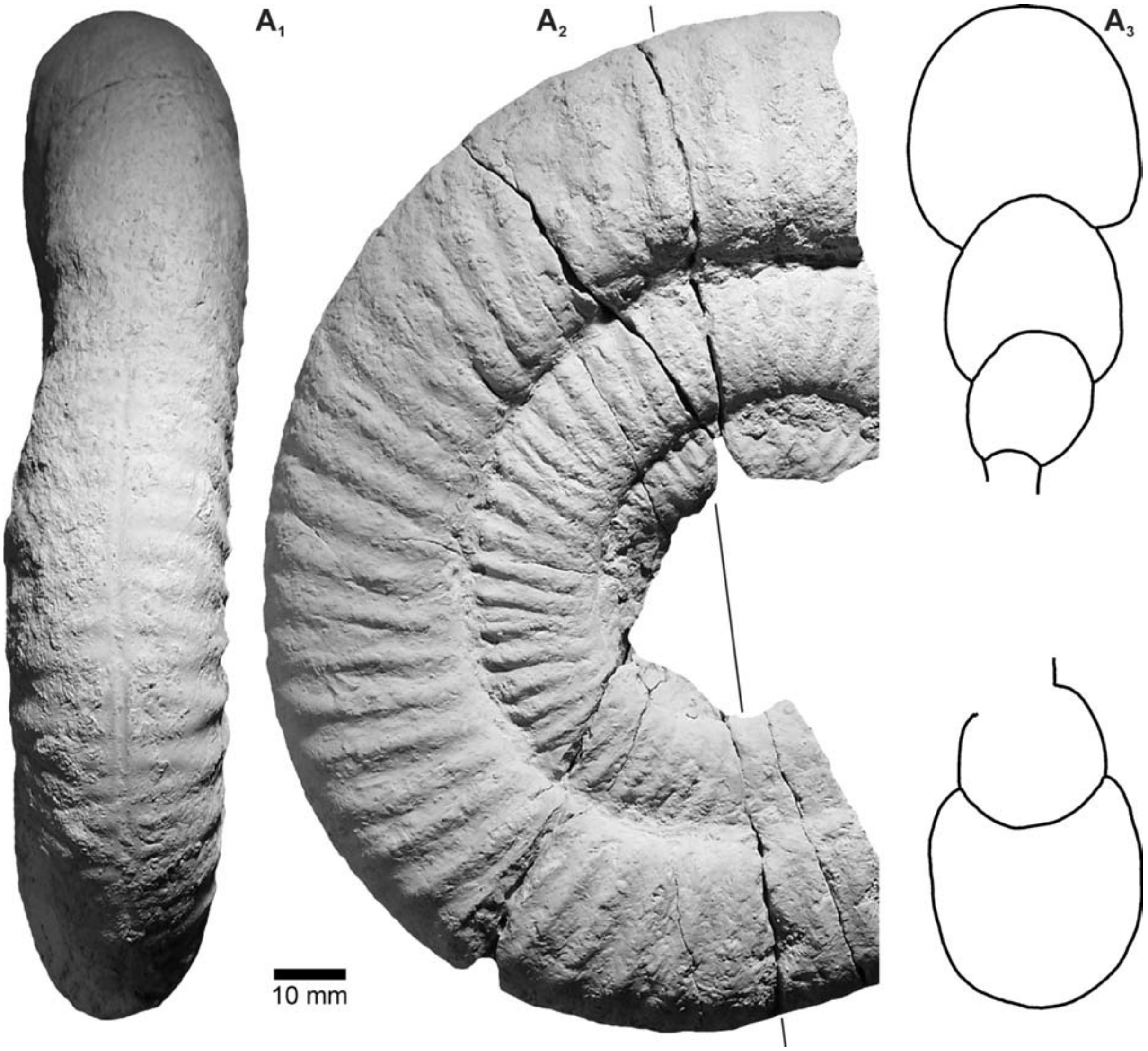


Fig. 14. "*Perisphinctes*" n. sp. A (morph A), ?complete adult [M] phragmocone (MOZ-PI 9524), bed VV-M-19, Pressulus Z. The thin line in the lateral view (A_2) indicates the diameter at which is reproduced the whorl section (A_3). – Natural size (x1).

Based on the wide variation in whorl section and the little variation in rib density, the specimens available can be roughly divided informally, for descriptive purposes, in three morphotypes.

Morph A (slender serpenticone: Figs. 13-15): very evolute and widely umbilicate, compressed suboval-subrectangular whorl section, denseley ribbed.

Morph B (inflate serpenticone: Fig. 16): evolute, widely umbilicate, whorl section suboval-subrectangular, ribbing prominent and acute on outer whorls.

Morph C (stout serpenticone to cadicone: Fig. 17): evolute with moderately narrow umbilicus, whorl section rounded in inner whorls, subrectangular wider than high with coarse ribbing on outer whorls.

Discussion and comparison: The morphotypes considered separately could seem to belong to two or three different species. Nevertheless, considering that the sculpture style is very constant in all the specimens, and that most of the variation is in shell-shape (Fig. 18A-D), we consider that they all belong to a single polymorphotypic species. The morph A occurs in levels VV-M-13-15 and 19, the morph B in levels VV-M-17 and 19, and the morph C is confined to the upper levels VV-M-19-20 (Fig. 18E). Due to the incomplete material available, this apparent trend, which would lead to the separation of two transients or chronospecies, could be a taphonomic or collection artifact. We have refrained from naming formally the new species awaiting to know the adult bodychamber from better material.

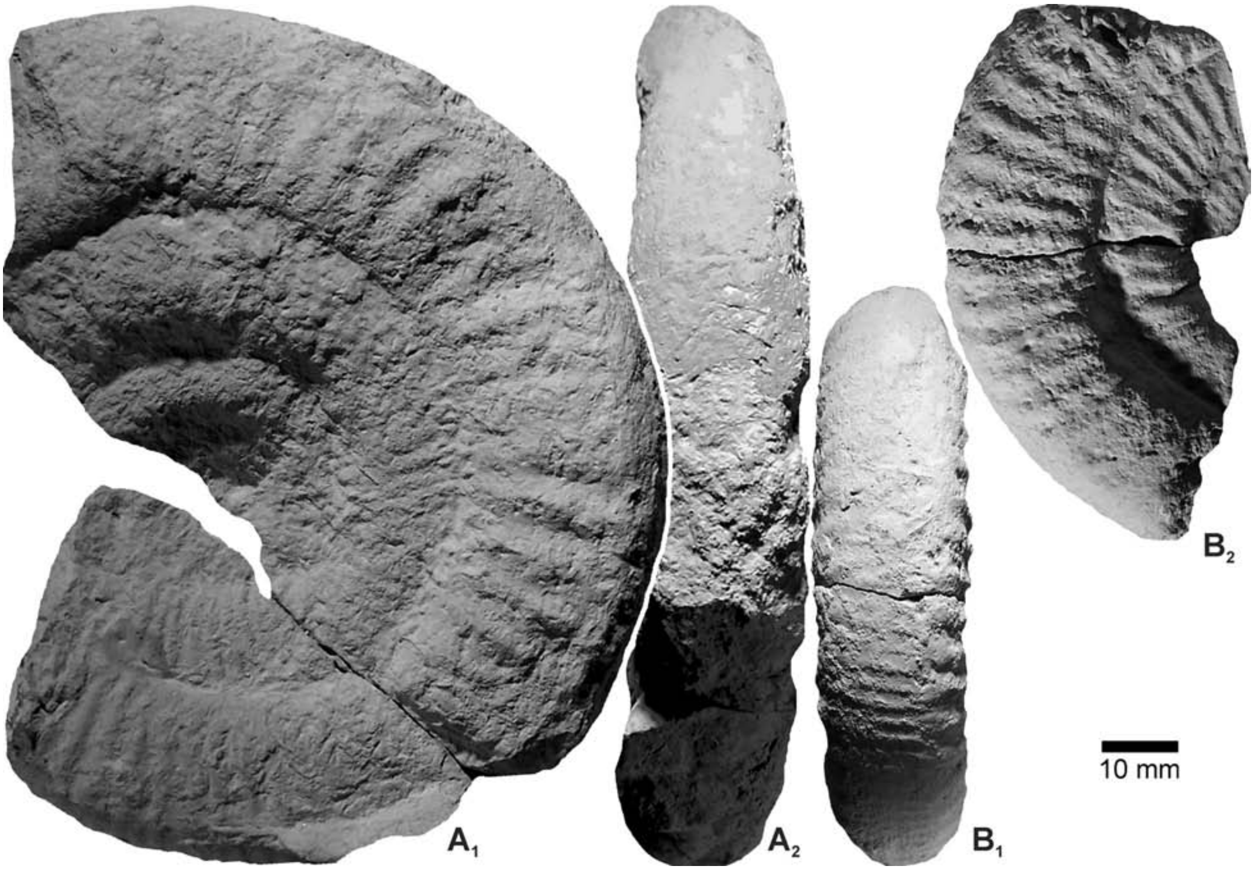


Fig. 15. "*Perisphinctes*" n. sp. A (morph A), bed VV-M-19, Pressulus Z. **A** – ?Complete adult [M] phragmocone (MOZ-PI 9532). **B** – Portion of adult [M] phragmocone (MOZ-PI 9523). – All natural size (x1).

The suboval-subrectangular whorl section of evolute serpenticones with regular ventro-lateral furcation of essentially radial-subradial primary ribs with marked adult variocostation, lead us to assign the present perisphinctids to the subfamily Perisphinctinae. Within the Perisphinctinae the present species could be probably assigned to *Perisphinctes* on morpho-ornamental grounds. The primaries swollen on the point of furcation produces a conspicuous aspect which is typical of *Perisphinctes*, contrary to *Properisphinctes* in which the bifurcation takes place gently.

The most depressed specimens (morph C) are hard to compare with any of the described species of *Perisphinctes*. However, it resembles *Alligaticeras rotifer* (Brown, 1849) from England (e.g., Cox 1988: pl. 22, figs. 1, 3), whereas the morphs A and B are almost indistinguishable from the specimens of, or aff. to *A. alligatum* figured by Cox (1988: pl. 23, fig. 5) and Bartolini et al. (2013: pl. 4, fig. 2) from the upper Lamberti Z.

The best general resemblance of "*Perisphinctes*" n. sp. A is with the earliest Perisphinctinae of the Lower Oxfordian, a group which remains not well known and hard to classify. Those of the Mariae Zone are most usually assigned to *Properisphinctes* Spath, 1931 [M&m] (e.g., Cox 1988: pl. 23, fig. 8; Tarkowski & Marchand 2004: fig. 2; Courville & Crônier 2004: pl. 6, fig. 1). However, the most closely comparable forms are those of the Cordatum Zone, assigned to *Properisphinctes* [m] / *Perisphinctes* (*Arisphinctes*)-*P.* (*Kranaosphinctes*) [M] (e.g., Matyja 1977: pl. 7, figs. 2, 6; Page 1991: 128; Scouflaire et al. 1997: 53, pl. 1, figs. 11, 15-16; Enay & Boullier 1981: 748, pl. 3, fig. 2; Tarkowski 2002: fig. 4). The rib density through the middle and outer whorls of *P.* n. sp. gr. *promiscuus* Bukowski (in Enay & Boullier 1981: pl. 3, fig. 2) cited above is the same of "*Perisphinctes*" n. sp. A (Fig. 18C).

Within this latter group of Cordatum Z. ammonites can be included *Perisphinctes tarkowskii* (new name pro *Perisphinctes orbignyi* Tarkowski, 2002: 693, fig. 4, holotype by monotypy; preoccupied by *Perisphinctes orbignyi* De Loriol, 1903, p. 81, pl. 11, fig. 2, lectotype designated by Ronchadzé 1917: 19). "*Perisphinctes*" n. sp. A shows close resemblance, especially in the morph A and the adult size could be similar, but our material is incomplete. However, the involution and whorl section are comparable as well as the style and density of ribbing (Fig.

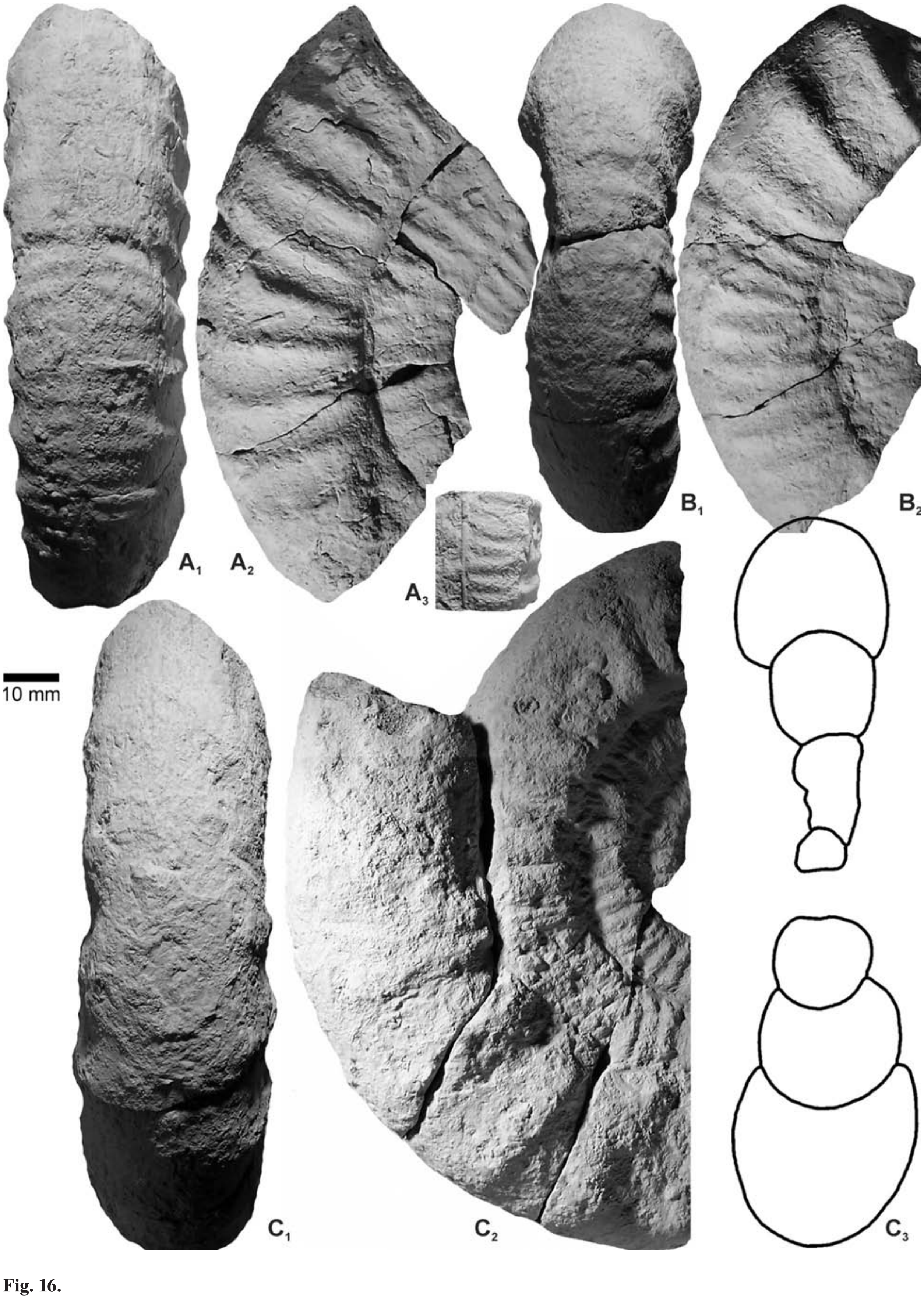


Fig. 16.

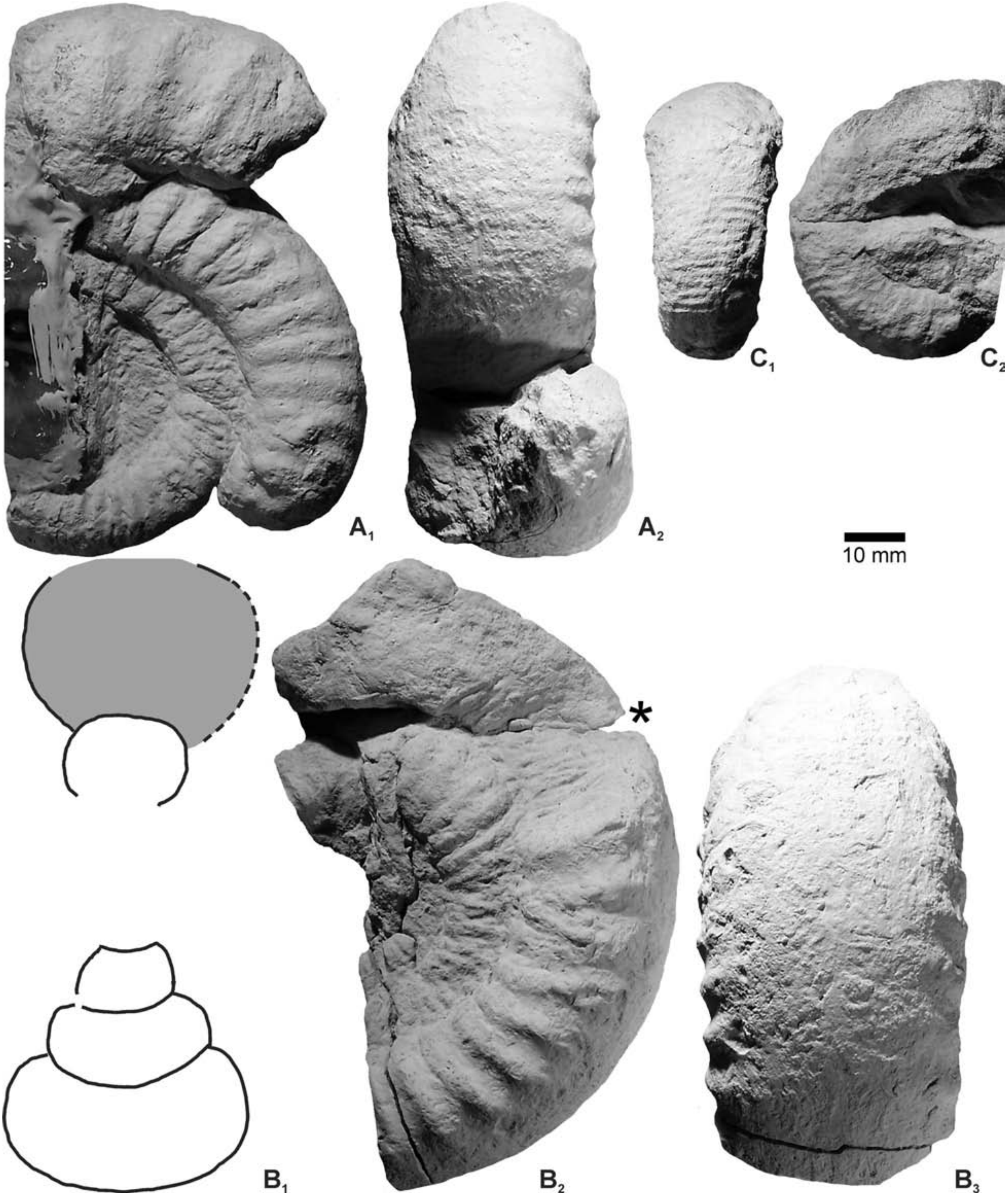


Fig. 17. "*Perisphinctes*" n. sp. A (morph C), Pressulus Z. **A** – Adult [M] phragmocone (MOZP-PI 9537), bed VV-M-19. **B** – Adult [M] phragmocone with beginning of the bodychamber (MOZ-PI 9540), bed VV-M-20; B_1: whorl section, bodychamber shaded. **C** – **I**nner whorls (MOZ-PI 9528), bed VV-M-19. – All natural size (x1), asterisk indicating the last septum.

Fig. 16. "*Perisphinctes*" n. sp. A (morph B), Pressulus Z. **A** – Adult [M] phragmocone (MOZ-PI 9477), bed VV-M-17 (*pressulus* Hz.); $\mathbf{A_3}$: ventral view of the penultimate whorl preserved. **B** – Last whorl of an adult [M] phragmocone (MOZ-PI 9538) showing the onset of the variocostation, bed VV-M-19. **C** – Complete adult [M] phragmocone (MOZ-PI 9533), bed VV-M-19. – All natural size (x1).

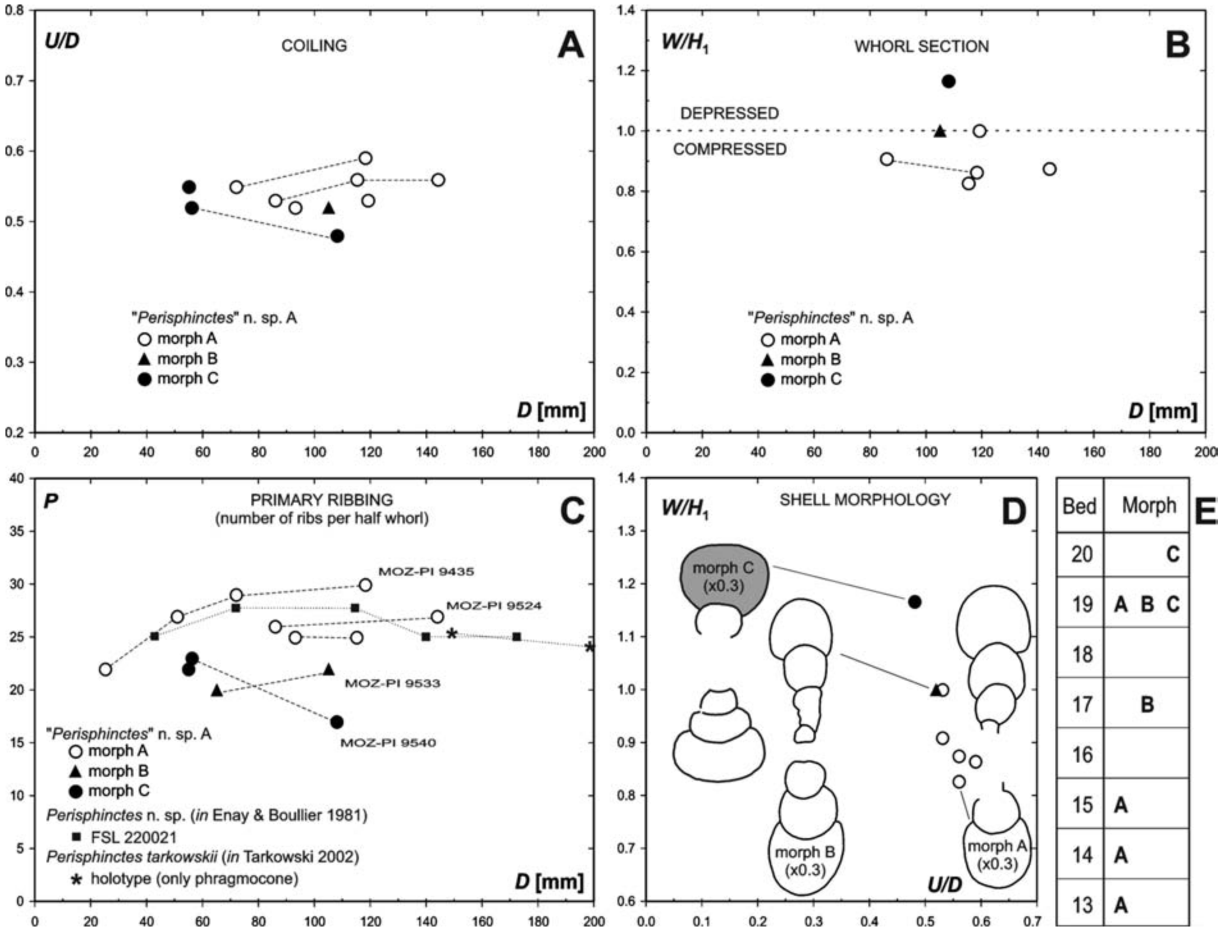


Fig. 18. "*Perisphinctes*" n. sp. A. Biometric characterization and comparison with similar forms discussed in text. **A** – Coiling ontogeny as measured by *U*/*D* versus *D*. **B** – Whorl section proportion W/H_1 versus *D*. **C** – Primary ribbing ontogeny described by *P* versus *D*. **D** – Shell morphology represented by the association of W/H_1 versus *U*/*D*. **E** – Succession of morphs (A, B, C) through the range of occurrence of the species (beds VV-M-13-20).

18C), which in *P. tarkowskii* becomes markedly prosocline on the bodychamber.

"*Perisphinctes*" n. sp. A shows close resemblance with the somewhat older ammonites figured as *Alligaticeras* cf. *alligatum* of the *lamberti* Hz. (Lamberti Z., Lamberti Subzone) from Savournon and Thuoux-Les-Lamberts (Fortwengler et al. 1997: figs. 5.11 and 6.1, respectively), and, especially, with the aff.-specimen from the same horizon at Saint-Pierre d'Argençon figured by Bartolini et al. (2013: pl. 4, fig. 2). This latter form is almost indistinguishable from the present specimens of morphs A and B, save for the strong prosocline constrictions, showing a rather similar process of abrupt variocostation from the last whorl of the phragmocone.

Some of the described specimens (e.g., Figs. 13B, 14, 15A-B) resemble Middle Oxfordian *Passendorferia*. Most representatives of *Passendorferia* have similar lateral ribbing, but typically dominated by single primaries on the oompressed outer whorls, and the inner whorls are strongly constricted (Brochwicz-Lewinski 1973: 304). Furthermore, inner and middle whorls usually bear "parabolae" which are completely absent in "*Perisphinctes*" n. sp. A. Nevertheless, the Passendorferiinae of the Lower Oxfordian are very poorly known (see Meléndez et al. 2009). The present species could be related to the earliest representatives of the Passendorferiinae.

In this context it is important to compare the present species with the ammonites described by Stipanicic (1951) from Arroyo de la Manga (Mendoza Province). The ensemble (group of ammonites coming from not horizoned or undifferentiated positions within the sequence) comprises several perisphinctids, a fragment of *Peltoceratoides pressulus* (see Parent 2006) and a small specimen which can be attributed to *Euaspidoceras ajax*. This ensemble can be assigned to the Pressulus Z. (Lower Oxfordian). The perisphinctids appear to belong to two different species: (1) *Perisphinctes* cf. *decurrens* (in Stipanicic 1951: pl. 1, fig. 1) which is very similar to the above cited specimen figured by Enay & Boullier (1981: pl. 3, fig. 2) as *"Perisphinctes* n. sp. gr. *promiscuus*" Bukowski and to "*Perisphinctes*" n. sp. A., and (2) the remaining specimens of Stipanicic (1951: pl. 1, figs. 2-3, pl. 2, fig. 2 and pl. 3, fig. 2) have been assigned to *Passendorferia* n. sp. A by Parent (2006: 48), based on the general shell-shape and style of ribbing, and the regular occurrence of primary ribs bifurcating on the umbilical shoulder followed by a pair of closely spaced simple ribs.

Occurrence: The species has been recorded within the interval of levels VV-M-13 to VV-M-20, ranging the uppermost part of the Upper Callovian Dimorphosus Z. through the Lower Oxfordian Pressulus Z. The specimen cited as *Passendorferia* cf. *teresiformis* in Parent (2006: 47, fig. 14) attributed to the Pseudokranaus-Passendorferia zones, although poorly preserved, is closely comparable to the present species (morph B).

Family Aspidoceratidae Zittel, 1895
Subfamily Peltoceratinae Spath, 1924
Genus *Peltoceratoides* Spath, 1924

Type species: *Peltoceras semirugosum* Waagen, 1875, by original designation.

Remarks: The subdivision of the subfamily Peltoceratinae in the Upper Callovian-Lower Oxfordian follows Bonnot (1995) and Parent (2006). It has been shown by Bonnot & Cariou (1999) that the ventro-lateral bituberculation of macroconchs usually attributed to *Peltomorphites* Buckman, 1925 is developed in variable degree and in different parts of the ontogeny of specimens otherwise indistinguishable from *Peltoceratoides*. *Peltomorphites* is herein treated as synonym of *Peltoceratoides*, considering the ventro-lateral bituberculation is nothing but a morphologic process within the intraspecific variability of some species.

The genus *Peltoceratoides* has a world-wide distribution and each basin seems to have its own specialities, morphotypes or local species (see Callomon 1990; Bonnot et al. 2002; Parent 2006; Alberti et al. 2011). In the Andean region the most abundant records are currently those of the Tarapacá Basin described by Hillebrandt & Gröschke (1995).

Peltoceratoides cf. *eugenii* (Raspail, 1842)
Fig. 19

Material: 1 specimen, part of an adult [M] phragmocone (MOZ-PI 9441/1), from bed VV-M-14; 1 phragmocone (MOZ-PI 9441/2) from bed VV-M-15.

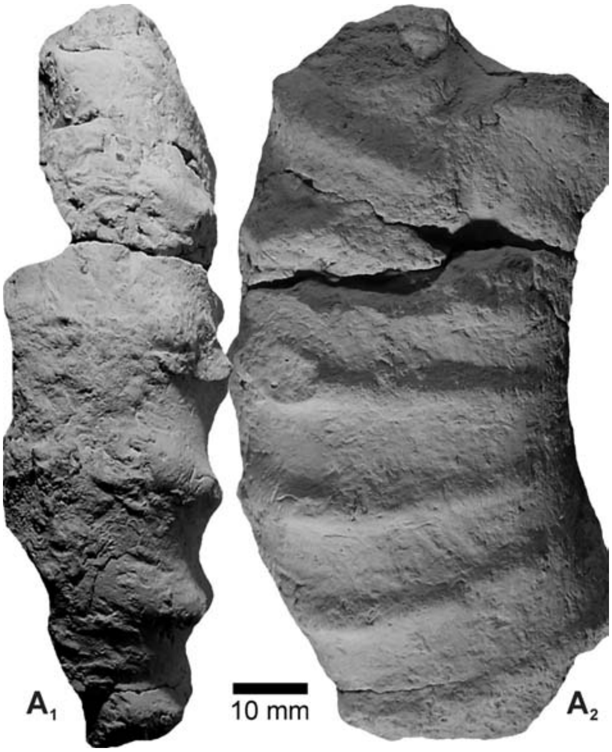


Fig. 19. *Peltoceratoides* cf. *eugenii* (Raspail, 1842), portion of an adult [M] phragmocone (MOZ-PI 9441/1), bed VV-M-14, Eugenii Z. – Natural size (x1).

Description: Evolute with subrectangular, higher than wide whorl section. Primary ribs arise from the umbilical shoulder and cross the flank radially. In the ventro-lateral shoulder there are two tubercles very closely spaced, giving the appearance of a bicuspid bulla.

Discussion: Although the available material is fragmentary (Fig. 19), it shows the very characteristic ventro-lateral bituberculation of the species, resembling the macroconchs figured by Hillebrandt & Gröschke (1995: pl. 4: 6) and those from the Scarburgense Subzone (Mariae Zone) of SE France (Bonnot et al. (1997: figs. 13.2, 13.3). However, these comparisons are limited to an adult whorl of the phragmocone.

Rursiceras ballenaensis Hillebrandt (in Hillebrandt & Gröschke 1995: pl. 4, figs. 1, 2 holotype) is based on a complete adult [m] with lappets whose inner whorls are, in umbilical view, identical to those of the Chilean specimens of *P. eugenii*. Both forms occur associated in the type horizon of *R. ballenaensis* at Portezuelo Azabache/Cerro La Ballena, thus it can be clearly assumed they represent a sexual dimorphic pair. On the other hand, this microconch is identical to the microconchs of *P. eugenii* figured by Bonnot et al. (1997: fig. 13.4-13.5) from the Scarburgense Subzone (Mariae Zone) of SE France. The microconch of *Peltoceratoides athletoides* (Lahusen, 1883) from the same subzone is also very similar, but more densely ribbed (see Bonnot et al. 1997: fig. 14.5).

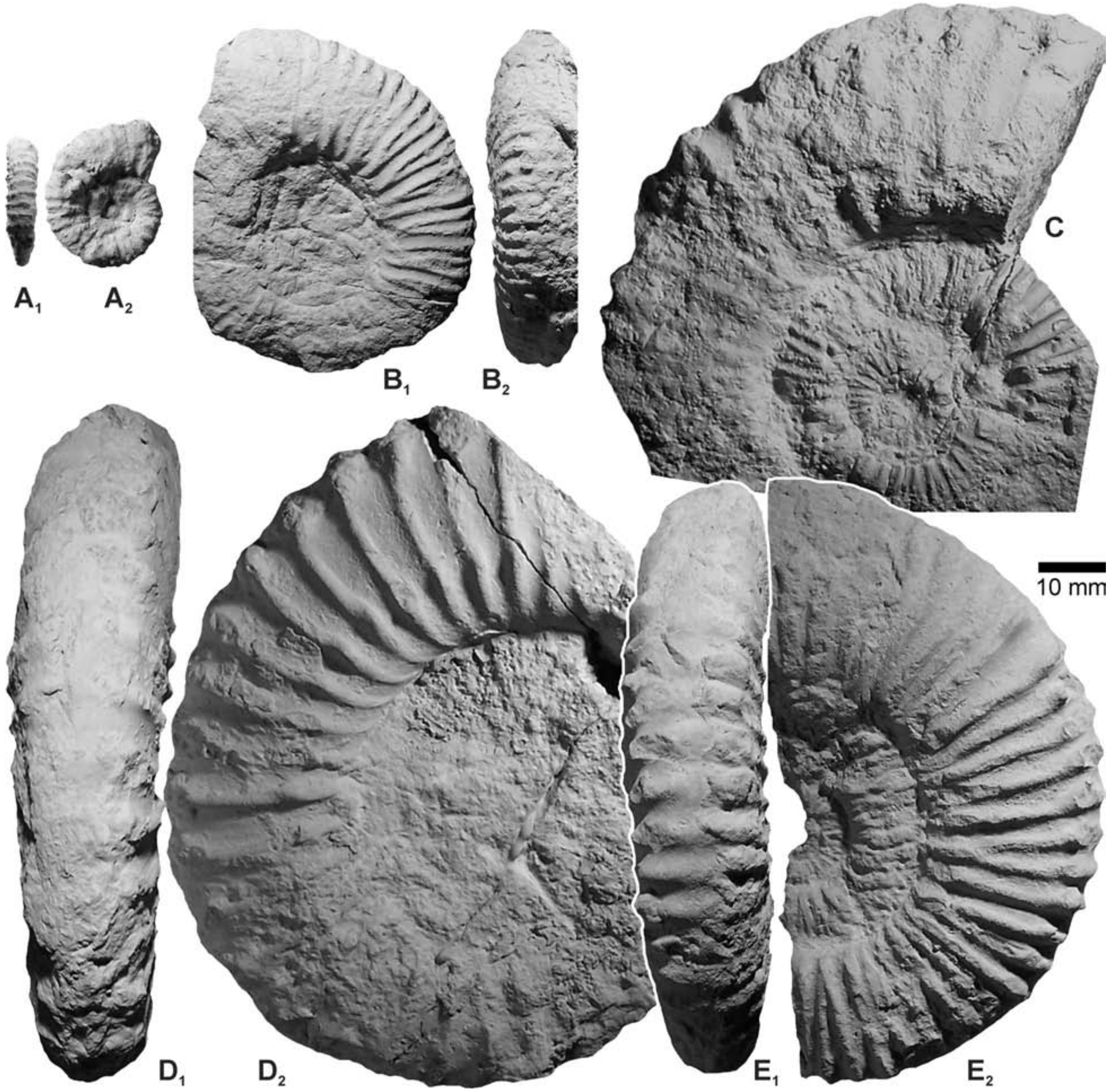


Fig. 20. *Peltoceratoides pressulus* (Leanza, 1947), bed VV-M-17, *pressulus* Hz., Pressulus Z. **A** – Inner whorls, probably [M] (MOZ-PI 9476). **B** – [M] phragmocone (MOZ-PI 9500). **C** – Adult [M] phragmocone (MOZ-PI 9483). **D** – Adult [M] phragmocone (MOZ-PI 9504). **E** – Adult [M] phragmocone (MOZ-PI 9501) with innermost whorls identical to A. – All natural size (x1).

Occurrence: Vega de la Veranada section level s VV-M-14-15. Eugenii Zone, lower Oxfordian.

Age of *Peltoceratoides eugenii*: From the study of well constrained ammonite successions from France, Bonnot et al. (1997, 2002) and Fortwengler et al. (2012) have shown that the stratigraphic range of *P. eugenii* is from the uppermost part of the Lamberti Z. (*paucicostatum* Hz.) up to the lower Mariae Z. (*scarburgense* Hz.). The range of the species seems to be of moderate vertical extension (*paucicostatum*, *thuouxensis* and *scarburgense* horizons), followed in the phylogeny proposed by these authors for NW Europe by *P. athletoides*.

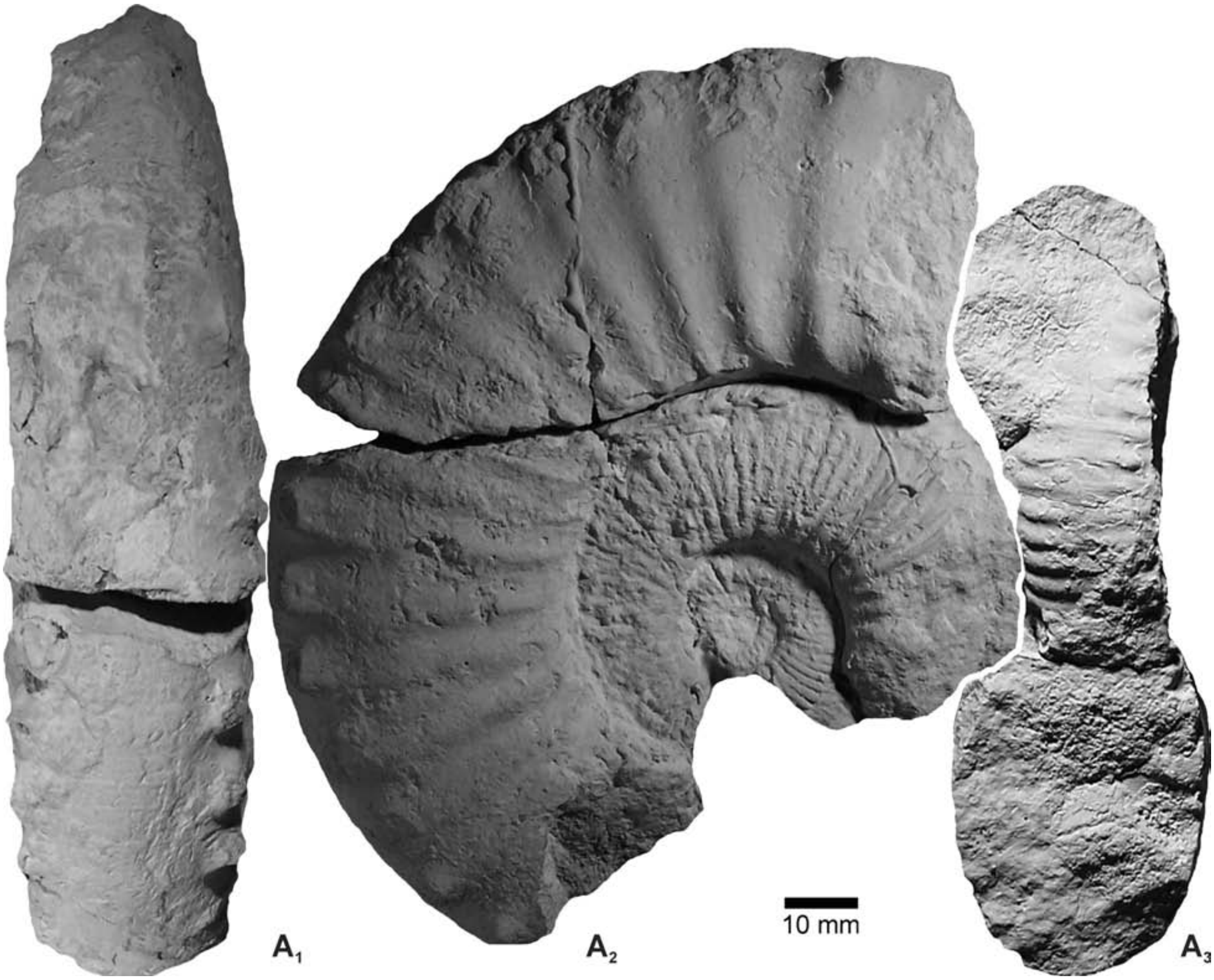


Fig. 21. *Peltoceratoides pressulus* (LEANZA, 1947), bed VV-M-17, *pressulus* Hz., Pressulus Z. Complete adult [M] phragmocone (MOZ-PI 9505). A_3: ventral view of the inner whorls after removal of the last whorl. – Natural size (x1).

Peltoceratoides pressulus (LEANZA, 1947)
Figs. 20-24, Table 1

*1947 *Nebrodites pressulus* n. sp. – LEANZA, p. 4, pl. 2, figs. 1 (holotype), 2-3 (paratypes).
*2006 *Peltoceratoides pressulus* (LEANZA, 1947). – PARENT, p. 25, fig. 27A (holotype refigured), B-E. [with further synonymy]

Material: 25 specimens, mostly incomplete adult [M] or phragmocones, from beds VV-M-15 (1 fragmentary specimen), VV-M-17 (the bulk of the material, 17 specimens), VV-M-18 (4 specimens), VV-M-19 (2 specimens), and VV-M-23 (1 fragmentary specimen).

Description: Macroconch moderately involute and compressed platyconic, with subrectangular, higher than wide whorl section. Ribbing on inner whorls fine and dense, bifurcated on the umbilical shoulder. Outer whorls more strongly ribbed with ventro-lateral tubercles and, in some, periumbilical bullae. Adult size may reach more than 300 mm in diameter at peristome. Microconch more evolute and smaller, estimated adult diameter about 80-90 mm.

Material from bed VV-M-17: this assemblage is the most abundant and best preserved, allowing to compose practically the whole ontogeny:
(1) Macroconch: Through D = 5 to 20 mm the shell is evolute, suboval to subcircular in whorl section; ribbing consists of radial, wiry primaries, most bifurcate on the umbilical shoulder. The secondaries and the undivided primaries cross the venter evenly spaced. From about D = 20 mm the whorl section pass gradually to subrectangular, higher than wide with flattish flanks and rounded to subtabulate venter.

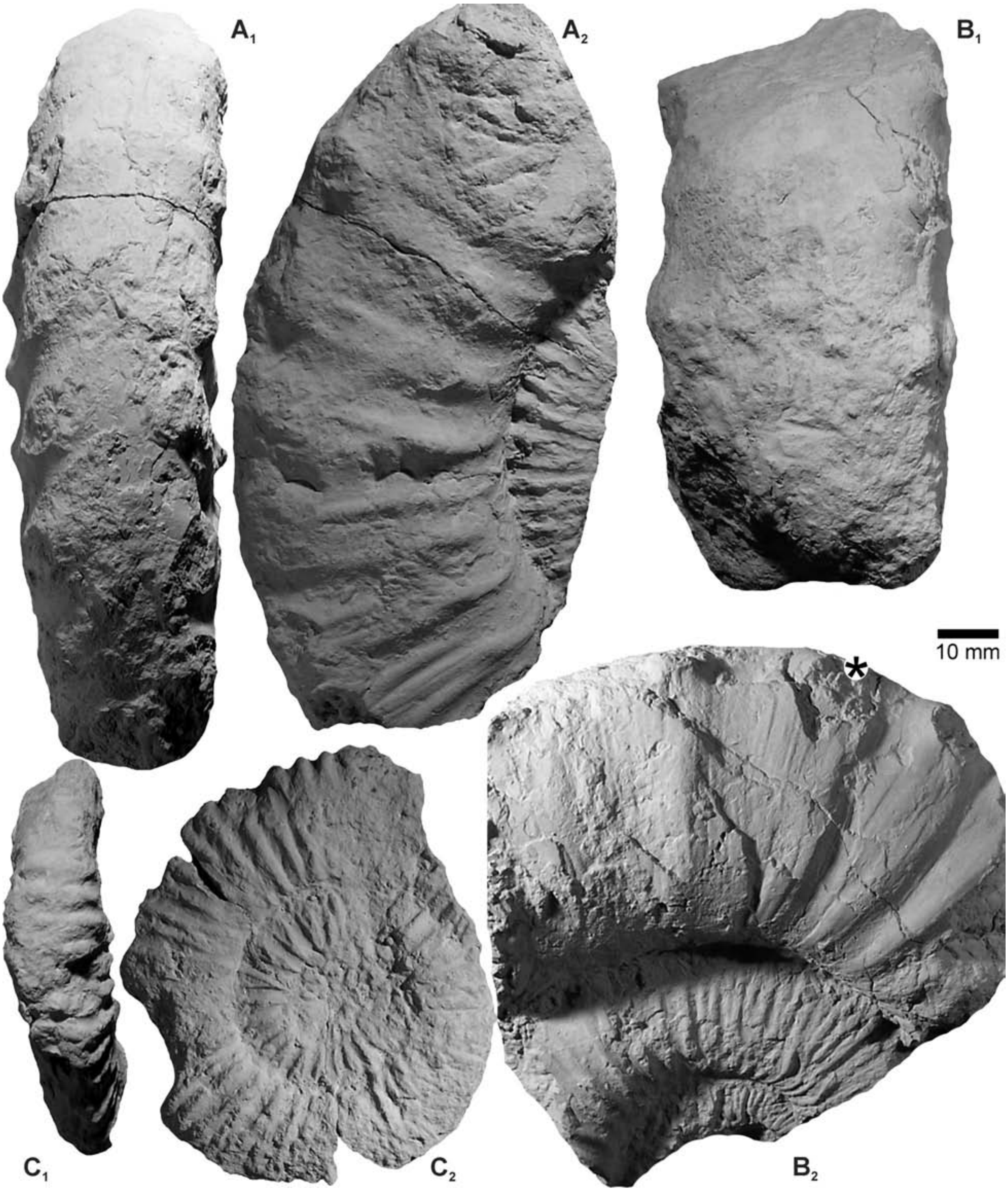


Fig. 22. *Peltoceratoides pressulus* (Leanza, 1947), bed VV-M-17, *pressulus* Hz., Pressulus Z. **A** – Large adult [M] phragmocone (MOZ-PI 9506). **B** – Large adult [M] phragmocone with the beginning of the bodychamber (MOZ-PI 9510). **C** – Complete adult [m] phragmocone (MOZ-PI 9502) with beginning of the bodychamber crushed. – All natural size (x1), asterisk indicating the last septum.

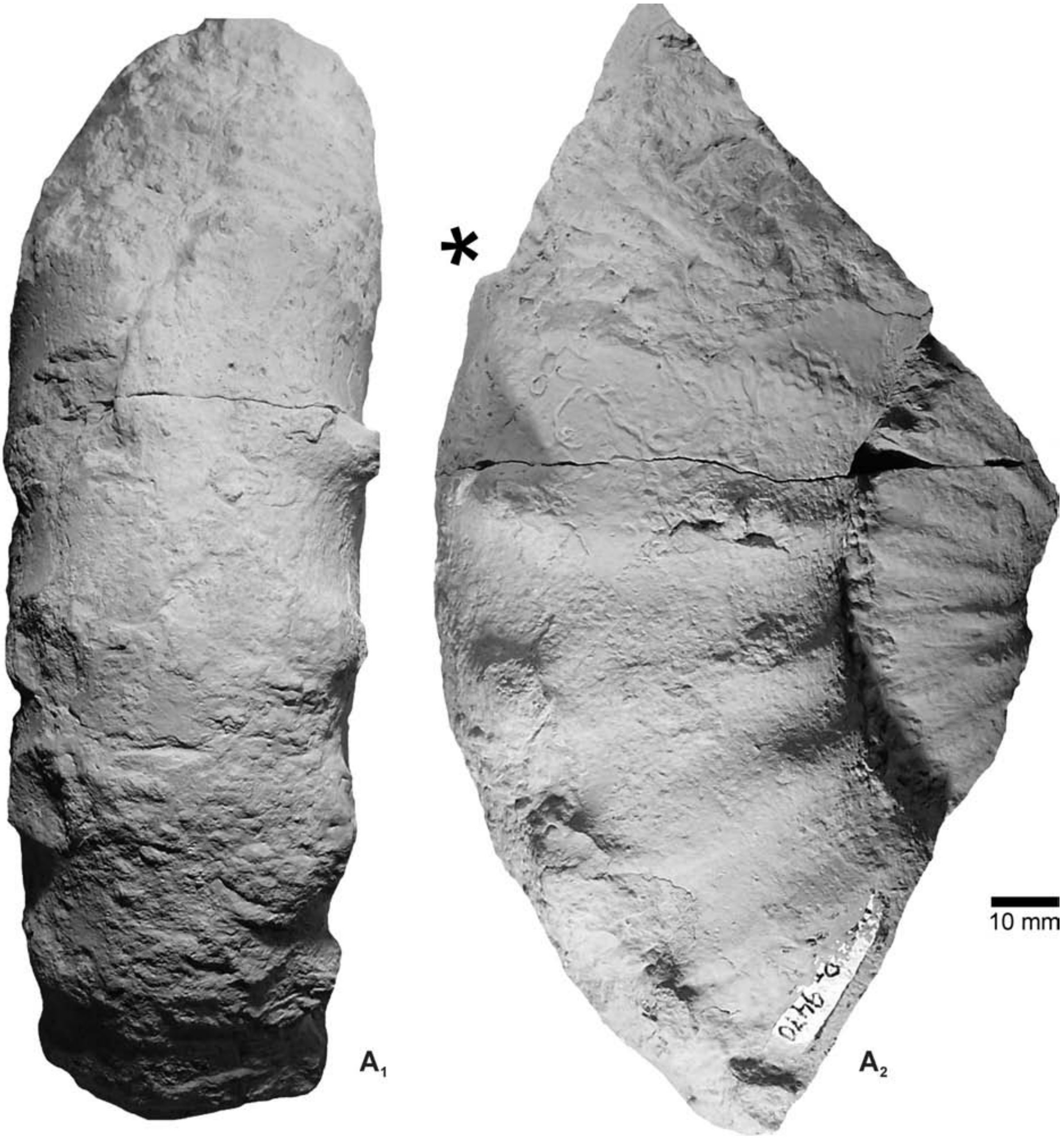


Fig. 23. *Peltoceratoides pressulus* (Leanza, 1947), bed VV-M-17, *pressulus* Hz., Pressulus Z. Large adult [M] phragmocone with the beginning of the bodychamber (MOZ-PI 9470). – Natural size (x1), asterisk indicating the last septum.

Primaries bifurcate from a delicate lamellar bulla on the umbilical shoulder. From about D = 60 mm primaries become prominent and acute, mostly undivided. All ribs form a small tubercle on the uppermost flank and cross the venter slightly weaken. From about D = 100 mm (adult phragmocone and beginning of bodychamber) the whorl section remains compressed, few specimens are stouter. Ribbing consists of prominent simple primaries which end on a tubercle at the ventro-lateral shoulder; venter narrow and smooth. The maximum preserved diameter is 230 mm at the beginning of the bodychamber, but D_{ls}-range is 160 to 230 mm within the available material. The poorly known adult bodychamber shows that at the beginning the primaries are somewhat coarser and more widely spaced. The maximum size at peristome would have been larger than 300 mm in diameter.

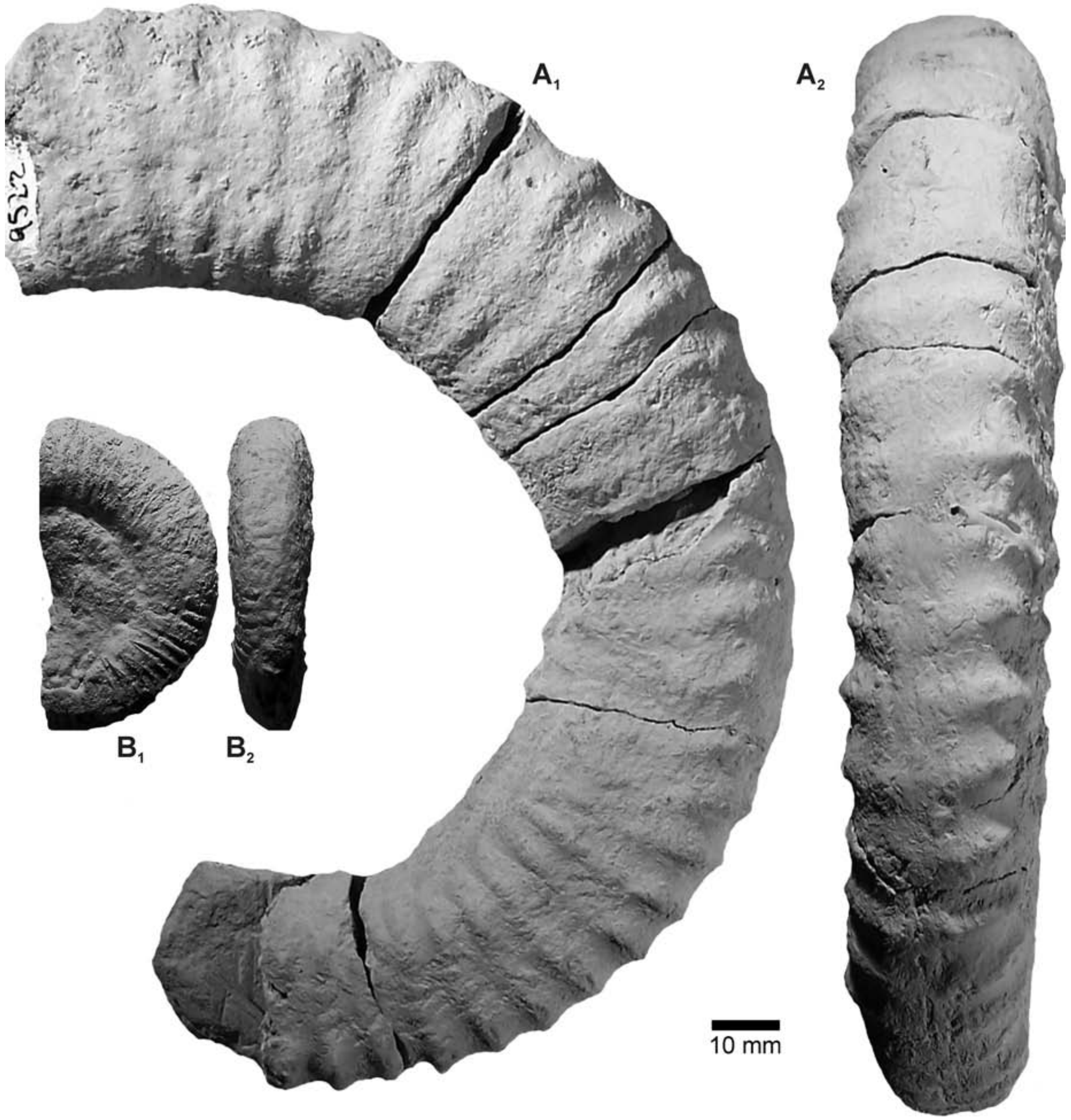


Fig. 24. *Peltoceratoides pressulus* (Leanza, 1947), Pressulus Z. **A** – Portion of whorl of a large [M] phragmocone (MOZ-PI 9522), bed VV-M-18. **B** – Inner whorls, possibly [M] (MOZ-PI 9536), bed VV-M-19. – All natural size (x1).

(2) Microconch: A single specimen, rather well preserved, maximum $D = 75$ mm. It is an adult phragmocone with the last whorl ending incipiently uncoiled and probably partially belonging to the bodychamber. Very evolute, compressed, with the sculpture comparable to that of the macroconch at similar diameter, but more widely spaced on the last whorl.

Remarks and comparison: The species has been recently revised (Parent 2006) from all the material available at that moment. The present material allows to describe the species from better specimens, including adult macroconchs with, at least, part of the bodychamber and a rather well preserved microconch. The phragmocone in Fig. 20E is practically identical to the holotype (Leanza 1947: pl. 2, fig. 1). The intraspecific variation is mainly expressed in the width of the whorl section of the adult phragmocone and the size at which the adult bodychamber begins (cf. Figs. 22B, 23). The lowermost occurrence (bed VV-M-15) consists of a poorly

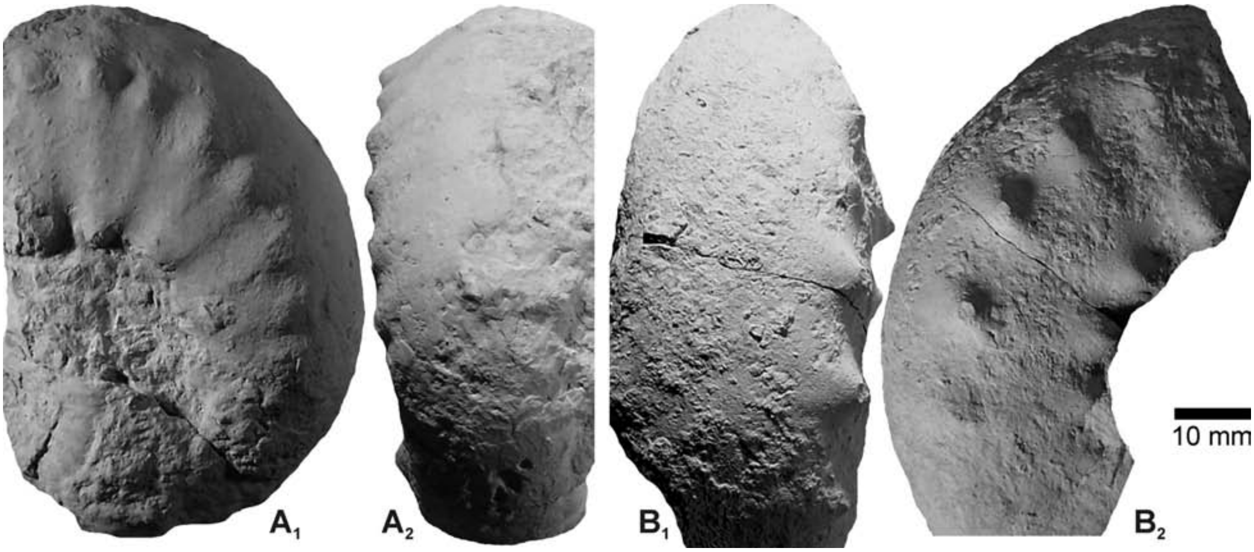


Fig. 25. *Euaspidoceras* cf. *depereti* (Collot, 1917), bed VV-M-13, Dimorphosus Z. **A** – [M] phragmocone (MOZ-PI 9430). **B** – [M] phragmocone (MOZ-PI 9427). – All natural size (x1).

preserved and barely identifiable specimen. The uppermost occurrence (bed VV-M-23) consists of a fragmentary bodychamber (not figured) of a large macroconch comparable with the largest macroconchs of bed VV-M-17 (Figs. 22B, 23) and VV-M-18 (Fig. 24A).

P. pressulus could likely be a synonym of *P. constantii* (d'Orbigny, 1848) because of the strong resemblance of the available macroconchs with the holotype (Enay et al. 1994: pl. 70, fig. 1). The differences could probably be of infraspecific significance originated in geographic differentiation, although Bonnot (1995) has described a wide intraspecific variation, including *P. constantii* as synonym of *P. williamsoni* (Phillips, 1829). Some of our specimens (Figs. 20C-E, 21) are very similar to specimens of the upper Mariae and lower Cordatum zones of France (Bonnot 1995: pl. 5, figs. 5-6, pl. 6, fig. 2) at comparable diameter. The local name is retained mainly because of the differences between our microconch (Fig. 22C), small and with no rursiradiate ribs compared to those figured by Bonnot (1995: pl. 6, figs. 5, pl. 7, figs. 1-2, 4-5).

Our specimen in Fig. 21 perfectly matches the large [M] of *P. constantii* figured by Matyja & Tarkowski (1981: pl. 5) from the Cordatum Z. of Zalas, Poland.

P. pressulus differs from *P. semirugosus* (most likely a synonym of *P. constantii*) by the well marked stage of looped primaries on the beginning of the bodychamber (Waagen 1875: pl. 14, fig. 1). However, the fragmentary specimen in Fig. 22A is exceptionally similar with several looped ribs and similar shell-shape at comparable size.

Among the *Peltoceratoides* described by Spath (1931) from India, there are three specimens which can be partially compared with the present species, what could be interesting for long-distance correlations between two regions which could have likely been well connected at these times (Early Oxfordian) through the Mozambique seaway. The holotype of *Peltoceratoides indicus* Spath (1931: pl. 104, fig. 5) is closely comparable with Fig. 20D. The very evolute and low whorled *Peltoceratoides aegoceroides* (Waagen) and *Peltoceratoides* aff. *torosus* (Oppel) in Spath (1931: pl. 103, figs. 1, 3), most likely microconchs, compare with Fig. 22C in these features.

Occurrence and distribution: Vega de la Veranada section levels VV-M-15 (Eugenii Z.) and VV-M-17-19 and 23 (Pressulus Z.), Lower Oxfordian. The close resemblance of *P. pressulus* [M] with *P. constantii-P. williamnsoni* [M] suggests time-correlation of the beds VV-M-17 (*pressulus* Hz.) to VV-M-23 with the lower Cordatum Z. Furthermore, the low, periumbilical rib bifurcation from the innermost whorls (as in the present material) is typical of *P. constantii-P. williamnsoni* (see Schindewolf 1925; Prieser 1937) and has been considered indicative of the Cordatum Z. by Bonnot et al. (2002). *P. pressulus* has been widely recorded from the Pressulus Z. of the Neuquén Basin (see Parent 2006) but, currently, not in the Tarapacá Basin.

Subfamily Aspidoceratinae Zittel, 1895
Genus *Euaspidoceras* Spath, 1931

Type species: *Ammonites perarmatus* Sowerby, 1822, by original designation.

Euaspidoceras cf. *depereti* (Collot, 1917)
Fig. 25

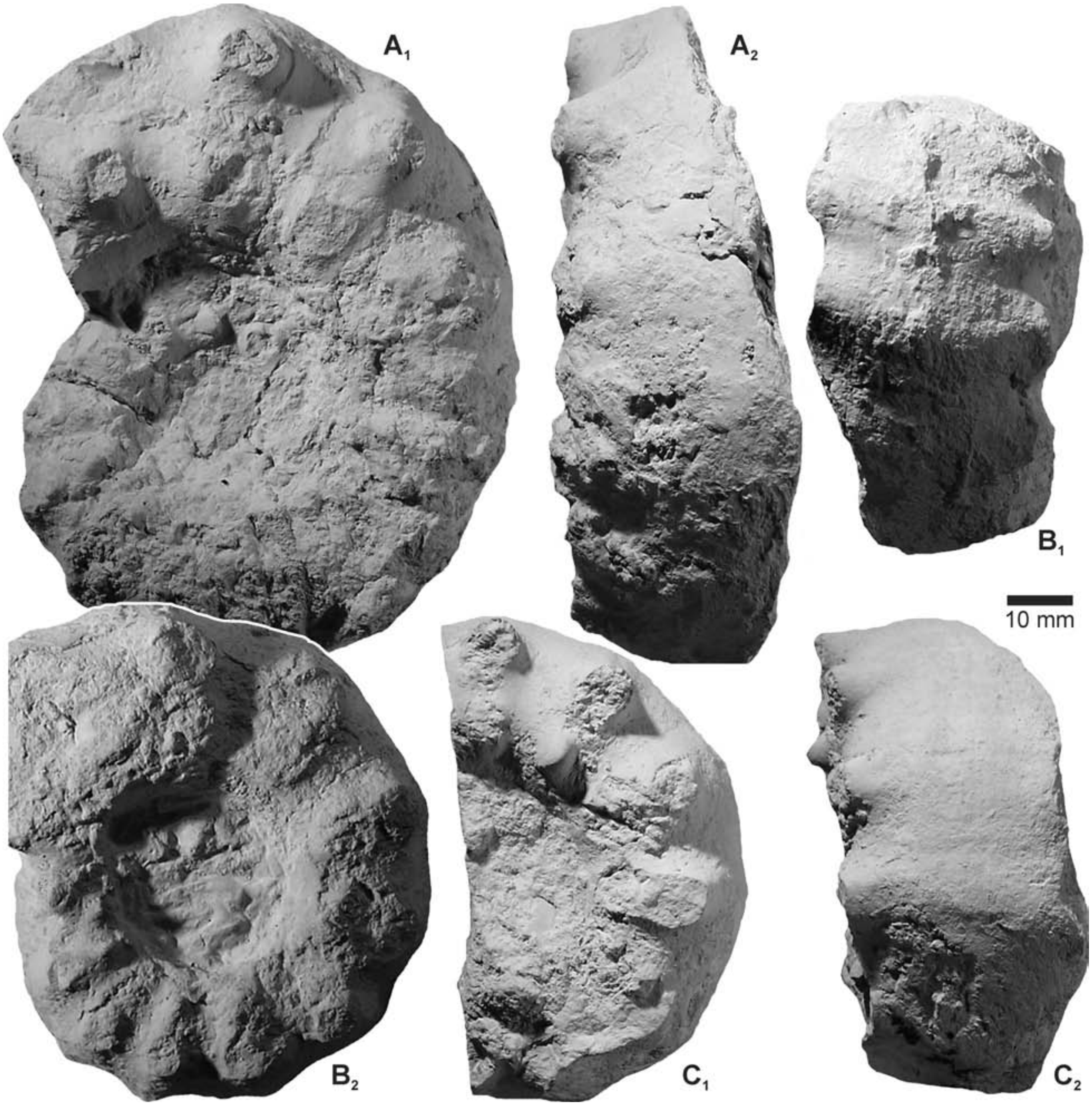


Fig. 26. *Euaspidoceras* cf. *subbabeanum* (Sintzov, 1888), Eugenii Z. **A** – Adult [M] phragmocone (MOZ-PI 9438), bed VV-M-14 (top). **B** – [M] phragmocone (MOZ-PI 9453), bed VV-M-15. **C** – [M] phragmocone (MOZ-PI 9451), bed VV-M-15). – All natural size (x1).

Material: 2 poorly preserved and fragmentary specimens from bed VV-M-12; 2 fragmentary [M] specimens (MOZ-PI 9427, 9430) from bed VV-M-13.

Description and remarks: Both specimens from bed VV-M-13 are wholly septate with maximum diameter of about 70 and 100 mm. Narrowly umbilicate, whorls subrectangular with two rows of lateral tubercles. From each periumbilical tubercle originate two divergent ribs, both ending at a ventro-lateral tubercle each.

The sculpture is rather infrequent for the genus. It is known in the inner whorls of *E. depereti* (see Bonnot & Courville 1999: pls. 1-2) from the Mariae Z. of France, and in some specimens of *E. waageni* Spath (1931: pl. 112: 1)

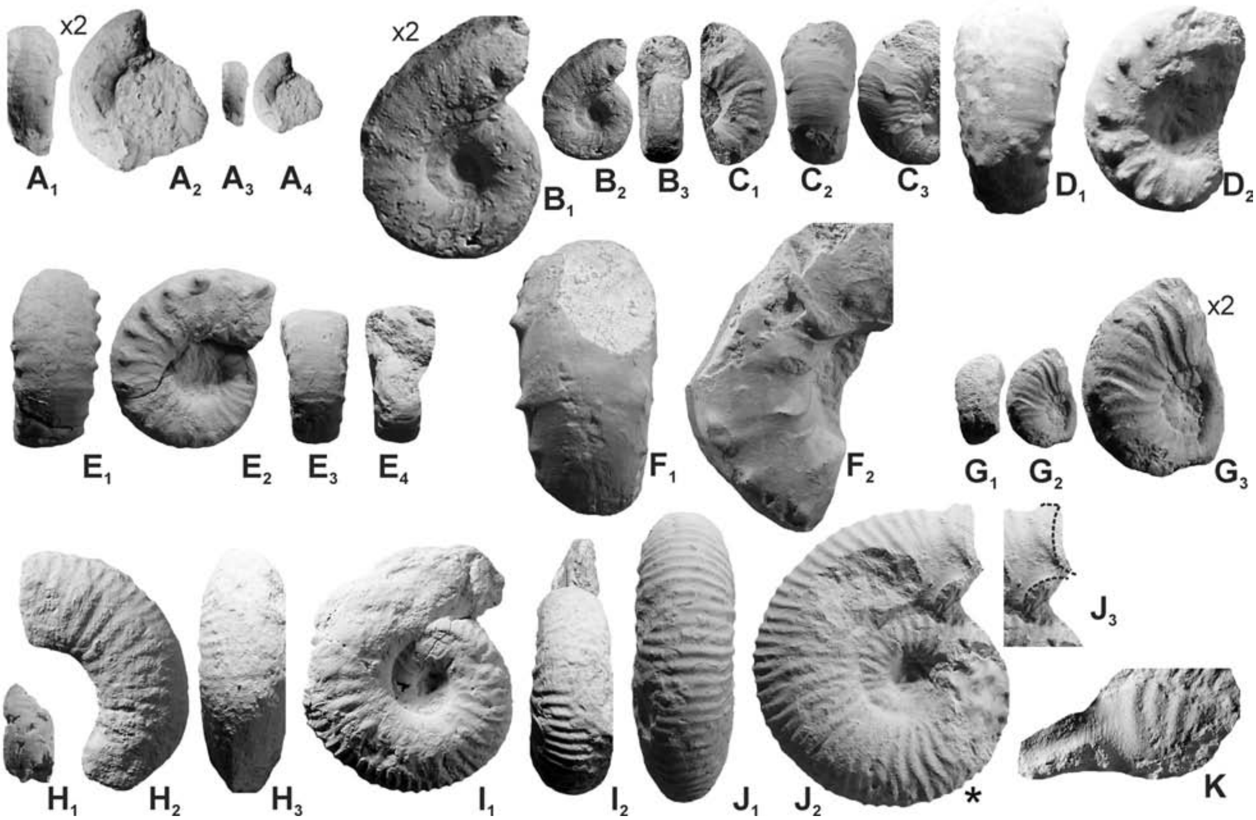


Fig. 27. *Euaspidoceras ajax* (Leanza, 1947), bed VV-M-15, Eugenii Z. **A** – [M] inner whorls (MOZ-PI 9448); A_1-A_2: enlarged (x2). **B** – [M] inner whorls (MOZ-PI 9449/2); B_1: enlarged (x2). **C** – [M] inner whorls (MOZ-PI 9449/5). **D** – [M] inner whorls (MOZ-PI 9449/4). **E** – [M] inner whorls (MOZ-PI 9449/3); E_3-E_4: ventral and apertural views last half whorl removed. **F** – [M] inner whorls (MOZ-PI 9449/1). **G** – [m] inner whorls (MOZ-PI 9449/6); G_3: enlarge (x2). **H** – Adult [m] (MOZ-PI 9449/10); H_1: inner whorl showing the smooth venter; H_2-H_3: bodychamber. **I** – Adult [m] (MOZ-PI 9476). **J** – Adult [m] (MOZ-PI 9454/1) with incomplete lappets. **K** – Adult [m] peristome with lappets (MOZ-PI 9454/2). – If not indicated otherwise all natural size (x1), asterisk indicating the last septum.

from the Lower Oxfordian of Samatra in the Kachchh Basin, India (most likely a synonym of, or closely related to *E. depereti*).

Occurrence: Vega de la Veranada section levels VV-M-12-13, Dimorphosus Zone, Upper Callovian.

Euaspidoceras cf. *subbabeanum* (Sintzov, 1888)
Fig. 26

Material: Three poorly preserved [M] phragmocones from top of bed VV-M-14 (MOZ-PI 9438) and bed VV-M-15 (MOZ-PI 9451, 9453).

Description: The specimens have a diameter of 75 to 100 mm, being involute with subrectangular whorls. From *D* = 40 mm two rows of bold lateral tubercles connected by a wide lateral rib. Prominent ventral ribs connecting the corresponding ventro-lateral tubercles of each flank.

Remarks: These specimens have a conspicuous morphology within the genus, without match in the literature. They best resemble *E. subbabeanum* figured by Bonnot (1995: pl 11, figs. 3-4) from the upper Lamberti Z. of Villers-sur-Mers, and the specimen figured as *E. ornatum* (de Loriol, 1900) by Bonnot (1995: pl. 11, fig. 24) from the Mariae Z. of Thuoux; but neither of these two forms has an umbilicus so narrow and a sculpture as heavy as the present species.

E. cf. *subbabeanum* differs from *E. ajax*, which co-occur in bed VV-M-15, by the prominent bituberculation and ventral ribs.

At first glance the present specimens resemble the most robust English morphotypes of *Peltoceras athleta* Phillips, 1829 (e.g., Spath 1931: pl. 106, fig. 3, pl. 107, fig. 5; Page 1991: pl. 26, fig. 1), especially concerning the ventral ribs connecting the ventro-lateral tubercles at each side. Never-

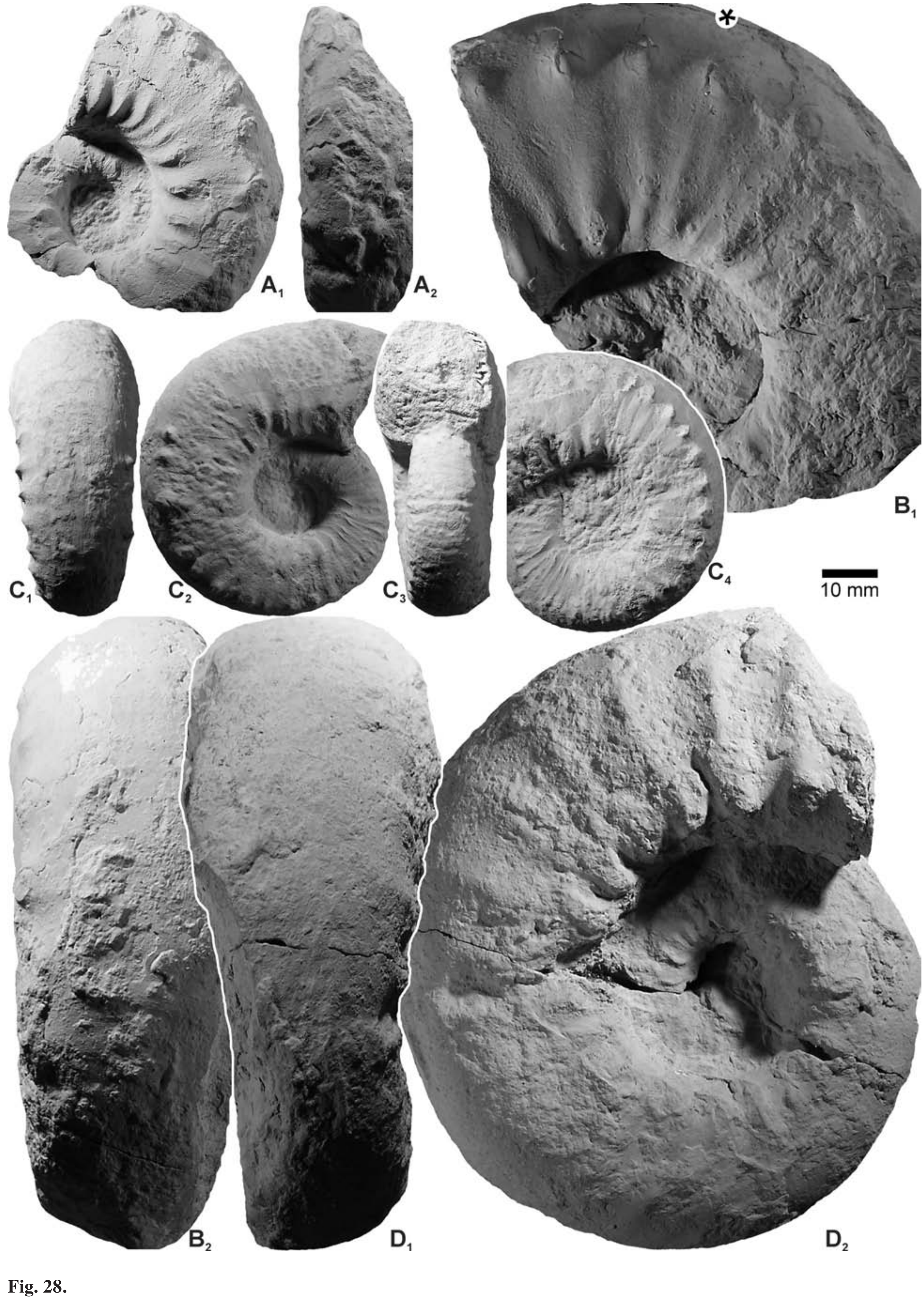


Fig. 28.

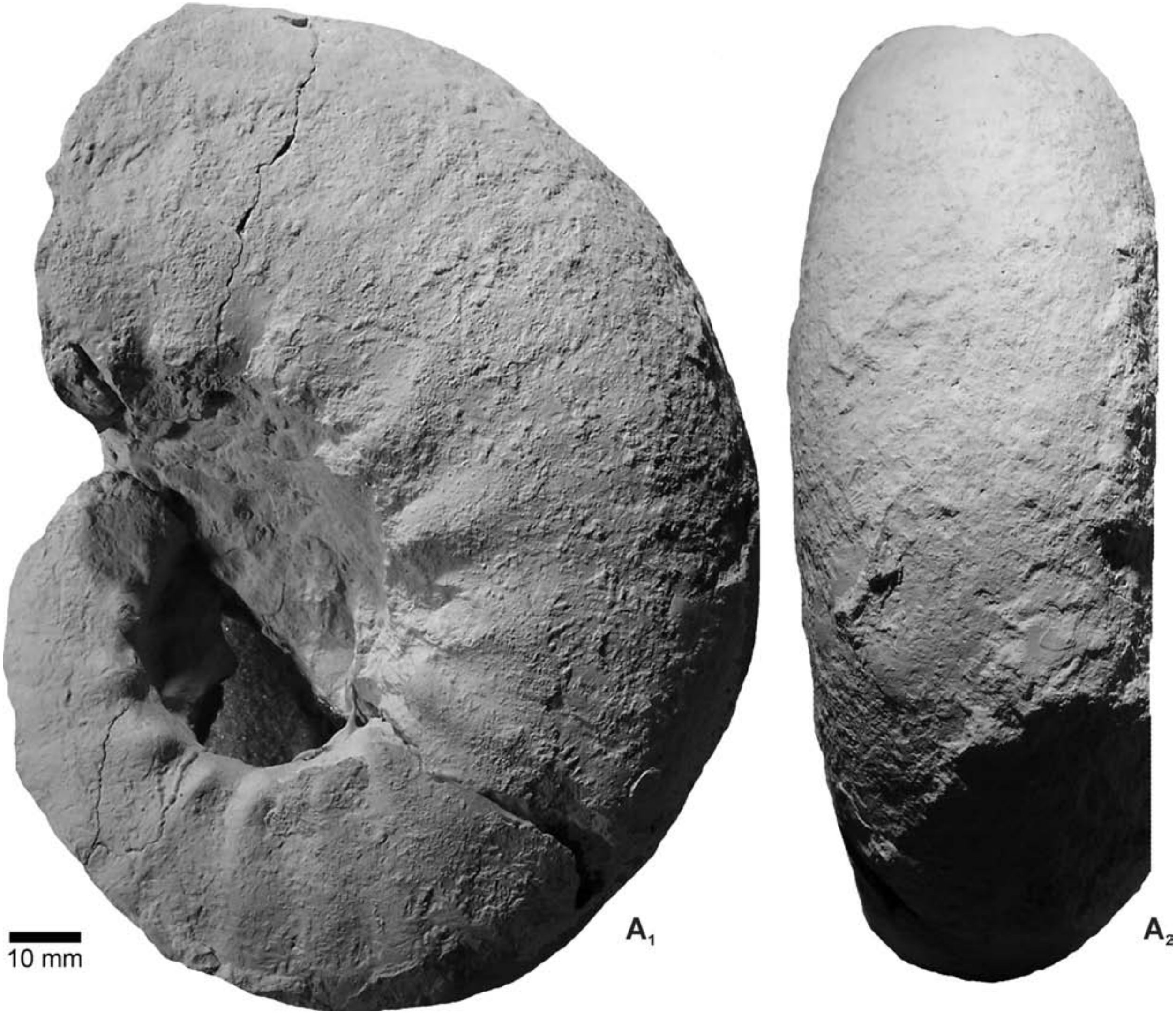


Fig. 29. *Euaspidoceras ajax* (Leanza, 1947), bed VV-M-16, Eugenii Z. Adult [M] phragmocone (MOZ-PI 9468), showing the transition of the morpho-ornamental change from bituberculate subrectangular to unituberculate suboval in whorl section. – Natural size (x1).

theless, *Peltoceras* has the inner whorls finely and densely ribbed whereas our specimens are strongly ribbed from at least *D* = 30-40 mm.

Occurrence: Vega de la Veranada section levels VV-M-14 (uppermost part) and VV-M-15, Eugenii Z., Lower Oxfordian.

Euaspidoceras ajax (Leanza, 1947)
Figs. 27-33; Table 1

*1947 *Euaspidoceras ajax* n. sp. – Leanza, p. 10, pl. 1, figs. 2-3 (lectotype), 4-5, pl. 3, figs. 3-4.
1951 *Euaspidoceras* (*Neaspidoceras*?) sp. – Stipanicic, p. 228, pl. 3, fig. 1.
1998 ?*Cubaspidoceras carribeanum* Myczynski. – Parent, p. 266.

Fig. 28. *Euaspidoceras ajax* (Leanza, 1947), Eugenii Z. **A** – [M] phragmocone (MOZ-PI 9449/7), bed VV-M-15. **B** – Juvenile? [M] with beginning of the bodychamber (MOZ-PI 9460), bed VV-M-15. **C** – [M] phragmocone (MOZ-PI 9449/8), bed VV-M-15. **D** – Adult [M] phragmocone (MOZ-PI 9465), bed VV-M-16. – All natural size (x1), asterisk indicating the last septum.

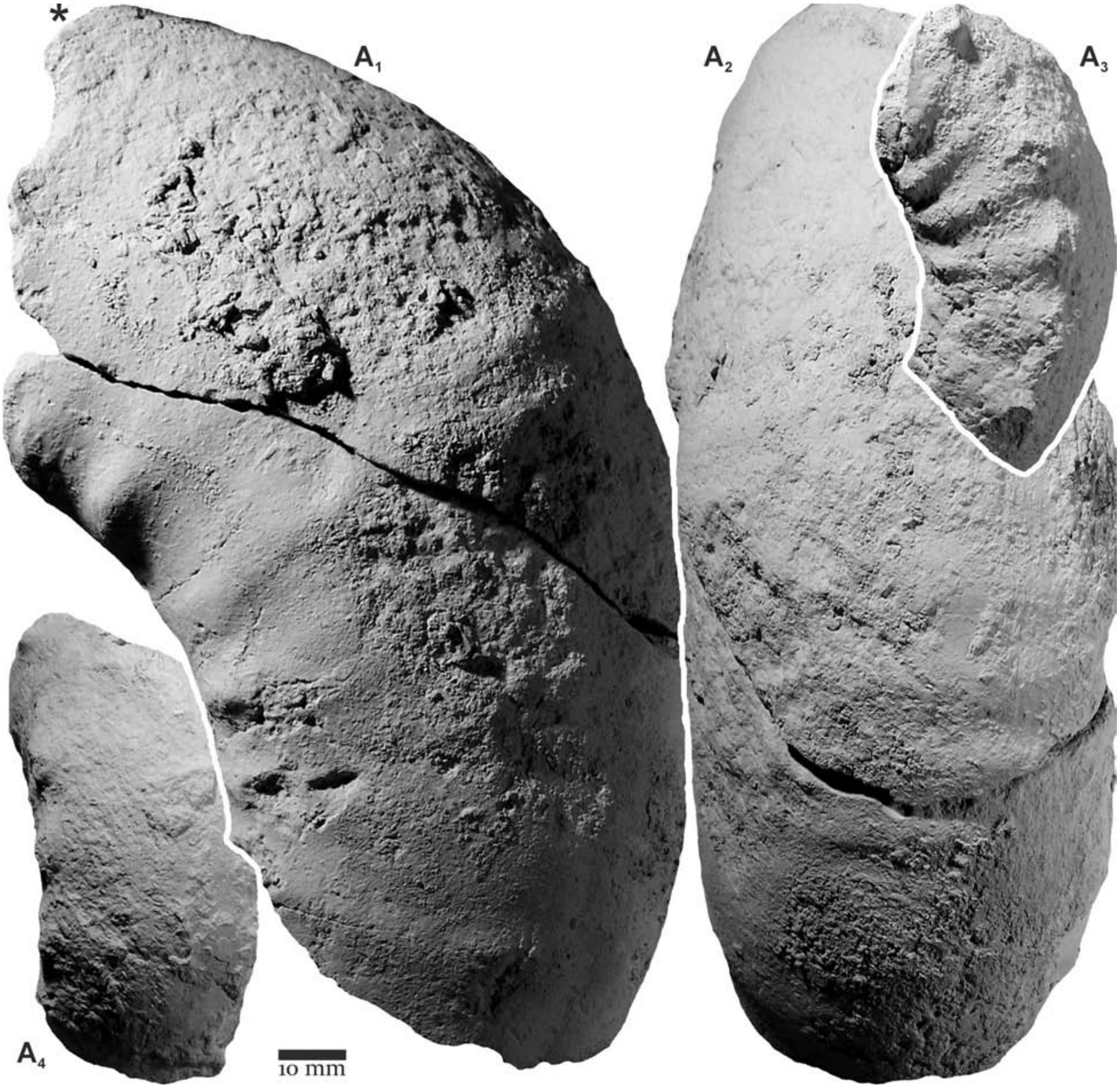


Fig. 30. *Euaspidoceras ajax* (Leanza, 1947), bed VV-M-16, Eugenii Z. Adult [M] phragmocone (MOZ-PI 9466) showing the morpho-ornamental differences between inner and outer whorls; A_1-A_2: outer whorl; A_3-A_4: inner whorl. – All natural size (x1), asterisk indicating the last septum.

2006 *Cubaspidoceras* n. sp. aff. *carribeanum* Myczynski. – Parent, p. 32, fig. 29A.

*2006 *Euaspidoceras ajax* (Leanza). – Parent, p. 29, fig. 29B (lectotype refigured), C-K.

Material: Several well-preserved but mostly incomplete specimens. From bed VV-M-15: 30 [M] phragmocones, 1 adult [M] with a portion of bodychamber, 5 more or less complete juvenil and adult [m]. Additionally, 7 [M] phragmocones and 2 adult [m] from beds VV-M-16-17; 3 adult [M] phragmocones and a bodychamber from bed VV-M-18.

Description: *Material from beds VV-M-15-16 (Figs. 27-30)*: this assemblage is the most abundant and best preserved, allowing to compose practically the whole ontogeny:
(1) Macroconch: inner whorls ($5 < D < 20$-25 mm) moderately involute, subrectangular whorls with flat flanks and widely rounded venter. Widely spaced primary ribs with

growth lines in-between; each primary forms a ventro-lateral parabolic structure which is soon replaced by well formed tubercles from about $D = 20$ mm. Middle whorls ($30 < D < 70$ mm) subrectangular and more or less involute. Bituberculate with a ventro-lateral row of conical, hollow tubercles and a row of periumbilical lamellar bullae from which the primary ribs originate. Primaries weak, rarely bifurcate, venter smooth or crossed by mild ribs. In outer whorls of phragmocone ($D > 70$-100 mm) and beginning of bodychamber ($D_{ls} = 180$-200 mm) the ventro-lateral tubercles vanish completely (save the rare specimen in Fig. 28B) and the whorl section becomes gradually suboval, moderately higher than wide. The periumbilical tubercles tend to be directed inwards the umbilicus producing a physodoceras-like morphology with wide and mild primary ribs which in some specimens cross the venter as wide undulations. The bodychamber is not completely preserved in any specimen, neither the septal suture lines.
(2) Microconch: inner whorls as in the [M], moderately involute with subrectangular to suboval whorl section and wide, smooth venter. From about $D = 10$ mm there are flexuous lateral ribs with ventro-lateral parabolae. The bodychamber begins at $D = 25$-26 mm, extends for more than a half whorl ($L_{BC} = 230°$ in the best preserved specimen), and ends in a constricted peristome at $D_p = 33$-39 mm, bearing two long and narrowly spatulate lateral lappets. It is uncoiled with a suboval, slightly higher than wide whorl section, covered by dense rursiradiate primaries bifurcating on the upper third of the flanks; secondary ribs cross the venter evenly spaced.

Material from beds VV-M-17-18 (Figs. 31-33):
(1) Macroconch: the specimens are preserved from 70 mm in diameter and do not differ significantly from those of bed VV-M-15. The largest specimen consists of half whorl of a bodychamber, which is heavily tuberculate periumbilically with primary ribs vanishing on mid-flank, markedly uncoiled and compressed towards the peristome. This specimen allows to estimate an adult size at peristome of about 230-260 mm in diameter (considering a half whorl long of bodychamber).
(2) Microconch: there is a well-preserved specimen without peristome. The inner whorls have primary ribs widely spaced, with smooth intercostal spaces or very fine growth lines. The bodychamber is identical to the microconchs of bed VV-M-15.

Remarks and comparison: The lectotype of *E. ajax* (designated and discussed in Parent 2006: 29) is a small nucleus ($D = 20$ mm) hardly interpretable in isolation. Nevertheless, the new material can be assigned confidently to the species since the ontogeny matches successively the three fragmentary specimens originally included in the species by Leanza (1947: pl. 1, figs. 2-5, pl. 3, figs. 3-4), which were all collected from a single bed and locality.

The slight differences between the specimens of bed VV-M-15 respect to those from bed VV-M-17-18, especially in the microconch, might suggest a differentiation in two transients. Nevertheless, more material from the upper levels is necessary for characterization, especially considering the broad intraspecific phenotypic plasticity (perhaps unstable morphology because of fast growth) of most aspidoceratids.

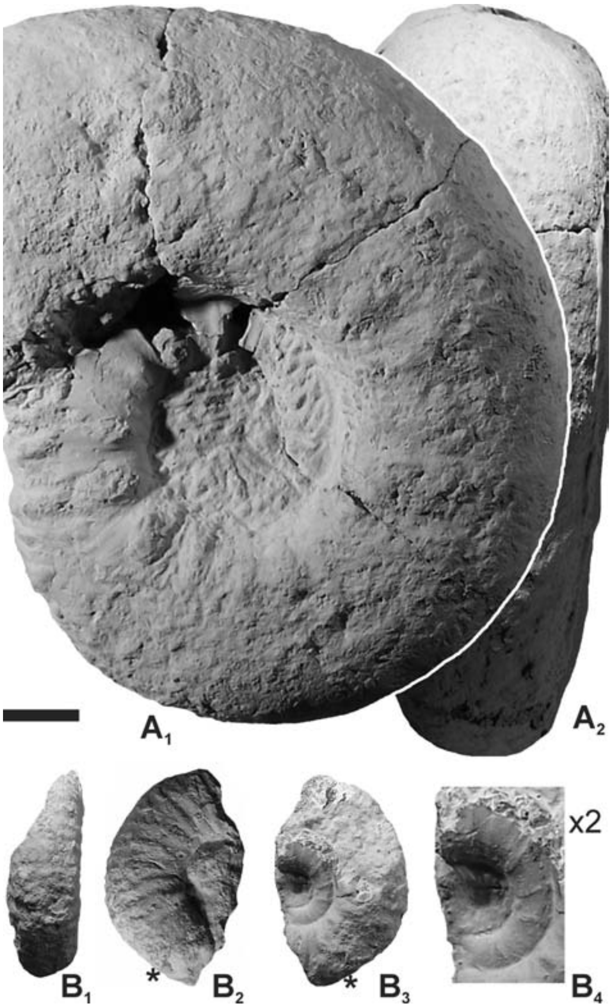


Fig. 31. *Euaspidoceras ajax* (Leanza, 1947), bed VV-M-17, *pressulus* Hz., Pressulus Z. **A** – Adult [M] phragmocone (MOZ-PI 9478). **B** – Adult [m] with incomplete bodychamber (MOZ-PI 9476); B_4: enlarged (x2) inner whorls showing the aspidoceratid morphology and sculpture. – All (except B_4, x2) natural size (x1), asterisk indicating the last septum.

The specimen in Fig. 31A perfectly matches that figured as *Cubaspidoceras* n. sp. aff. *carribeanum* (Myczinski, 1976) by Parent (2006: fig. 29A). It was formerly assigned to *Cubaspidoceras* for the rounded compressed, unituberculate outer whorls which are characteristic of that genus, but this close resemblance seems to be a case of homoeomorphy produced between the adult whorls of *E. ajax* and the late Middle Oxfordian *C. carribeanum*.

The outermost whorls of *E. ajax* are somewhat similar to the lectotype of *Euaspidoceras babeanum* (d'Orbigny, 1848) figured by Enay et al. (1994: pl. 69, fig. 3, upper Mariae-lower Cordatum zones) which tends to loose the outer row of tubercles in the bodychamber and to become

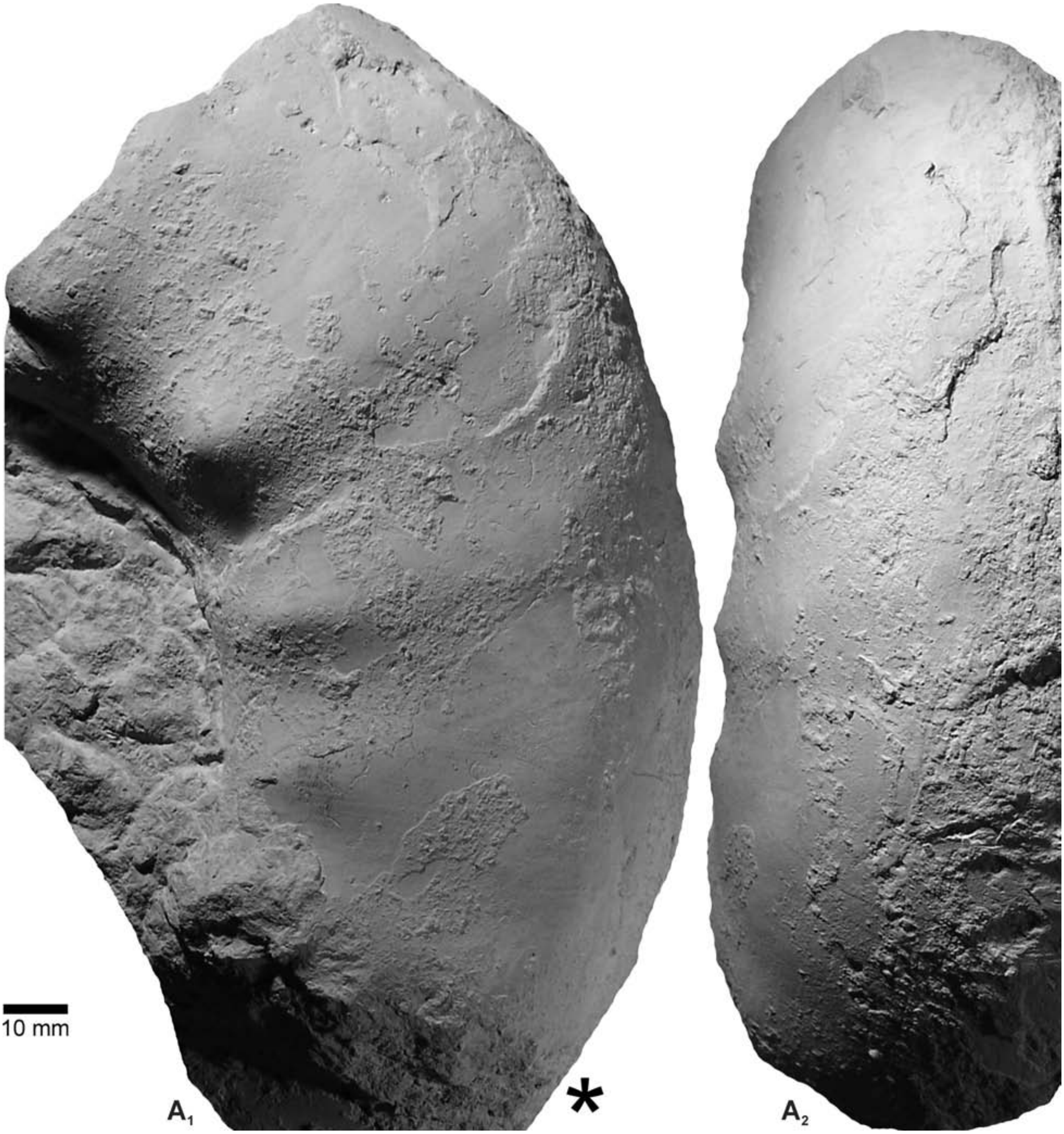


Fig. 32. *Euaspidoceras ajax* (Leanza, 1947), bed VV-M-17, *pressulus* Hz., Pressululs Z. Portion of an adult [M] body-chamber (MOZ-PI 9480), showing the contraction of the whorl section towards the peristome. – Natural size (x1), asterisk indicating the last septum.

compressed towards the peristome, as in adults of *E. ajax* [M]. Nevertheless, the inner whorls of *E. babeanum* (Enay et al. 1994: pl. 69, fig. 4) are very different by being involute, globose and heavely ornamented with large conical lateral tubercles. The Oxfordian specimen from Vanda in the Kachchh Basin, India, figured by Waagen (1875: pl. 19) as "*Aspidoceras babeanum* Orbigny" shows external resemblance with *E. ajax* but strongly differs by its persistent bituberculate sculpture, its subrectangular whorl section, becomiing depressed in the last whorl (bodychamber?) with a median row of stout conical tubercles and one of smaller tubercles on the ventro-lateral shoulder (see Spath 1931: 601

Fig. 33. *Euaspidoceras ajax* (Leanza, 1947), bed VV-M-18, Pressulus Z., Lower Oxfordian. Adult [M] with a quarter whorl of bodychamber (MOZ-PI 9513). – Natural size (x1), asterisk indicating the last septum.

for the redescription of the failed drawing in Waagen 1875: pl. 19). Similar differences exist to the large, evolute [M] of *E. babeanum* figured by Arkell (1944: pl. 62, fig. 4) which shows a sculpture ontogeny matching close to the above cited specimen from India and the lectotype of *E. babeanum*.

The microconchs of bed VV-M-15 are indistinguishable from the type specimen of *Ammonites vernoni* Young & Bird, 1828 (see Buckman 1922: pl. 333), the type species of *Klematosphinctes* Buckman, 1922. Thus, the present material gives strong support to the sexual dimorphic correspondence of *Klematosphinctes* with the late Callovian and Early Oxfordian macroconch *Euaspidoceras* (see Spath

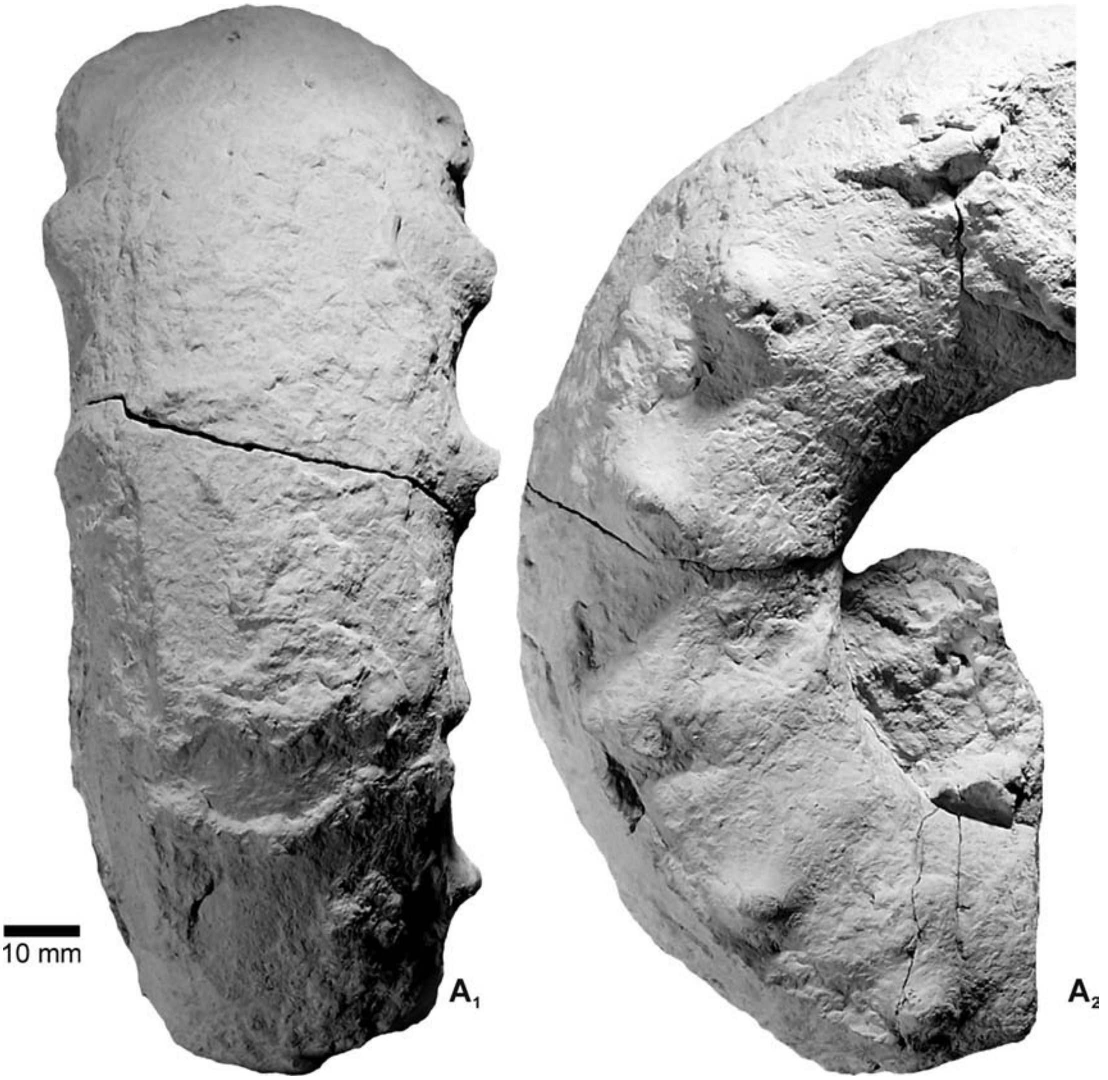


Fig. 34. *Euaspidoceras veranadaense* Parent, 2006, bed VV-M-17, *pressulus* Hz., Pressulus Z. Adult [M] phragmocone (MOZ-PI 9484). – Natural size (x1).

1931: 588, Bonnot et al. 1994). Furthermore, the clear Grossouvria-like aspect of the aspidoceratid *Klematosphinctes vernoni* (including the key-feature of parabolic structures in the phragmocone) strongly suggests the origin of E*uaspidoceras* from Late Callovian ammonites of the genus *Grossouvria*.

Occurrence: Vega de la Veranada section levels VV-M-15-16 (Eugenii Z.) and VV-M-17-18 (Pressulus Z.), Lower Oxfordian.

Euaspidoceras veranadaense Parent, 2006
Fig. 34

Material: 1 incomplete adult [M] phragmocone (MOZ-PI 9484) from bed VV-M-17.

Description and remarks: Maximum diameter 140 mm, evolute (*U*/*D* = 0.42) with subrectangular-suboval whorl section. Widely spaced radial primary ribs originate indistinctly on the periumbilical area and form a tubercle on the uppermost flank. This specimen is comparable with the holotype of *E. veranadaense* (type locality Vega de la Veranada), although somewhat wider in whorl section. The stratigraphic position of the holotype is similar ("faunal level VV-2" in Parent 2006: 31).

Occurrence: Vega de la Veranada section level VV-M-17, *pressulus* Hz., Pressulus Z., Lower Oxfordian.

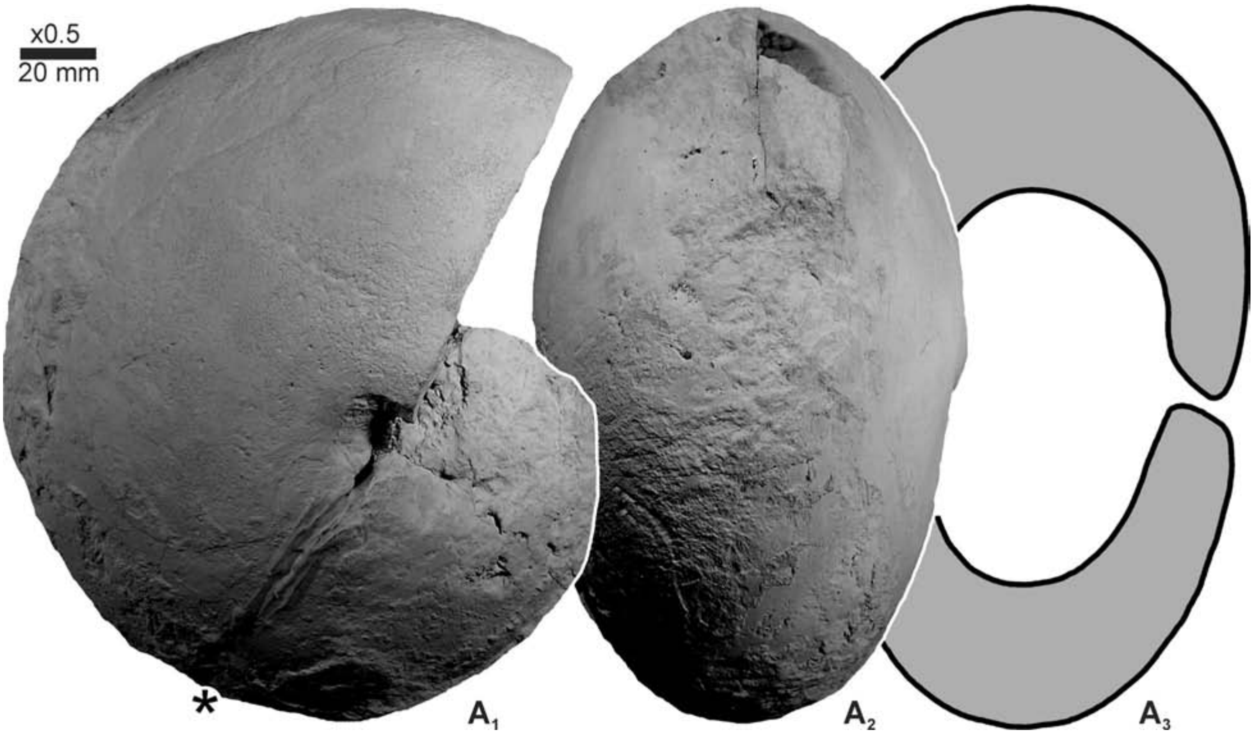


Fig. 35. *Araucanites reyesi* (Westermann & Riccardi, 1976), bed VV-M-9, Dimorphosus Z. Almost complete adult [M] (MOZ-PI 9423); A_3: whorl section through the maximum diameter preserved, bodychamber (shaded). – All reduced x0.5, asterisk indicating the last septum.

Superfamily Stephanoceratoidea Neumayr, 1875
Family Sphaeroceratidae Buckman, 1920
Subfamily Eurycephalitinae Thierry, 1976

Remarks: The Callovian-Oxfordian Eurycephalitinae are similar to some Mayaitinae and Eucycloceratinae. They can be differentiated in general considering: (1) the phylogenetically persistent smooth lower mid-flanks in the Eurycephalitinae, and (2) the suture line, that in *Epimayaites* and allied members of the Mayaitinae is strongly protracted or strongly curved forward near umbilicus (Westermann 2001; Westermann & Yi-Gang 1988), a configuration not known in the Eurycephalitinae which have a basic design similar to that of the Macrocephalitinae (see Thierry 1975: fig. on p. 1544).

Genus *Araucanites* Westermann & Riccardi, 1976

Type species: *Mayaites stipanicici* Westermann & Riccardi, 1976, by original designation.

Araucanites reyesi (Westermann & Riccardi, 1976)
Figs. 35, 36A, Table 1

*1976 *Mayaites (Araucanites) reyesi* sp. nov. – Westermann & Riccardi in Stipanicic et al., p. 296, pl. 3, figs. 1-2, pl. 4, pl. 5, figs. 1-2.

1976 *Mayaites (Araucanites)* sp. nov.? I. – Westermann & Riccardi in Stipanicic et al., p. 300, pl. 5, figs. 3-4.

2006 *Araucanites reyesi* Westermann & Riccardi. – Parent, p. 50, fig. 45C (whorl section).

Material: 1 adult [M] (MOZ-PI 9423) from bed VV-M-9; 1 adult [m] (MOZ-PI 9421) from bed VV-M-11; 1 fragmentary [m] from bed VV-M-12.

Description: Macroconch (bed VV-M-9): Maximum preserved D = 190 mm with half a whorl of bodychamber preserved. Involute globular spherocone with very small umbilicus and suboval whorl section from D = 40 mm. Bodychamber smooth, beginning at about D_{ls} = 150 mm; slightly uncoiled although the umbilicus tends to be occluded by a projection of the external wall of the shell (Fig. 35A$_3$). Diameter at peristome would have been about 220 mm if considered three quarters whorl of bodychamber.

Microconch (bed VV-M-11): Maximum preserved D c. 55 mm with incomplete (adult) bodychamber. Involute spherocone with suboval to subrectangular whorls (W/H_1 = 1.19 at D c. 45 mm). Primary ribs prosocline (P = 10 at the last septum), bi- or trifurcating on mid-flank in narrowly splayed secondaries of the same strength. The secondaries with few intercalatories cross the venter evenly spaced. From the beginning of the bodychamber the ribbing is comparatively wider spaced. Diameter at peristome could be estimated as 65 mm (considering three quarters whorl of bodychamber as usual in the microconchs of the Eurycephalitinae).

Remarks and comparison: The [M] matches the larger of the paratypes (Stipanicic et al. 1976: fig. 4b, pl. 4) in shell-shape and whorl section. The [m] closely resembles *Eurycephalites*? sp. C in Hillebrandt & Gröschke (1995: pl. 5, fig. 5) from the Primus Z. of Agua del Carretón (Tarapacá Basin). The microconchs of *Araucanites* are smaller than the [M] and the ribbing persists up to the peristome (Westermann et al. 2002). The adult ribbing of these microconchs is distinctive within the Eurycephalitinae, consisting of primary ribs polyfurcating into three to five secondaries from the adult phragmocone as shown by Westermann et al. (2002: figs. 5L, N, 6I, J) from material of New Zealand. This feature is also present in *Eurycephalites*? sp. C and in our [m] (Fig. 36A$_1$) and supports their assignment to *Araucanites*. The adult bodychamber of microconch *Eurycephalites* Spath, 1928 and *Lilloettia* Crickmay, 1930 (upper Bathonian to middle Callovian), mostly included in the morphogenus *Xenocephalites*, are variocostate bearing strong bifurcate ribbing up to the peristome (Riccardi & Westermann 1991; Parent 1998a).

The [M] of *Araucanites prereyesi* Parent, 2006 is very similar, especially the holotype which is the only well preserved specimen. The main differences with respect to the [M] of *A. reyesi* described herein are the more compressed whorls and the somewhat smaller adult size. The putative microconchs of *A. prereyesi* (see Hillebrandt & Gröschke 1995: pl. 6, figs. 2-3) are very incompletely preserved, showing a subtabulate venter and much stronger ventral ribbing.

Occurrence and distribution: Vega de la Veranada section levels VV-M-9, 11-12; Dimorphosus Z., uppermost Callovian.

Stratigraphic distribution of *Araucanites*: *Araucanites* was founded by Riccardi & Westermann (in Stipanicic et al. 1976) from material collected in beds of the La Manga Fm in Vega de la Veranada and several close localities of the Sierra de Reyes (i.e. Aguada de Campos, Cañada Honda, Aguada de La Mula and Quebrada de la Buitrera; see Fig. 1). The type (*A. stipanicici*) and the remaining species (*A. reyesi* and *A. mulai*) were based on specimens from Sierra de Reyes. From Vega de la Veranada only a single specimen was cited as *Araucanites* sp. with other ammonites noted as *Euaspidoceras chilense* Leanza, *E. akantheen* (Buckman), *E.* aff. *loricatum* (Bean), *E.* (*Clambites*) sp., *Peltoceras* (*Peltomorphites*) *hoplophorus* (Buckman), *Perisphinctes* (*Prososphinctes*) sp. and *P.* (*Kranaosphinctes*) sp. The interval yielding *Araucanites* in Vega de la Veranada and Sierra de Reyes was considered to belong to the Plicatilis Z., and that could extend downward into the upper Cordatum Z. (Stipanicic et al. 1976: 287). Nevertheless, it has been shown in the last years that the latest representatives of *Peltoceratoides* occur, all throughout the Tethyan Realm, in the upper Cordatum Z. (e.g. Bonnot et al. 2002) in the form of *P. interruptum* (Neumann, 1907), see Bonnot (1995: fig. 6A.1, pl. 7, fig. 6), Matyja (1977), Callomon & Cope (1971). Although the ammonites cited by Stipanicic et al. (1976) have not been figured, the occurrence of several Peltoceratinae in all their lists attests to an age not younger than the late Early Oxfordian Cordatum Z. Moreover, Stipanicic (1965: 425) has indicated the occurrence of large specimens of "*Peltoceras* sp." in the uppermost levels of the La Manga Fm in Aguada de Campos and Cañada Honda. Our preliminary conclusion is that the ammonite fauna of Stipanicic et al. (1976) including the *Araucanites* of the La Manga Fm in Vega de la Veranada and Sierra de Reyes is not younger than Early Oxfordian.

The macro- and microconchs of *A. reyesi* collected in our survey come from beds tentatively assigned to the Dimorphosus Z. (Upper Callovian, or earliest Oxfordian?). This apparent lower occurrence of *A. reyesi* [M&m] compared to the material of *Araucanites* of Stipanicic et al. (1976) from Sierra de Reyes can not be discussed in detail for the time being, mainly because these faunas have not been described or figured. Moreover, the upper levels of the studied section have not yielded ammonites (Fig. 3).

The holotype of the earlier species *Araucanites prereyesi* Parent, 2006 was collected in beds of the Dimorphosus Z. of Cerro Amarillo (Tarapacá Basin), and could likely be the ancestor of *A. reyesi* (Parent 2006).

Genus *Veranadaites* nov.

Etymology: After the type locality of the type species, Vega de la Veranada.

Type species: *Veranadaites palmicostatus* n. gen. n. sp.

Diagnosis: Small and compressed sphaerocone with wide umbilicus. Adult phragmocone and bodychamber periumbilically smooth with acute primary ribs prorsiradiately fasciculated from mid-flank.

Species included: Currently only the type species.

Remarks and comparison: *Veranadaites* has some superficial similarities with some mayaitids like *Epimayaites* Spath, 1928. Nevertheless, the new genus is asigned to the Eurycephalitinae because of the differential feature of the smooth lower flanks. The septal suture line is very poorly known, but seems to be radial, not protracted (see remarks under Eurycephalitinae). The macroconchs of *Araucanites* are larger and more narrowly umbilicate, with the bodychamber laterally or completely smooth. The macroconchs of *Eurycephalites* (uppermost Bathonian-Middle Callovian) are more inflate and involute, and the bodychamber tends to be smooth. The macroconchs of *Lilloettia* (Upper Bathonian-lower Callovian) are similar in shell-shape to *Veranadaites* n. gen. but more narrowly umbilicate and the flanks of the bodychamber are smooth.

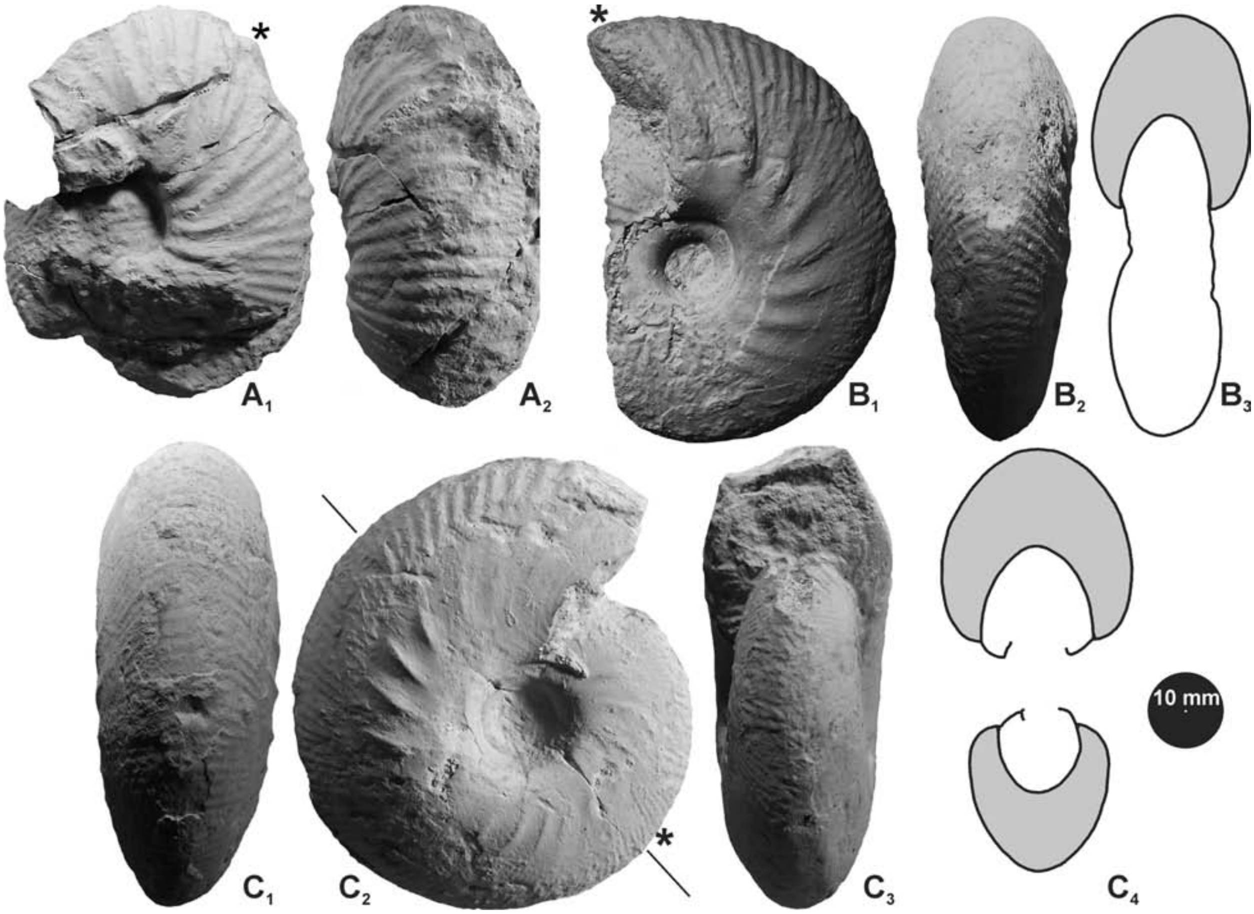


Fig. 36. **A** – *Araucanites reyesi* (Westermann & Riccardi, 1976), bed VV-M-11, Dimorphosus Z. Adult [m] with incomplete bodychamber (MOZ-PI 9421). **B-C** – *Veranadaites palmicostatus* n. gen. n. sp., Pressulus Z. **B**: Paratype, complete adult [M] phragmocone with the beginning of the bodychamber crushed (MOZ-PI 9475), bed VV-M-17, *pressulus* Hz.; B_3: whorl section at $D = 54$ mm, bodychamber shaded. **C** – Holotype, complete adult [M] (MOZ-PI 9521), bed VV-M-18; C_4: whorl section through the bodychamber (shaded) after the last septum ($D = 56$ mm), position indicated by the thin line in C_2. – All natural size (x1), asterisk indicating the last septum.

Veranadaites palmicostatus n. gen. n. sp.

Fig. 36B-C, Table 1

Etymology: After the primary ribs polyfurcating in palmate style.

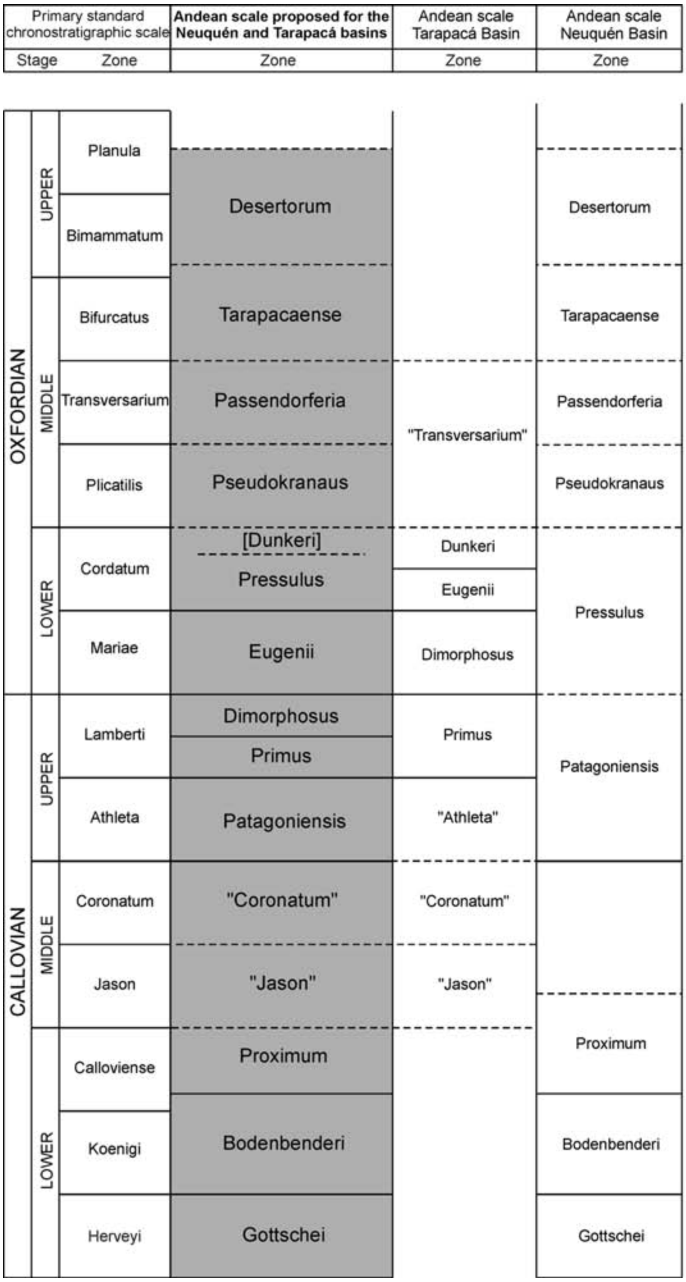
Material: Holotype (MOZ-PI 9521) from bed VV-M-18; Paratype (MOZ-PI 9475) from bed VV-M-17.

Type locality and section: Vega de la Veranada, Neuquén Province, Argentina (Figs. 1, 3).

Type horizon: Bed VV-M-18 of the type section (Fig. 3), La Manga Fm, Pressulus Zone, Lower Oxfordian.

Description: Adult phragmocone and bodychamber compressed-sphaerocone, involute (whorls strongly overlapping) with relatively wide umbilicus and suboval whorl section. Primary ribs prominent and acute; they originate slightly above the umbilical shoulder in the adult phragmocone, but on the lower flank in the bodychamber. The smooth periumbilical area widens from the last whorl of the adult phragmocone towards the peristome. Each primary polyfurcates in palmate style into three to five fine, prorsiradiate secondaries which cross the venter sweeping forward. On the bodychamber ($L_{BC} = 270°$) the secondaries are weakly connected with the primaries, which vanish near the peristome. The peristome, almost completely preserved, is slightly contracted and smooth. The septal suture line can be observed partially at different sizes in the holotype: narrow ventral and lateral lobes and wide lateral saddles; subradially arranged umbilical lobes. Innermost whorls unknown.

Remarks and comparison: The specimens are considered macroconchs as suggested by the progressive smoothing of



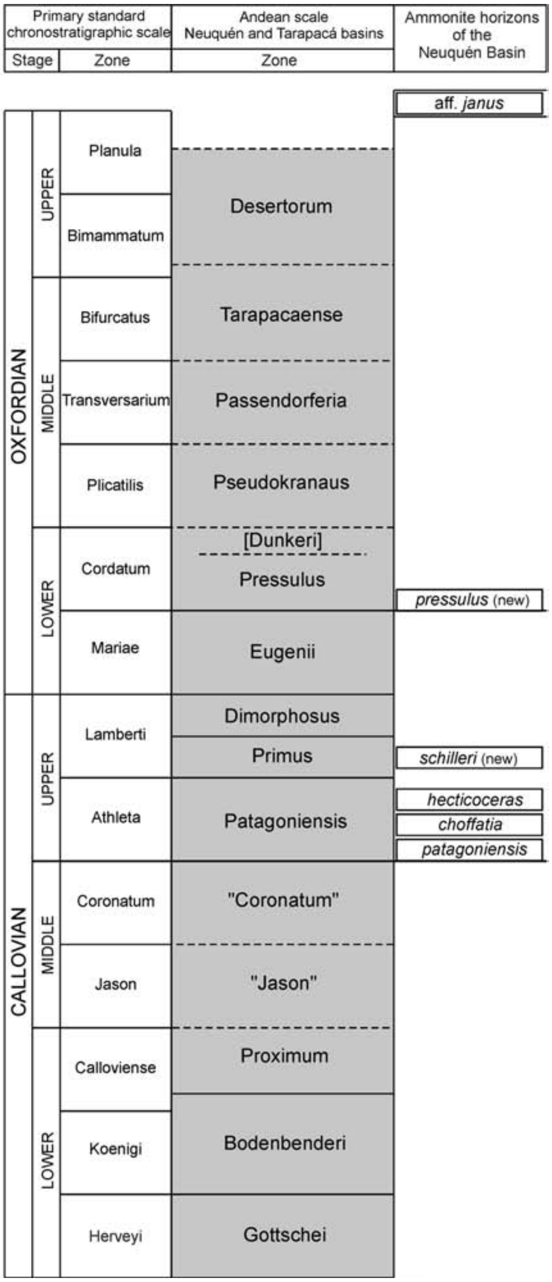


Fig. 37. Correlation of the ammonite-zone scales of Hillebrandt & Gröschke (1995) for the Tarapacá Basin and Parent (2006) for the Neuquén (or Neuquén-Mendoza) Basin with the Primary Standard Chronostratigraphic Scale. Lower and lower Middle Callovian zonation of the Neuquén Basin after Riccardi et al. (1989) and Garrido & Parent (2013).

Fig. 38. Chronostratigraphic scale of ammonite zones proposed for the Callovian-Oxfordian interval in the Neuquén and Tarapacá basins. The ammonite horizons indicated have been recognized only in some localities of the Neuquén Basin. See text for further explanation.

the lower flank from the adult phragmocone onwards and by the secondaries being finer than the primaries (Fig. 36B_1, C_2), sweeping forwards on the venter (Fig. 36B_2, C_1). The polyfurcate ribbing of the outer whorls of *A. reyesi* [m] (Fig. 36A_1) has a similar appearance to that of *V. palmicostatus* n. gen. et n. sp., but the latter has primaries stronger and well differentiated from the finer secondary ribbing (Fig. 36B_1, C_2).

Occurrence: *V. palmicostatus* n. gen et n. sp. occurs in the Vega de la Veranada section levels VV-M-17-18, Pressulus Z., Lower Oxfordian.

4. Chronostratigraphic scale for the Andean Callovian-Oxfordian

Hillebrandt & Gröschke (1995) proposed a chronostratigrahic scale of ammonite zones for the Upper Callovian-Lower Oxfordian of northern Chile (Tarapacá Basin), whereas Parent (2006) proposed a different scale for the Neuquén Basin and correlated both scales (Fig. 37). This later zonation has been proven useful in recent studies in Sierra de Reyes (Veiga et al. 2011), Picún Leufú (Garrido & Parent 2013), and Portada Covunco (not yet published). The relatively broad interval covered by the Patagoniensis and Pressulus zones has yielded only few ammonites leading to a subdivision of the Upper Callovian-Lower Oxfordian in only these two zones. The studied section at Vega de la Veranada is exceptional in this sense as there are several levels rich in ammonites in this interval (Fig. 3). Collections in the last years, new studies published around the world, and the ammonite fauna described above allow to compare both scales more closely. The result of this comparison after a revision of the age of the guide ammonites, allows the merging of both former zonations into a more complete scheme proposed herein, which then will be useful in both basins.

The zonation proposed for the Andean Callovian-Oxfordian of the Neuquén and Tarapacá basins is shown in Fig. 38. It consists of the use of the Primus, Dimorphosus and Eugenii zones as divisions (and replacement) of the upper part of the Patagoniensis Z. and lower part of the Pressulus Z. which is now considered to be restricted to the Cordatum Z. in age.

The Patagoniensis Zone in its type locality, Manzano Escondido (Fig. 1A), contains ammonites not older than the Athleta Z., in a sequence of three ammonite biohorizons (from below: *patagoniensis* Hz., c*hoffatia* Hz. and *hecticoceras* Hz.; see Parent 2006, Garrido & Parent 2013) which is correlated or equivalent to the "Athleta" Z. of Hillebrandt & Gröschke (1995). The former extension of the Patagoniensis Z. into the Lamberti Z. (Parent 2006: fig. 48) was merely conventional, since there were no good ammonite-bearing horizons recorded from these levels.

The Primus Z. can be correlated mainly with the Lamberti Z. (Hillebrandt & Gröschke 1995), although its lower part could even belong to the upper part of the Athleta Z., considering the occurrence of *Binatisphinctes binatus* (Leckenby, 1859 in Hillebrandt & Gröschke 1995: pl. 6, figs. 7-8), *Peltoceratoides* cf. *schroederi* (Prieser, 1937 = *Peltoceratoides*? sp. in Hillebrandt & Gröschke 1995: pl. 2, figs. 2, ?5; see Bonnot & Cariou 1999) and *Distichoceras* (see Fortwengler et al. 2012).

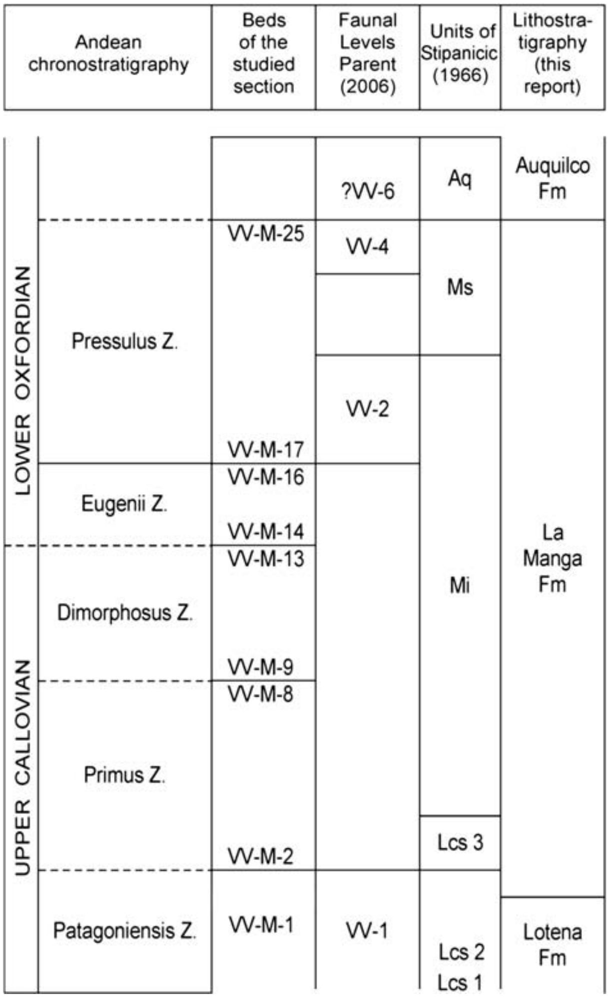
The Dimorphosus Z. is herein correlated with the upper Lamberti Z., mainly by the constraint of the Mariae Z. age of the next overlying Eugenii Z.

The Eugenii Z. was correlated by Hillebrandt & Gröschke (1995) with the Cordatum Z. Nevertheless, on the basis of recent studies of well constrained ammonite successions from France, Bonnot et al. (1997), Bonnot et al. (2002) and Fortwengler et al. (2012) have shown that *P. eugenii* is mainly confined to the lower Mariae Z. (see above, under *P.* cf. *eugenii*). The ammonites associated with *P. eugenii* (including its microconch *R. ballenaensis*) in Portezuelo Azabache/Cerro La Ballena are indeterminate oppeliids, eurycephalitines, reineckeiids and, according to Hillebrandt et al. (2000: 67), *Euaspidoceras* cf. *freii* (Jeannet, 1951), all of which do not help in correlation. The specimens of *P. eugenii* in Hillebrandt & Gröschke (1995) compare well with the material from France. Thus, although there could be some small difference in the age of the local representatives, we follow Fortwengler et al. (2012) in correlating the Eugenii Z. with the Mariae Z.

The Pressulus Z. in its type locality, Chacay Melehué-Rahuecó (Fig. 1), contains the time-diagnostic ammonites *P. pressulus* and *Prososphinctes* gr. *mazuricus*/*matheyi* which are closely comparable with Tethyan species of the Cordatum Z. (see Parent 2006: 57, and discussion above; Fortwengler et al. 2012). The range of the zone is now more firmly established from the material described above and correlated with the Cordatum Z.

The Dunkeri Z. can not be correlated with confidence because of the scarce ammonite bearing-horizons within the sections studied by Hillebrandt et al. (2000: 69). However, this zone has not been recognized in the Neuquén Basin by which Parent (2006) correlated it tentatively with the uppermost Cordatum Z., whereas Hillebrandt et al. (2000) considered it could range up into the lowermost Plicatilis Z. In Fig. 38 the Dunkeri Z. has been indicated tentatively as part of, or equivalent to, the upper Pressulus Z.

The "Transversarium Z." of Hillebrandt & Gröschke (1995; see also Hillebrandt et al. 2000) can be correlated with the Pseudokranaus and Passendorferia zones. The Pseudokranaus, Passendorferia, Tarapacaense and Desertorum zones have been correlated with the Plicatilis, Transversarium, Bifurcatus and Bimammatum-Planula (pars) zones, respectively, of the Primary Standard (see Parent 2006). For the Middle Callovian we follow the scheme of Hillebrandt & Gröschke (1995) with a "Jason Zone" and a "Coronatum Zone", poorly recorded in both basins, especially in the Neuquén Basin where they are mostly represented by the evaporitic Tábanos Fm. The zonation of the Lower Callovian follows the scheme of Riccardi et al. (1989) slightly modified by Garrido & Parent (2013: fig. 18).



Andean chronostratigraphy		Beds of the studied section	Faunal Levels Parent (2006)	Units of Stipanicic (1966)	Lithostratigraphy (this report)
LOWER OXFORDIAN			?VV-6	Aq	Auquilco Fm
	Pressulus Z.	VV-M-25 VV-M-17	VV-4 VV-2	Ms Mi	La Manga Fm
	Eugenii Z.	VV-M-16 VV-M-14		Mi	
UPPER CALLOVIAN	Dimorphosus Z.	VV-M-13 VV-M-9		Mi	
	Primus Z.	VV-M-8 VV-M-2		Mi Lcs 3	
	Patagoniensis Z.	VV-M-1	VV-1	Lcs 2 Lcs 1	Lotena Fm

Fig. 39. Chronostratigraphic correlation of the studied section with the former "faunal levels" of Parent (2006), the units of Stipanicic (1965) and the lithostratigraphic succession adopted in this paper.

5. Biostratigraphy of the studied section

The biostratigraphy of the La Manga Fm at Vega de la Veranada and the several closely related localities of the Sierra de Reyes (Fig. 1) was studied by Groeber (1953), Stipanicic (1965), Stipanicic et al. (1976), Riccardi & Westermann (1991), and Parent (2006). Groeber (1953) assigned the La Manga Fm to the Oxfordian in broad terms, based on the ammonites of this formation in Arroyo de la Manga described by Stipanicic (1951).

In a broad and detailed survey of the Vega de la Veranada area, Stipanicic (1965) assigned the La Manga Fm (his units Mi and Ms) to the interval Cordatum-Transversarium zones. This was based on the lists of ammonites given in that paper (unfortunately unfigured) and partial comparisons with the fauna described in Stipanicic (1951). The ammonites listed by Stipanicic (1965: 417-420, fig. 5) for his unit Lcs can be clearly attributed to the Patagoniensis and Primus zones (Fig. 39). Later, Stipanicic et al. (1976) resumed the faunal lists and described only the ammonites which they assigned to the genus *Araucanites*. Then they restricted the age of the La Manga Fm to the interval Cordatum?-Plicatilis zones.

Parent (2006) described additional ammonites and assigned the La Manga Fm in Vega de la Veranada to the Lower Oxfordian-lower Middle Oxfordian interval, Pressulus-Pseudokranaus zones (his "faunal levels VV-2 and VV-4"). The new bed-by-bed collections together with the detailed stratigraphic study of the Vega de la Veranada section presented in this report allow a much finer subdivision based on the several sampled ammonite levels from which the previous classification (Figs. 38-39) can be revised. Many of the ammonite bearing-horizons of the studied section seem to be not recorded in other studied localities of the Neuquén Basin. These ammonites are thus important for correlation for they include: (a) ammonites known in the Tarapacá Basin which are recorded for the first time in the Neuquén Basin by similar forms (*P.* cf. *eugenii* and *R.* cf./aff. *patagoniensis* transitional to *Jaspeiceras*), and (b) ammonites new for both basins which can be more or less closely compared with European species supporting time-correlation with the Primary Standard Chronostratigraphic Scale (*H.* aff. *lairense*, *C.* cf. *falloti*, *C.* cf. *poculum*, *N. girardoti, E.* cf. *subbabeanum,* and *E.* cf. *depereti*). The comparison is the most valuable when based on similarities of the ammonite assemblages and, especially, considering their successions.

The chronostratigraphic classification of the studied section (Figs. 3, 39) is referred to the new zonation discussed above (Fig. 38) and based as far as possible on the ammonite associations on the type section of the respective zones:

Patagoniensis Zone – Bed VV-M-1 (base of the section): We have not found new fossils in this bed. It corresponds to the "faunal level VV-1" in Parent (2006: fig. 14) with *Choffatia* sp. B (= *Choffatia* cf. *isabellae* Bonnot et al., 2008 in Garrido & Parent 2013), *Pseudopeltoceras* cf. *chauvinianum* (d'Orbigny, 1847), *Rehmannia patagoniensis* and *Araucanites prereyesi*. This level most likely represents the *choffatia* Hz. of the Patagoniensis Z. The *hecticoceras* Hz. does not seem to be represented, indicating a non-sequence between the levels VV-M-1 and VV-M-2.

The association of the unit Lcs-2 of Stipanicic (1965: 420) apparently composed exclusively of variants of *Rehmannia patagoniensis* could be tentatively assigned to the *patagoniensis* Hz. of the Patagoniensis Z. This horizon is the standard base of the Patagoniensis Z. (Garrido & Parent 2013).

Primus Zone – Beds VV-M-2-8: The basal bed VV-M-2 yielded ammonites suggesting correlation with the Primus Z. Especially significant is *R*. cf./aff. *patagoniensis* (Fig. 6C-D) which is very closely comparable, probably conespecific, with *Reineckeia* s.l. n. sp. A (in Hillebrandt & Gröschke 1995: pl. 6, fig. 11) from the Primus Z. in Cerro Paisaje (Tarapacá Basin). *C*. cf. *falloti* supports time-correlation with the the Lamberti Z. The association of the unit Lcs-3 of Stipanicic (1965: 420) could likely belong to the lower part of this zone.

schilleri **Horizon (new), bed VV-M-2**: This conspicuous bed includes several ammonite species (*H*. aff. *lairense*, *Choffatia schilleri* n. sp., *C*. cf. *falloti*, and *R*. cf./aff. *patagoniensis*) which form an assemblage well characterized by macroconchs not known from other levels. It seems useful to consider this bed as a new bio-horizon, the *schilleri* Hz. It is possible that the stratigraphic position of this horizon is near or at the base of the Primus Z., considering the close affinity of some of its ammonites with those of the Patagoniensis Z.

Dimorphosus Zone – Beds VV-M-9-13: Fauna: *Araucanites reyesi* [M&m], *Choffatia* cf. *poculum*, *Euaspidoceras* cf. *depereti*, and "*Perisphinctes*" cf. *hillebrandti*. These beds are tentatively assigned to the Dimorphosus Z. *C*. cf. *poculum* is, as discussed above, likely Lamberti Z. in age as assumed for the Dimorphosus Z. *A*. *reyesi* is supposed to have evolved from *A*. *prereyesi*, whose holotype comes from the Dimorphosus Z. of Cerro Amarillo (Tarapacá Basin).

Eugenii Zone – Beds VV-M-14-16: Fauna: "*Perisphinctes*" n. sp. A, *Vinalesphinctes* n. sp. A, *Peltoceratoides* cf. *eugenii*, *Euaspidoceras* cf. *subbabeanum*, *Euaspidoceras ajax*, *Neoprionoceras girardoti*, and *Peltoceratoides pressulus* (only a poor specimen). These beds are tentatively assigned to the Eugenii Z. considering the occurrence of *P*. cf. *eugenii* in beds VV-M-14-15 underlying the levels with abundant fauna of the Pressulus Z.

Pressulus Zone – Beds VV-M-17-23: Fauna: "*Perisphinctes*" n. sp. A., *Vinalesphinctes* n. sp. A, *Euaspidoceras ajax*, *Neoprionoceras girardoti*, *Peltoceratoides pressulus*, *Lissoceratoides erato*, *Veranadaites palmicostatus* n. gen. et n. sp., *Euaspidoceras veranadaense*, *Subvinalesphinctes*? sp. A and *Cubasphinctes herreroduclouxi*. This assemblage includes the characteristic guide ammonites of the Pressulus Z. (Parent 2006). The uppermost ammonite recorded in our sampling is a fragmentary, large *P*. *pressulus* in the bed VV-M-23.

pressulus **Horizon (new), bed VV-M-17**: this bed is remarkable for the diversity and abundance of fossils including a specimen of *Retroceramus galoi* (Boehm, 1907), belemnites (to be described elsewhere) and the following ammonites: "*Perisphinctes*" n. sp. A., *Vinalesphinctes* n. sp. A, *E*. *ajax*, *E*. *veranadaense*, *N*. *girardoti*, *P*. *pressulus*, *L*. *erato*, and *Veranadaites palmicostatus* n. gen. et n. sp. This association is exclusive of this level and its ammonites are well characterized, thus suitable for proposing a new bio-horizon, the *pressulus* Hz. This bio-horizon forms the base of the Pressulus Z. in the studied section, therefore, the bed VV-M-17 – *pressulus* Hz. is herein designated as the standard base of the Pressulus Z.

?Pressulus Zone – Beds VV-M-24-25 (top of the section): No fossils were found in these beds which could likely belong to the Pressulus Z. Nevertheless, Stipanicic (1965) indicated that throughout his entire unit Ms (i.e. our levels VV-M-21 to VV-M-25, see Fig. 39) *Perisphinctes* (*Kranaosphinctes*) sp. and *Perisphinctes* (*Arisphinctes*) sp. occur. These perisphinctids nominally would indicate some part of the interval Cordatum-Plicatilis zones (Lower-Middle Oxfordian), roughly equivalent to the interval Pressulus-Pseudokranaus zones. Thus, although his indication is rather loose for a bed-by-bed sampling approach, we can not disregard the possibility that the uppermost levels of the La Manga Fm in Vega de la Veranada could range up into the Pseudokranaus Z. (lower Middle Oxfordian).

6. Conclusion

The La Manga Fm in Vega de la Veranada, as delimited in the present report (Figs. 2-3), is assigned to the interval Upper Callovian-Lower Oxfordian in age (Fig. 39), stratigraphically older than previously assumed (e.g., Stipanicic 1965; Stipanicic et al. 1976; Parent 2006). The uppermost levels could be lowermost Middle Oxfordian (Pseudokranaus Z.) but there is not clear evidence.

The ammonite fauna, sampled bed-by-bed, shows a moderate diversity including 20 species (13 are new for the Neuquén Basin) belonging to 14 genera. *Araucanites reyesi* [M&m] was collected from beds assigned to the Upper Callovian in Vega de la Veranada, although could range higher (Early Oxfordian) in the Sierra de Reyes where the material has been collected on which the genus was originally based.

The strongest affinity of the fauna (number of common genera) as a whole is with the Western Tethys. Several perisphinctids of the Vinalesphinctinae have been recorded in beds of the Eugenii and Pressulus zones (Lower Oxfordian). These records and those in Parent (2006) and Parent et al. (2006) are the oldest known for the *Cubasphinctes* and *Subvinalesphinctes-Vinalesphinctes* lineages, strongly suggesting they both originated in the Andean region, expanded through the Caribbean (Cuba and Mexico) region during the early Middle Oxfordian, and developed up to the late Middle Oxfordian in both domains.

The ammonite succession of the studied section and the revision of the time-correlation of the Andean successions with the Primary Standard Chronostratigraphic Scale indicates that differences between the Callovian-Oxfordian faunas of the Neuquén Basin and Tarapacá Basin would be mainly due to the different ages of the horizons usually recorded (Parent 2006: fig. 48) rather than biogeographic differentiation.

An ammonite zonation for both basins is proposed (Fig. 38) with the Primus, Dimorphosus, and Eugenii zones between the Patagoniensis and Pressulus zones. These two latter zones are thus reduced from the range of their original definition.

Two new horizons are introduced: the *schilleri* Hz. (new) assigned tentatively to the Primus Z. (Upper Callovian), and the *pressulus* Hz. (new) assigned to the Pressulus Z. (Lower Oxfordian). The Pressulus Zone is standarized by designation of the *pressulus* Hz. as its base.

Acknowledgements

Gerd E.G. Westermann (Ontario), Alain Bonnot (Dijon), Günter Schweigert (Stuttgart), Mikhail Rogov (Moscow), Annette Kossler (Berlin), Matthias Alberti (Kiel), Wojciech Brochwicz-Lewinski (Warszaw), Philippe Courville (Rennes), and Axel Hillebrandt (Berlin) for valuable discussion and/or important information and literature. Dirección Provincial de Minería (Gobierno de la Provincia del Neuquén) and Facultad de Ingeniería (Universidad Nacional de Rosario) funded the field works. Matthias Alberti (Kiel) and a second, anonymous referee have provided valuable reviews on the manuscript.

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Manuscript received: July 7th, 2014.
Revised version accepted by the Stuttgart editor: October 27th, 2014.

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