

ANDEAN LOWER TITHONIAN (PICUNLEUFUENSE ZONE) AMMONITES AND APTYCHUS FROM ESTANCIA MARIA JUANA, SOUTHERN NEUQUÉN BASIN, ARGENTINA

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Boletín
del Instituto de
Fisiografía y Geología

Parent H., Garrido A.C., Schweigert G. & Scherzinger A., 2013. Andean Lower Tithonian (Picunleufuense Zone) ammonites and aptychus from Estancia María Juana, Southern Neuquén Basin, Argentina. *Boletín del Instituto de Fisiografía y Geología* 83: 27-34. Rosario, 27-12-2013. ISSN 1666-115X.

Abstract: The ammonite fauna of the Lower Tithonian of the locality Estancia María Juana, southern Neuquén Basin is described for first time. The studied material was collected from the Portada Covunco Member (lower part of the Vaca Muerta Formation) which consists of finely sandy shaly marls with large concretions containing abundant crushed ammonites, aptychi, bivalves and gastropods. The ammonites belong to the species *Choicensisphinctes platyconus* and *Lithacoceras picunleufuense* transient, indicating the *picunleufuense* Horizon, which is the base of the Lower Tithonian Picunleufuense Standard Chronostratigraphic Zone. Middle Tithonian ammonites occur as poorly preserved specimens of *Catutosphinctes* in calcareous sandstones.

An aptychus, collected from a concretion, among the bulk of *Choicensisphinctes platyconus* is of the Praestriptychus-type and is concluded it belongs to this ammonite. This association gives additional support to the hypothesis on the origin of *Choicensisphinctes* from *L. picunleufuense* in the Late Kimmeridgian or earliest Tithonian.

The concretions of the *picunleufuense* Horizon are interpreted as late diagenetic, showing that this kind of concretions are among the few marine sedimentary settings where ammonites with their aptychus in-situ could have been preserved.

Key-words: Ammonoidea; Argentina; Tithonian; Picunleufuense Zone; Praestriptychus; Late diagenetic concretions.

Resumen: Amonites y aptychus del Tithoniano Inferior andino (Zona Picunleufuense) de Estancia María Juana, sur de la Cuenca Neuquina, Argentina. Se describe por primera vez la fauna de amonites del Tithoniano Inferior de la localidad denominada Estancia María Juana situada en el Sur de la Cuenca Neuquina. El material estudiado fue colectado en niveles del Miembro Portada Covunco (parte inferior de la Formación Vaca Muerta) que consiste en margas pizarrosas finamente arenosas con grandes concreciones conteniendo abundantes amonites aplastados en grado variable, aptychi, bivalvos y gastrópodos. Los amonites corresponden a las especies *Choicensisphinctes platyconus* y *Lithacoceras picunleufuense* transient, los cuales indican el Horizonte picunleufuense, el cual es la base de la Zona Cronoestratigráfica Estándar Picunleufuense, base del Tithoniano Inferior andino. Amonites del Tithoniano Medio ocurren como especimens pobremente preservados del género *Catutosphinctes* en niveles de areniscas calcáreas.

Entre el abundante material de *Choicensisphinctes platyconus*, un aptychus muy bien preservado fué extraído de una concreción. Este aptychus es del tipo Praestriptychus, y luego del estudio tafonómico y taxonómico se ha concluído que corresponde a *C. platyconus*. Esta asociación se considera evidencia adicional para la hipótesis sobre el origen de *Choicensisphinctes* a partir de *L. picunleufuense* en el Kimmeridgiano tardío o Tithoniano temprano.

Las concreciones del Horizonte picunleufuense son interpretadas como estructuras formadas durante las fases tardías de la diagénesis, lo cual indica que este tipo de concreciones sería uno de los pocos arreglos sedimentarios marinos donde se habrían preservado amonites con sus aptychus in-situ.

Palabras clave: Ammonoidea; Argentina; Tithoniano; Zona Picunleufuense; Praestriptychus; Concreciones de diagénesis tardía.

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Received: 13/06/2013; accepted: 08/10/2013

Editor: Eduardo P. Peralta

INTRODUCTION

The Andean Neuquén Basin is emplaced through W-Central Argentina and a small part of Central Chile. Its southern end is delimited by a distinctive basement structure called the Huincul Arch (Dorsal de Huincul, see Fig. 1; De Ferraris 1947). This sector of the basin is usually denominated Picún Leufú Sub-Basin and has a Tithonian marine record of variable thickness, mainly represented by the Vaca Muerta, Carrín Curá, and Picún Leufú formations. The latter two units pass gradationally from the bituminous sandy shales and calcareous ne-grained sandstones of the Vaca Muerta Fm into near-shore green sandstones and platform limestones respectively (Leanza & Hugo 1997, Leanza et al. 2003).

The lowermost Tithonian, typically represented in the Picún Leufú Sub-Basin by the Portada Covunco Mb of the Vaca Muerta Fm (Parent et al. 2013), is well characterized by an ammonite assemblage widely recorded throughout the basin, lying below the so called “Mendozanus Zone” (Parent, Garrido et al. 2011). Hitherto this latter zone was considered representing the earliest part of the Tithonian in the basin and correlated with the Darwini Zone or time-equivalent units of Europe (e.g., Leanza 1981 and references therein). These ammonites conform the guide-assemblage of the Picunleufuense Standard Chronostratigraphic Zone (Picunleufuense Z. hereafter) in Picún Leufú (Fig. 1) with the *picunleufuense* Horizon as its base, likely more or less equivalent to the base of the Hybonotum Zone in the Tethys and adjacent Submediterranean. The guide assemblage of the *picunleufuense* H. consists of the species *Lithacoceras picunleufuense* transient, *Choicensisphinctes platyconus*, *Catutosphinctes guenenakenensis* (the three taxa defined in Parent, Garrido et al. 2011) and *Cieneguiticeras perlaevis* (Steuer, 1897; see Parent et al. 2010).

C. platyconus is considered as the earliest representative of the genus and most likely originated from *L. picunleufuense* (Parent, Garrido et al. 2011). Evidence supporting this relation comes both from morphologic resemblance and geographic and stratigraphic co-occurrence. The aptychi of the Tethyan Lithacoceratinae are rather well known (Oppel 1863, Schweigert 1998, 2000) and it has been argued recently that aptychi are multifunctional organs of high taxonomical value in Ammonoidea systematics (Parent et al. in print). Thus, the recognition of the aptychi of *Choicensisphinctes* would be an important additional evidence for its relation.

We have sampled the Tithonian rocks of the Vaca Muerta Fm in the locality known as Estancia María Juana (EMJ hereafter; see Fig. 1), south of Cordón de la Piedra Santa (see Leanza et al. 2003: fig. 2). Only beds of the Lower Tithonian Picunleufuense Z. have yielded ammonites in abundance, mainly *L. picunleufuense*, *C. platyconus* and a well preserved aptychus (*Praestriptychus*) beside others preserved as fragments. The purpose of this report is to describe this material, mainly the monotypic assemblage of *C. platyconus* to which the aptychus is assigned. The age of the Portada Covunco Mb (lower Vaca Muerta Fm) in the study area and the taphonomy and implications in the preservation of aptychi are discussed.

STRATIGRAPHY

The study area is located in the southern Neuquén Basin

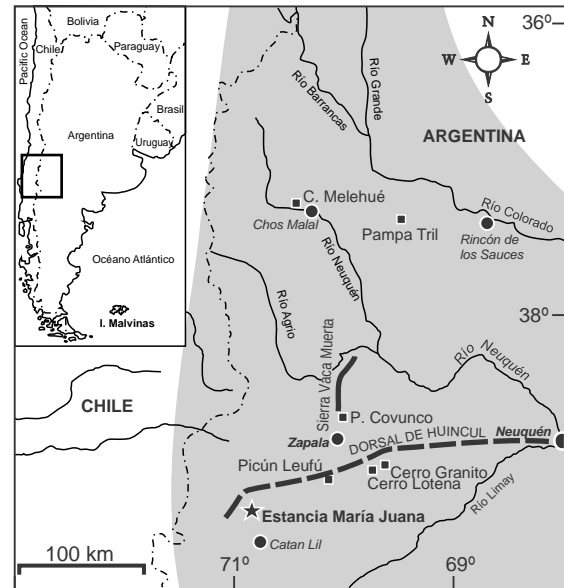


Figure 1. Southern Neuquén Basin (gray area) with indication of the studied locality Estancia María Juana (marked with a star) and others cited in text (modified from Parent et al. 2013).

(Fig. 1), in the region called Fortín 1° de Mayo. The geology of this region and its environs has been studied by Groeber (1918, 1929), Digregorio (1972), Turner (1973, 1976), Leanza & Leanza (1979) and Leanza (1992), among others. More recently Leanza et al. (2003) have published a detailed geological description.

The outcrops of the Vaca Muerta Fm in the studied locality are mostly covered by modern sediments. Only the basal beds of this unit (latest Kimmeridgian?-lower Tithonian) have provided fossils moderately abundant and well preserved, although they are crushed. The lithology of the Middle Tithonian, which outcrops poorly in the studied locality, consists of sandstones with very scarce and poorly preserved specimens of *Catutosphinctes* sp. in isolated concretions. The Upper Tithonian was not recognized in our sampling area. The main lithological features and fossils are as follows (Fig. 2), from below:

- From the calcareous bed EMJ-1 (0.1 m) comes a specimen of *Choicensisphinctes platyconus*, the only fossil observed.
- From the finely sandy, shaly marl bed EMJ-2 (0.8-1.0 m) comes the bulk of the material described, consisting of *C. platyconus* only. Additionally there occur: (1) abundant small oysters, loose and adhered to the flanks of outer whorls and the umbilicus of almost all the ammonites, (2) abundant fragments of indeterminate bivalves, and (3) sparse adult and juvenile specimens of the gastropod *Exelissa? arcuatoconcava* Gründel & Parent, 2001.
- The bed EMJ-3 (0.05 m) is a thin bank of unfossiliferous sandstone.
- From the finely sandy, shaly marl bed EMJ-4 (0.1-0.2 m) comes abundant but fragmentary *L. picunleufuense* transient, conforming also in this case a monotypic assemblage.
- The beds EMJ-1-EMJ-4 can be attributed to the Lower Tithonian Picunleufuense Zone, discussed below. The upper part of the studied section is poorly exposed and the lithology differs significantly. Above the bed EMJ-4 follow finely sandy siltstones (EMJ-5) which are mostly covered

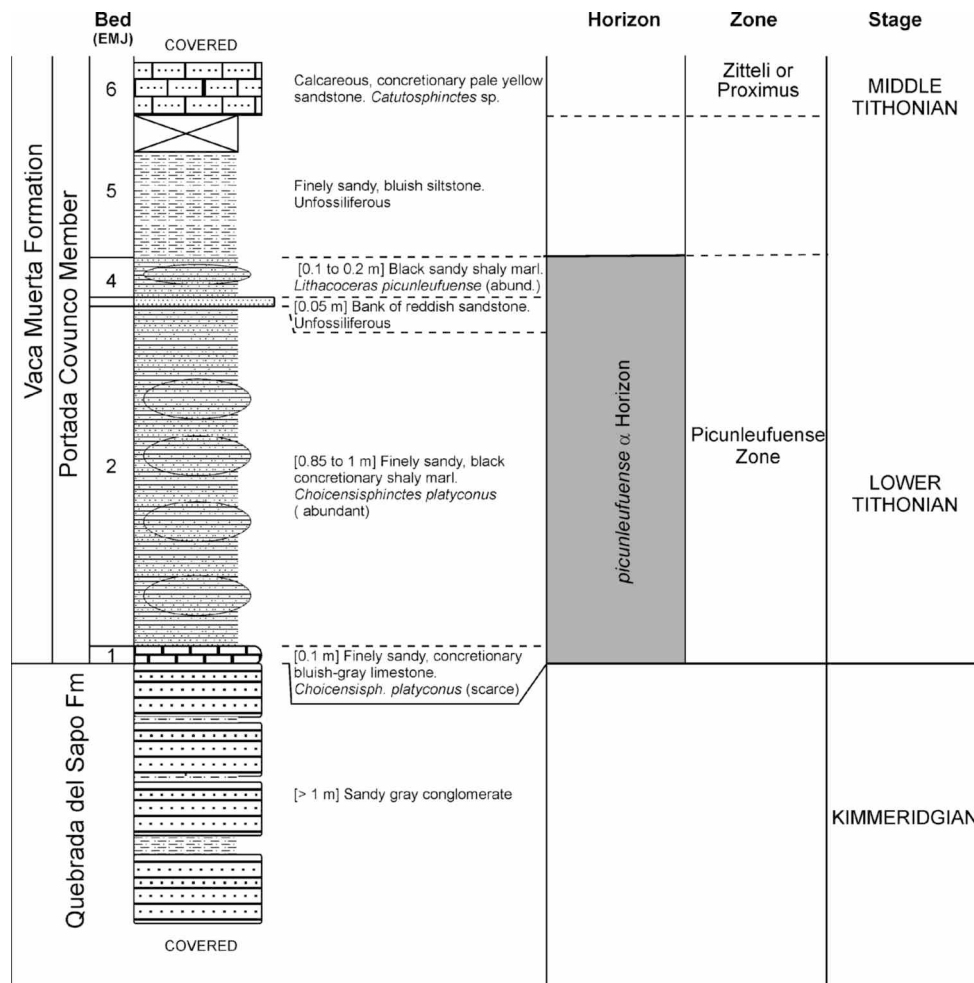


Figure 2. Log-section, fauna and litho- and chronostratigraphic classifications of the studied outcrop at Estancia María Juana. Beds cited in the text with the number preceded by the abbreviation of the locality name: EMJ. Local chronostratigraphic classification based on Leanza (1981) and Parent, Garrido et al. (2011). Broken lines indicate non-standard boundaries or tentative correlations.

and unfossiliferous. The top of the section is observed in a nearby exposure at the opposed hill, consisting of a thick transect of calcareous sandstones with concretions (EMJ-6) yielding scarce and poorly preserved specimens of *Catutosphinctes* sp. suggesting the Zitteli or Proximus zones of the Middle Tithonian.

Taphonomy of ammonites and aptychi from bed EMJ-2

The large concretions of bed EMJ-2 are ellipsoidal with the major axis parallel to the bedding plane; the layers inside and outside are planar and run parallel to the surrounding sediment layers, with no deformation inside or outside. The ammonites occur mostly as crushed impressions and in some cases with most of the test lost. The aptychus preserves the calcitic mineralized sheet. Oyster shells are abundant and well preserved. Those attached to ammonites are the smaller ones and partially crushed. Outside of the concretions ammonites and oysters are rather scarce but preserved under identical conditions; such oysters are mostly uncrushed.

Ammonite shells had been originally chiefly aragonitic,

whereas the corresponding aptychi had been calcitic (e.g. Hall & Kennedy 1967). Oyster shells are mostly calcitic although aragonite can be also present in some species (Stenzel 1971). These bivalves attach, invariably by their left valve, at least during early life cycle, whereas adults mostly have a free life-style (Stenzel 1971).

After deposition, compaction of sediments would have crushed most of the fossils and during early diagenesis the aragonite of the ammonite shell has been replaced by calcite, considering that aragonite is much more soluble than calcite. Oysters would have not been dissolved significantly because of their calcitic composition. Following Marshall & Pirrie (2013) it can be interpreted that these concretions were formed during late diagenesis. Late diagenetic concretions would have enabled the preservation of aptychus and ammonite shells together.

SYSTEMATIC PALAEONTOLOGY

Conventions.- The described material is housed in the

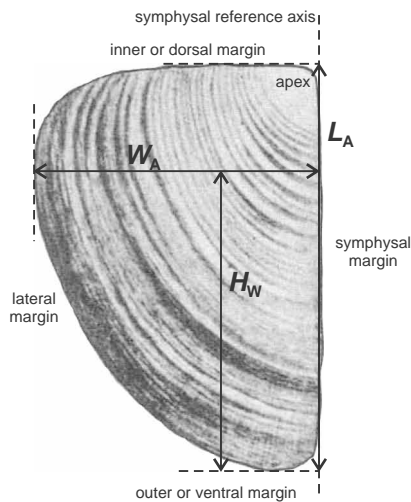


Figure 3. Dimensions of aptychus (see text). Adult valve (last folds or ribs crowded) of the Praetriptychus of a *Lithacoceras* sp., re figured from Oppel (1863: pl. 74: 2).

collections of the Museo Provincial de Ciencias Naturales “Prof. Dr. Juan A. Olsacher”, Zapala (MOZ-PI); collection numbers of the figured specimens are given in the figure captions. Macroconch (female): [M], microconch (male): [m]. Dimensions measured: diameter (D), diameter at the last adult septum (D_{is}), final adult diameter at peristome (D_p), umbilical width (U), whorl width (W), whorl height (H_1), and whorl ventral height (H_2), all given in millimeters [mm]. Number of primary (P) and ventral (V) ribs per half whorl. Dimensions of the aptychi (Fig. 3) are indicated as defined by Trauth (1930, 1931), on the basis of a reference axis along the symphysis to refer orthogonal dimensions of the maximum length (L_A), maximum width (W_A) and its height on the symphysis axis (H_w).

Superfamily Perisphinctoidea Steinmann, 1891
Family Ataxioceratidae Buckman, 1921
Subfamily Lithacoceratinae Zeiss, 1968

Genus *Lithacoceras* Hyatt, 1900

Type species: *Ammonites ulmensis* Oppel, 1858; by OD.

***Lithacoceras picunleufuense* Parent, Garrido,
 Schweigert & Scherzinger, 2011**

Remarks.- For synonymy see Parent, Garrido et al. (2011). This species, only recorded from bed EMJ-4, occurs in abundance and forms a monotypic assemblage, but the specimens are very fragmentary. The style and density of ribbing and the involution allow to identify the species clearly and to discriminate it as the early transient. The species ranges all throughout the Picunleufuense Zone all along the Neuquén Basin; in some localities, e.g. Pampa Tril (description to be published elsewhere), it can be observed a succession of several morphotypes or transients.

Genus *Choicensisphinctes* Leanza, 1980

Type species: *Perisphinctes choicensis* Burckhardt, 1903; by OD.

***Choicensisphinctes platyconus* Parent, Garrido,
 Schweigert & Scherzinger, 2011**

Fig. 4A-G

Synonymy.- See Parent, Garrido et al. (2011).

Material.- Twenty specimens from concretions of bed EMJ-2, all of them more or less crushed: 5 microconchs, 14 macroconchs, 1 aptychus. A well preserved adult macroconch from bed EMJ-1.

Description.- Shell. Macroconch: largest adult preserved at $D = 123$ mm with half whorl of bodychamber (Fig. 4A); estimated $D_p = 150$ mm. Phragmocone moderately involute and densely ribbed. Primary ribs arise from the umbilical wall being slightly curved forward on the lower third of the whorl, wherefrom they divide into two or three secondaries. From about $D = 30$ -50 mm the ribbing is more irregular and some isolated virgatomes and polyschizotomes appear, generally associated with constrictions (Fig. 4A, F). The adult bodychamber is covered by strong and slightly prosocline primaries which, on the middle of the whorl, divide into sheaves of 6-12 very fine secondaries that cross the venter evenly spaced but fade out towards the peristome. The specimen shown in Fig. 4A has $P = 12$ at $D = 103$ mm.

The specimen from bed EMJ-1 is the only one preserved three-dimensionally (Fig. 4G). It consists of a macroconch with the beginning of the bodychamber slightly uncoiled and strongly varicostate towards the peristome (Fig. 4G₃). The whorl section is subrectangular to suboval, higher than wide, with well rounded venter. Behind the last septum there are two closely spaced transitional or preadult peristomes (Fig. 4G₂, arrows). At last septum: $D_{is} = 60$ mm, $U/D = 0.30$, $W/D = 0.30$, $W/H_1 = 0.78$.

Microconch: Largest specimen $D_p = 77$ mm, with complete bodychamber and lateral lappets (Fig. 4B); about half the size of the adult macroconch. The ornamentation of the phragmocone is identical to that of the macroconch at comparable diameters. The bodychamber remains almost unchanged in sculpture. Close to the peristome develops the complex typical sculpture of the microconchs of the type material of the species. It consists of a varicose primary rib preceded by a virgatome and a well-marked constriction just behind the peristome. Two rather small lateral lappets are projected from the peristomatic border from about the middle of the whorls. The best preserved specimen (Fig. 4B) has $P = 21$ and $V = 80$ at $D = 72$ mm.

Aptychus (Fig. 4C): Both valves well preserved and complete, slightly crushed. The lower face is visible; the outline of each valve is broad subtriangular with a straight symphysis and well-rounded borders. The surface is covered with concentric folds parallel to the lateral margin, reflecting growth steps. All folds are regularly spaced from the apex up to the outer or ventral margin. Dimensions: $L_A = 10$ mm, $W_A = 7$ mm, $H_w = 6$ mm.

Remarks and comparison.- The sample from bed EMJ-2 conforms a monotypic ammonite assemblage with a somewhat lower individual variation than in the coeval material from the type locality Picún Leufú (Parent, Garrido et al. 2011). Indeed, all the specimens from bed EMJ-2 match in every detail of shell-shape and sculpture with the morphotypes B, C or D defined in the lower Picunleufuense Zone, *picunleufuense* Hz. of Picún Leufú (Parent, Garrido et al. 2011: 67, pls. 14-16, 19), including the holotype (a macroconch) and microconchs.

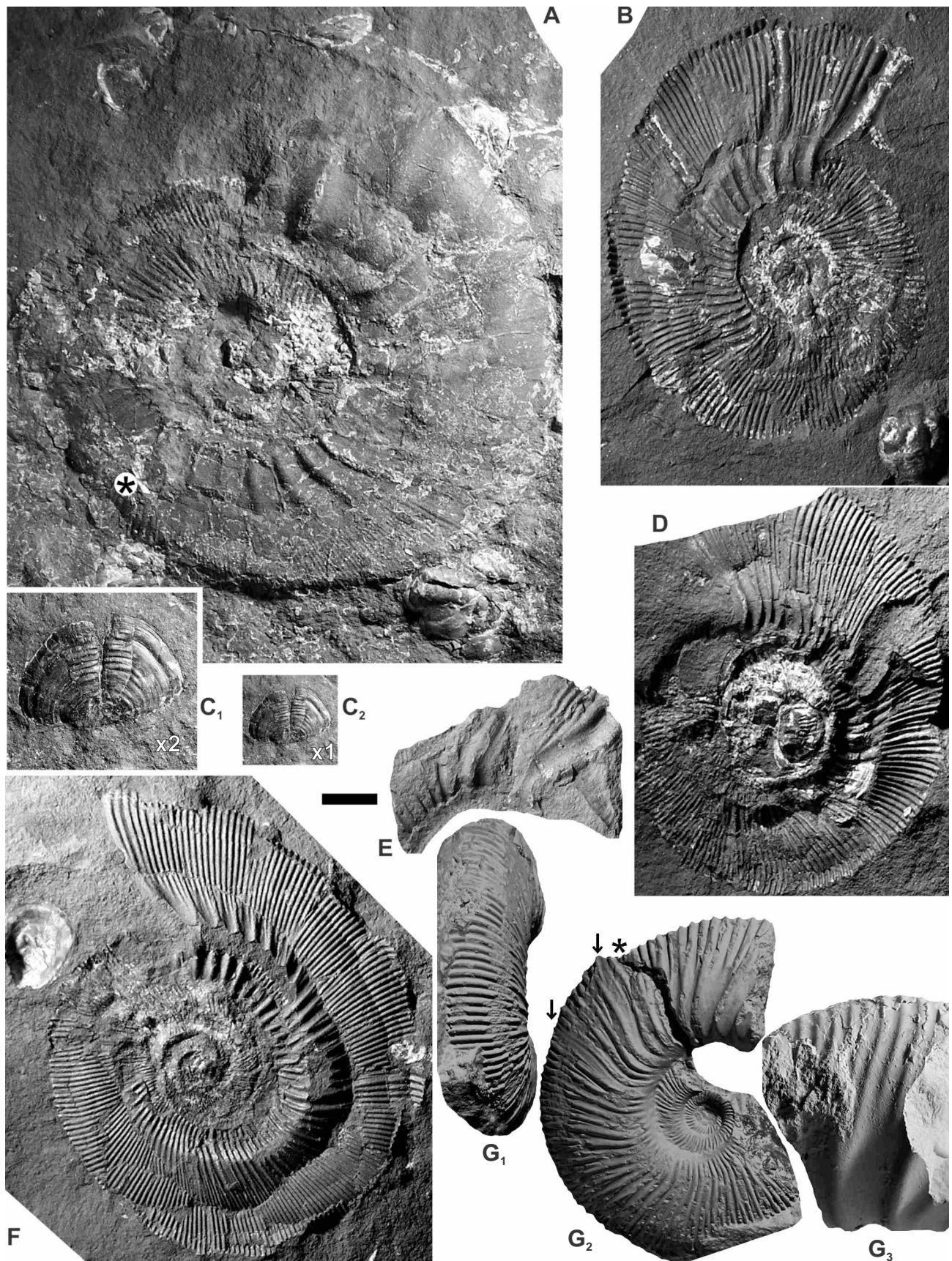


Figure 4. *Choicensisphinctes platyconus* Parent, Garrido, Schweigert & Scherzinger, 2011; Est. María Juana, *picunleufuense* Horizon, Picunleufuense Zone, Lower Tithonian. **A:** Almost complete adult [M] (MOZPI 9573), bed EMJ-2. **B:** Complete adult [m] with lappets (MOZPI 9582), bed EMJ-2. **C:** Aptychus (*Præstriptychus* type) (MOZPI 9586), bed EMJ-2; nat. size (C₂) and double size (C₁) views. **D:** Juvenile [M] (MOZPI 9585) with oysters in the umbilicus, bed EMJ-2. **E:** Peristome of an adult [m] with lappets (MOZPI 9569), EMJ-2. **F:** Juvenile [M] with part of the bodychamber (MOZPI 9572), EMJ-2. **G:** Phragmocone (G₁-G₂) and part of bodychamber (G₃) of an adult [M] (MOZPI 9587), bed EMJ-1; arrows indicate preadult peristomes. All natural size (x1) except C₁ (x2); the bar represents 10 mm length in all cases except C₁. The asterisk indicates the last septum or base of the bodychamber.

The Praestriptychus described was found lying few centimeters besides of a macroconch of *C. platyconus* in the same fracture plane of a large concretion. Correspondence between this aptychus and *C. platyconus* can be assumed since the concretions contain a monotypic assemblage of this ammonite. Moreover, the outline of the two-valved aptychus is with the general outline of *C. platyconus* at about $D = 45\text{--}60$ mm with the arrangement shown by Westermann (1954: g. 32; 1990: g. 5), between the venter of the preceding whorl and the ventral wall of the bodychamber.

The present Praestriptychus is smaller but otherwise indistinguishable from that assigned to *Lithacoceras ulmense* by Oppel (1863: pl. 74: 4; reproduced herein in Fig. 3), and similar to that of *Lithacoceras fasciferum* (Neumayr, 1873) figured by Schweigert (1998: pl. 7: 1) from the Late Kimmeridgian *hoelderi* Hz. of the Nusplingen Plattenkalk, although this latter is almost smooth. The specimen illustrated by Oppel most likely belongs to a *Lithacoceras*, but not to *L. ulmense* as Oppel suggested, because the specimen is from the Solnhofen Lithographic Limestones, where *L. ulmense* does not occur. The Praestriptychus of the corresponding microconchs of *Lithacoceras* (genus *Silicisphinctes* Schweigert & Zeiss, 1998) is very similar to that of the macroconchs but somewhat slender and warped from a shoulder along the growth axis (see Schweigert 1998: pl. 10: 1), suggesting sexual dimorphic differences. Praestriptychus is well-known as belonging to *Lithacoceras/Silicistphinctes* in the late Kimmeridgian and early Tithonian (Trauth 1937, Schweigert 1998) whereas the aptychus of the closely allied early Tithonian *Eurvirgalithacoceras* [M]/*Subplanites* [m] is of the Strigogranulaptychus-type (Schweigert 2000). The association of Praestriptychus with *C. platyconus* is in accord with the proposed origin of the latter from *Lithacoceras*, likely *L. picunleufuense* in the latest Kimmeridgian or earliest Tithonian (Parent, Garrido et al. 2011).

BIOSTRATIGRAPHY AND TIME-CORRELATION

The ammonites described indicate that the base of the Vaca Muerta Fm in the study area belongs to the lowermost Tithonian Picunleufuense (Standard Chronostratigraphic) Zone, *picunleufuense* Hz. (Fig. 2). The present material of *C. platyconus* perfectly matches with the main morphotypes of the species in Picún Leufú, only the rare morphotype A (Parent, Garrido et al. 2011: g. 17) seems to be not represented in our sample. Another species of the characteristic assemblage of this horizon is *L. picunleufuense* transient which occurs in bed EMJ-4. These two ammonites, although occurring in subsequent beds, are considered being an assemblage allowing to recognize the *picunleufuense* Hz., the base of the Picunleufuense Zone. This assignation can be safely assumed because of the matching of the specimens of *C. platyconus* and *L. picunleufuense* (transient with the type material, even when the species of *Catutosphinctes* and *Cieneguiticeras*, which also conform the characteristic assemblages of the horizons of the zone (see Parent, Garrido et al. 2011 and Parent, Scherzinger et al. 2011: g. 40), have not been recorded in beds EMJ-1-EMJ-4. Ammonites of the overlying beds or from the upper part of the section suggest the Zitteli Zone or Proximus zones by the aspect of the poor material assigned to *Catutosphinctes* sp.

Leanza et al. (2003) have indicated the occurrence of a more complete ammonite succession in the area. The oldest ammonites these authors mentioned are *Choicensisphinctes choicensis* and “*Virgatosphinctes*” *andesensis* (Douvillé, 1910), attributed to the “Mendozanus” Zone. This zone is under revision since the assemblage of its nominal species has been recorded as associated with *Pseudolissoceras zitteli* (Burckhardt, 1903), indicative of the overlying Zitteli Zone in several localities within the Neuquén Basin (see discussion in Parent, Garrido et al. 2011 and Parent, Scherzinger et al. 2011). The Zitteli Zone has been indicated by the occurrence of the index species (Leanza et al. 2003) which we have not found. Finally the latter authors have indicated the Proximus Zone by the occurrence of *Catutosphinctes proximus* (Steuer, 1897). This latter species is a perfect representative of the genus *Catutosphinctes* Leanza & Zeiss, 1992 (see Parent, Scherzinger et al. 2011, Parent et al. 2013), assigned by Leanza et al. (2003) to the Indo-Madagascan late Tithonian Himalayitid genus *Aulacosphinctes* Uhlig, 1910.

CONCLUSION

The base of the Vaca Muerta Fm in Estancia María Juana (Picún Leufú Sub-basin, southern Neuquén Basin) contains ammonites diagnostic of the *picunleufuense* Hz.: *Choicensisphinctes platyconus* and *Lithacoceras picunleufuense* transient. This faunal horizon is the base of the Picunleufuense (Standard Chronostratigraphic) Zone at the base of the Andean Lower Tithonian. It is thus older than previously suggested datings by Leanza et al. (2003).

The attribution of Praestriptychus to *Choicensisphinctes*, at least to the early forms, gives clear support to the inclusion of this genus in the subfamily Lithacoceratinae. Moreover, it supports the derivation of *Choicensisphinctes* from *Lithacoceras* as proposed by Parent, Garrido et al. (2011). The segregation of the ammonites of beds EMJ-2 and EMJ-4 in respectively two monotypic assemblages in the short term implied by a faunal horizon, could be due to changes in the local ecological conditions as suggested by the thin bank of sandstone (bed EMJ-3) intercalated.

Late diagenetic concretions seem to be one of the few types of marine sedimentary settings where ammonites with their aptychus in-situ would have been preserved.

Acknowledgements: A. Greco (Universidad Nacional de Rosario, Argentina) and G. Westermann (Burlington, Canada) for discussion and advice. Facultad de Ingeniería (Universidad Nacional de Rosario) and Dirección Provincial de Minería (Gobierno de la Provincia del Neuquén) funded the field work. Vasily Mita (Moscow) and a further anonymous reviewer contributed to enhance the original manuscript as reviewers of the journal.

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