

THE MIDDLE TITHONIAN (UPPER JURASSIC) AMMONOID FAUNA OF CAÑADÓN DE LOS ALAZANES, SOUTHERN NEUQUÉN-MENDOZA BASIN, ARGENTINA.

Horacio PARENT



Boletín
del Instituto de
Fisiografía y Geología

Parent H., 2001. The Middle Tithonian (Upper Jurassic) ammonoid fauna of Cañadón de los Alazanes, Southern Neuquén-Mendoza Basin (Argentina). [La fauna del Tithoniano Medio de Cañadón de los Alazanes, sur de la cuenca Neuquén-Mendoza (Argentina)]. Boletín del Instituto de Fisiografía y Geología, Volúmen 71, Números 1-2, pp. 19-38. Rosario, 25-12-2001. ISSN 1666-115X.

Abstract.- The Middle Tithonian rock and ammonite successions of Cañadón de los Alazanes (southern Neuquén-Mendoza Basin, Argentina), sampled for the first time, correlate almost exactly with those of the close localities Mallín de los Caballos and Mallín Quemado, but showing a comparatively reduced thickness. The studied fauna comprises: *Pseudolissoceras zitteli* (Burckhardt) [M&m], *Neochetoceras?* sp., *Pseudhimalayites subpretiosus* (Uhlig) [M, = *P. steinmanni* (Haupt)], *Torquatisphinctes proximus* (Steuer) transient α and transient β , and *Corongoceras* cf. *alternans* (Gerth) [M]. This fauna shows strong Tethyan affinities enabling close time-correlation with the European standard chronostratigraphic scale. The type specimens of *P. zitteli*, *P. planiusculum* (Zittel), *P. rasile* (Zittel), *C. alternans* and *C. lotenoense* (Spath) are figured. The Haploceratid genus *Pseudolissoceras* Spath most probably originated in Early Tithonian Hybonotum Zone populations of *Haploceras carachtheis* of Crussol (France), widely expanded its biogeographic distribution in the Semiforme Zone in the form of *P. zitteli*, prior to the diachronous disappearance of local adaptations in the Neuquén-Mendoza basin [*P. pseudoolithicum* (Haupt)] and northern Central Tethys (*P. concorsi* Donze and Enay = *P. bavaricum* Barthel). *P. subpretiosus* occurs in the lower Proximus Biozone (approximately upper Semiforme-lower Fallauxi Zones), although it appears to range, with its local microconch *Simocoscoceras adversum andinum* Leanza and Olóriz, through the upper Zitteli and lower Proximus Biozones in other localities of the basin. *T. proximus* occurs abundantly, differentiated in transients α and β , the latter giving gradually origin to the early Andean himalayitids [e.g., *Windhausenicerias internispinosum* (Krantz)] via *Torquatisphinctes?* *windhausenii* (Weaver sensu Leanza), a form close to "*Burckhardticerias?* *peroni* (Roman). Both transients of *T. proximus* are mainly confined to the Proximus Biozone and their sexual dimorphism remains unrecognized.

Key words: Middle Tithonian, Neuquén-Mendoza Basin, Ammonoidea, Biogeography, Time-correlation.

Resumen.- La fauna de ammonoideos del Tithoniano Medio (Jurásico Superior) de Cañadón de los Alazanes, sur de la Cuenca Neuquén-Mendoza (Argentina). Las sucesiones estratigráfica y fáunica de Cañadón de los Alazanes (sur de la cuenca Neuquén-Mendoza, Argentina), muestreadas por primera vez, correlacionan muy estrechamente con las de Mallín de los Caballos y Mallín Quemado, aunque con un espesor comparativamente reducido. La fauna estudiada comprende: *Pseudolissoceras zitteli* (Burckhardt) [M&m], *Neochetoceras?* sp., *Pseudhimalayites subpretiosus* (Uhlig) [M, = *P. steinmanni* (Haupt)], *Torquatisphinctes proximus* (Steuer) transient α y transient β , y *Corongoceras* cf. *alternans* (Gerth) [M]. Esta fauna muestra fuertes afinidades tethysianas lo cual permite establecer correlaciones temporales bastante confiables con la escala cronoestratigráfica europea. Los especímenes tipo de *P. zitteli*, *P. planiusculum* (Zittel), *P. rasile* (Zittel), *C. alternans* y *C. lotenoense* (Spath) son figurados. El género *Pseudolissoceras* Spath, probablemente originado en poblaciones de *Haploceras carachtheis* de Crussol (Francia), expandió ampliamente su distribución biogeográfica durante la Zona Semiforme bajo la forma de *P. zitteli*. Siguiendo un patrón de desaparición diacrónica los últimos representantes del género se conocen en la cuenca Neuquén-Mendoza [*P. pseudoolithicum* (Haupt)] y en el norte del Tethys Central (*P. concorsi* Donze y Enay = *P. bavaricum* Barthel) como adaptaciones locales. *P. subpretiosus* (Uhlig) ocurre en la parte inferior de la Biozona Proximus (aproximadamente Zona Semiforme superior-Fallauxi inferior), aunque parece extenderse, junto con su microconcha local, *Simocoscoceras adversum andinum* Leanza y Olóriz, desde la parte alta de la Biozona Zitteli en otras localidades de la cuenca. *T. proximus* ocurre abundantemente diferenciado en dos formas transicionales (transients α y β), la más tardía dando origen gradual a los himalayitidos andinos tempranos [e.g., *Windhausenicerias internispinosum* (Krantz)] via *Torquatisphinctes?* *windhausenii* (Weaver sensu Leanza), forma muy cercana a "*Burckhardticerias?* *peroni* (Roman). Ambos transients de *T. proximus* están principalmente confinados en la Biozona Proximus y su dimorfismo sexual no ha sido aún reconocido con certeza.

Palabras clave: Tithoniano Medio, Cuenca Neuquén-Mendoza, Ammonoidea, Biogeografía, Correlación temporal.

H. Parent [parent@fceia.unr.edu.ar]: Laboratorio de Paleontología y Biocronología, Instituto de Fisiografía y Geología, FCEIA, Universidad Nacional de Rosario, Pellegrini 250, 2000 Rosario, Argentina.

Contribution 08/03 to Research Programm "El Jurásico Medio-Superior Andino" (LPB, IFG, UNR). Contribution 03/03 to PID UNR 2000.

Manuscrito recibido 10/09/2001; aceptado 20/12/2001.

Editor: O. A. Albert.

INTRODUCTION

During petroleum prospection in Neuquén Province, a new section of the Andean Tithonian was recently exposed in Cañadón de Los Alazanes (Fig. 1), near Manzano Escondido at the southern tip of Cordón Curymil, Sierra Vaca Muerta (Hoja Geológica 35b Zapala, Lambert 1956). In a recent field work Middle and Upper Tithonian and typically Perigondwanic ammonites were collected in that section. Tithonian ammonites from this locality were never described, only some indirect references may be found in Lambert (1956). Although the material is scarce its description is useful both paleontologically and biostratigraphically on the basis of the precise sampling of the succession and the occurrence of some taxa which need revision or are poorly known.

The associated gastropod fauna from beds CA02-04 (Fig. 2) is described by Gründel and Parent (2001).

The aim of this paper is to describe the new section and its ammonite fauna and to discuss the biostratigraphical and chronostratigraphical implications of the faunal succession and assemblages.

STRATIGRAPHY

Through the transect Mallín Quemado-Portada Covunco (Fig. 1), the Middle Tithonian spreads through about 100 to 200 m, whereas the whole Tithonian may reach a thickness of 833 m in Mallín Quemado and 1000 m near Mallín de los Caballos, of which no more than 100 to 150 m belong to the Lower Tithonian *Mendozanus* Biozone (cf. Leanza 1973, Leanza and Hugo 1977).

The studied section is shown in Figure 2. The lowermost part (*Mendozanus* Biozone) is covered, and

therefore only some loose fragments of Lithacoceratids were seen in the field. The Middle Tithonian strata (*Zitteli*, *Proximus* and *Internispinosum* Biozones) span about 35 m in the Vaca Muerta Fm. They consist of black shales with limestone concretions at the base, and limestone and mudstone banks upwards in the section. The lithologic and ammonite successions of Cañadón de los Alazanes (Fig. 2) are the same as at Mallín Quemado and Mallín de los Caballos (cf. Leanza 1973, Leanza 1975, Leanza and Hugo 1977), but it is a half of the thickness, decreasing from Mallín de Los Caballos, surely in relation with the proximity to the shelf edge at Cañadón de los Alazanes. At the top, the Picún Leufú Fm. consisting of yellow massive limestones overlies the black shales and marls of the upper part of the Vaca Muerta Fm. (see Lambert 1956: fig. 4, Leanza 1973, Leanza and Zeiss 1990, 1992) from which were collected Berriasian ammonites near Los Catutos (between Zapala and Portada Covunco). These yellow limestones must correspond to the distal lens of the Picún Leufú Fm. described by Leanza (1973).

The lithology suggests a relatively deep and poorly oxygenated environment, becoming somewhat shallower and more oxygenated towards the upper part, in which the proportion of limestone beds increases. The oxidation of Iron ($\text{Fe}^{2+} \rightarrow \text{Fe}^{3+}$) by weathering results in a reddish-brown coloration of the limestones, and there is no shell debris, thus indicating deposition in a poorly oxygenated, confined environment. These depositional conditions suggest distal platform, close to the talus, which fits well with the facies maps given by Gulisano (*in* Riccardi et al. 1992), Leanza et al. [1977: 200 (fig. 2)], and to the above indicated gradient of thickness, showing a decreasing trend from Mallín de Los Caballos (talus to central basin) towards Cañadón de los Alazanes (shelf edge).

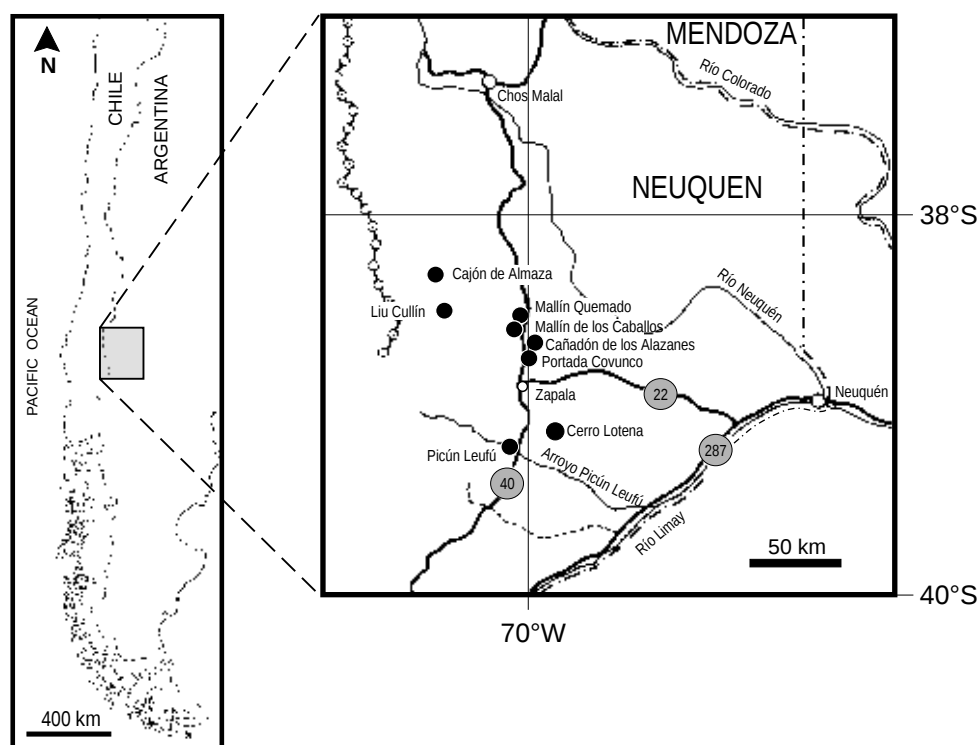


Figure 1. Reference map. Southern Neuquén-Mendoza basin. *Figura 1. Mapa de referencia. Sur de la cuenca Neuquén-Mendoza.*

TITHONIAN STRATIGRAPHY OF CAÑADÓN DE LOS ALAZANES, NEUQUÉN

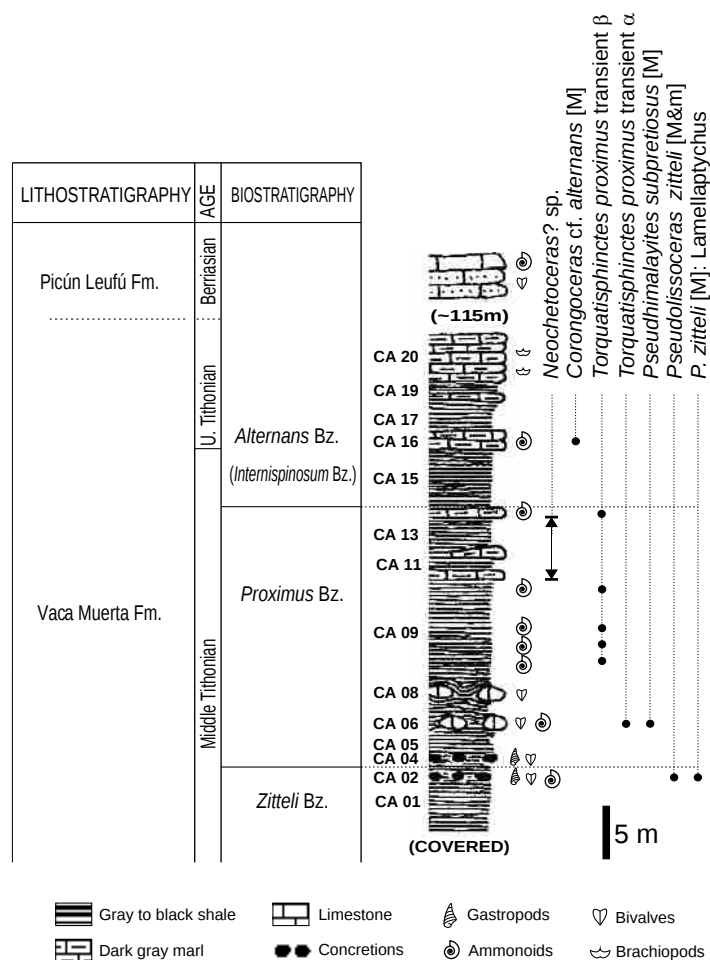


Figure 2. Log-section and ammonites of Cañadón de los Alazanes, southern end of Cordón Curymil, Sierra de Vaca Muerta, Neuquén. Lito- and biostratigraphic classifications modified from Leanza (1981) as indicated in text and Figure 10. **Figura 2.** Columna litológica y amonites de Cañadón de los Alazanes, extremo sur del Cordón Curymil, Sierra de Vaca Muerta, Neuquén. Clasificaciones lito- y bioestratigráfica modificadas de Leanza (1981) como se indica en el texto y en Figura 10.

SYSTEMATIC PALEONTOLOGY

The studied material is housed at the Laboratorio de Paleontología y Biocronología (LPB), Universidad Nacional de Rosario and Museo Prof. Olsacher (MOZP), Zapala, Neuquén. Photographs and casts of type and other specimens were kindly provided by Martin Sander (Paläontologisches Institut der Universität Bonn, GPIBO) and Gerhard Schairer (Bayerische Staatssammlung für Paläontologie und Geologie, BSPM). Measurements are indicated as follows: diameter (D), diameter at the last adult septum (D_L), 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]; counts of number of primary (P) and ventral (V) ribs per half-whorl; length of bodychamber (LBC) in degrees [$^\circ$]. Bodychamber is abbreviated with BC and phragmocone with Ph; female (macroconch): [M], male (microconch): [m].

Superfamily Haplocerataceae Zittel, 1884

Family Haploceratidae Zittel, 1884

Genus *Pseudolissoceras* Spath, 1925

Type species. *Neumayria zitteli* Burckhardt, 1903 by SD Roman (1938); Middle Tithonian of Argentina.

Discussion. The genus has been treated in some detail by Barthel (1962) and Olóriz (1978). Recently published data and new stratigraphically well located material from Cañadón de los Alazanes, Cerro Lotena and Chacay Melehué (Neuquén-Mendoza Basin) allow to review briefly the taxonomy and biostratigraphy of the species of the genus. The first step in support of the discussion below is to figure photographically the type specimens of the oldest nominal species whose type specimens were originally figured by hand-drawing pictures: *P. zitteli* (Burckhardt, 1903) (Fig. 3A-B, Table 1), *P. planiusculum* (Zittel, 1870) (Fig. 3C-D, Table 1), and *P. rasile* (Zittel, 1870) (Fig. 3E, Table 1).

The genus is widely distributed (see Cecca 1999 for references) through the Central Tethys (*sensu* Cecca 1999), Kurdistan (Northern Iran), the Caribbean Province (Mexico

and Cuba), the Neuquén-Mendoza Basin (Argentina), and South Primorie (Far East Russia). There are few, bad preserved specimens from Alexander Island, Antarctica described as *Pseudolissoceras*? sp. by Thomson (1979: 12, pl. 3: b) which most probably belong to *Haploceras* taking in consideration the aspect of the suture line (Thomson 1979: fig. 4c), which is the most consistent diagnostic feature of the genus *Pseudolissoceras*. Derivation of *Pseudolissoceras* from *Haploceras* Zittel, in the Lower Tithonian Hybonotum Zone, appears to be the most plausible hypothesis accounting for: 1) sutures differ only in the broader first lateral lobe and lower lateral saddle of *Pseudolissoceras*, 2) inner whorls of *P. zitteli* (described below) are closely comparable with those of *Haploceras*, 3) lower mandibles described for the species of both genera are of the same type (Lamellaptychus = Laevilamellaptychus), 4) sexual dimorphism is similar in both genera (see description of *P. zitteli* below). The most probable ancestor by stratigraphic position and morphological aspect appears to be the Hybonotum Zone *Haploceras carachtheis* (Zeuschner, 1846) [M&m] from Crussol (France) described by Enay and Cecca (1986: pl. 2: 10, pl. 4: 3). In the Mediterranean and Submediterranean domains of the Tethys the most complete succession of morphospecies of *Pseudolissoceras* is recorded which may be compiled from Barthel (1962), Olóriz (1978), Cecca and Santantonio (1988), and Fözy (1988). These morphospecies have in common the inner whorls rounded, depressed and widely umbilicated (Figs. 4A-B, 5E); by the aspect of the outer whorls they are commonly separated in the *P. zitteli*-group and *P. rasile*-group, the latter including the forms with more inflated and widely umbilicated subadult and adult shells (Figs. 3E, 4A-B). Thus, the current structure of the genus is that of a group of sculptureless ammonite morphospecies, having all of them variable vertical range (black vertical bars in Fig. 6). This vertical classification of parallel ranging morphospecies may be converted in a horizontal classification (Simpson 1937, Tintant 1952, Callomon 1985) of chronospecies (labelled by the names in white boxes in Fig. 6) by assuming a broad range of intraspecific variation within essentially monospecific assemblages. The meaning of the vertical range of each morphospecies then become to represent merely the temporal persistence of the morphotype in the clade, as part of the total variation of the chronospecies. The resulting evolutionary sequence of chronospecies could be as follows (Fig. 6):

Pseudolissoceras olorizi Fözy, 1988. The earliest occurrences of the genus are confined to the Hybonotum Zone of Central Tethys: 1) the "Lithographic Zone" specimen of *Pseudolissoceras* originally included in *Haploceras subelimum* Fontannes, 1879 (Huguenin's collection at Faculté des Sciences de Lyon; see Donze and Enay 1961: 47), 2) *P. olorizi* Fözy, 1988 [M] from Hungary (see Fig. 5E), and 3) *P. rasile* (Zittel) and *P. aff. rasile* from Spain (Olóriz 1978: pl. 2: 6, 11), two macroconchs that could be included in *P. olorizi*.

Pseudolissoceras rasile (Zittel, 1870). In the Darwini Zone of Italy and Spain occurs mainly *P. rasile* (Olóriz 1978; Cecca and Santantonio 1988); *P. olorizi* may persist locally (Fözy 1988).

Pseudolissoceras zitteli (Burckhardt, 1903). Nominally, *P.*

zitteli and/or close forms are cited all along the area of geographic distribution of the genus through the interval Semiforme-lower Fallauxi Zones. Most reliable records from European localities appear to indicate Semiforme Zone as the most consistent biochron for *P. zitteli*; the lectotype (Fig. 3A-B) comes from an unknown level of the Zitteli Biozone of western Mendoza, most likely Semiforme Zone in age (see below). In these forms the most notorious morphologic change in the evolution of the genus occurs, that is greater involution combined with a moderately variable periumbilical depression on the lower third of the flanks of the last whorls (Figs. 4A-B, 6). Concurrently with this change in modal morphology the genus shortly expands its geographic distribution into Northern Iran (in the form of *P. zitteli* and *P. advena* Spath, 1950 [M], most probably synonyms), Cuba (Myczynski 1989, 1994; Myczynski and Pszczolkowski 1994; Imlay 1942), Mexico (*P. subbrasilis* [M], *P. aff. subbrasilis* Burckhardt 1906 [m], *P. zitteli* [M&m], see Cantu-Chapa 1967, Verma and Westermann 1973, Olóriz et al. 1999, Villaseñor et al. 2000), the Neuquén-Mendoza Basin and South Primorie (*P. zitteli* in Sey and Kalacheva 1996, 1997; Sey et al. 1988). In the upper Zitteli Biozone of Neuquén, Argentina, occurs the poorly known *P. pseudoolithicum* (Haupt, 1907), morphologically very close to *P. rasile* (Fig. 6), and here considered as a local adaptation of *P. zitteli*, thus the terminal form of the genus in the Neuquén-Mendoza Basin. Some specimens from the upper Zitteli Biozone of Chacay Melehué and Cerro Lotena (Leanza 1980: pl. 1: 5) are transitional in coiling and whorl section between *P. zitteli* and *P. pseudoolithicum*. Arnould-Saget (1951a, 1951b) figured three small specimens from Central Tunisie which belong, in morphologic terms, to *P. rasile-pseudoolithicum*, but they are not useful in the present analysis due to uncertain stratigraphic position within the Tithonian. Similar consideration is applied to several later citations of *Pseudolissoceras* by Memmi (1967) within the Upper Tithonian and Lower Berriasian of Central Tunisie. A complete characterization of *P. zitteli* in the Neuquén-Mendoza Basin is given below.

P. concorsi Donze and Enay, 1961. *P. bavaricum* Barthel, 1962 and *P. concorsi* (northernmost Central Tethys) are defined by almost identical holotypes from the interval upper Semiforme-lower Fallauxi Zones; the stratigraphic position of the holotype of *P. bavaricum* in the lower Fallauxi Zone was recently defined by Scherzinger and Schweigert (1999). These forms show the most accentuated periumbilical depression and more simple suture line (less developed auxiliary elements); the "ceratitic aspect" of the sutures was noted by Barthel (1962: 15), Olóriz (1978: 38) and by G. Schweigert (*pers. comm.* 24-10-2001) and A. Scherzinger (*pers. comm.* 23-11-2001). Moreover, there appears to exist a positive correlation between the simplification of sutures and the accentuation of periumbilical depression, although the basic sutural plan remains unchanged. Transitional in morphology between *P. zitteli* and *P. concorsi-bavaricum*, showing a weak periumbilical depression, are specimens such as those figured as *P. gr. bavaricum* (Cecca et al. 1983-1984: pl. 6: 4) and *P. zitteli* (Haupt 1907: pl. 7: 4b). *P. concorsi* is the terminal chronospecies of the genus, probably of the same age like *P. aff. zitteli* (in Cecca and Santantonio 1988), cited

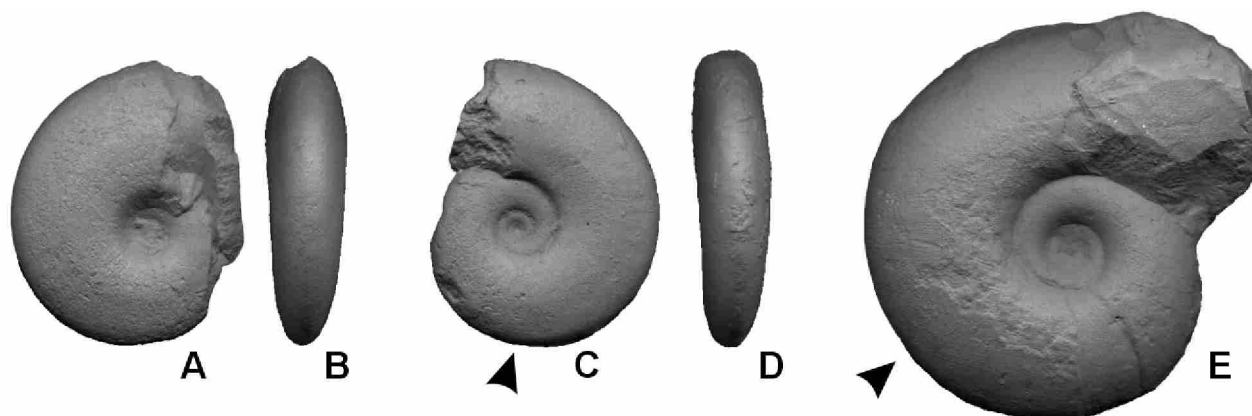


Figure 3. A-B: *Pseudolissoceras zitteli* (Burckhardt, 1903) [M?], lateral (A) and ventral (B) views of a cast (LPB-M 102) of the lectotype (BSPM - ASI616) figured by Burckhardt (1903: pl. 10: 6-7); completely septated specimen from Paso entre Cajón del Burro y Río Choica[s], Mendoza, Argentina; middle Tithonian. C-D: *Pseudolissoceras planiusculum* (Zittel, 1870) [m], lateral (C) and ventral views (D) of a cast (LPB-M 103) of the holotype (BSPM - ASIII56) figured by Zittel (1870: pl. 28: 3); adult specimen with bodychamber lacking peristome from Rogoznik, Poland; middle Tithonian. E: *Pseudolissoceras rasile* (Zittel, 1870) [M], lateral view of a cast (LPB-M 101) of the holotype (BSPM - 1868X504) figured by Zittel (1870: pl. 28: 2); specimen with incomplete bodychamber, probably adult from Monte Catria, Apennines, Italy; middle Tithonian. All natural size (x1); arrows denoting the base of the bodychamber. Whorl sections in Fig. 6B, F, K. **Figura 3.** A-B: *Pseudolissoceras zitteli* (Burckhardt, 1903) [M?], vistas lateral (A) y ventral (B) de un molde (LPB-M 102) del lectotipo (BSPM - ASI616) figurado por Burckhardt (1903: pl. 10: 6-7); espécimen completamente tabicado proveniente de Paso entre Cajón del Burro y Río Choica[s], Mendoza, Argentina; Tithoniano medio. C-D: *Pseudolissoceras planiusculum* (Zittel, 1870) [m], vistas lateral (C) y ventral (D) de un molde (LPB-M 103) del holotipo (BSPM - ASIII56) figurado por Zittel (1870: pl. 28: 3); espécimen con cámara habitacional sin peristoma proveniente de Rogoznik, Polonia; Tithoniano medio. E: *Pseudolissoceras rasile* (Zittel, 1870) [M], vista lateral de un molde (LPB-M 101) del holotipo (BSPM - 1868X504) figurado por Zittel (1870: pl. 28: 2); espécimen con cámara habitacional incompleta, probablemente un adulto proveniente de Monte Catria, Apenninos, Italia; Tithoniano medio. Todos en tamaño natural (x1); las flechas indican la base de la cámara habitacional. Secciones de vuelta en Fig. 6B, F, K.

for the Fallauxi Zone of the Umbria-Marchese-Sabine Apennines of Central Italy, but unfortunately the material is lost (F. Cecca, pers. comm. 05/11/01).

P. planiusculum (Figs. 3C-D, 4A-B, 6) has been cited through the Darwini-lower Fallauxi Zones of the Central Tethys, and most probably includes the microconch of the forms of this interval. Figured Tethyan specimens attributed to *P. planiusculum* (the holotype, Fig. 3C-D; Bernoulli and Renz 1970: pl. 5: 3; Avram 1976; Olóriz 1978; Fözy 1994) range in adult diameter between 30-40 mm, are very evolute ($U/D = 0.25-0.35$), and the whorl section is rather compressed during juvenile and adult ontogeny (Fig. 4A-B) with flattish flanks in the bodychamber. All these features fit very well into the ontogenetic trajectories of the lappetted microconch of *P. zitteli* (Fig. 4A-B, 7C-F) described below, although lappetted specimens of *P. planiusculum* have not been described yet. Identical morphotypes occur in Mexico, like *P. aff. subrasilis* Burckhardt (1906: pl. 34: 12-14) and *P. zitteli* (in Cantu-Chapa 1967: pl. 1: 5, pl. 7: 9), from rocks that could be time-equivalent to the Semiforme Zone (cf. Olóriz et al. 1999). The stratigraphic distribution, covering almost the whole range of the genus, supports the sexual dimorphic correspondence.

In summary (Fig. 6), the genus may be interpreted as a succession of chronospecies with a paleobiogeographic distribution confined to Central Tethys during its early evolution (Hybonotum-Darwini Zones), and widely expanded through Central Tethys, Caribbean Province, Neuquén-Mendoza Basin and South Primorie during the Semiforme Zone. During the early Fallauxi Zone the latest, terminal forms -local adaptations- were restricted to northern Central Tethys and, probably, the Neuquén-

Mendoza Basin (diachronous disappearance *sensu* Westermann 1992). The morphologic evolution follows a trend subordinated throughout the evolutionary sequence, from inflated evolute forms passing gradually into more compressed and involute suboxycones with a periumbilical depression and less developed auxiliary sutural elements. A marked step of this trend occurred at the early Semiforme Zone in coincidence with the biogeographic expansion event of the genus (Fig. 6). Excluding the Andean terminal form *P. pseudoolithicum*, this pattern might be described as a peramorphocline (Fig. 6) -clinal occurrence of the ancestral adult morphology in successive descendant juvenile stages of the development (McNamara 1982, 1986; Dommergues et al. 1986)- driven in this case by an acceleration process. Sexual dimorphism, in the forms of the interval Darwini-Semiforme Zones results from a paedomorphic microconch by complex progenesis (*sensu* Landman et al. 1991; Parent 1997). This type of sexual dimorphism leads to a characteristic evolutionary trend, that is, microconchiate males changing slowly their morphology along peramorphic clades, in which macroconchs show evident changes in the adult morphology not reached by microconchs (Parent 1998; cf. Dommergues 1990).

***Pseudolissoceras zitteli* (Burckhardt, 1903) [M&m]**

Figs. 2, 3A-B, 4A-B, 5A-E, 6, 7A-G; Table 1

- ?1900a *Oppelia* aff. *perlaevis* Steuer.- Burckhardt, p. 46, pl. 26: 5-6, pl. 29: 11.
- *1903 *Neumayria zitteli* n. sp.- Burckhardt, p. 55, pl. 10: 1-5, 6-7 [lectotype], 8.
- ?1946 *Neumayria zitteli* Burckh.- Sokolov, p. 9.
- 1967 *Pseudolissoceras zitteli* (Burckhardt).- Cantu-Chapa, p. 4, pl. 1: 5, pl. 7: 9.

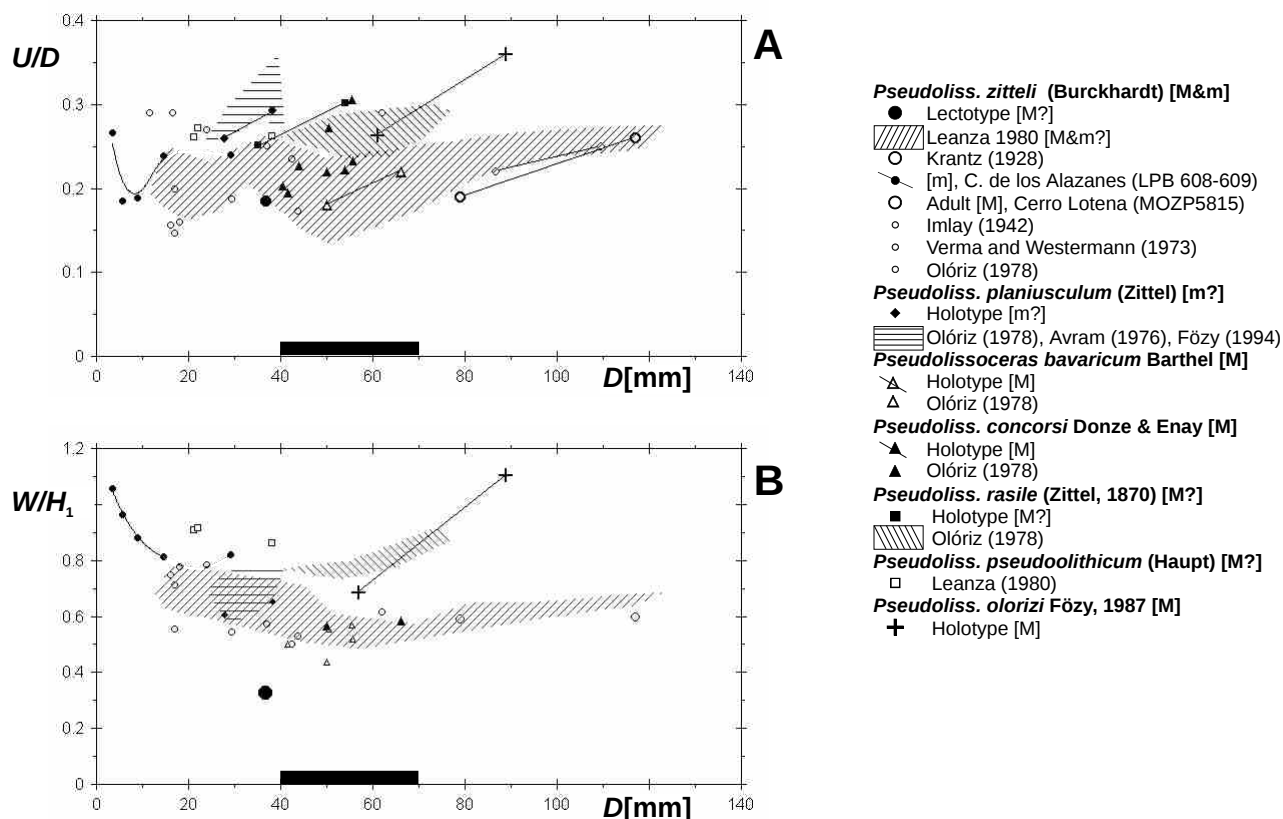


Figure 4. Variation of U/D (A) and W/H_1 (B) relative to D in *Pseudolissoceras zitteli* and the remaining nominal species of the genus. The black bold line on the D axis indicates the size range of maximum involution and periumbilical depression of *P. zitteli* and *P. concorsi-bavaricum*. **Figura 4.** Variación de U/D (A) y W/H_1 (B) respecto a D en *Pseudolissoceras zitteli* y las demás especies nominales del género. La línea negra gruesa sobre el eje D indica el intervalo de talla de máximas involución y depresión periumbilical de *P. zitteli* and *P. concorsi-bavaricum*.

- 1980 *Pseudolissoceras zitteli* (Burckhardt).- Leanza, p. 17, pl. 1: 1-2. [Complementary synonymy]
- 1989 *Pseudolissoceras zitteli* (Burckhardt).- Myczynski, p. 85, pl. 1: 2, pl. 5: 8, pl. 9: 10b, pl. 10: 4b.
- 1990 *Pseudolissoceras zitteli* (Burckhardt).- Myczynski, pl. 1: 1b.
- ?1996 *Pseudolissoceras* ex. gr. *zitteli* (Oppel [recte Burckhardt]).- Sey and Kalacheva, p. 299, pl. 1: 1-2.
- ?1997 *Pseudolissoceras* ex. gr. *zitteli* (Burckhardt).- Sey and Kalacheva, p. 93, pl. 1: 13-17.
- 1999 *Pseudolissoceras zitteli* (Burckhardt).- Parent and Capello, p. 349.

Lectotype. The specimen from "Paso entre Cajón del Burro y Río Choica[s]", Mendoza, middle Tithonian, originally figured by Burckhardt (1903: pl. 10: 6-7, hand-drawing), refigured herein photographically from a cast (Fig. 3A-B). Many of the ammonites figured by drawings in Burckhardt (1903) were formerly illustrated by excellent photographs in Burckhardt (1900a, 1900b); nevertheless none of the specimens figured by him as *Oppelia* aff. *perlaevis* Steuer (Burckhardt 1900a: pl. 26: 5-6) corresponds to the lectotype of *P. zitteli*.

Material. One fragmentary macroconch bodychamber (LPB608/1), one almost complete adult microconch (LPB608), two incomplete ?microconchs (LPB 608/2, 609); several pieces of *Lamellaptychus* (LPB 600, 611-

613); all specimens collected from concretions of bed CA02, *Zitteli* Biozone (Middle Tithonian, Semiforme Zone).

Description. Macroconch: The poorly preserved bodychamber of the sample shows smooth, slightly convex flanks without sculpture preserved; umbilicus open about one fifth of the diameter on the umbilical shoulder of last whorl at $D \approx 60$ mm. Microconch: Inner whorls ($3 < D < 10$ mm) evolute and depressed with subcircular whorl section and almost smooth flanks, only gentle, flexuose growth lines are visible on the middle of the flank. The body chamber ($D > 18$ mm) is more evolute and compressed with much higher whorl section, rounded venter, and flattened flanks passing by a rounded shoulder to a convex and relatively high umbilical wall. The sculpture of the body chamber consists of flexuose growth lines which delineate the mid-flank-projected lappets towards the aperture. Growth lines are preserved on both the test and the internal mold and follow a pattern identical to that of adult macroconchs. Mandibles: Following Krantz (1928), Spath (1950), and Barthel (1962) mandibles are here described under the supposed species they belong to. The most appropriate name for the present specimens, among those described by Arkell (1957), is *Lamellaptychus*. After Arkell (1957: L439) *Lamellaptychus* is narrow-valved with the surface covered by soft oblique folds. Abundant nodules containing a single valve and a few with the two valves in anatomical connection, have been collected from level CA02; all of them appear to correspond to individuals of

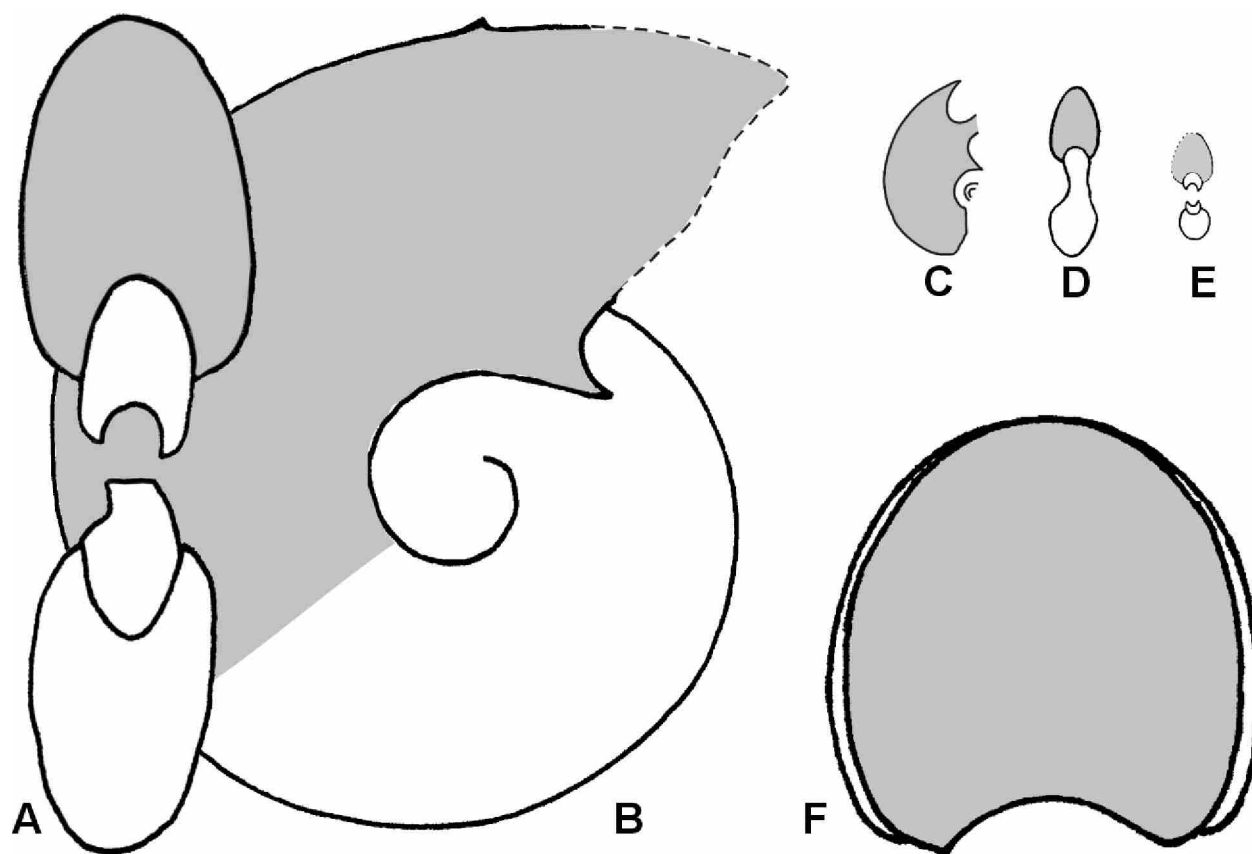


Figure 5. A-B: whorl section and lateral view of *Pseudolissoceras zitteli* [M], specimen MOZP5815; C-D: *Pseudolissoceras zitteli* [m], lateral view and whorl section of specimen LPB608; E: *Pseudolissoceras zitteli* [m], whorl section of specimen LPB609; F: whorl section of *Corongoceras cf. alternans* [M], specimen LPB605. All natural size (x1), bodychamber shaded. **Figura 5.** A-B: sección de vuelta y vista lateral de *Pseudolissoceras zitteli* [M], espécimen MOZP5815; C-D: *Pseudolissoceras zitteli* [m], vista lateral y sección de vuelta del espécimen LPB608; E: *Pseudolissoceras zitteli* [m], sección de vuelta del espécimen LPB609; F: sección de vuelta de *Corongoceras cf. alternans* [M], espécimen LPB605. Todo en tamaño natural (x1), cámara habitacional sombreada.

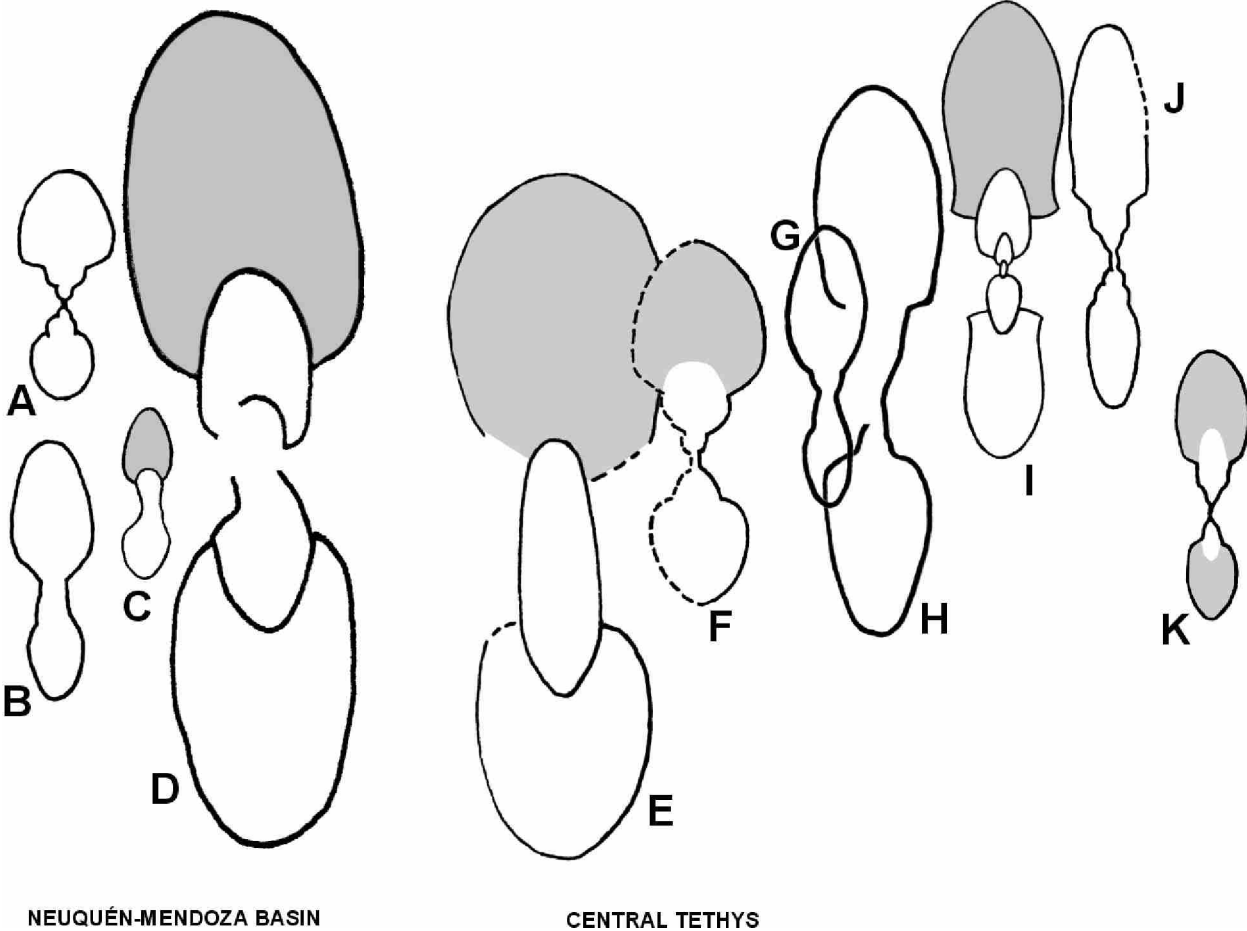
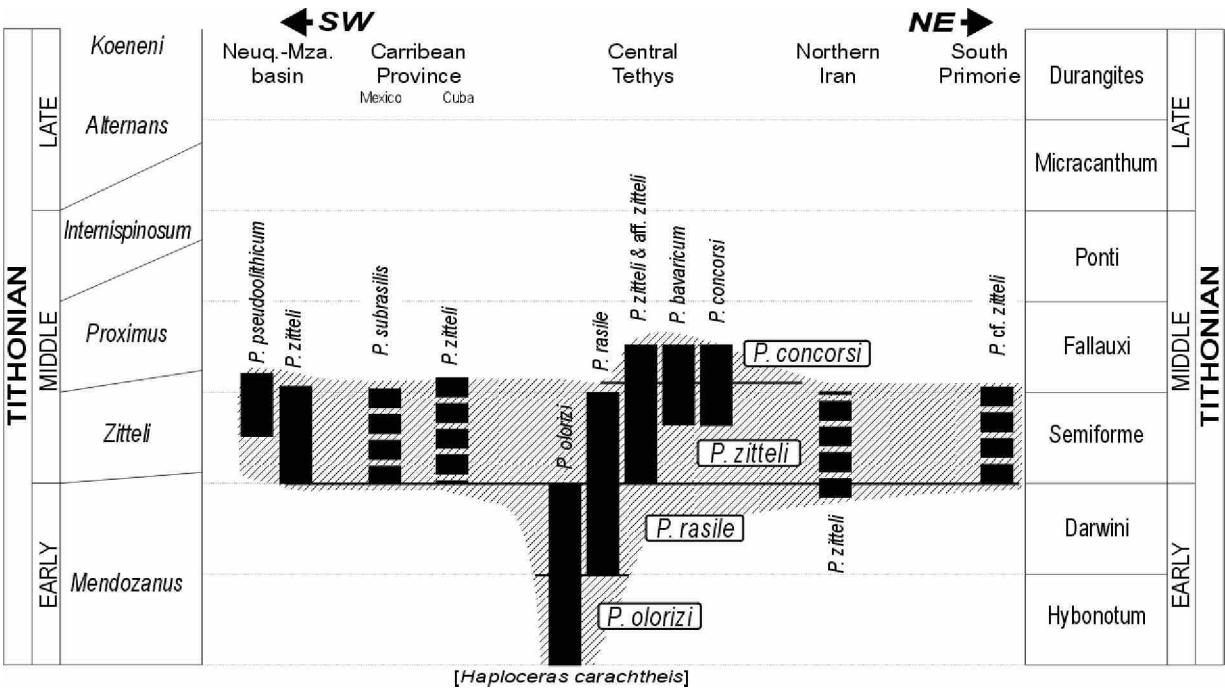
Pseudolissoceras zitteli [M] which occur in association in the same level and sometimes, in other localities, even in the same concretion. The size of the specimens corresponds to macroconchs of *P. zitteli*, much larger than the corresponding microconch as described above. Tithonian aptychi as small as to fit into the microconch bodychamber described above have not yet been described from the Neuquén-Mendoza Basin.

Discussion. The microconch is almost identical with the holotype of *P. planiusculum* (Fig. 3C-D) and those specimens figured by Avram (1976: pl. 7: 5, pl. 8: 2). The specimens of *P. zitteli* described by Cantu-Chapa (1967: pl. 1: 5, pl. 7: 9) from Mazatepec, Mexico (Semiforme Zone; cf. Olóriz et al. 1999), are microconchs which are indistinguishable from the present ones. The shape of the peristome of the described microconch matches many figured Kimmeridgian and Tithonian haplocerataceans such as those described as *Glochiceras carachtheis* (in Barthel 1962: pl. 2: 1, pl. 3: 1, 4; Olóriz 1978: pl. 10: 6), *Glochiceras planulatum* (in Ziegler 1958: pl. 15: 10; Berckheimer and Hölder 1959: pl. 26: 138), *Haploceras fialar* Oppel (in Burckhardt 1906: pl. 20: 15). The characteristic features that make our complete microconch a *P. zitteli* are not only the constraints of the recorded associated macroconch specimens but especially the smooth, rounded venter, the moderate involution, the flattened preapertural portion of the flanks, and, most

importantly, the morphology of the inner whorls identical to that of *P. zitteli* [M]. Sexual dimorphism is not only related to different adult size between dimorphs as indicated by Verma and Westermann (1973), but moreover includes apertural lappets in the smaller microconchiate male.

Identical Tithonian pieces of *Lamellaptychus* were described by Cloos (1961: pl. 3: 6, pl. 4: 8-9) from some localities of Neuquén as *Laevaptychus crassissimus* (Haupt 1907), Cerro Lotena and *Lamellaptychus*, from Cerro Negro. Spath (1950: pl. 10: 12) figured "*Lamellaptychus* sp. indet." from the Tithonian of Kurdistan, which matches in every visible detail with the present pieces, although Spath suggested relationships with *Haploceras*. Barthel (1962) described under *Pseudolissoceras bavaricum* a piece of *Laevilamellaptychus* which strongly resembles the present ones.

A typical, almost complete adult macroconch (Figs. 5A-B, 7A-B, Table 1) from the *Zitteli* Biozone of Cerro Lotena (Fig. 1) is herein illustrated in order to give a complete picture of the species from both sexual dimorphs. This macroconch shows a ventral, transverse fold or ridge connected with a flexuose lateral fold or rib at D 110 mm, on the last preserved whorl, close to the peristome. The biological meaning, thus the taxonomic significance of this structure is not easy to assess from known material, but supports inclusion of *Pseudolissoceras* in Haploceratidae. Haploceratids which show consistently these folds are, e.g.



Haploceras verruciferum (Zittel, 1870), *H. staszycii* (Zeuschner, 1846) as noted by Olóriz (1978: 18), and *H. cassiferum* Fözy (1988: pl. 5: 2-3) besides many other examples in literature. Microconchs of *H. verruciferum* (Zittel), as described by Enay and Cecca (1986), show similar folds whereas they are lacking in the above described microconch specimens of *P. zitteli*.

The periumbilical depression of the flanks, typical of the morphospecies *P. concorsi* and *P. bavaricum*, is shown, in attenuated form, by some adult macroconchs of *P. zitteli* (Krantz 1928: pl. 1: 6, Leanza 1980: pl. 1: 1) as a flattening of the lower third of the flanks, in coincidence with the end of the phragmocone and the base of the bodychamber ($40 < D < 70$ mm). This flattening is associated with a contraction of the umbilical width, clearly evident in the graph $U/D-D$ (Fig. 4A). *P. pseudoolithicum* Haupt, 1907 differs from *P. zitteli* in having a more inflated whorl section and a wider umbilicus through the late juvenil and adult ontogeny, but they have identical inner whorls ($D < 10$ mm).

Family Oppeliidae Douvillé, 1890

Subfamily Streblitinae Spath, 1925

Genus *Neochetoceras* Spath, 1925

Type species. *Ammonites steraspis* Oppel, 1863, OD; Lower Tithonian.

Neochetoceras? sp.

Figs. 2, 8A-C.

Material. One adult phragmocone (LPB 607), loose from beds CA10-13, *Proximus* Biozone (Middle Tithonian, Fallauxi Zone).

Description. Compressed subtriangular whorl section with smooth lower half of flanks; moderately open umbilicus; about 5 rounded and low primary ribs per half whorl appear to be confined to the upper half of flanks.

Remarks. The preliminar inclusion of the specimen into *Neochetoceras* Spath rather than in *Ochetoceras* Haug, 1885 (Type species: *Ammonites canaliculatus* von Buch, 1831; SD Munier-Chalmas, 1892) rests, not only in stratigraphic position, but on the apparently smooth lower half of the flanks and the rounded distant primary ribs only

on the upper half, lacking any vestige of secondary or ancillary ribbing. Some species of *Streblites* have similar ornamentation but arising on the umbilical shoulder and their umbilicus is characteristically narrower. Within many similar specimens in literature, stands the closely comparable specimen of *Neochetoceras* sp. [M] figured by Cecca and Enay (1991: pl. 1: 9) from the Fallauxi Zone of Le Pouzin, France. Many older forms compare well too, for example, the latest Kimmeridgian *Ochetoceras irregulare* Beckhemer and Hölder (1959: pl. 23: 118, pl. 25: 130) and *Ochetoceras canaliferum* var. *tenuis* Beckhemer and Hölder (1959: pl. 25: 133). *Neochetoceras* has never been figured or cited for the Andean Tithonian. However, from material of Western Cuba, Myczynski (1989: pl. 1: 8-10) described as *Neochetoceras* aff. *steraspis* (Oppel) several specimens which are very similar to the present one, like that figured by Myczynski and Pszczolowski (1994: pl. 2: 1) as *Taramelliceras* (*Parastreblites*) sp. Kiessling et al. (1999: fig. 7A) have figured one specimen, assigned to the lower Tithonian of the Antarctic Peninsula, as *Neochetoceras?* sp., and Witham and Doyle (1989: fig. 6e) figured a minute specimen from the Tithonian of the Longing Member, northern Longing Gap as *Neochetoceras* sp.

Some morphotypes of *Semiformiceras semiforme* (Oppel, 1865) of the upper Semiforme Zone of Spain, France, Italy and Hungary, like those illustrated by Enay (1983: fig. 3.11-14), Olóriz (1978: pl. 3: 1-2), Cecca and Enay (1991: pl. 2: 18-19), Cecca et al. (1983-1984: pl. 6: 4) and Fözy (1988: pl. 1: 1-2, 4) show some resemblance with our specimen. The bodychamber of these forms is more inflated than the phragmocone, which is the part of the shell described above; the presence of the diagnostic groove of *Semiformiceras* cannot be evaluated.

Superfamily Perisphinctaceae Steinmann, 1890

Family Aspidoceratidae Zittel, 1895

Genus *Pseudhimalayites* Spath, 1925

Type species. *Aspidoceras steinmanni* Haupt, 1907 (= *Cosmoceras subpretiosum* Uhlig, 1878); Middle Tithonian.

Pseudhimalayites subpretiosus (Uhlig, 1878) [M]

Figs. 2, 8I-J

Figure 6. Chronologic-geographic-morphologic phylogenetic framework for the genus *Pseudolissoceras* Spath as probably originated from the early Tithonian *Haploceras carachtheis* (sensu Enay and Cecca 1986). Current morphospecies (black vertical bars, solid: controlled range, dotted: tentative range) may be considered variants within a succession of chronospecies (labelled by the names in the white boxes) by assuming a moderately broad range of intraspecific variation (plotted in Fig. 4A-B) around type specimens. The microconchs are nominally known as *P. planiusculum*, except for Andean *P. zitteli* whose microconch is herein described under the same name. Typical morphology indicated by whorl section of type specimens and a few additional ones, A: *P. pseudoolithicum* (Haupt), B: *P. zitteli* [M] (lectotype in Fig. 3A-B), C: *P. zitteli* [m] (Fig. 5D), D: *P. zitteli* [M] (Fig. 5A), E: *P. olórizi* [M] (holotype, drawn from Fözy 1988: pl. 6: 2), F: *P. rasilé* [M] (holotype, see Fig. 3E), G-H: *P. zitteli* [M] (in Olóriz 1978: p. 43), I: *P. concorsi* [M] (holotype), J: *P. bavaricum* [M] (holotype), K: *P. planiusculum* [m] (holotype, Fig. 3C-D). All sections in natural size (x1); bodychamber shaded. B, F and K: after Barthel (1962); I: after Donze and Enay (1961). Geography depicted not at scale; time correlation of the Andean biozonation as in Figure 10 and text. **Figura 6.** Filogenia del género *Pseudolissoceras* Spath en un contexto temporal-geográfico-morfológico, supuestamente derivado de *Haploceras carachtheis* (sensu Enay y Cecca 1986) en el Tithoniano temprano. Las morfoespecies (barras negras verticales, continuas: rango controlado, punteadas: rango tentativo) pueden considerarse variantes dentro de una sucesión de cronoespecies (etiquetadas por los rectángulos blancos) asumiendo un moderadamente amplio espectro de variabilidad intraspecífico (ploteado en Fig. 4A-B) alrededor de los especímenes tipo. Las microconchas son conocidas nominalmente como *P. planiusculum*, excepto para *P. zitteli* en los Andes cuya microconcha es descrita bajo el mismo nombre específico. La morfología típica indicada por la sección transversal de los especímenes tipo y algunos adicionales, A: *P. pseudoolithicum* (Haupt), B: *P. zitteli* [M] (lectotipo en Fig. 3A-B), C: *P. zitteli* [m] (en Fig. 5D), D: *P. zitteli* [M] (Fig. 5A), E: *P. olórizi* [M] (holotipo, dibujado a partir de Fözy 1988: pl. 6: 2), F: *P. rasilé* [M] (holotipo en Fig. 3E), G-H: *P. zitteli* [M] (in Olóriz 1978: 43), I: *P. concorsi* [M] (holotipo), J: *P. bavaricum* [M] (holotipo), K: *P. planiusculum* [m] (holotipo en Fig. 3C-D). Todas las secciones en tamaño natural (x1); cámara habitacional sombreada. B, F y K: tomado de Barthel (1962); I: tomado de Donze y Enay (1961). Geografía fuera de escala; correlaciones temporales de la biozonación andina como en Figura 10 y el texto.



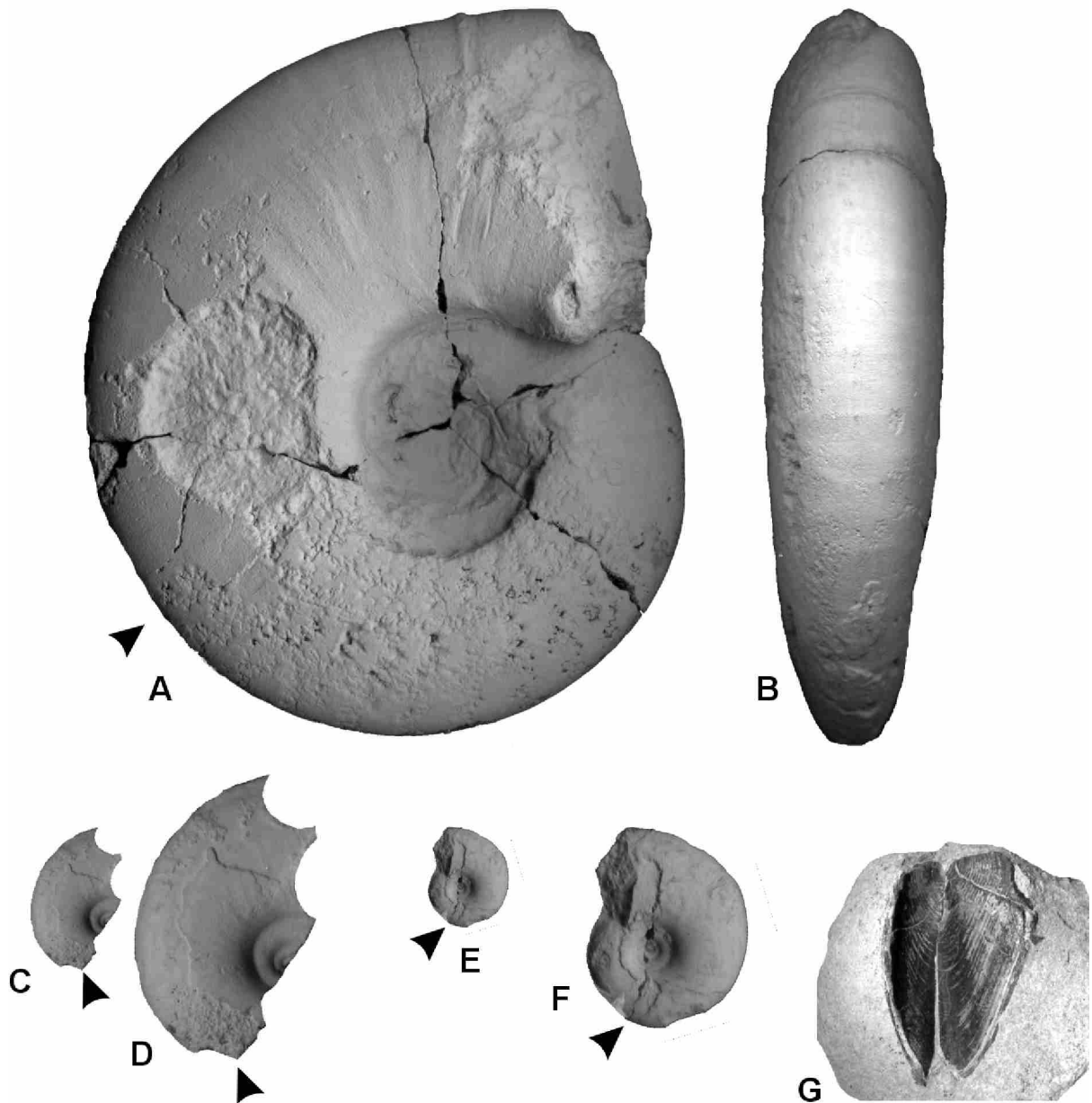


Figure 7. *Pseudolissoceras zitteli* (Burckhardt) [M&m]. A-B: lateral and ventral views (x1) of an almost complete adult macroconch (MOZP 5815) from Cerro Lotena, Neuquén, lower part of the Zitteli Biozone (probably from bed 3 in Leanza 1980: 9); C-D: lateral views of a virtually complete adult microconch (LPB608, C: x1, D: x2), bed CA02; E-F: lateral views of an almost complete microconch (LPB609, E: x1, F: x2), bed CA02; G: Lamellaptychus (upper face, concave), lower mandibles of a macroconch (LPB 600, x1), bed CA02. Arrows denoting the base of the bodychamber. **Figura 7.** *Pseudolissoceras zitteli* (Burckhardt) [M&m]. A-B: vistas lateral y ventral (x1) de una macroconcha adulta casi completa (MOZP 5815) proveniente de Cerro Lotena, Neuquén, parte inferior de la Biozona Zitteli (probablemente del estrato 3 en Leanza 1980: 9); C-D: vistas laterales de una microconcha adulta virtualmente completa (LPB608, C: x1, D: x2), nivel CA02; E-F: vistas laterales de una microconcha adulta prácticamente completa (LPB609, E: x1, F: x2), nivel CA02; G: Lamellaptychus (cara superior, cóncava), mandíbulas inferiores de una macroconcha (LPB 600, x1), nivel CA02. Las flechas indican la base de la cámara habitacional.

Macroconch

- *1878 *Cosmoceras subpretiosum* n. sp.- Uhlig, p. 637 [non vidum], pl. 17: 8.
- 1907 *Aspidoceras Steinmanni* nov. sp.- Haupt, p. 189, pl. 7: 1 [lectotype of *P. steinmanni*].
- 1925 *Aspidoceras Steinmanni* Haupt.- Gerth, p. 39.
- 1928 *Aspidoceras (Pseudhimalayites) Steinmanni* Haupt.- Krantz, p. 13, 47-48.
- 1985 *Pseudhimalayites steinmanni* (Haupt).- Checa, p. 112, pl. 20: 2-5.
- *1988 *Simocoscoceras subpretiosum* (Uhlig).-

Malinowska, p. 481, pl. 143: 6.

- *1997 *Pseudhimalayites subpretiosum* (Uhlig) (= *Aspidoceras steinmanni* Haupt).- Schweigert, p. 6, pl. 1: 4 [holotype], pl. 2: 1a-b [lectotype of *P. steinmanni*]; with synonyms.

Microconch

- 1987 *Simocoscoceras adversum* (Oppel) *andinum* n. ssp.- Leanza and Olóriz, p. 204, fig. 2.
- 1989 *Simocoscoceras pszczolkowskii* n. sp.- Myczynski, p. 94, pl. 8: 4, pl. 10: 4a, 5.

Table 1. Measurements of type and studied specimens of *Pseudolissoceras*, *Torquatisphinctes* and *Corongoceras*. **Tabla 1.** Medidas de especímenes tipo y material estudiado de los géneros *Pseudolissoceras*, *Torquatisphinctes* y *Corongoceras*.

Specimen	[M/m]	Ph/BC	D	U	U/D	W	W/D	H ₁	H ₁ /D	W/H ₁	H ₂	H ₂ /D	P	V	LBC[°]
<i>Pseudolissoceras zitteli</i> (Burckhardt)															
LPB 608	m	BC	29.1	7.0	0.24	10.5	0.36	12.8	0.44	0.81	-	-	0	0	190
LPB 609	m	BC	14.5	3.5	0.24	5.2	0.36	6.4	0.44	0.81	-	-	0	0	>180
		Ph	9.0	1.7	0.19	3.7	0.41	4.2	0.47	0.88	-	-	0	0	
		Ph	5.6	1.0	0.18	2.7	0.48	2.8	0.50	0.78	-	-	0	0	
		Ph	3.4	0.9	0.27	1.9	0.55	1.8	0.53	0.74	-	-	0	0	
MOZP 5815	M	BC	109.5	27.3	0.25	29.7	0.27	50.3	0.46	0.59	-	-	0	0	>190
		Ph-BC	86.8	18.8	0.22	27.1	0.34	44.0	0.51	0.62	-	-	0	0	
LECTOTYPE (Fig. 3A-B)	M?	Ph	36.8	6.8	0.19	6.2	0.17	19.0	0.52	0.33	-	-	0	0	
<i>Pseudolissoceras rasile</i> (Zittel)															
HOLOTYPE (Fig. 3E)	M?	BC	54.0	16.3	0.30	-	-	-	-	-	-	-	0	0	
		Ph	35.0	8.8	0.25	-	-	-	-	-	-	-	0	0	
<i>Pseudolissoceras planiusculum</i> (Zittel)															
HOLOTYPE (Fig. 3C-D)	m	BC	38.3	11.2	0.29	10.1	0.26	15.5	0.41	0.65	13.8	0.36	0	0	200
		Ph	27.8	7.2	0.26	7.8	0.28	12.9	0.46	0.61	-	-	0	0	
<i>Torquatisphinctes proximus</i> (Steuer) transient β															
LPB 606	?M	BC	40.2	18.5	0.46	12.2	0.30	12.1	0.30	1.01	10.4	0.26	16	31	>250
		Ph-BC	29.1	-	-	-	-	-	-	-	-	-	-	-	
<i>Corongoceras lotenoense</i> (Spath)															
HOLOTYPE (in Haupt 1907: pl. 9: 7a-b)		Ph	28.0	10.0	0.36	10.0	0.36	10.0	0.36	1.00	8.0	0.29	14	20	
		Ph	20.0	7.0	0.35	7.0	0.35	8.0	0.29	0.89	-	-	15	22	
<i>Corongoceras alternans</i> (Gerth)															
HOLOTYPE (in Gerth 1925: pl. 6: 3-3e)	M	BC	75.0	32.0	0.43	19.8	0.26	24.5	0.33	0.81	23.5	0.31	15	28	-
		Ph	39.0	13.0	0.33	-	-	15.0	0.38	-	13.0	0.33	14	-	

1993 *Simocoscoceras adversum andinum* Leanza and Olóriz.- Leanza, p. 76.

1997 *Simocoscoceras adversum* (Oppel).- Schweigert, p. 4-6, pl. 1: 2-3.

Holotype. The specimen figured by Uhlig (1878: pl. 17: 8), refigured by Malinowska (1988: pl. 143: 6) and Schweigert (1997: pl. 1: 4).

Material. One fragmentary bodychamber of an adult macroconch (LPB 603) from bed CA06, lower *Proximus* Biozone (Middle Tithonian, upper Semiforme-lower Fallauxi Zones).

Description. The specimen is an internal mold with remains of the shell, corresponding to the end of phragmocone and the base of the body chamber. The estimated dimensions are $D \approx 45$ mm, $W \approx 37$ mm. The umbilical wall is not completely preserved. The whorl section is very depressed with low flanks and a broad, rounded venter. The ornamentation is composed of three rows of tubercles: one of small top-stamped bullae at the umbilical shoulder; a second one of somewhat larger tubercles located just below the ventro-lateral shoulder; and a third row on the venter, composed of radially elongated bullae. Short undivided ribs connect the periumbilical and ventro-lateral tubercles. On the venter the two row of tubercles are separated by a smooth band. Sutures are too incompletely preserved for description.

Remarks. The subjective synonymy of the macroconchs *P. steinmanni* (Haupt) with *P. subpretiosus* (Uhlig) as proposed by Schweigert (1997) is accepted herein, attending that both forms are of the same age and have identical inner whorls. The present specimen is very close to that one figured by Checa (1985: pl. 20: 4) at a comparable diameter, but the closest resemblance is with the specimen figured by Haupt (1907: pl. 7: 1, lectotype of *P. steinmanni*)

and refigured by Schweigert (1997: pl. 2: 1a-b). The microconchs of the Middle Tithonian *Pseudhimalayites* are included in *Simocoscoceras* Spath, 1925 as pointed out by Schweigert (1997); Spath (1925: 132) had noted the aspidoceratid aspect of *Simocoscoceras*, stressing its superficial resemblance with *Sutneria* Zittel, 1884. In Cerro Lotena, Neuquén, in levels which contain *P. subpretiosus* occurs *Simocoscoceras adversum andinum* Leanza and Olóriz, 1987 [m]. The holotype of this latter form is very similar, if not identical, with inner whorls of *P. subpretiosus* so that there is little doubt that it represents the local microconchiate male as already suggested by Schweigert (1997: 5).

After the description by Haupt (1907) no other Andean specimen of *P. subpretiosus* was figured. Our specimen documents the association with *T. proximus* transient α in a single basal bed of the *Proximus* Biozone, above beds of the local *Zitteli* Biozone, thus fixing its stratigraphic position in the sequence (see discussion below in the biostratigraphic chapter). The morphological identity with the lectotype of *P. steinmanni* strongly suggests the same age for the two specimens, although the lectotype has hitherto not been precisely placed in the normal succession. *P. subpretiosus* has been recorded throughout most of the Neuquén-Mendoza Basin and although its stratigraphic position is not clearly established, it appears to have some range through the upper *Zitteli* and lower *Proximus* Biozones, documented by either one of the dimorphs, as follows:

Picún Leufú, Neuquén (Fig. 1): Leanza (1993: 76) cited the microconch *Simocoscoceras adversum andinum* Leanza and Olóriz.

Cerro Lotena, Neuquén (Fig. 1): Haupt (1907) originally

described *P. steinmanni* on material from this locality but he did not give a precise indication of its stratigraphic position. Krantz (1928: 13) indicated the occurrence of the species in this locality without giving further information. Leanza and Hugo (1977: 253) indicated an occurrence apparently below beds containing *Windhausenicerias internispinosum* (Krantz, 1928), thus by definition within the *Proximus* Biozone. Leanza and Olóriz (1987: 203) recorded the type specimen of *Simocoscoceras adversum andinum* [m] in the upper *Zitteli* Biozone, in association with *P. steinmanni* (Haupt), here interpreted as *P. subpretiosus* [M].

Cañadón de los Alazanes, Neuquén (Fig. 1): associated with *T. proximus* transient α , basal *Proximus* Biozone, this report.

Bardas Blancas, Mendoza (see fig. 1A in Parent, in press): Gerth (1925: 39-40) indicated the occurrence of *P. steinmanni* in this locality. Later, on this base, Krantz (1928: 47) listed the faunal content of the Middle Tithonian of this locality including, under current taxonomy: *P. subpretiosus*, *P. zitteli*, *Volanoceras krantzense* Cantu-Chapa [= *Simoceras* aff. *volanense* (Oppel) in Krantz (1928)], and *Taramelliceras waageni* (Zittel). The presence of *P. zitteli* indicates the homonymous biozone, and if the group of species is considered as an assemblage, it leaves little doubt of the Semiforme Zone age when compared with similar Tethyan assemblages (see Parent and Capello 1999), although *Taramelliceras* is said to end in the top of the Darwini Zone in Europe (Olóriz 1978, Kutek and Wierzbowski 1986).

Arroyo Cieneguitas, Mendoza (see fig. 1A in Parent, in press): Krantz (1928: 48) indicates the occurrence of *P. zitteli* and *P. subpretiosus* in the Middle Tithonian.

Family Ataxioceratidae Buckman, 1921 **Subfamily Torquatisphinctinae Tavera, 1985**

Remarks. Composition and scope of this subfamily following Parent (in press; cf. Tavera 1985).

Genus Torquatisphinctes Spath, 1924

Type species. *Ammonites torquatus* Sowerby, 1840; Kimmeridgian of Kachchh, India.

***Torquatisphinctes proximus* (Steuer, 1897)**

Figs. 2, 8D-H; Table 1

Synonymy. See Parent (in press).

Material. One almost complete adult specimen (LPB606) from bed CA14; several crushed specimens from level CA09, several fragmentary and crushed specimens from nodules of level CA06 (LPB601-602, 616); *Proximus* Biozone (Middle Tithonian, upper Semiforme-Fallauxi Zones).

Remarks. The species was recently revised (Parent, in press) within the context of a taxonomic revision of the ataxioceratids of the Neuquén-Mendoza Basin. Two morphotypes were distinguished within the species. The new material confirms their vertical succession, as formerly suspected (Parent, in press), by which they must be regarded as transients of the species. *T. proximus* transient β [the younger and also the type transient since it includes the lectotype; see Fig. 8F-H; Parent, in press: fig. 9I-J

(lectotype), fig. 13C; ?Leanza 1980: pl. 6: 4] has smaller adult size, shows a higher point of bifurcation of the ribs and a more evolute and compressed aspect than *T. proximus* transient α . This latter (see Parent, in press: Fig. 13A-B) is intermediate in morphology and age between *T. mendozanus* (see Burckhardt 1900a: pl. 25: 6-8, the type series originally described as *P. aff. lothari* Oppel) of the lower Tithonian *Mendozanus* Biozone and *T. proximus* transient β of the Middle Tithonian upper *Proximus* Biozone, but mostly resembling *T. mendozanus* in adult size, whorl section and coiling. *T. proximus* transient β strongly resembles "*Parapallasiceras* aff. *pseudocolubrinoide*" Olóriz (in Leanza 1980: pl. 8: 3) of the *Internispinosum* Biozone of Cerro Lotena in ribbing style and size, thus suggesting that the specimen of level CA14 (Fig. 8F-H) could already come from the base of that biozone. A specimen which resembles the present one was figured by Corvalán (1959: pl. 5: 20) as *Aulacosphinctes proximus* (Steuer) from bed B-2 (*Proximus* Biozone, sic) of Río Leñas, Chile.

The ventral groove or interruption of ribbing is a very variable feature in *T. proximus*, visible on the internal molds of either inner whorls or on the last whorl of the phragmocone. This variability appears to be the same in both transients by which an evolutionary pattern can not be described at present and the taxonomic importance can not be assessed. Furthermore, Guex (1970) has demonstrated that in dactylioceratids the variability of this feature is extremely wide, and, like in *T. proximus*, the groove is only observed in internal molds, so that its taxonomic value is very restricted.

Sexual dimorphism in the species is not yet recognized. Nevertheless, some undescribed, large variocostate macroconchs in the collection of the Museo Olsacher (Zapala), coming from the middle Tithonian of Cerro Lotena show identical inner whorls.

There is a close resemblance (homoeomorphy?) between late representatives of *T. proximus* with the upper Middle Tithonian *Parapallasiceras praecox* (Schneid, 1915). They compare very well in the evolute coiling, rounded whorl section and simple, rather straight prosocline ribbing, bifurcating in the upper half of the flanks, and with some trifurcations at constrictions.

Family Himalayitidae Spath, 1925

Remarks. In Europe, the earliest himalayitid "*Burckhardticerias*" *peroni* (Roman, 1936 *sensu* Olóriz 1978) may have arisen in the Ponti Zone (= Burckhardticerias Zone) from late representatives of the Torquatisphinctinae (cf. Donovan et al. 1981). In "B." *peroni* the primary ribs become prominent at the point of bifurcation, conforming a lamelliform tuberculation (Olóriz 1978: 624: "tuberculación lameliforme") near the ventrolateral shoulder that most probably gave origin to the diagnostic tuberculation of the early Late Tithonian Himalayitidae. In South America, the latest *T. proximus* transient β may represent, via *Torquatisphinctes?* *windhausenii* (Weaver, 1931 in Leanza 1980: pl. 8: 2), the origin of Andean himalayitids such as *Windhausenicerias internispinosum* (Krantz) and *Micracanthoceras mirum* (Leanza, 1945). Inner whorls of the lectotype of *T. proximus* (transient β) and *W. internispinosum* (in Leanza 1980: pl. 9: 1) are almost identical, characterized by an evolute coiling

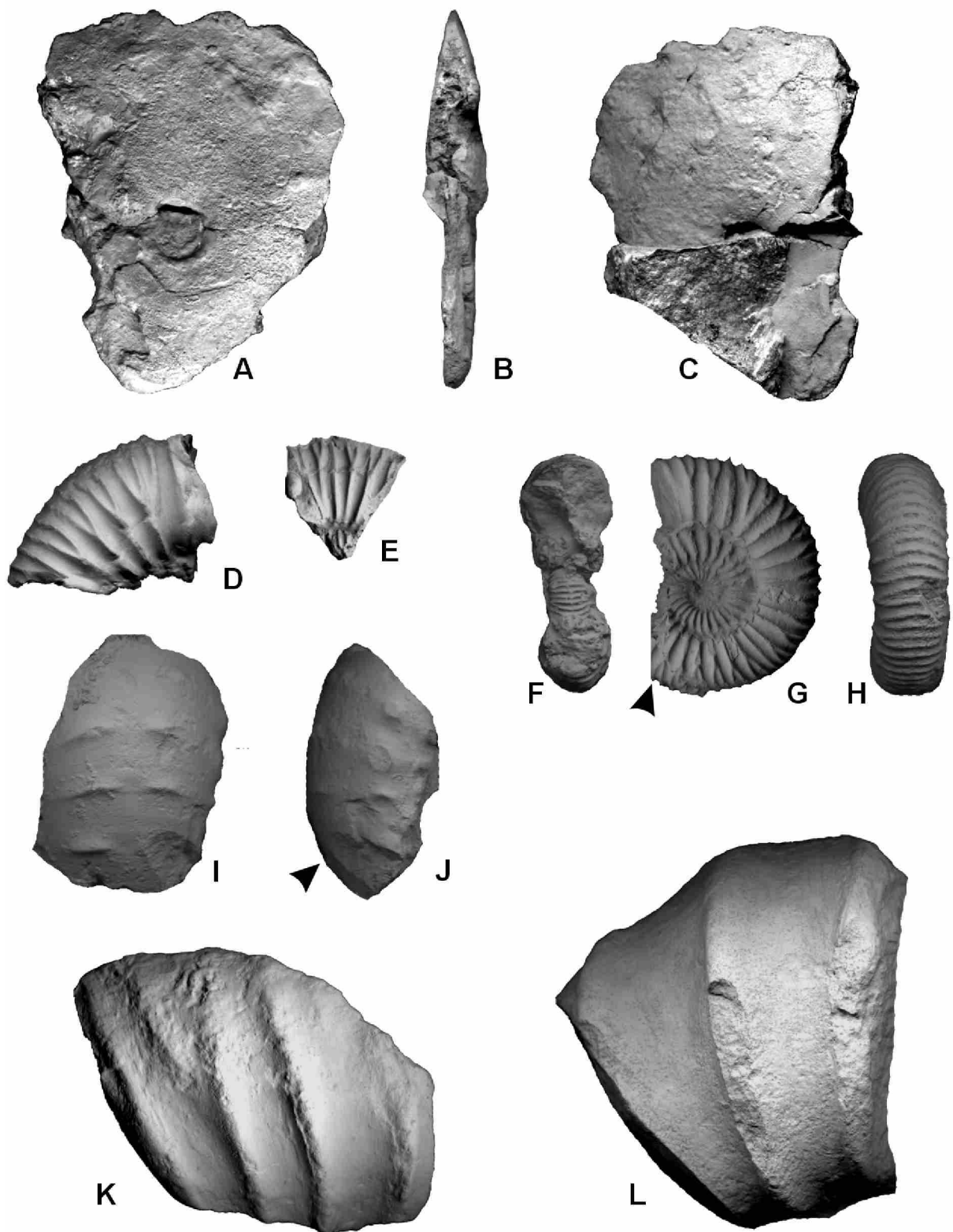


Figure 8. A-C: *Neochetoceras?* sp., adult phragmocone (LPB607), loose from beds CA10-13, A-B: lateral views, B: frontal view through the last septum; D-E: *Torquatisphinctes proximus* transient α (D: LPB601, E: LPB602) from bed CA06 (in a concretion with LPB 603); F-H: *Torquatisphinctes proximus* transient β , almost complete adult (LPB606) from bed CA14; I-J: *Pseudhimalayites subpretiosus* [M], adult bodychamber (LPB 603) from bed CA06; K-L: *Corongoceras* cf. *alternans* [M] (K: LPB604, L: LPB605) from bed CA16. All natural size (x1); arrows denoting the base of the bodychamber. **Figura 8.** A-C: *Neochetoceras?* sp., frágmacono adulto (LPB607), desprendido de alguno de los estratos CA10-13, A-B: vistas laterales, B: vista frontal a través del último septo; D-E: *Torquatisphinctes proximus* transient α (D: LPB601, E: LPB602) del nivel CA06 (en la misma concreción que LPB 603); F-H: *Torquatisphinctes proximus* transient β , adulto casi completo (LPB606) del nivel CA14; I-J: *Pseudhimalayites subpretiosus* [M], cámara habitacional adulta (LPB 603) del nivel CA06; K-L: *Corongoceras* cf. *alternans* [M] (K: LPB604, L: LPB605) del nivel CA16. Todos en tamaño natural (x1); las flechas indican la base de la cámara habitacional.

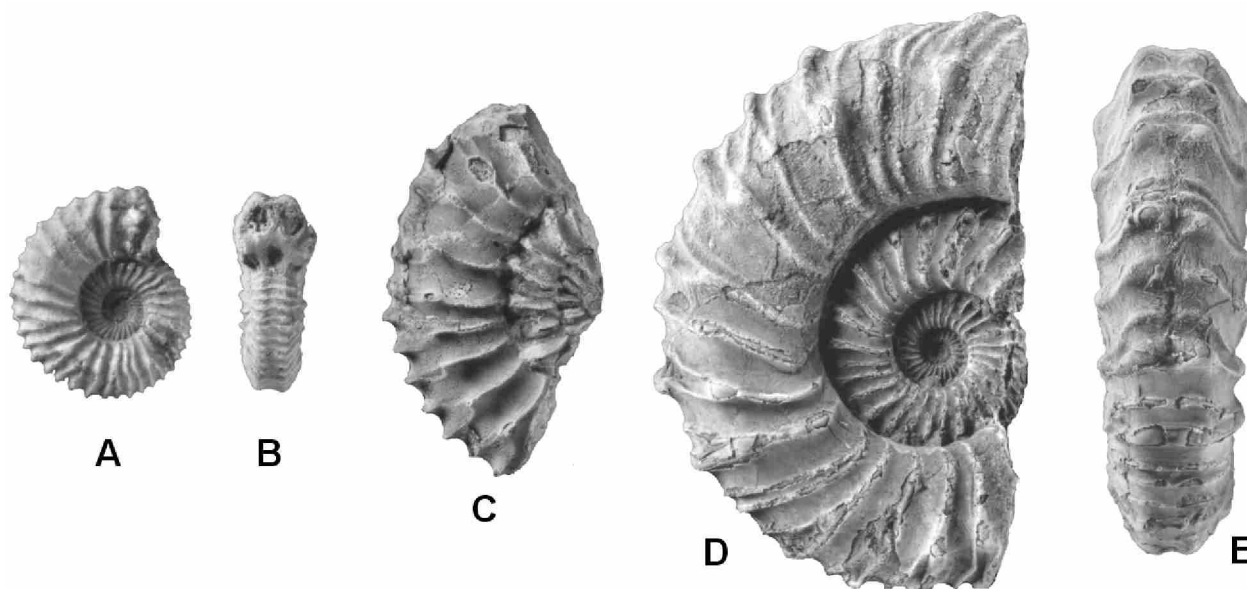


Figura 9. A-B: *Corongoceras lotenoense* (Spath), lateral (A) and ventral (B) views of the holotype figured by Haupt (1907: pl. 9: 7a-b), phragmocone; C: *Corongoceras lotenoense* (Spath), lateral view of the specimen figured by Haupt (1907: pl. 9: 7d), phragmocone with remains of bodychamber; D-E: *Corongoceras alternans* (Gerth) [M], lateral (D) and ventral (E) views of the holotype figured by Gerth (1925: pl. 6: 3-3a). All natural size (x1) specimens at the Paläontologisches Institut der Universität Bonn (GPIBO). **Figura 9.** A-B: *Corongoceras lotenoense* (Spath), vistas lateral (A) y ventral (B) del holotipo figurado por Haupt (1907: pl. 9: 7a-b), fragmácono; C: *Corongoceras lotenoense* (Spath), vista lateral del espécimen figurado por Haupt (1907: pl. 9: 7d), fragmácono con restos de cámara habitacional; D-E: *Corongoceras alternans* (Gerth) [M], vistas lateral (D) y ventral (E) del holotipo figurado por Gerth (1925: pl. 6: 3-3a). Todos los especímenes en tamaño natural (x1), depositados en el Instituto de Paleontología de la Universidad de Bonn.

and a strong ribbing with bifurcations in the upper third of the flanks after a more or less notorious lamelliform tuberculation. The stratigraphic succession of these forms is evident in the material described by Leanza A.F. (1945) and Leanza H.A. (1980) which, in Cerro Lotena, occur immediately above levels containing *T. proximus* (?transient β). This latter and *T. windhausenii* show great resemblance with "*B. peroni*", although their general aspect is still more that of a torquatisphinctid than himalayitid. Some specimens of *T. proximus* transient α develop an incipient ventro-lateral prominence of their primary ribs at the point of bifurcation on the innermost whorls ($3 < D < 10$ mm), anticipating the himalayitid-like sculpture which is seen more markedly in middle and outer whorls of later forms. The derivation of Himalayitidae from late *Torquatisphinctes* close to "*Burckhardticerat*" is in accord with the resemblance of some *Aulacosphinctes* Uhlig, 1910 (the microconchs of *Micracanthoceras* Spath, 1925) with those late *Torquatisphinctes*; this is clearly seen in the Andean faunas and could be the explanation for the common confusion assigning *T. proximus* (Steuer) to *Aulacosphinctes*. The specimens from Chacay Melehué, Neuquén, cited by Sokolov (1946) as *Hoplites microcanthus* Perón are probably related to these forms.

Genus *Corongoceras* Spath, 1925

Type species. *Corongoceras lotenoense*; pro *Hoplites köllikeri* Oppel, 1863 *sensu* Haupt, 1907. Upper Tithonian of Cerro Lotena, Argentina. The holotype (Fig. 9A-B, Table 1, the measurements given by Haupt 1907: 201 appear to be erroneous) consists of inner whorls, without bodychamber. This incomplete specimen has induced subjective interpretations of both, the species and the genus; an example appears to be "*Corongoceras submendozanum* Krantz, 1928, a species defined by a typically Andean berriassellid

ammonite (Krantz 1928: pl. 4: 6, holotype by monotypy) with compressed and finely, densely ribbed phragmocone.

Corongoceras cf. alternans (Gerth, 1925)

Figs. 2, 5F, 8K-L, 9D-E, Table 1

Holotype. By monotypy, the specimen originally figured by Gerth (1925: pl. 6: 3) from Arroyo Durazno, West-Central Mendoza (SD Leanza 1945: 47), refigured herein (Fig. 9D-E). The holotype of *C. lotenoense* (Fig. 9A-B, Table 1) is identical in every detail at a comparable diameter. The other specimen figured by Haupt (1907: pl. 9: 7d) (Fig. 9C) is very different in sculpture and whorl section.

Material. Two fragments of adult bodychambers (LPB 604-605) from bed C16, *Alternans*? Biozone (upper Middle Tithonian lower Upper Tithonian).

Description. Deduced maximum diameter about 200 mm. Whorl section stout suboval, slightly wider than high, with broad rounded venter and slightly arched flanks. The fragments are too short portions of the whorl to estimate the curvature ratio at the umbilical shoulder, but the umbilicus appears to have been moderately open. Ribs are strong, widely spaced, concave forwards, arising from the umbilical wall, and elevated on the umbilical shoulder. Bifurcation is in the upper half of the flanks with secondaries as strong as the primaries. The two last primaries of the bigger specimen remain undivided.

Remarks. The ribbing is typically himalayitid, especially resembling (but at larger size) that of the type species of *Aulacosphinctes* Uhlig 1910, as illustrated by Arkell (1957), and "*Djurjuriceras mediterraneum* Tavera (1985: pl. 19: 1, holotype) from the lower Microcanthum Zone of Sierra Gorda, Spain. No closer comparisons are possible because of the fragmentary preservation of the described material. *C. alternans* is known from the holotype (Fig. 9D-

E) and other few figured specimens. Closely comparable is the specimen from Mallín Redondo figured by Leanza (1945: pl. 1: 2-3) which, moreover, is very similar to the holotype and almost identical with some specimens recently collected in Cajón de Almaza, Neuquén (Fig. 1). The studied specimens should represent adult macroconchs which are as large as those *Corongoceras alternans* figured as *Reineckeia köllikeri* Oppel by Burckhardt (1900b: pl. 20: 14-15, pl. 21: 1) from the Upper Tithonian of Liu Cullín, Neuquén (Fig. 1). A significant difference with the present specimens is the occurrence of tubercles at the points of furcation of ribs.

BIOSTRATIGRAPHY AND TIME-CORRELATION (Figs. 2, 10)

The described fauna is composed, at specific or generic taxonomic level, by taxa well known from the Central Tethys. This faunal affinity enables close time-correlation of Andean ammonite assemblages with the standard chronostratigraphic scale of Europe (Geyssant 1997) based on Leanza (1980, 1981), Olóriz and Tavera (1989) and Parent and Capello (1999). The equivalent zonation developed by Olóriz (1978) could be applied too in chronostratigraphic sense.

The occurrence of *P. zitteli* in the basal beds CA01-CA02, below *T. proximus* transient α , indicates the *Zitteli* Biozone. This biozone is commonly correlated with the lower Middle Tithonian Semiforme Zone of the European standard chronostratigraphic scale (Leanza 1980, 1981; Parent and Capello 1999; cf. Olóriz and Tavera 1989; Zeiss 1983).

The interval CA03-14 represents the *Proximus* Biozone, an interval biozone defined as the rocks comprised between the last occurrence of *P. zitteli* (top of the *Zitteli* Biozone) and the first occurrence of *Windhausenicerias internispinosum* (see Leanza 1980, 1981). The first occurrence of this latter species defines the base of the *Internispinosum* Biozone. The top of the *Proximus* Biozone in the studied section is supposed to be located around the beds CA14-15. However, the bed CA15 has not yielded fossils and is tentatively included in the *Internispinosum* Biozone accounting by the "early-himalayitid" aspect of the specimen of *T. proximus* transient β collected from bed CA14. The level CA06 is age significant by yielding *T. proximus* transient α and *P. subpretiosus* in a single concretion. This latter species has been widely recorded throughout the Tethys (see above and Schweigert 1997 for a review), Cuba (as the microconch *Simocosmoceras* Spath, Myczinski 1989, 1990) and Argentina. Its stratigraphic range in Europe appears to be confined to the Semiforme Zone judging by the ammonite assemblages described in literature. The association of *P. zitteli* with *Volanoceras krantzense* (Cantu-Chapa, 1990) is recorded at Bardas Blancas, Mendoza (Gerth 1925, Krantz 1928, Parent and Capello 1999) indicating the Semiforme Zone (work in progress by Schweigert, Parent and Scherzinger suggests the upper part of the Semiforme Zone). This is a solid indication that the base of the *Proximus* Biozone in Cañadón de los Alazanes lies in the upper Semiforme Zone, what is slightly lower than commonly advocated (cf. Leanza 1980, 1981; Callomon 1993; Parent and Capello 1999). As discussed above, *T. proximus* transient β shows some

resemblance to "*Burckhardticeras*" *peroni* (Roman), and *W. internispinosum*, what suggests a late Middle Tithonian Ponti Zone age for the upper part of the *Proximus* Biozone and, probably, lower part of the *Internispinosum* Biozone. Biostratigraphically, the uppermost part of the range of *T. proximus* lies around the top of the *Proximus* and the base of *Internispinosum* Biozones, where it is more completely represented (e.g., Cañadón de los Alazanes, Cerro Lotena).

The record of a loose specimen of *Neochetoceras*? sp. coming from around the levels CA10-CA13 is interesting because it is the first record of such a form in the basin, although it contributes little for correlation. The resemblance with some forms of Fallauxi Zone age (see above) is suggestive of this Middle Tithonian interval within which may be approximately included in the *Proximus* Biozone in southern Neuquén-Mendoza Basin.

It is interesting to note, that if new sampling yields *P. zitteli* in beds higher than CA02, the boundary between the *Zitteli* and *Proximus* Biozones might be moved higher than traced herein. It is a consequence of the nature of biozones: rocks characterized by their fossil content, defined independently of time. The need for the development of a standard chronostratigraphic classification of the Andean Tithonian becomes evident when biostratigraphic time-correlation is intended (see Callomon 1985, 1995 for full general discussion).

There is no further sampled material from bed CA16 for correlation besides the fragments described as *Corongoceras* cf. *alternans*, which suggest some part of the homonymous biozone. Leanza (1980, 1981) and Parent and Capello (1999) have correlated the fauna of the *Alternans* Biozone with the lower Upper Tithonian Microcanthum Zone. In the Tithonian succession at Los Catutos (between Zapala city and Portada Covunco in the map of Fig. 1), Leanza and Zeiss (1990: fig. 4, table 1) indicate the occurrence of *Djurjuriceras catutosense* Leanza and Zeiss, 1990, *Djurjuriceras*? sp. and *Corongoceras* sp. in levels "x+a" to "y", top of *Proximus* and lower *Internispinosum* Biozones (cf. Leanza and Zeiss 1992). This succession suggests that bed CA16 could belong to the *Internispinosum* Biozone, although the expected lithographic limestones of Los Catutos, described by Leanza and Zeiss (1990, 1992), appear to be missing at Cañadón de los Alazanes.

CONCLUSION

The rock and ammonite successions at Cañadón de los Alazanes fit the general patterns seen through the basin and closely compare with those of Mallín de Los Caballos and Mallín Quemado. *Pseudolissoceras zitteli* [M&m] is more closely related to haploceratids than to oppeliids as indicated by the form of its sexual dimorphism, the tendency to flatten flanks and the development of ventral folds or ridges seen in macroconchs. In the Andes *P. zitteli* is nearly confined to rocks of Semiforme Zone age in correspondence with the range in Europe and the short biogeographic expansion of the genus during that time. The widely distributed, but typically scarce, *Pseudhimalayites subpretiosus*, here represented by a specimen identical to the lectotype of *P. steinmanni*, associated with *Torquatisphinctes proximus* transient α , indicates that the base of the *Proximus* Biozone may lie in the upper Semiforme-lower Fallauxi Zones. *T. proximus* transient α is

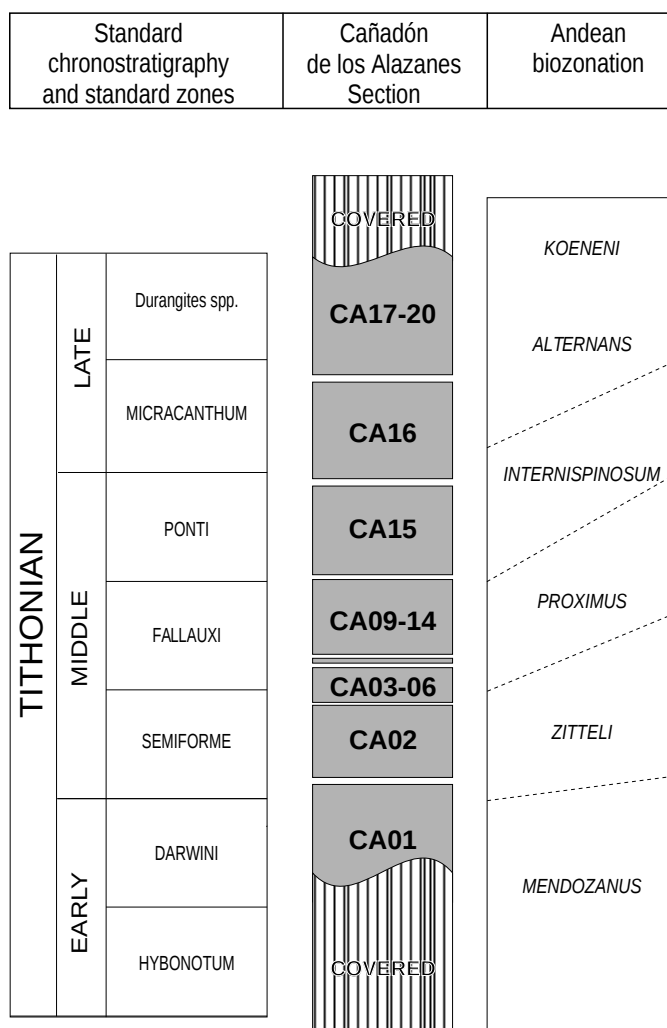


Figure 10. Correlation chart based on Leanza (1981), Parent & Capello (1999) and present results; shaded boxes indicate the estimated temporal range (age) of faunal levels based on the ammonoid fauna; inclined dotted lines in Andean biozonation denote the variation of the temporal limits of the biozones through the basin. Separation between boxes does not represent magnitude of time, but only probable gaps. **Figura 10.** Carta de correlación basada en Leanza (1981), Parent & Capello (1999) y los presentes resultados; las cajas sombreadas indican el intervalo temporal estimado (edad) de los niveles fáunicos con base en la fauna de ammonoideos; las líneas punteadas inclinadas en la biozonación andina denotan la variación de los límites temporales de las biozonas a través de la cuenca. La separación entre las cajas sombreadas no representa magnitud de tiempo, sino simplemente probables discontinuidades temporales.

close to the lower Tithonian *T. mendozanus*, and the late transient β strongly resembles early himalayitids, thus suggesting the origin of this family in the latter *T. proximus* (transient β). Sexual dimorphic status remains unclear, like for the whole genus *Torquatisphinctes*.

Direct faunal affinities between Andean and Central Tethyan Tithonian ammonite faunas are proved once again from samples of internal areas of the longitudinally arranged Neuquén-Mendoza Basin. Longitudinal-type and latitudinal-type basins are expected to generate very different paleobiogeographic patterns and scenarios. These faunal affinities, noted previously (Parent and Capello 1999; Parent, in press), allow direct intercontinental correlation of some Andean faunal assemblages with the standard time scale of Europe. Definition of faunal horizons containing associations of species also recognized in Europe may become the base for intercontinental time-correlations of a standard chronostratigraphic classification of the Andean Upper Jurassic (under current study).

Acknowledgements

I am indebt with F. Olóriz (Granada) and G. Schweigert (Stuttgart) who made important suggestions for improving the manuscript. For many fruitful discussions, information, and bibliography I deeply thank to many friends and colleagues: S. Cocca, R. Cocca, A. Carlini (Zapala), G. Schweigert (Stuttgart), A. Scherzinger (Hattingen), F. Olóriz (Granada), F. Cecca (Marseille), C. Sarti (Bologna), R. Myczynski (Warsaw), Matilde Beresi (Mendoza), H.A. Leanza (Buenos Aires), A.B. Villaseñor (Mexico), J.M. Tavera and A. Checa (Granada), G. Schairer (München), J.H. Callomon (London), N. Clark (Glasgow), J.C.W. Cope (Cardiff), M.R.A. Thomson (Cambridge), M. Santantonio (Roma), A. Benetti (Velo Veronese), I.G. Sapunov (Sofia), A.J. Crame (Cambridge), I. Fözy (Budapest), R. Enay (Lyon), A. Zeiss (Erlangen), A. Wierzbowski (Warsaw), I. Sey (St. Petersburg). Casts and photographs of type material were kindly provided by G. Schairer (München) and M. Sander (Bonn). O.D. Capello and L.S. Filippi (Rosario) collaborated in laboratory work. The following institutions have given kind and valuable support: Museo Olsacher, Zapala, Ministère de l'Industrie de La Republique Tunisienne (Larbi Cherif, Tunis), Library of the Servicio Geológico de México (México DF), Royal Ontario Museum (Ontario), Staatliches Museum für Naturkunde (Stuttgart), Bayerische Staatssammlung für Paläontologie und Geologie (München). Field-work has been funded by Facultad de Ingeniería, Universidad Nacional de Rosario and supported by the Museo Olsacher (Zapala).

REFERENCES

- Arkell W.J., 1957. Jurassic ammonites. In Arkell W.J., Kummel B. and Wright C.W.: Treatise on Invertebrate Paleontology, (L) Mollusca 4, R.C. Moore (ed.).- *University of Kansas Press and Geological Society of America, Kansas and New York*, 22+490p.
- Arnould-Saget S., 1951a. Sur la présence de *Pseudolissoceras Zitteli* (Burckhardt) en Tunisie centrale.- *Bulletin de la Société des Sciences Naturelles de Tunisie* 4(1-4): 16-17.
- Arnould-Saget S., 1951b. Les Ammonites pyriteuses du Tithonique Supérieur et du Berriasien de Tunisie Centrale.- *Annales des Mines et de la Géologie* 10: 1-5 + 1-133.
- Avram E., 1976. Les fossiles du flysch éocénétique et des calcaires tithoniques des hautes vallées de la Dofnana et du Tirlung (Carpates Orientales).- *Mémoires Institut de Géologie et de Géophysique* 24: 5-74.
- Barthel, K.W., 1962. Zur Ammonitenfauna und Stratigraphie der Neuburger Bankkalke.- *Bayerische Akademie der Wissenschaften, Mathematisch-naturwissenschaftliche Klasse* 105: 1-30.
- Berckhemer F. and Hölder H., 1959. Ammoniten aus dem Oberen Weien Jura Süddeutschlands.- *Beihefte zum Geologischen Jahrbuch* 35: 1-135.
- Bernoulli D. and Renz O., 1970. Jurassic Carbonate Facies and New Ammonite Faunas from Western Greece.- *Eclogae geologicae Helvetiae* 63(2): 573-607.
- Burckhardt C., 1900a. Profils géologiques transversaux de la Cordillere Argentino-Chilienne. Stratigraphie et Tectonique.- *Annales del Museo de La Plata, Sección Geología y Minería* 2: 1-136.
- Burckhardt C., 1900b. Coupe géologique de la Cordillere entre Las Lajas et Curacautin.- *Annales del Museo de La Plata, Sección Geología y Minería* 3: 1-102.
- Burckhardt C., 1903. Beiträge zur Kenntnis der Jura- und Kreideformation der Cordillere.- *Palaeontographica* 50: 1-145.
- Burckhardt C., 1906. La faune jurassique de Mazapil avec un appendice sur les fossiles du Crétacique inférieur.- *Boletín del Instituto Geológico de México* 23: 1-216.
- Callomon J.H., 1985. The evolution of the Jurassic ammonite family Cardiocerataidae.- *Special Papers in Palaeontology* 33: 49-90.
- Callomon J.H., 1993. Upper Jurassic, especially of Mexico. Part 4: Biochronology. 12. Ammonite Zones of the Circum-Pacific Region. Hillebrandt A. von, Smith P., Westermann G.E.G. and Callomon J.H.- In: Westermann G.E.G. (Ed.): *The Jurassic of the Circum-Pacific*: 247-272.
- Callomon J.H., 1995. Time from fossils: S.S. Buckman and Jurassic high-resolution geochronology. In: Le Bas M.J. (ed.): *Milestones in Geology.- Geological Society London, Memoirs* 16: 127-150.
- Cantu-Chapa A., 1967. El límite Jurásico-Cretácico en Mazatepec, Puebla (Mexico).- *Instituto Mexicano del Petróleo, Sección Geología, Monografía* 1: 3-24.
- Cantu-Chapa A., 1990. *Volanoceras chignahuapense* sp. nov., amonita del Tithoniano Inferior de Puebla, Centro de México.- *Revista Sociedad Mexicana de Paleontología* 3(1): 41-45.
- Cecca F., 1999. Palaeobiogeography of Tethyan ammonites during the Tithonian (latest Jurassic).- *Palaeogeography, Palaeoclimatology, Palaeoecology* 147: 1-37.
- Cecca F. and Enay R., 1991. Les Ammonites des zones à Semiforme et à Fallaux du Tithonique de l'Ardeche (sud-Est de la France): Stratigraphie, Paléontologie, Paléobiogeographie.- *Palaeontographica* A219: 1-87.
- Cecca F. and Santantonio M., 1988. Kimmeridgian and Early Tithonian ammonite assemblages in the Umbrian-Marchese-Sabine Apennines (Central Italy).- *Proceedings 2nd International Symposium on Jurassic Stratigraphy* (Lisboa): 525-542.
- Cecca F., Cresta S., Pallini G. and Santantonio M., 1983-1984. Biostratigrafia ed Ammoniti del Dogger Malm di Colle Tordina (Monti della Rossa, Appennino Marchigiano).- *Bollettino del Servizio Geologico d'Italia* 104: 177-204.
- Cecca A., 1985. Los Aspidoceratiformes en Europa (Ammonitina, fam. Aspidoceratidae, subfamilias Aspidoceratinae y Physodoceratinae).- *Tesis doctorales Universidad Granada*, 136: 1-17 + 1-413.
- Cloos D., 1961. Los "Aptychi" (Cephalopoda Ammonoidea) de Argentina.- *Revista de la Asociación Geológica Argentina* 16(3-4): 117-141.
- Corvalán J., 1959. El Tithoniano de Río Leñas, Provincia de O'Higgins, con una revisión del Tithoniano y Neocomiano de la parte Chilena del geosinclinal andino.- *Boletín del Instituto de Investigaciones Geológicas de Chile* 3: 1-63.
- Dommergues J.-L., 1990. Ammonoids.- In K.J. McNamara (ed.): *Evolutionary Trends*. Belhaven Press (London): 162-187.
- Dommergues J.-L., David B. and Marchand D., 1986. Les relations ontogénese-phylogénese: applications paléontologiques.- *Geobios* 19(3): 335-356.
- Donovan D.T., Callomon J.H. and Howarth M.K., 1981. Classification of the Jurassic Ammonitina. In Hourse M.R. and Senior J.R. (eds.): *The Ammonoidea.- Systematics Association Special Volume* 18: 101-155. Academic Press, London and New York.
- Donze P. and Enay R., 1961. Les Céphalopodes du Tithonique Inferieur de la Croix-de-Saint-Concors pres Chambéry (Savoie).- *Travaux Laboratoire Géologique de Lyon* NS7: 1-236.
- Enay R., 1983. Spéciation phylétique dans le genre d'ammonite téthysien Semiformiceras Spath, du Tithonique inférieur des chaînes bétiques (Andalousie, Espagne).- *Colloques internationaux du CNRS* 330: *Modalités, rythmes, mécanismes de l'évolution biologique. Gradualisme phylétique et équilibres ponctués?*, Dijon, 1982. CNRS, Paris, p. 115-123.
- Enay R. and Cecca F., 1986. Structure et evolution des populations tithoniques du genre d'ammonites téthysien *Haploceras Zittel*, 1868.- In G. Pallini, F. Cecca, S. Cresta, M. Santantonio (eds.): *Atti del primo convegno internazionale Fossili, Evoluzione, Ambiente, Pergola* 1984: 37-53.
- Fontannes F., 1879. Description des ammonites des calcaires du Chateau de Crussol, Ardeche (zones à *Oppelia tenuilobata* et *Waagenia beckeri*).- *Georg edit.*, p. 1-11+1-123, Lyon.

- Fözy I., 1988. Tithonian ammonites (Oppeliidae, Haploceratidae and Simoceratidae) from the Transdanubian Central Range, Hungary.- *Annales Universitatis Scientiarum Budapestinensis de Rolando Eötvös Nominatae, Sectio Geologica* **28**: 43-119.
- Fözy I., 1994. A unique lower Tithonian fauna in the Gerecse Mts., Hungary.- *Palaeopelagos Special Publication* **1**: 155-165.
- Gerth H., 1925. Contribuciones a la estratigrafía y paleontología de los Andes Argentinos I: Estratigrafía y distribución de los sedimentos mesozoicos en los Andes Argentinos.- *Actas de la Academia Nacional de Ciencias de la República Argentina* **9(1-2)**: 7-55.
- Geyssant J., 1997. Tithonien. In: E. Cariou and P. Hantzpergue (eds.): Groupe Français d'étude du Jurassique: Biostratigraphie du Jurassique Ouest-Européen et Méditerranéen.- *Bulletin Centre Recherche Elf Exploration Production Mémoire* **17**: 97-102.
- Gründel J. and Parent H., 2001. Lower and Middle Tithonian (Upper Jurassic) marine gastropods from the Neuquén-Mendoza Basin, Argentina.- *Boletín del Instituto de Fisiografía y Geología* **71(1-2)**: 13-18.
- Guex J., 1970. Sur les moules internes des Dactylocératidés.- *Bulletin de la Société vaudoise des Sciences naturelles* **70(332)**: 1-7.
- Haupt O., 1907. Beiträge zur Fauna des Oberen Malm und der Unteren Kreide in der argentinischen Cordillere.- *Neues Jahrbuch für Mineralogie, Geologie und Paläontologie* **23**: 187-236.
- Imlay R.W., 1942. Late Jurassic fossils from Cuba and their economic significance.- *Bulletin of the Geological Society of America* **63**: 953-992.
- Kiessling W., Scasso R., Zeiss A., Riccardi A.C. and Medina F.A., 1999. Combined radiolarian-ammonite stratigraphy for the Late Jurassic of the Antarctic Peninsula: implications for radiolarian stratigraphy.- *Geodiversitas* **21(4)**: 687-713.
- Krantz F., 1928. La fauna del Titono superior y medio en la parte meridional de la provincia de Mendoza.- *Actas de la Academia Nacional de Ciencias de la República Argentina* **10**: 9-57.
- Kutek J. and Wierzbowski A., 1986. A new account on the Upper Jurassic stratigraphy and ammonites of the Czorsztyn succession, Pieniny Klippen Belt, Poland.- *Acta Geologica Polonica* **36(4)**: 289-316.
- Lambert L.R., 1956. Descripción geológica de la Hoja 35b. Zapala (T.N. de Neuquén).- *Dirección Provincial de Minería Boletín* **83**: 1-93.
- Landman N.H., Dommergues J.-L. and Marchand D., 1991. The complex nature of progenetic species: examples from Mesozoic ammonites.- *Lethaia* **24**: 409-421.
- Leanza A.F., 1945. Amonites del Jurásico Superior y del Cretácico inferior de la Sierra Azul, en la parte meridional de la provincia de Mendoza.- *Annales del Museo de La Plata, NS* **1**: 1-99.
- Leanza H.A., 1973. Estudio sobre los cambios faciales de los estratos limítrofes Jurásico-Cretácicos entre Loncopué y Picún Leufú, provincia de Neuquén, República Argentina.- *Revista de la Asociación Geológica Argentina* **28(2)**: 97-132.
- Leanza H.A., 1975. *Himalayites andinus* n. sp. (Ammonitina) del Tithoniano superior de Neuquén, Argentina.- *Actas del Primer Congreso Argentino de Paleontología y Bioestratigrafía* **1**: 581-588.
- Leanza H.A., 1980. The Lower and Middle Tithonian Fauna from Cerro Lotena, Province of Neuquén, Argentina.- *Zitteliana* **5**: 3-49.
- Leanza H.A., 1981. The Jurassic-Cretaceous boundary beds in west central Argentina and their ammonites zones.- *Neues Jahrbuch für Geologie und Paläontologie Abhandlungen* **161(1)**: 62-92.
- Leanza H.A., 1993. Estratigrafía del Mesozoico posterior a los Movimientos Intermálicos en la comarca del Cerro Chachil, Provincia del Neuquén.- *Revista de la Asociación Geológica Argentina* **48(1)**: 71-84.
- Leanza H.A. and Hugo C.A., 1977. Sucesión de ammonites y edad de la Formación Vaca Muerta y sincrónicas entre los paralelos 35° y 50°S, Cuenca neuquina-mendocina.- *Revista de la Asociación Geológica Argentina* **32(4)**: 248-264.
- Leanza H.A., Marchese H.G. and Riggi J., 1977. Estratigrafía del Grupo Mendoza con especial referencia a la Formación Vaca Muerta entre los paralelos 35° y 40°S, Cuenca neuquina-mendocina.- *Revista de la Asociación Geológica Argentina* **32(3)**: 190-208.
- Leanza H.A. and Olóriz F., 1987. Presencia del género *Simocoscoceras* Spath (Cephalopoda Ammonoidea) en el Tithoniano andino y su significado paleobiogeográfico.- *Ameghiniana* **24**: 203-209.
- Leanza H.A. and Zeiss A., 1990. Upper Jurassic Lithographic limestones from Argentina (Neuquén Basin): Stratigraphy and fossils.- *Facies* **22**: 169-186.
- Leanza H.A. and Zeiss A., 1992. On the ammonite fauna of the Lithographic Limestones from the Zapala region (Neuquén province, Argentina), with the description of a new genus.- *Zentralblatt für Geologie und Paläontologie (Teil 1)* **6**: 1841-1850.
- Malinowska L., 1988. Geology of Poland, vol. 3. Atlas of guide and characteristic fossils, Part 2b, Mesozoic, Jurassic.- *Instytut Geologiczny*, 476 pp.
- McNamara K., 1982. Heterochrony and phylogenetic trends.- *Paleobiology* **8(2)**: 130-142.
- McNamara K., 1986. A guide to the nomenclature of Heterochrony.- *Journal of Paleontology* **60(1)**: 4-13.
- Memmi L., 1967. Succession de faunes dans le Tithonique supérieur et le Berriasien du Djebel Nara (Tunisie centrale).- *Bulletin de la Société Géologique de France* (7), **9**: 267-272.
- Munier-Chalmas M., 1892. Sur la possibilité d'admettre un dimorphisme sexuel chez les Ammonitidés.- *Compte-rendu sommaire Séances Société géologique de France* (3) **20, 14**: 170-174.
- Myczynski R., 1989. Ammonite biostratigraphy of the Tithonian of Western Cuba.- *Annales Societatis Geologorum Poloniae* **59**: 43-125.
- Myczynski R., 1990. *Simocoscoceras* Spath (Perisphinctidae, Ammonitina) in the Lower Tithonian of Sierra del Rosario (Western Cuba).- In G. Pallini, F. Cecca, S. Cresta, M. Santantonio (eds.): Atti del secondo convegno internazionali Fossili, Evoluzione, Ambiente, Pergola 1987: 401-403.
- Myczynski R., 1994. Caribbean Ammonite Assemblages from Upper Jurassic Lower Cretaceous sequences of

- Cuba.- *Studia Geologica Polonica* **105**: 91-108.
- Myczynski R. and Pszczolkowski A., 1994. Tithonian stratigraphy and microfacies in the Sierra del Rosario, Western Cuba.- *Studia Geologica Polonica* **105**: 7-38.
- Olóriz F., 1978. Kimmeridgiano-Tithónico inferior en el sector central de las Cordilleras Béticas (Zona Subbética). Paleontología, Bioestratigrafía.- *Tesis doctorales Universidad de Granada* **184**, 758p.
- Olóriz F. and Tavera J.M., 1989. The significance of Mediterranean ammonites with regard to the traditional Jurassic-Cretaceous boundary.- *Cretaceous Research* **10**: 221-237.
- Olóriz F., Villaseñor A.B., Gonzalez-Arreola C. and Westermann G.E.G., 1999. Ammonite biostratigraphy and correlations in the Upper Jurassic lowermost Cretaceous La Caja Formation of North-Central Mexico (Sierra de Catorce, San Luis Potosí).- In F. Olóriz and F.J. Rodríguez-Tovar (eds.): *Advancing Research on Living and Fossil Cephalopods*: 463-492. Kluwer Academic / Plenum Publishers, New York.
- Oppel A., 1862-1863. III. Über jurassische Cephalopoden.- *Paleontologisches Mitteilungen* **1**: 127-262.
- Oppel A., 1865. Die tithonische Etage.- *Zeitschrift der Deutschen Geologischen Gesellschaft* **17**: 535-558.
- Parent H., 1997. Ontogeny and sexual dimorphism of *Eurycephalites vergarensis* (Burckhardt) [M] / *Xenocephalites gottschei* (Tornquist) [m] of the Andean Lower Callovian (Ammonoidea, Middle Jurassic, Argentine-Chile).- *Geobios* **30**: 407-419.
- Parent H., 1998. Upper Bathonian and lower Callovian ammonites from Chacay Melehué (Argentina).- *Acta Paleontologica Polonica* **43**(1): 69-130.
- Parent H., in press. The Ataxioceratid Ammonite Fauna of the Tithonian (Upper Jurassic) of Casa Pincheira, Mendoza (Argentina). In H. Parent, G. Meléndez and F. Olóriz (eds.): *Jurassic of South America.- Journal of South American Earth Sciences, Special Issue*.
- Parent H. and Capello O.D., 1999. Ammonites del Tithoniano inferior de Casa Pincheira, Mendoza (Argentina).- *Revue de Paléobiologie* **18**(1): 347-353.
- Riccardi A.C., Gulisano C.A., Mojica J., Palacios O., Schubert C. and Thompson M.R.A., 1992. 6. Western South America and Antarctica.- In Westermann G.E.G. (Ed.): *The Jurassic of the Circum-Pacific*, 122-161. Cambridge University Press.
- Roman F., 1936. Le Tithonique du Massif du Djurdjura.- *Materiaux pour la Carte Géologique de L'Algérie, Serie 1 (Paléontologie)* **7**: 1-43.
- Roman F., 1938. Les ammonites Jurassiques et Crétacées.- *Masson et Cie.*, Paris, 554p.
- Scherzinger A. and Schweigert G., 1999: Die Ammoniten-Faunenhorizonte der Neuburg-Formation (Oberjura, Südliche Frankenalb) und ihre Beziehungen zum Volgium.- *Mitteilungen der Bayerischen Staatssammlung für Paläontologie und historische Geologie* **39**: 3-12.
- Schneid T., 1915. Die Ammonitenfauna der obertithonischen Kalke von Neuburg a. d. Donau.- *Geologische und Palaeontologische Abhandlungen (Neue Folge) Band 13*: 305-416.
- Schweigert G., 1997. Die Ammonitengattungen *Simoceras* Spath und *Pseudhimalayites* Spath (Aspidoceratidae) im süddeutschen Oberjura.- *Stuttgarter Beiträge zur Naturkunde* **B246**: 1-29.
- Sey I.I. and Kalacheva E.D., 1996. Upper Jurassic-Lower Cretaceous Biostratigraphy and Fauna of South Primorie (Russian Far East).- *Geology of Pacific Ocean* **12**: 293-312.
- Sey I.I. and Kalacheva E.D., 1997. Ammonite complexes from the Middle Tithonian deposits of Southern Seaside, Far-East of Russia (Haploceratidae, Oppeliidae, Ataxioceratidae).- *Regional Geology and Metallogeny* **6**: 90-102.
- Sey I.I., Kalacheva E.D. and Khudoley K.M., 1988. 1.3. Ammonites and bivalves of the Far East (1. Soviet Union).- *Newsletters in Stratigraphy* **19**(1-2): 35-65.
- Simpson G.G., 1942. Patterns of phyletic evolution.- *Bulletin of the Geological Society of America* **48**: 303-313.
- Sokolov D.N., 1946. Algunos fósiles suprajurásicos de la República Argentina.- *Revista de la Asociación Geológica Argentina* **1**(1): 7-16.
- Sowerby J.C. de, 1840. Memoir to illustrate a geological map of Kutch.- *Transactions of the Geological Society of London* **(2)**, 5.
- Spath L.F., 1924. On the Blake Collection of Ammonites from Kacch, India.- *Palaeontographica Indica* **9**: 1-29.
- Spath L.F., 1925. Ammonites and Aptychi. The Collection of Fossils and Rocks from Somaliland.- *Monographs Geological Department of the Hunterian Museum* **1**: 111-164.
- Spath L.F., 1950. A new Tithonian ammonite fauna from Kurdistan, northern Iraq.- *Bulletin British Museum of Natural History* **1**: 95-137.
- Steuer A., 1897. Argentinische Jura-Ablagerungen. Ein Beitrag zur Kenntniss der Geologie und Paläontologie der argentinischen Anden.- *Paläontologische Abhandlungen* **3**(3), 127-222.
- Steuer A., 1921. Estratos Jurásicos Argentinos. Contribución al conocimiento de la Geología y Paleontología de los Andes Argentinos entre el río Grande y el río Atuel.- *Actas de la Academia Nacional de Ciencias de la República Argentina* **7**(2): 25-128. [Spanish translation of Steuer A., 1897].
- Tavera J.M., 1985. Los ammonites del Tithónico superior-Berriasense de la Zona Subbética (Cordilleras Béticas).- *Tesis doctorales Universidad de Granada* **587**: 1-381.
- Thomson M.R.A., 1979. Upper Jurassic and Lower Cretaceous Ammonite Faunas of the Ablation Point Area, Alexander Island.- *British Antarctic Survey Scientific Reports* **97**: 1-37.
- Tintant H., 1952. Principes de la Systématique. In J. Piveteau (Director): *Traité de Paléontologie*, **Tome 1**: 41-64.- *Masson et Cie.*, Paris.
- Uhlig V., 1878. Beiträge zur Kenntnis der Jura-Formation in den Karpatischen Klippen.- *Jahrbuch der kaiserlich-königlichen geologischen Reichsanstalt* **28**: 641-658.
- Uhlig V., 1903-1910. The Fauna of the Spiti Shales.- *Palaeontographica Indica* **15**(4): 1-395.
- Verma H.M. and Westermann G.E.G., 1973. The Tithonian (Jurassic) Ammonite Fauna and Stratigraphy of Sierra Catorce, San Luis Potosí, Mexico.- *Bulletins of American Paleontology* **63**, 277: 103-320.
- Villaseñor A.B., Olóriz F. and González-Arreola C., 2000.

- Recent Advances in Upper Jurassic (Kimmeridgian Tithonian) Ammonite Biostratigraphy of North-Central Mexico Based on Recently Collected Ammonite Assemblages.- *Georesearch Forum* **6**: 249-262.
- Weaver C., 1931. Paleontology of the Jurassic and Cretaceous of West Central Argentina.- *Memoires of the University of Washington* **1**: 1-496.
- Westermann G.E.G., 1992. Limits of global bio-event correlation: diachronous ammonite "extinction" across Jurassic bioprovinces.- *Revista de la Asociación Geológica Argentina* **47(4)**: 353-364.
- Witham A.G. and Doyle P., 1989. Stratigraphy of the Upper Jurassic-Lower Cretaceous Nordenskjöld Formation.- *Journal of South American Earth Sciences* **2**: 371-384.
- Zeiss A., 1983. Zur Frage der Äquivalenz der Stufen Tithon/Berrias/Wolga/Portland in Eurasien und Amerika. Ein Beitrag zur Klärung der weltweiten Korrelation der Jura-/Kreide-Grenzschichten im marinen Bereich.- *Zitteliana* **10**: 427-438.
- Zejszner L., 1846. Nowe lub niedokładnie opisane gatunki skamieniałości Tatrów odkrył i opisał.- *Poszyt* **1**: 1-32(?).
- Ziegler B., 1958. Monographie der Ammonitengattung *Glochiceras* im epikontinentalen Weissjura Mitteleuropas.- *Palaeontographica* **A110**: 93-164.
- Zittel K.A., 1870. Die Fauna der älteren Cephalopoden führenden Tithonbildungen. - *Palaeontographica*, **Supplement-Band**: 1-192.