

AMMONITES OF THE MIDDLE TITHONIAN INTERNISPINOSUM ZONE FROM BARDA NEGRA, SOUTHERN NEUQUÉN-MENDOZA BASIN, ARGENTINA

Horacio PARENT, Armin SCHERZINGER, Günter SCHWEIGERT & Oscar D. CAPELLO



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Abstract.- An ammonite fauna from an isolated outcrop of the Upper Jurassic Vaca Muerta Formation is described from Barda Negra in the southern part of the Neuquén-Mendoza Basin. It comprises several macroconch specimens of the species *Aspidoceras* cf. *euomphalum* Steuer, 1897 besides macroconchs and microconchs of *Windhausenicerias internispinosum* (Krantz, 1926), the index species of the Andean Middle Tithonian Internispinosum Zone. Morphological and taxonomic relationships of the studied aspidoceratids with previously described species and the sexual dimorphism in *W. internispinosum* are discussed.

Key-words: Tithonian, Neuquén-Mendoza Basin, *Aspidoceras*, *Windhausenicerias*, Sexual Dimorphism, Biostratigraphy.

Resumen.- Amonites de la Zona Internispinosum del Tithoniano Medio de Barda Negra, sur de la Cuenca Neuquén-Mendoza, Argentina. Se describe una fauna de amonites colectada en un afloramiento aislado de la Formación Vaca Muerta en Barda Negra, en la parte sur de la Cuenca Neuquén-Mendoza. Esta fauna comprende especímenes de *Aspidoceras* cf. *euomphalum* Steuer, 1897 y macroconchas y microconchas de *Windhausenicerias internispinosum* (Krantz, 1926), la especie índice de la Zona Internispinosum del Tithoniano Medio andino. Se discuten las relaciones morfológicas y taxonómicas de los aspidoceratidos estudiados con las especies previamente descritas y el dimorfismo sexual de *W. internispinosum*.

Palabras clave: Tithoniano, Cuenca Neuquén-Mendoza, *Aspidoceras*, *Windhausenicerias*, Dimorfismo sexual, Bioestratigrafía.

Horacio Parent [e-mail: parent@fceia.unr.edu.ar]: *Laboratorio de Paleontología, FCEIA, Universidad Nacional de Rosario, Pellegrini 250, 2000 Rosario, Argentina.*

Armin Scherzinger [e-mail: Armin.Scherzinger@t-online.de]: *Hewenstraße 9, 78194 Immendingen-Hattingen, Germany.*

Günter Schweigert [e-mail: schweigert.smns@naturkundemuseum-bw.de]: *Staatliches Museum für Naturkunde, Rosenstein 1, 70191 Stuttgart, Germany.*

Oscar D. Capello: *Tucumán 1990, 2000 Rosario, Argentina.*

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INTRODUCTION

Barda Negra is the name generally used to indicate a rather flat, wide area located west of the large basaltic Meseta Barda Negra, about 20 km south of Zapala, in the southeastern part of the Neuquén-Mendoza Basin (Fig. 1). This area belongs to the Geological Sheet 36c – Cerro Lotena (Neuquén), which was masterly described by Suero (1951). Almost the whole area is covered by recent sands and other modern materials. Outcrops of marine rocks from the Upper Jurassic and Lower Cretaceous are small and scattered. There were no published descriptions of ammonites from this area. During recent fieldwork related with the inspection for potential limestone exploitations, a small outcrop (Fig. 1) has been discovered. The outcrop consists of decimetric beds of limestones belonging to the Vaca Muerta Formation and containing a rich marine fauna of Tithonian age. The exposed few meters of limestones belong to the Andean Middle Tithonian Internispinosum Zone. The lithology is similar to the equivalent horizons in Cerro Lotena (see Leanza 1980). The fauna includes bivalves, gastropods (*Tornatellaea mendozana* Gründel et al., 2007), nautiloids and ammonites. The ammonites are abundant, in general moderately well-preserved, and some of them with their preserved aptychi, besides some microconchs showing the adult peristome with the lappets.

The aim of this paper is to describe the ammonite fauna and to correlate the stratigraphic horizon based on the ammonite biostratigraphy of the Neuquén-Mendoza Basin.

STRATIGRAPHY

The section at the outcrop studied is about 2.63 m thick with the following stratigraphic succession (Fig. 1), from top:

Bed BN-15: 0.21 m, hard, grey to white limestone. Decapods and gastropods (*Tornatellaea mendozana*).

Bed BN-14: 0.06 m, yellowish white marl.

Bed BN-13: 0.18 m, hard, grey to white limestone.

Bed BN-12: 0.01 m, yellowish white marl.

Bed BN-11: 0.24 m, hard, grey to white limestone.

Bed BN-10: 0.13 m, yellowish white marl.

Bed BN-9: 0.20 m, hard, grey to white limestone.

Bed BN-8: 0.15 m, yellowish white marl.

Bed BN-7: 0.36 m, hard, grey to white limestone.

Bed BN-6: 0.10 m, yellowish white marl.

Bed BN-5: 0.50 m, hard, grey to white limestone.

Bed BN-4: 0.08 m, light brown sandy marl.

Bed BN-3: 0.18 m, grey-yellowish, finely sandy limestone. Ammonites (*W. internispinosum*, *A. cf. euomphalum*), gastropods (*Tornatellaea mendozana*), nautiloids, bivalves.

Bed BN-2: 0.05 m, light brown sandy marl.

Bed BN-1: c. 0.18 m, grey-yellowish, finely sandy limestone. Reddish brown weathered. Beds 1-3 are at the base of the outcrop, exposed after a recent excavation which has provided fresh material.

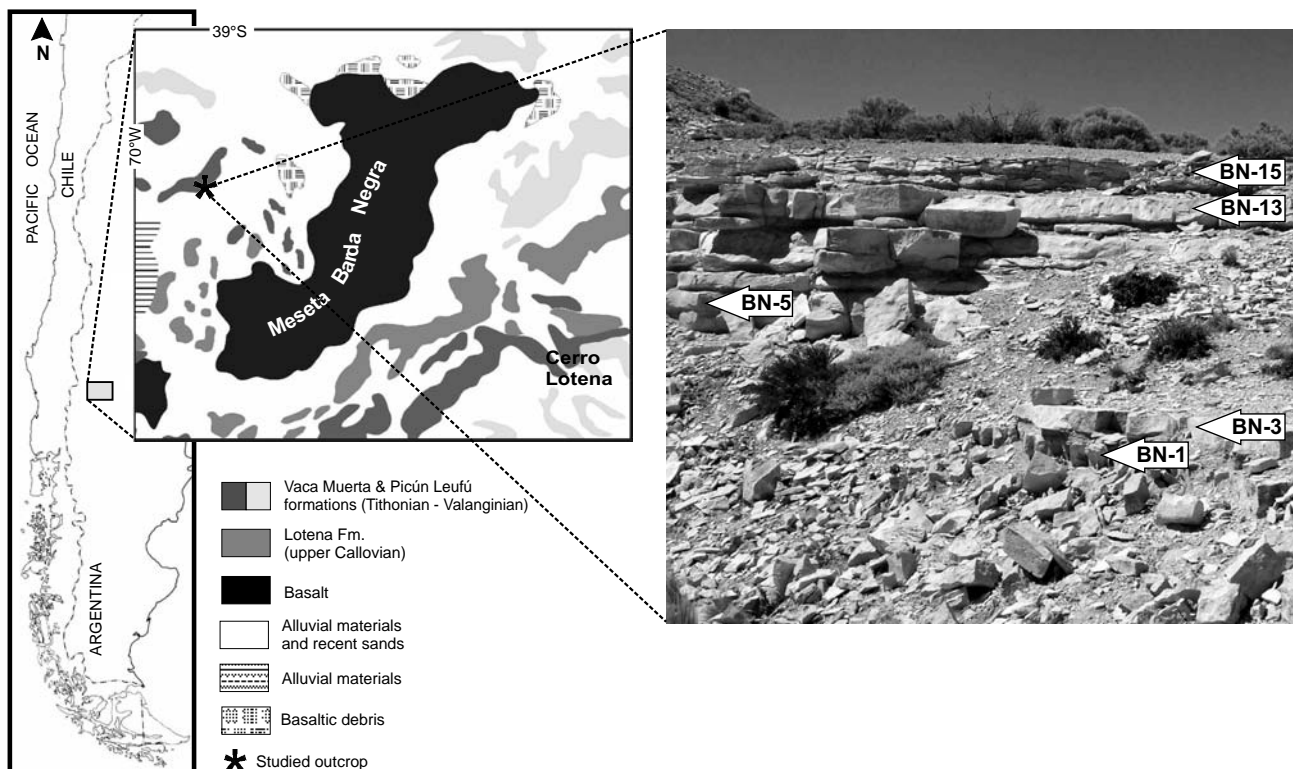


Figure 1. Geographic location of the Barda Negra area, geological map (based in Delpino & Deza 1995) with indication of the position of the outcrop (asterisk) where were collected the ammonites studied, and detailed view of the outcrop with indication of reference beds as numbered in text.

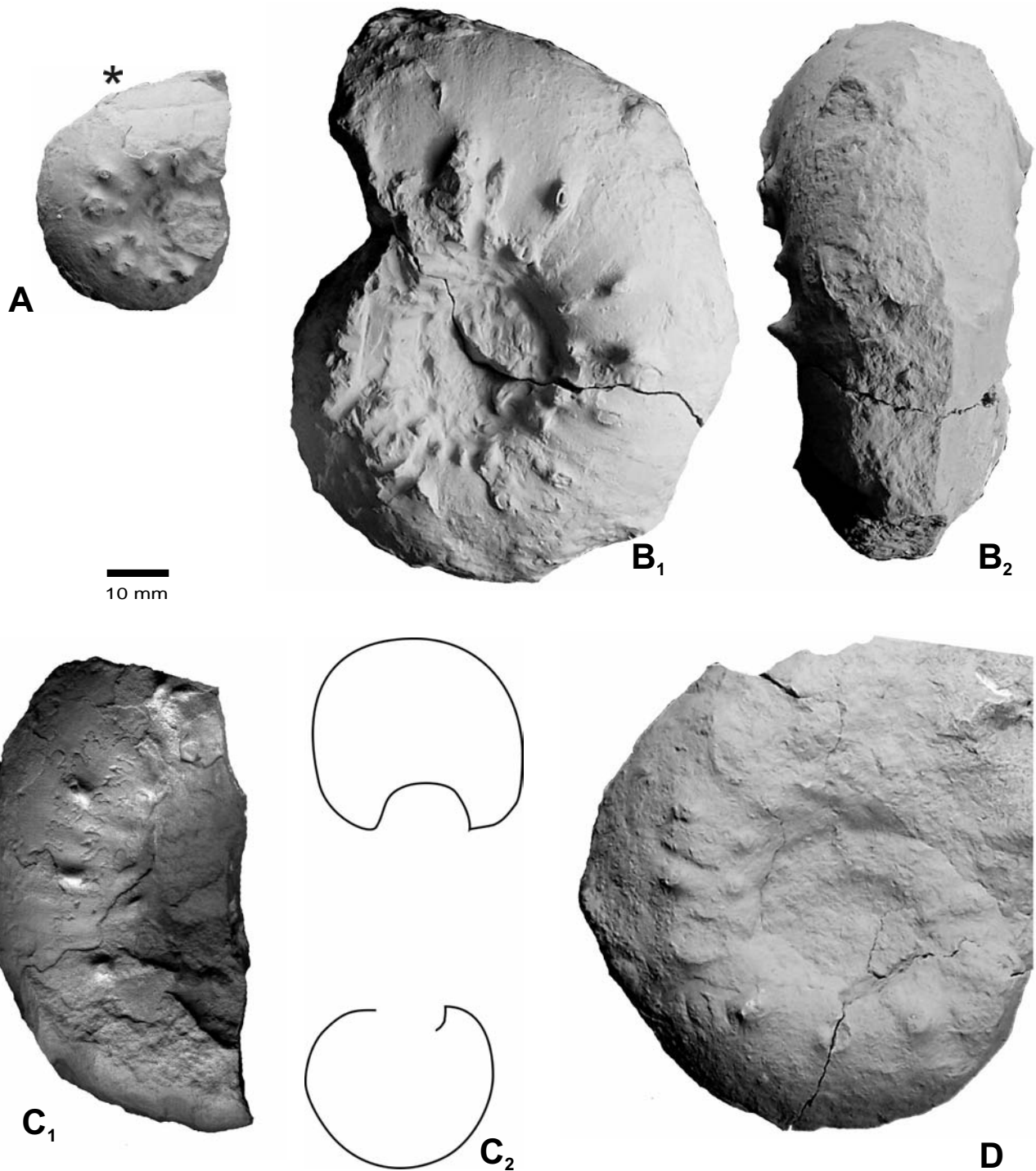


Figure 2. *Aspidoceras* cf. *euomphalum* Steuer, 1897. **A:** Lateral view of a juvenile macroconch with beginning of bodychamber (MOZP 7561). **B:** Lateral (**B₁**) and ventral (**B₂**) views of a juvenile macroconch phragmocone (MOZP 7565). **C:** Juvenile macroconch phragmocone (**C₁**: lateral view, **C₂**: whorl section) (MOZP 7568). **D:** Lateral view of a juvenil macroconch (MOZP 7564). Barda Negra, bed BN-3, Middle Tithonian, Internispinosum Zone. All natural size. Asterisk marks last septum.

SYSTEMATIC PALEONTOLOGY

The studied material is housed in the collections of the Museo Olsacher (MOZP), Zapala, Neuquén. Body-chamber is abbreviated with Bc and phragmocone with Ph; macroconch: [M], microconch: [m]. Dimensions are indicated as follows: diameter (D), diameter at last septum

(D_{ls}), diameter at peristome (D_p), umbilical width (U), width of whorl section (W), height of whorl section (H_1), and ventral or apertural height of whorl section (H_2), all given in millimeters (mm); approximated values denoted by (e); length of body-chamber (L_{bc}) in degrees [$^\circ$]. Number of primary (P) and ventral (V) ribs, and lateral (T_l) and umbilical (T_u) tubercles per each half whorl.

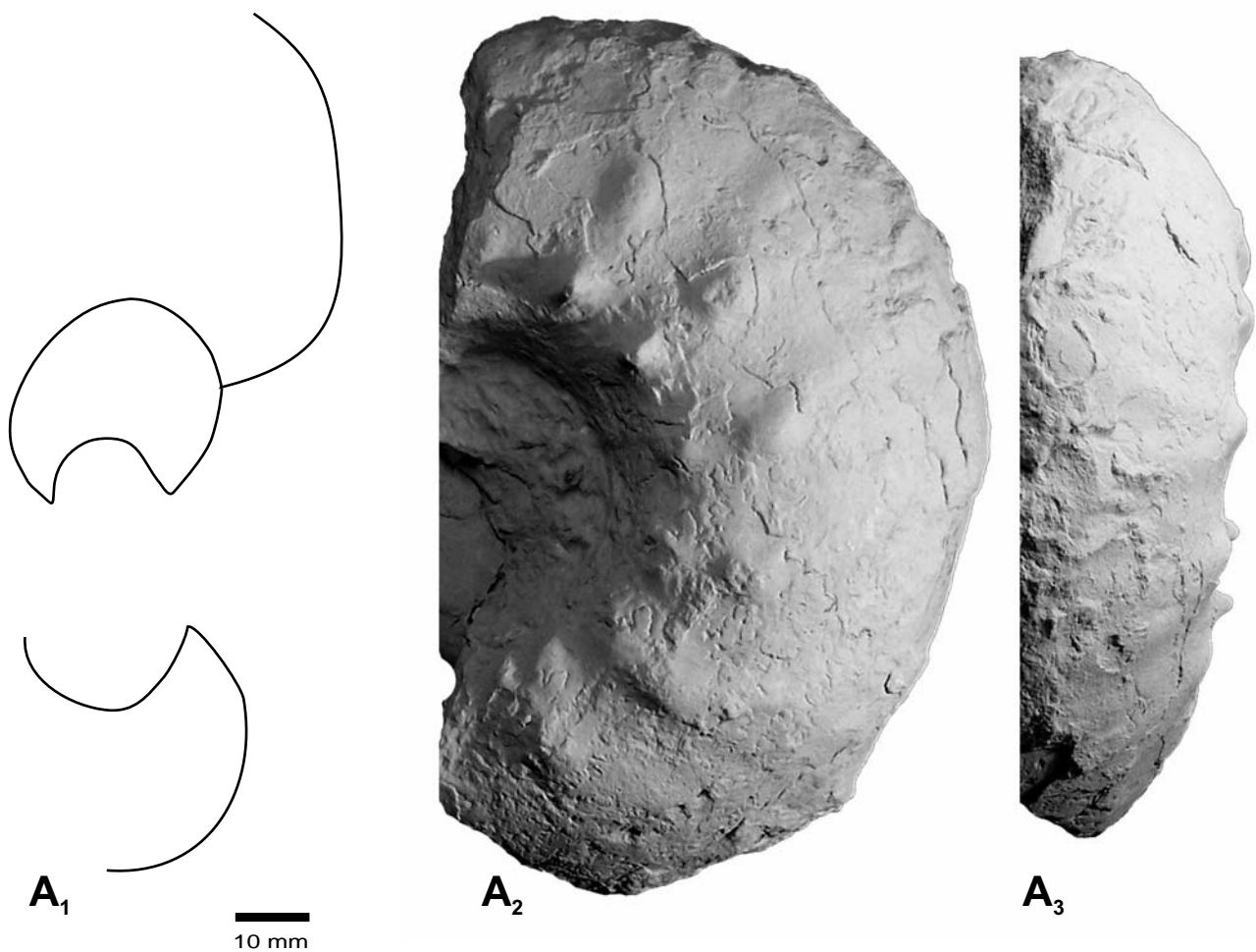


Figure 3. *Aspidoceras* cf. *euomphalum* Steuer, 1897. Whorl section (**A₁**) and lateral (**A₂**) and ventral (**A₃**) views of the subadult phragmocone of a macroconch (MOZP 7562). Barda Negra, bed BN-3, Middle Tithonian, Internispinosum Zone. All natural size.

Order Ammonoidea Zittel, 1884
Suborder Ammonitina Zittel, 1884
Superfamily Perisphinctoidea Steinmann, 1890
Family Aspidoceratidae Zittel, 1895
Subfamily Aspidoceratinae Zittel, 1895
Genus *Aspidoceras* Zittel, 1868

Type species: *Ammonites rogoznicensis* Zejszner, 1846
 (by monotypy)

***Aspidoceras* cf. *euomphalum* Steuer, 1897**

Figs. 2-7

- cf.1897 *Aspidoceras euomphalum* nov. sp.- Steuer: 195, pl. 5: 1-4 [lectotype, herein designated].
 cf.1921 *Aspidoceras euomphalum* nov. sp.- Steuer: 98, pl. 5: 1-4 [= lectotype].
 1973 *Aspidoceras haupti* Krantz.- Verma & Westermann: 193, pl. 36: 2, pl. 37: 1.
 ?1973 *Aspidoceras* sp. - Leanza: 125.
 1980 *Aspidoceras euomphalum* Steuer.- Leanza: 41, pl. 8: 1.
 1981a *Aspidoceras euomphalum* Steuer.- Leanza: 80.
 1981b *Aspidoceras euomphalum* Steuer.- Leanza: pl. 2: 11.
 1990 *Aspidoceras* aff. *altum* Biro-Bagoczky.- Leanza

& Zeiss: 176, pl. 36: 3.

- ?1992 *Aspidoceras altum* Biro-Bagoczky.- Leanza & Zeiss: 1844.
 ?1994 *Aspidoceras altum* Biro-Bagoczky.- Leanza & Zeiss: 250.
 2007 *Aspidoceras* cf./aff. *altum* Biro-Bagoczky.- Gründel et al.: 144.
 2007 *Aspidoceras* aff. *neuquensis* Weaver.- Gründel et al.: 144.

Material.- Eight moderately well-preserved macroconchs of very different sizes (two are adult, the remaining juvenile), some of them with parts of the body-chamber (MOZP 7561-7568) and remains of test. Several aptychi (MOZP 7560). All from bed BN-3.

Description.- Available material includes macroconchs only, some of them with part of the body-chamber, along a wide range of sizes allowing to compose the ontogeny of the species from about 30 mm in diameter. Ornamentation (ribs and tubercles, base of spines) irregular in density and arrangement throughout the ontogeny. At about $30 < D < 80$ mm shell rather involute with subcircular whorl section ($W/H_1 = 0.90 - 1.10$); umbilicus narrow ($U/D = 0.20 - 0.25$) and deep; two rows of tubercles; the umbilical

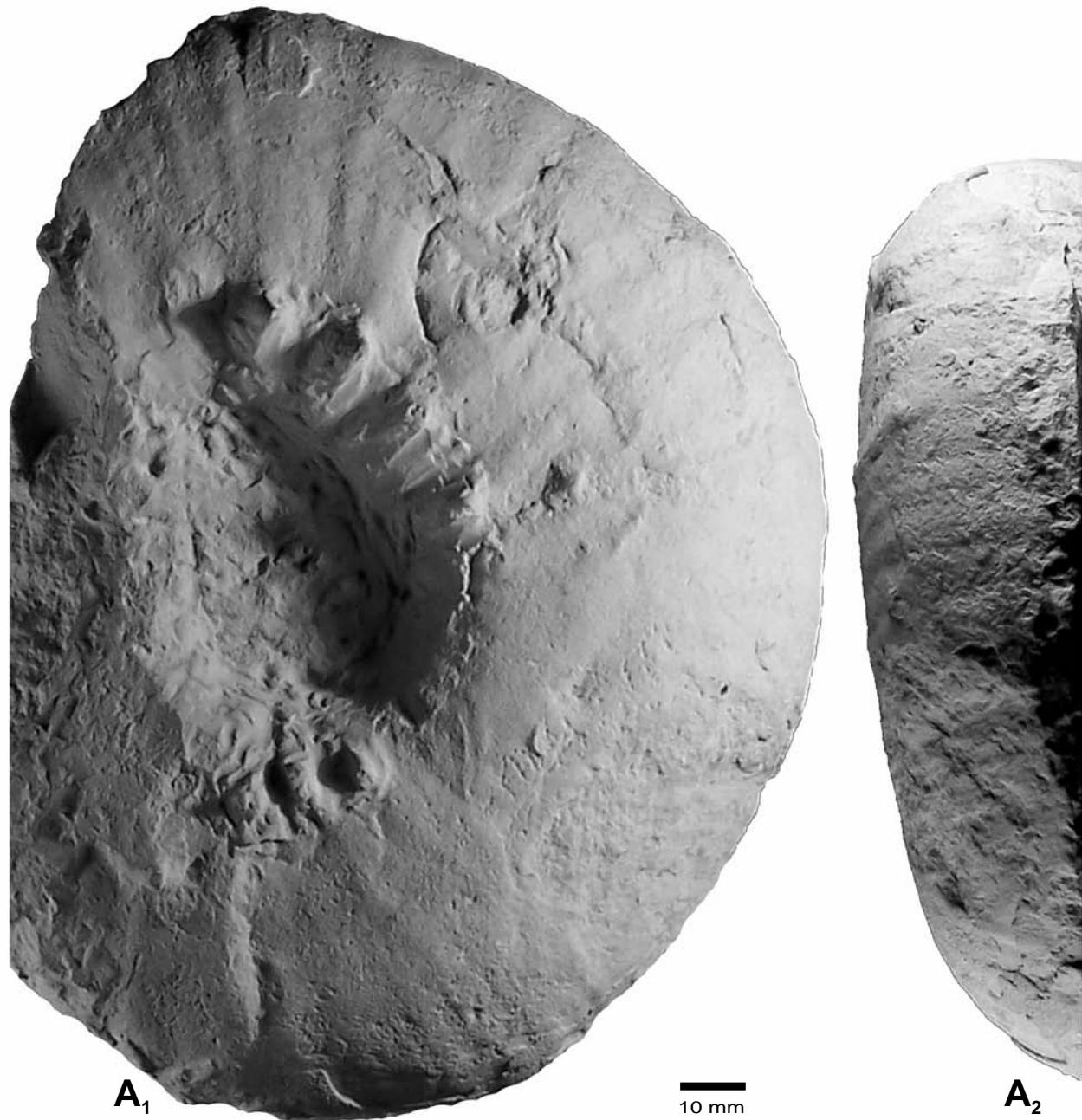


Figure 4. *Aspidoceras* cf. *euomphalum* Steuer, 1897. Lateral (A_1) and ventral (A_2) views of an adult macroconch with beginning of body-chamber (MOZP 7563). See whorl section in Fig. 5B. Barda Negra, bed BN-3, Middle Tithonian, Internispinosum Zone. All natural size. [This specimen shows the transition from rounded, bispinose whorls (cf. Figs. 2B-D, 3) to the more compressed and strongly ribbed whorls with unpaired tuberculation as seen in Fig. 5A].

tubercles are small, radially elongated, corresponding one to one with the lateral ones which are conical and larger. Some pairs are connected by a wide rib, lower than the tubercles and confined between them. In pairs unconnected by a rib, the umbilical tubercle is commonly larger than the lateral one. The venter is smooth. At about $80 < D < 180$ mm (last whorl of phragmocone) the shell is more evolute with the umbilicus somewhat wider ($U/D = 0.25 - 0.35$); whorl section subcircular to suboval ($W/H_1 = 0.90 - 1.00$). Ornamentation is composed by two rows of tubercles as in preceding whorls, and from the last part of phragmocone, dense, strong primary ribs borne on the

umbilical shoulder, commonly from a tubercle, and cross the flanks and venter almost radially, undivided and unchanged on the venter. Growth lines are dense, parallel to the ribs, well-marked on the test but not on the internal mold. The adult body-chamber tends to be more compressed ($W/H_1 < 1.00$) with flattish, slightly convex flanks. The two rows of tubercles are stronger; each five umbilical tubercles there are about three lateral ones, one of them connected by ribs to an umbilical pair. The largest macroconch of the sample, D_p close to 450 mm, is uncoiled in the last portion, subrectangular in whorl section with indistinct peristome, simple and smooth.

Mandibles: There is a well-preserved specimen in the same piece of rock with a macroconch (MOZP 7563). It represents a typical *Laevaptychus*, two pieces, spherical triangles with a striated concave face and a punctate convex face.

Discussion and comparison.- The sample allows to characterize a moderately involute and irregularly ornamented Aspidoceratid, with an early and persistent umbilical row of tubercles and a more irregular and less dense row of lateral tubercles (Fig. 7A-C), most of which are connected by a rib; and on the adult, abundant wide ribs crossing venter. The adult body-chamber has *Toulishphinctes*-like aspect (see Schweigert 1997: fig. 5), but the persistent bituberculation from inner whorls and the arrangement of ribs and tubercles indicate that the present species belongs to the genus *Aspidoceras*. The suture line, partially observed in some specimens, is typical of the genus *Aspidoceras*, without significations for distinguishing species, their lobes and saddles varying in wide and height depending of the inflation of the whorl section which changes in present species during ontogeny as described above (see Figs. 2C₂, 3A₁, 5A₁, 5B, 7A).

The studied specimens can be compared best with *A. euomphalum* Steuer, 1897. The lectotype [Steuer 1897 (Spanish translation 1921): pl. 5: 1-2; herein designated and figured photographically in Fig. 8] comes from Arroyo Cieneguita (Mendoza), "bed III", most likely from the interval Alternans-Koeneni zones (Upper Tithonian) as indicated by the ammonites listed by Steuer (1921), including those from his "bed I" of Loncoche (Mendoza). The lectotype preserves only a short part of its body-chamber and does not look like an adult, thus preventing full comparison with the specimens described. The phragmocone is very similar and the last whorl shows vanishing of the lateral tubercles as seen in the macroconch shown in Fig. 4. The main differences are that the lectotype has no ribs on its last preserved whorl and comes from beds of higher biostratigraphical levels. In this way the described species could be interpreted as an early transient of *A. euomphalum*, and the specific name could be retained with indication of this feature (see Dietze et al. 2005 for the meaning of transient as used here). Krantz (1928: 11) pointed out that specimens of *A. euomphalum* (including material from the Internispinosum Zone of Cerro Lotena associated with *Aspidoceras haupti* Krantz, 1926) exhibits the shift from regular one-to-one correspondence between lateral and umbilical tubercles in inner whorls up to $D = 30-40$ mm to the irregular pattern of a denser umbilical row. The specimen figured as *A. euomphalum* by Leanza (1980: pl. 8: 1) clearly belongs to the species described, showing similar differences from the Steuer's lectotype and has the same stratigraphic position as the studied material from Barda Negra.

The holotype of *Aspidoceras altum* Biró-Bagóczy, 1980 from the lower Upper Tithonian (Alternans Zone) of Lo Valdés, Chile, exhibits a close resemblance with the present material concerning its arrangement of ribs and tubercles and whorl section in its last preserved whorl, but it is more widely umbilicate. Its inner whorls are not preserved, precluding comparison of the diagnostic ontogeny of ornamentation. Leanza & Zeiss (1990: pl. 36: 3) figured a fragment of a large macroconch body-chamber as *A. aff. altum*, collected at Los Catutos, which is identical to our largest specimens and comes from a similar stratigraphic position within the Internispinosum

Zone. Later citations of specimens by Leanza & Zeiss (1992, 1994) cannot be evaluated because of the lack of illustrations.

The holotype of *Aspidoceras haupti* Krantz (1928: pl. 4: 2, holotype by monotypy) matches closely both in morphology and ornamentation with the described material at comparable diameters, being only somewhat more depressed (Fig. 7A). The specimen was collected at Cerro Lotena within an ammonite assemblage of the Internispinosum Zone (see Krantz 1928: 47). It may be considered a junior synonym of *A. euomphalum*, an older transient than that of the lectotype.

The holotype of *Aspidoceras neuquensis* Weaver (1931: pl. 52: figs. 341-342) was also collected in Cerro Lotena in beds with *Windhauseniceratid internispinosum* (Krantz, 1926), *A. euomphalum*, *Pseudhimalayites steinmanni* Haupt, 1907, and *Corongoceras lotenoense* Spath, 1925, indicative of the Internispinosum Zone. The original illustrations and measurements of the holotype (as given by Weaver 1931) show an ammonite closely comparable to the lectotype of *A. euomphalum* (see Fig. 8) but slightly differing by its well-marked ventral ribbing. The specimens of Barda Negra shown in Fig. 2B-C and Fig. 3 look identical in all aspects. *A. neuquensis* may be considered as another junior synonym of *A. euomphalum*, an older transient than that of the lectotype.

It is interesting to note that our sample of *A. cf. euomphalum* from Barda Negra was collected from a single stratigraphic horizon in a single point and exposure and exhibits, either through the ontogeny or through individual variation at specified diameters, comparable morphologies to those seen upper, in the middle – upper Tithonian rock succession of the basin (e.g. *A. altum*, *A. euomphalum*). These species are in close succession through the interval Internispinosum – Koeneni zones and are morphologically similar around a common and characteristic "Bauplan". They seem to conform a lineage of species as shown in Fig. 11, with a rather wide spatio-temporal distribution in the basin although its record is still rather poor.

Aspidoceras andinum Steuer (1897; 1921: pl. 5: 5-7, holotype by monotypy) from an unspecified Tithonian level of Arroyo de La Manga (Mendoza), and *Aspidoceras cieneguitense* Steuer (1897; 1921: pl. 5: 8-10, holotype by monotypy), inner whorls from "bed II" (Proximus to Internispinosum zones) of Arroyo Cieneguita, cannot be compared reliably. Both holotypes show regularly spaced rows of lateral and umbilical tubercles in exact one-to-one correspondence. This feature strongly differs from the ontogeny of the described species, which is characterized by irregularities dominated by a denser row of umbilical tubercles, and a narrower umbilicus. The holotype of *A. andinum* looks exactly like the aspidoceratid figured as *A. rogoznicense* by Checa (1985: pl. 16: 4) from the Hybonotum Zone of Sierra Gorda, Spain, which exhibits a regular one-to-one correspondence between umbilical and lateral tubercles.

Aspidoceras almitocense (Aguileira in Castillo & Aguileira, 1895) in Verma & Westermann (1973: pl. 35: 1) has significant differences respect to our material and the other discussed nominal species. The whorl section is much wider and depressed in the inner whorls, and the number of umbilical tubercles is smaller than the number of lateral tubercles, an opposite pattern to that seen in the described material. However, *A. almitocense* is an independent species from the Andean lineage discussed

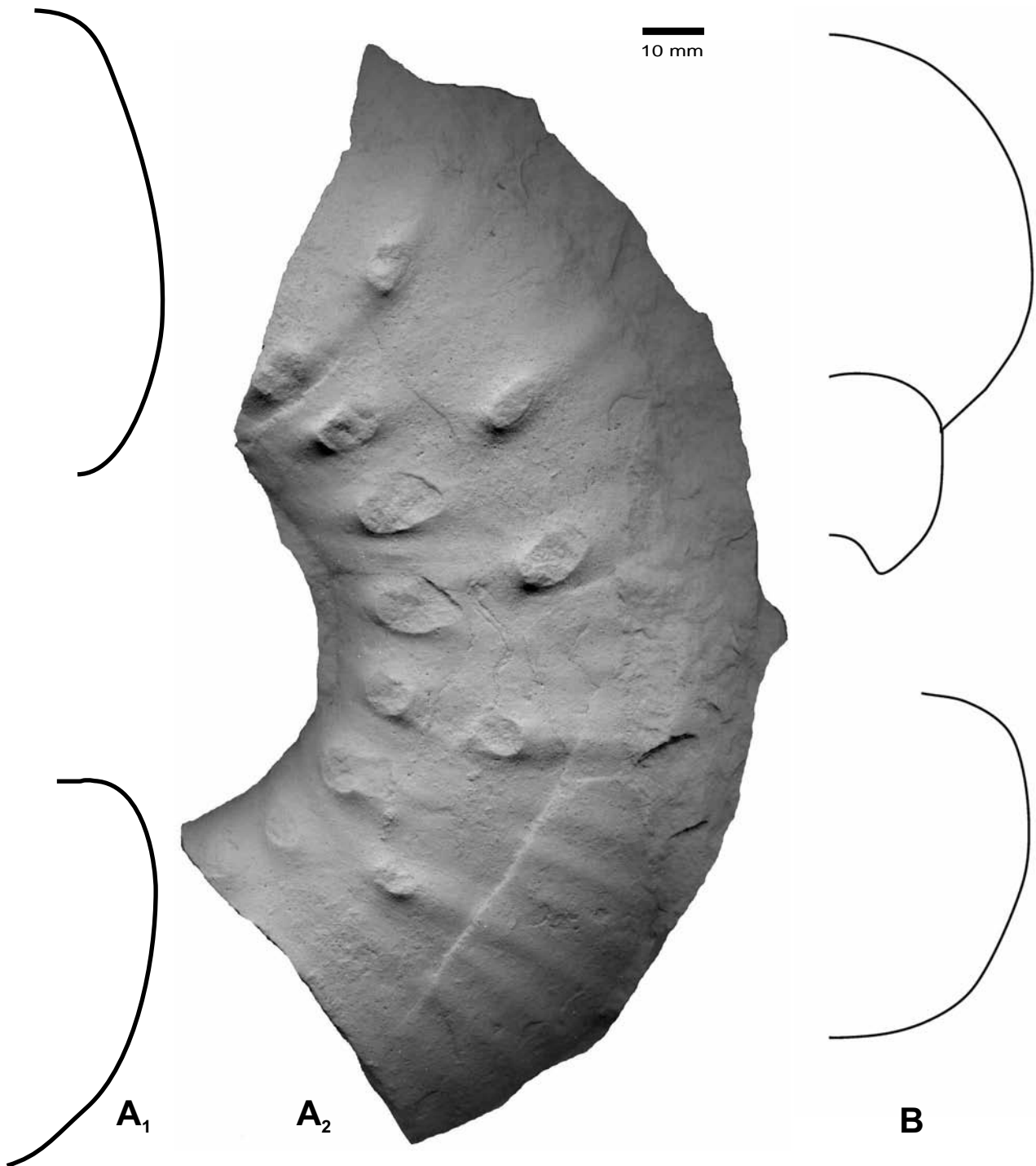


Figure 5. *Aspidoceras* cf. *euomphalum* Steuer, 1897. Whorl section (A₁) and lateral view (A₂) of a portion of an adult macroconch body-chamber (MOZP 7566). B: whorl section of the specimen in Fig. 4. Barda Negra, bed BN-3, Middle Tithonian, Internispinosum Zone. All natural size.

above, and could very likely belong to the genus *Toulisphinctes* Sapunov, 1979 (Type species: *Toulisphinctes zieglerei* Sapunov, 1979) as already indicated by Schweigert (1997). The specimen figured by Verma & Westermann (1973: pl. 35: 2) as *A.* cf. *alamitocense* is a very broad and depressed aspidoceratid with two rows of lateral tubercles and a third one on the venter in the shape of elongated elevations, all three tubercles occurring along a single rib. These features are

characteristic of *Pseudhimalayites* Spath, 1925 (Type species: *Aspidoceras steinmanni* Haupt, 1907 = *Cosmoceras subpretiosum* Uhlig, 1878).

Family Himalayitidae Spath, 1925
Genus *Windhausenicerus* Leanza, 1945

Type species: *Perisphinctes internispinosus* Krantz, 1926; by OD.

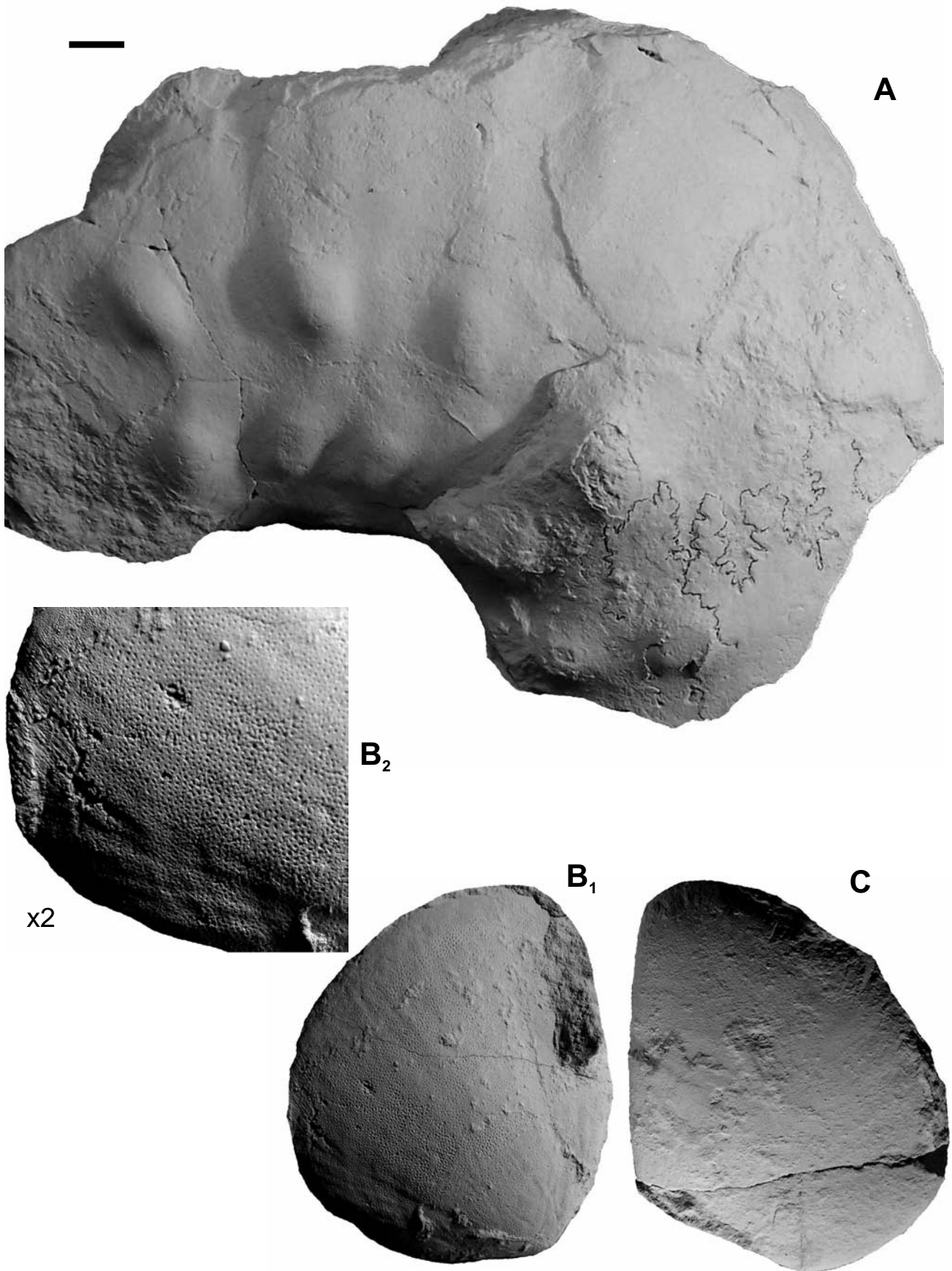
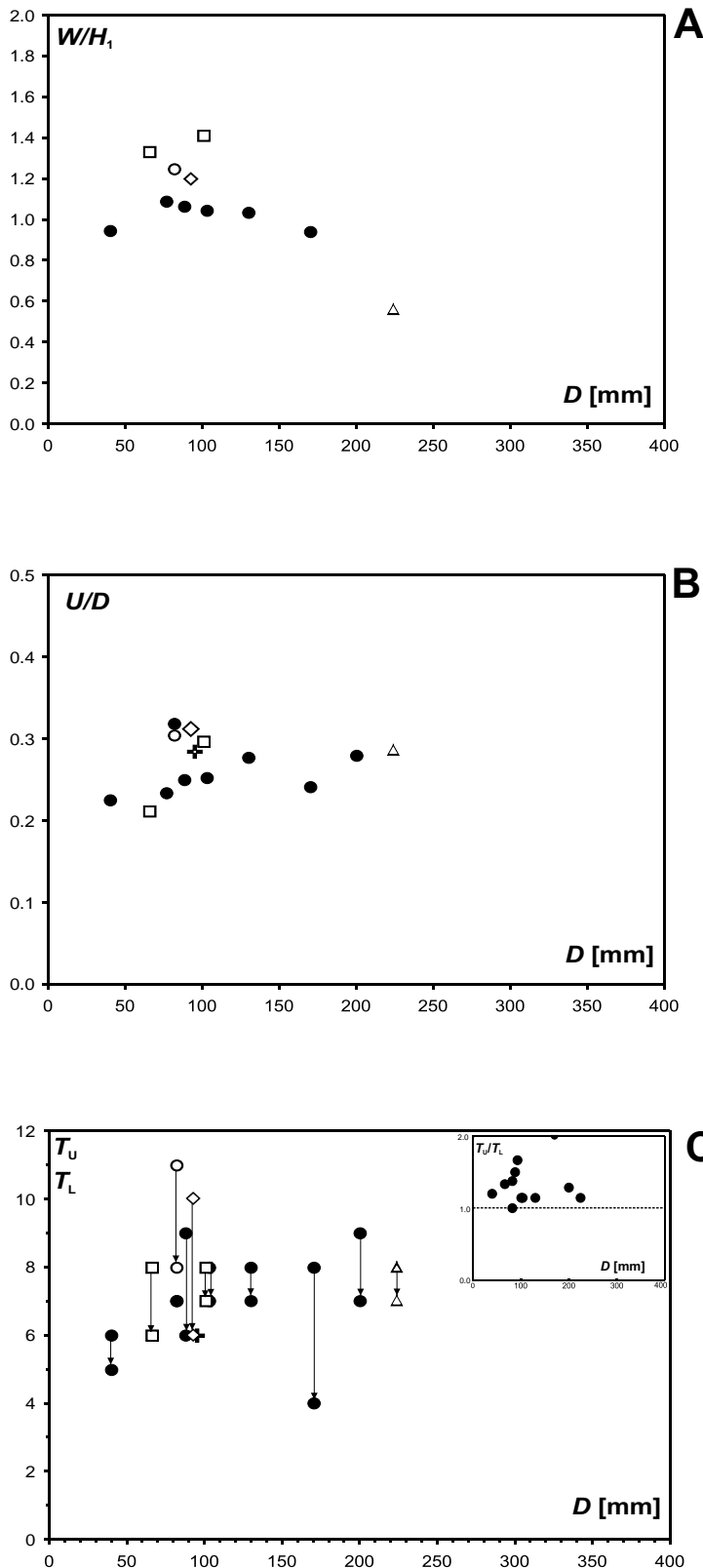


Figure 6. *Aspidoceras* cf. *euomphalum* Steuer, 1897. **A:** Lateral view of the terminal portion of a large macroconch phragmocone (MOZP 7567/1). **B-C:** pair of valves of *Laevaptychus* (MOZP 7560): lower (concave) face views of both valves (**B₁** and **C**) and enlarged (x2) view (**B₂**) of a sector of the valve in **B₁**. Barda Negra, bed BN-3, Middle Tithonian, Internispinosum Zone. All natural size except **B₂**; bar scale is 10 mm for **A**, **B₁** and **C**, but 5 mm for **B₂**.



References

Aspidoceras cf. *euomphalum* Steuer
(Internispinosum Zone)

- Barda Negra, this report.
- Cerro Lotena (in Leanza 1980: pl. 8: 1).

Aspidoceras *haupti* Krantz
(Internispinosum Zone)

- C. Lotena, holotype (in Krantz 1926: pl. 4: 1).

Aspidoceras *neuquensis* Weaver
(Internispinosum Zone)

- ◇ C. Lotena, holotype (in Weaver 1931: pl. 52: figs. 341-342).

Aspidoceras *altum* Biró-Bagóczy
(Alternans Zone)

- △ Lo Valdés, Chile, holotype (in B.-Bagóczy 1980: pl. 2: 1a).

Aspidoceras *euomphalum* Steuer
(upper Alternans or Koeneni Zone)

- ✚ Arroyo Cieneguita, lectotype (in Steuer 1897: pl. 5: 1-2).

Figure 7. *Aspidoceras* cf. *euomphalum* Steuer from Barda Negra, described above, and comparative material. **A:** Ontogeny of whorl section proportions ($W/H_1 - D$). **B:** ontogeny of umbilical width ($U/D - D$). **C:** Ontogeny of ornamentation based on number of umbilical (T_u) and lateral (T_l) tubercles per half whorl; inset showing the ratio $T_u/T_l - D$ which is always higher than the unit.

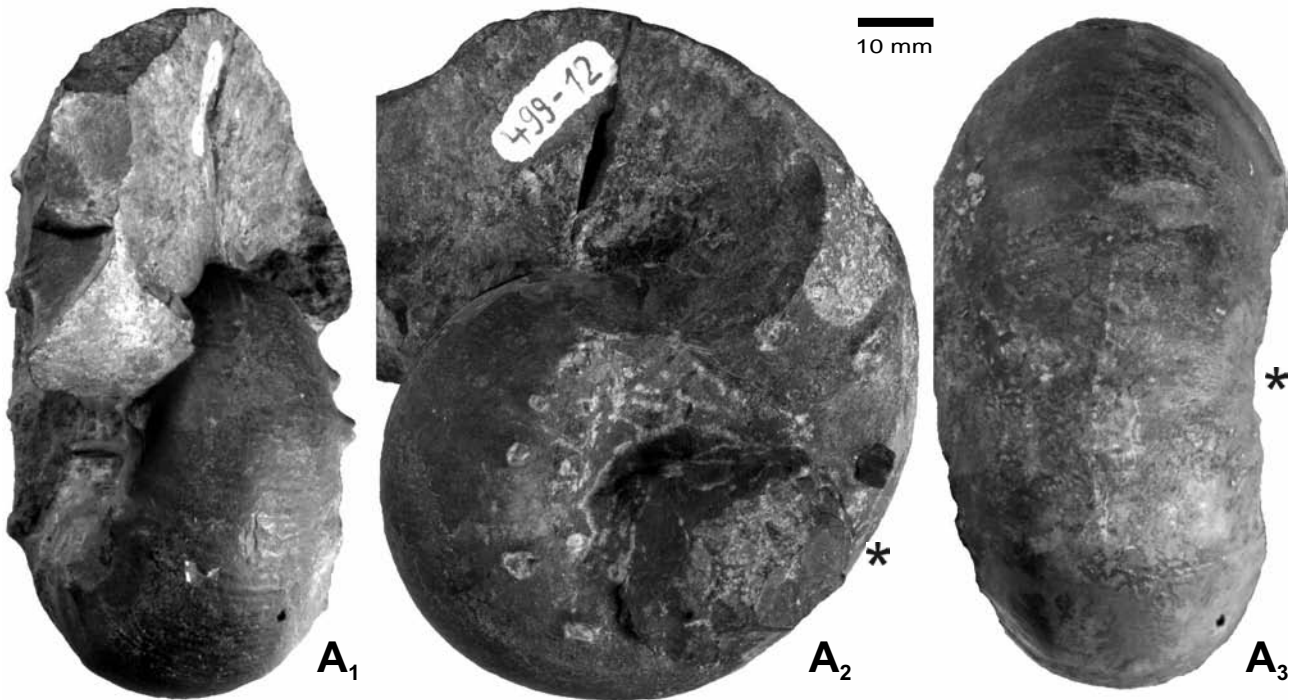


Figure 8. *Aspidoceras euomphalum* Steuer, 1897. Lectotype: apertural (A₁), lateral (A₂) and ventral (A₃) views. Arroyo Cieneguita, Mendoza Province, Argentina. Specimen number 499-12 in the collection of the Geowissenschaftliches Zentrum der Universität Göttingen, Germany. Photographs by courtesy of Dr. Mike Reich, Göttingen. All natural size. Asterisk marks last septum.

***Windhausenicerias internispinosum* (Krantz, 1926)**

Figs. 9-10

Synonymy.- See Parent (2003).

Material.- Two complete, adult microconchs (MOZP 7557-7558) with test, one adult macroconch with incomplete body-chamber (MOZP 7556), and several fragmentary specimens (MOZP 7559). All from bed BN-3.

Description.- Macroconch: evolute throughout the ontogeny, depressed inner whorls becoming compressed towards the adult phragmocone and body-chamber; strongly ribbed by primaries divided on a tubercle at the ventro-lateral shoulder in inner whorls, then tubercles disappear completely and primaries divide at about mid-flank and intercalatories become frequent. The adult body-chamber becomes more compressed and primary ribs are strengthened on the lower half of the flank.

Microconch: The phragmocone is identical to that of the macroconch at comparable diameter: at $D < 40$ mm whorls depressed with strong primary ribs trifurcated on a ventro-lateral mammiform tubercle; at $40 < D < 70$ mm general aspect remains coniform but tubercles pass to lamelliform; at $D > 70$ mm (body-chamber) whorl section is slightly more compressed, suboval and tubercles tend to fade away. The final adult peristome is developed from 90 and 93 mm, respectively, in the two best preserved microconchs. Peristome is preceded by a constriction, and from the last primary rib, posterior to that, develop the lappets. These are externally concave, wide, terminated in a rounded and widened end, with a length of about 25 mm. Body-chamber is half a whorl long, thus relatively shorter than in the corresponding macroconch.

Remarks.- The microconchs described leave no doubts on the structure of the sexual dimorphism in this species, which was previously not clear (Parent 2003: 356); the lectotype definitely represents a macroconch. In Fig. 10 is figured a finely preserved, adult macroconch from the Internispinosum Zone of Cerro Lotena. It is almost identical with the lectotype and considering the remains of the umbilical wall preserved in the specimen, the maximum diameter at the peristome could have been about 230 mm and L_{BC} near 360° . In upper levels of the Internispinosum Zone at Cerro Lotena, fragments of body-chambers have been collected suggesting adult diameters of more than 400 mm.

BIOSTRATIGRAPHIC CHRONOSTRATIGRAPHY

The current chronostratigraphic classification of the Andean Tithonian (Fig. 11) was discussed in detail by Leanza (1981a, b), although it seems to have not been indicated the kind of “zones” of the scale.

The single taxon range biozone of *W. internispinosum* (that is the interval between the lowermost and uppermost rocks yielding this species in the type locality), defines the chronostratigraphic, non-standard, Internispinosum Zone. This zone consists of all the rocks between two time planes which are defined by the first and last occurrences of the index-guide species. These two time planes may be of different ages in different localities where the zone is recognized, since the index-guide species could span different temporal intervals in different facies, or same facies in different places. For the time being the whole zonation of the Andean Tithonian remains to be standardized, and this is the kind of zones

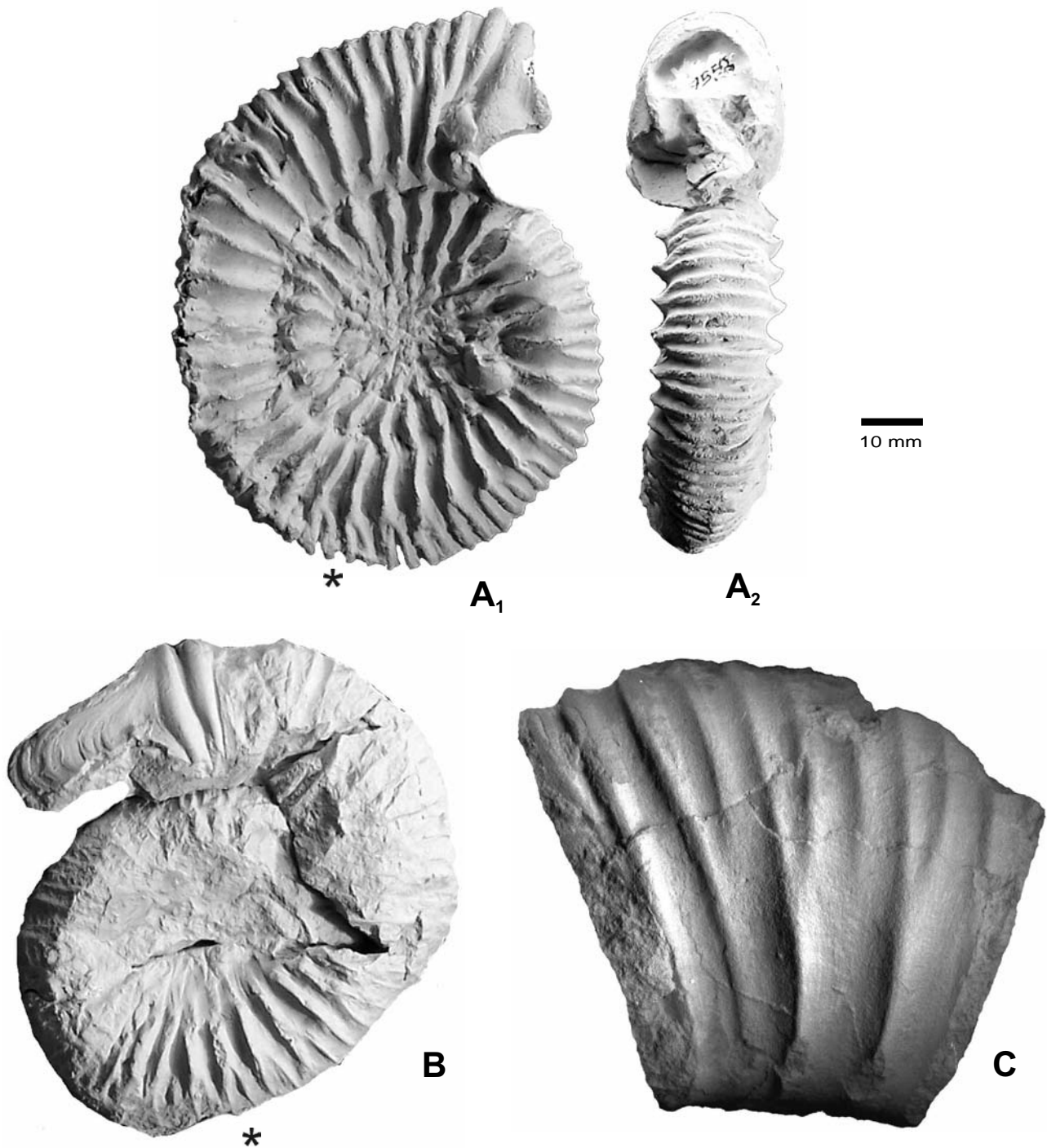


Figure 9. *Windhausenicerias internispinosum* (Krantz, 1926). A: Lateral (A₁) and apertural (A₂) views of an adult microconch with incomplete lappet (MOZP 7558). B: Lateral view of an adult microconch with complete lappet preserved (MOZP 7557). C: Lateral view of a fragment of the terminal portion of the bodychamber of an adult macroconch (MOZP 7556/1). Barda Negra, bed BN-3, Middle Tithonian, Internispinosum Zone. All natural size. Asterisk marks last septum.

considered in the following discussion. Correlation of the *Internispinosum* Biozone and its conjugate chronostratigraphic, non-standard Internispinosum Zone, was already discussed in Parent (2003) where it was concluded an acceptable approximate correlation with the Ponti Zone (uppermost Middle Tithonian) of the Primary Standard Chronostratigraphic Scale.

The occurrence of the index-guide species *W. internispinosum* in the studied horizon indicates the upper

Middle Tithonian Internispinosum Zone. A more accurate relative position within this zone cannot be indicated only on the basis of the described fauna because of the isolation of the exposure. Nevertheless, it can be done a comparison with the more developed and well-known succession of Cerro Lotena near the studied locality, less than 10 km east, behind the Meseta Barda Negra (Fig. 1), a basaltic structure formed during the Miocene-Pliocene. In this locality the lower part of the Internispinosum Zone

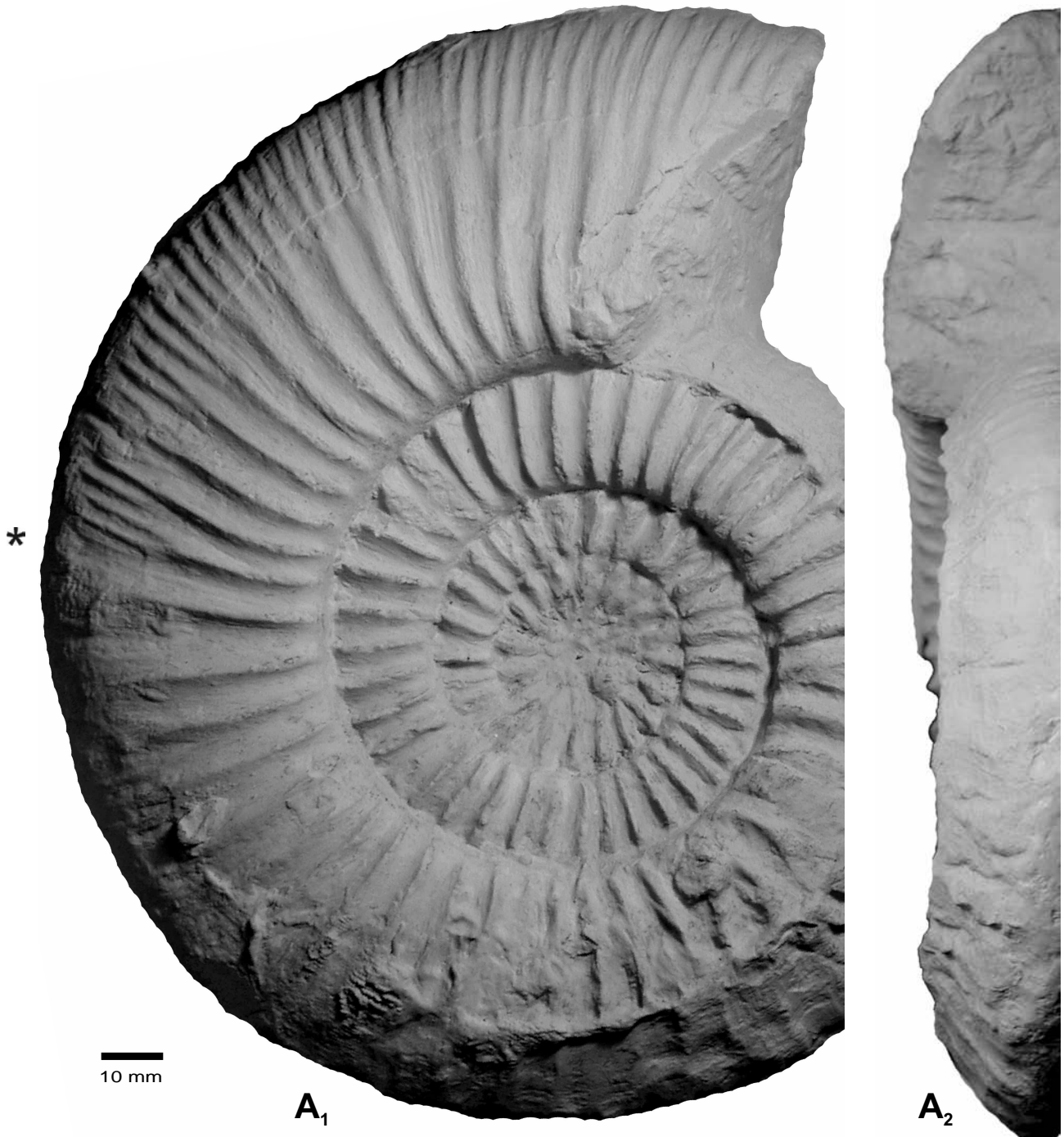


Figure 10. *Windhausenicerias internispinosum* (Krantz, 1926). Lateral (A_1) and apertural (A_2) views of an adult macroconch (MOZP7860) with one fourth of its body-chamber. Cerro Lotena, Middle Tithonian, Internispinosum Zone. All natural size. Asterisk marks last septum.

contains the same species described above. Moreover, material under study shows even the same morphotypes of *Aspidoceras* and *W. internispinosum*. Specimens of *W. internispinosum* [M] from the lower part of its stratigraphic range are characterized by the morphology shown by the specimens of Barda Negra, the specimen from Cerro Lotena shown in Fig. 10 coming from beds equivalent to those of Leanza (1980) mentioned above, or the lectotype. In the upper part of its stratigraphic range the

predominant morphology seems to shift to a more subcircular whorl section and tubercles reaching the outermost whorls, as illustrated in the specimen figured by Leanza (1980: pl. 9: 2). It is concluded that the faunal level BN-3, containing the ammonites described above, most likely belongs to the lower part of the Internispinosum Zone.

The lithology of the upper part of the section studied (BN-4 – BN-15), hard, white to yellowish gray

Andean chronostratigraphy		Barda Negra	Cerro Lotena	Los Catutos	Arroyo Cieneguitas	Lo Valdés
Sub-stage	Zone					
Upper Tithonian	Koeneni				<i>A. euomphalum</i>	
	Alternans				(4)	<i>A. altum</i>
Middle Tithonian	Internispinosum	BN-4 - BN-15			<i>A. aff. altum</i>	(5)
		BN-3	<i>A. cf. euomphalum</i>	<i>A. cf. euomphalum</i>		
		BN-1 - BN-2	(1)	(2)		
	Proximus					
	Zitteli					
Lower Tithonian	Mendozanus					

Figure 11. Spatio-temporal distribution of the morphospecies related to *Aspidoceras euomphalum* in the Andean Tithonian as discussed in text. Gray boxes indicate the estimated stratigraphic position. (1): this report (BN-1 to BN-15 are the beds of the section of Barda Negra as in text, see Fig. 1); (2): Leanza (1980) and unpublished material (the holotypes of *Aspidoceras haupti* Krantz and *A. neuquensis* Weaver could likely come from this interval); (3): Leanza & Zeiss (1990); (4): lectotype (Steuer 1897); (5): holotype (Biró-Bagóczyky 1980). Chronostratigraphy based on Leanza (1981a). The zonation is drawn on a scale of equispaced zones, not implying equal time intervals; the non-standard condition of the zones is indicated by dashed line boundaries.

limestones and marls, is the same in the middle part of the Internispinosum Zone at Cerro Lotena (see Leanza 1980).

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