Fossil Record **10**(2) (2007), 125–163 / **DOI** 10.1002/mmng.200700003

Tournaisian (Early Carboniferous/Mississippian) ammonoids from the Ma'der Basin (Anti-Atlas, Morocco)

Volker Ebbighausen[*,1] **and Jürgen Bockwinkel**[**,2]

[1] Engstenberger Höhe 12, D-51519 Odenthal, Germany
[2] Dechant-Feinstraße 22, D-51375 Leverkusen, Germany

Received 17 December, 2006, accepted 8 February 2007
Published 1 August 2007

With 50 figures

Keywords: Ammonoids, biostratigraphy, Early Carboniferous, Anti-Atlas, Morocco.

Abstract

Three succeeding assemblages of Early Tournaisian (Mississippian) ammonoids are described from Fezzou (Ma'der) in the Anti-Atlas of Morocco; they are, in ascending order, composed of the following genera: (1) *Gattendorfia-Eocanites* Assemblage: *Acutimitoceras*, *Costimitoceras*, *Imitoceras*, *Kornia*, *Gattendorfia*, *Kazakhstania*, and *Eocanites*; (2) *Gattendorfia-Kahlacanites* Assemblage: *Acutimitoceras*, *Hasselbachia*, *Gattendorfia*, *Becanites*, and *Kahlacanites*; and (3) *Goniocyclus-Protocanites* Assemblage: *Globimitoceras*, *Imitoceras*, *Gattendorfia*, *Goniocyclus*, *Eocanites*, and *Protocanites.* The following taxa are newly described: *Globimitoceras rharrhizense* n. sp., *Acutimitoceras sarahae* n. sp., *A. endoserpens* n. sp., *A. pentaconstrictum* n. sp., *Costimitoceras aitouamar* n. sp., *Hasselbachia arca* n. sp., *Kornia citrus* n. gen. n. sp., *Gattendorfia lhceni* n. sp., and *G. gisae* n. sp.

Schlüsselwörter: Ammonoidea, Biostratigraphie, Unter-Karbon, Anti-Atlas, Marokko.

Zusammenfassung

Drei aufeinander folgende Vergesellschaftungen von Ammonoideen aus dem Tournaisium (Mississippium) werden von Fezzou (Ma'der) im Anti-Atlas von Marokko beschrieben; diese werden, in aufsteigender Reihenfolge, durch die folgenden Gattungen zusammen gesetzt: (1) *Gattendorfia-Eocanites* Assemblage: *Acutimitoceras*, *Costimitoceras*, *Imitoceras*, *Kornia*, *Gattendorfia*, *Kazakhstania* und *Eocanites*; (2) *Gattendorfia-Kahlacanites* Assemblage: *Acutimitoceras*, *Hasselbachia*, *Gattendorfia*, *Becanites* und *Kahlacanites*; und (3) *Goniocyclus-Protocanites* Assemblage: *Globimitoceras*, *Imitoceras*, *Gattendorfia*, *Goniocyclus*, *Eocanites* und *Protocanites.* Die folgenden Taxa werden neu beschrieben: *Globimitoceras rharrhizense* n. sp., *Acutimitoceras sarahae* n. sp., *A. endoserpens* n. sp., *A. pentaconstrictum* n. sp., *Costimitoceras aitouamar* n. sp., *Hasselbachia arca* n. sp., *Kornia citrus* n. gen. n. sp., *Gattendorfia lhceni* n. sp. und *G. gisae* n. sp.

Introduction

The area around Fezzou in the Ma'der region of the eastern Anti-Atlas in Morocco is well known for its rich Late Devonian ammonoid assemblages in limonitic preservation (e.g. Petter 1959, 1960), with specimens contained in numerous collections worldwide. These faunas were the subjects of several research projects, and their succession is now rather precisely known (Korn 1999; Becker et al. 2002; Ebbighausen & Korn 2007).

The occurrence of Carboniferous ammonoids in the Ma'der, particularly at the Aguelmous ridge immediately north-east of Fezzou has been known since the 1930's, when Clariond (1935) mentioned "*Muensteroceras* sp." and "*Aganides* sp." from a

* Corresponding author: e-mail: volker@vxr.de
** E-mail: jbockwinkel@t-ontline.de

locality a few kilometres east of Fezzou and proclaimed a Tournaisian age for this record. This view was adopted in the Carte Géologique du Maroc 1:200,000 (mapsheet Todhra-Ma'der), published by the Service Géologique du Maroc (Destombes & Hollard 1988), in which Tournaisian sedimentary rocks are shown as exposed in the Aguelmous Syncline. Though it has long been known that "*Gattendorfia*" and "*Prionoceras subbilobatum*" can be found in this area (Hollard 1958), there has been no extensive collection of ammonoid faunas. During several field excursions in the years 2003 to 2006, the Carboniferous ammonoids of the Aguelmous Syncline were extensively collected, and now more than 1,300 specimens from four horizons are available for study.

The ammonoid-bearing section at Aguelmous

The Aguelmous is located northeast of Fezzou in the eastern Anti-Atlas of Morocco (Fig. 1). In the literature and on local maps, the name Aguelmous is used for two slightly different topographic structures, i.e., (1) the entire area north-east of Fezzou, and (2) the ridge beginning directly behind the houses north-east of Fezzou and extending for approximately 16 km towards the north-east. This ridge forms the north-western flank of the Aguelmous Syncline and has a SW-NE axis, extending 18 km, with an average width of 6 km. Late Devonian and Early Carboniferous strata have an inclination of 10–15° on both flanks of the syncline and show only little additional deformation. The section begins with fossil-rich Famennian claystones, followed by latest Devonian sandstones of the Aoufital Formation that form a striking topographic ridge (Aguelmous on the north-western flank, Rharrhiz and Rich el Mbidia on the south-eastern flank). The depression in the centre of the syncline is composed of Early Carboniferous shales and thin sandstone beds.

Below the Aoufital sandstones, late Devonian grey shales with *Wocklumeria*-bearing assemblages (Ebbighausen & Korn 2007) are overlain by the two to three metres thick equivalent of the Hangenberg Black Shale, first discovered and stratigraphically dated by Korn (1999) in the area of Madène el Mrakib southeast of Fezzou. At this place, Korn discovered poorly preserved specimens of *Acutimitoceras* sp. from the basalmost sandstones of the Aoufital Formation.

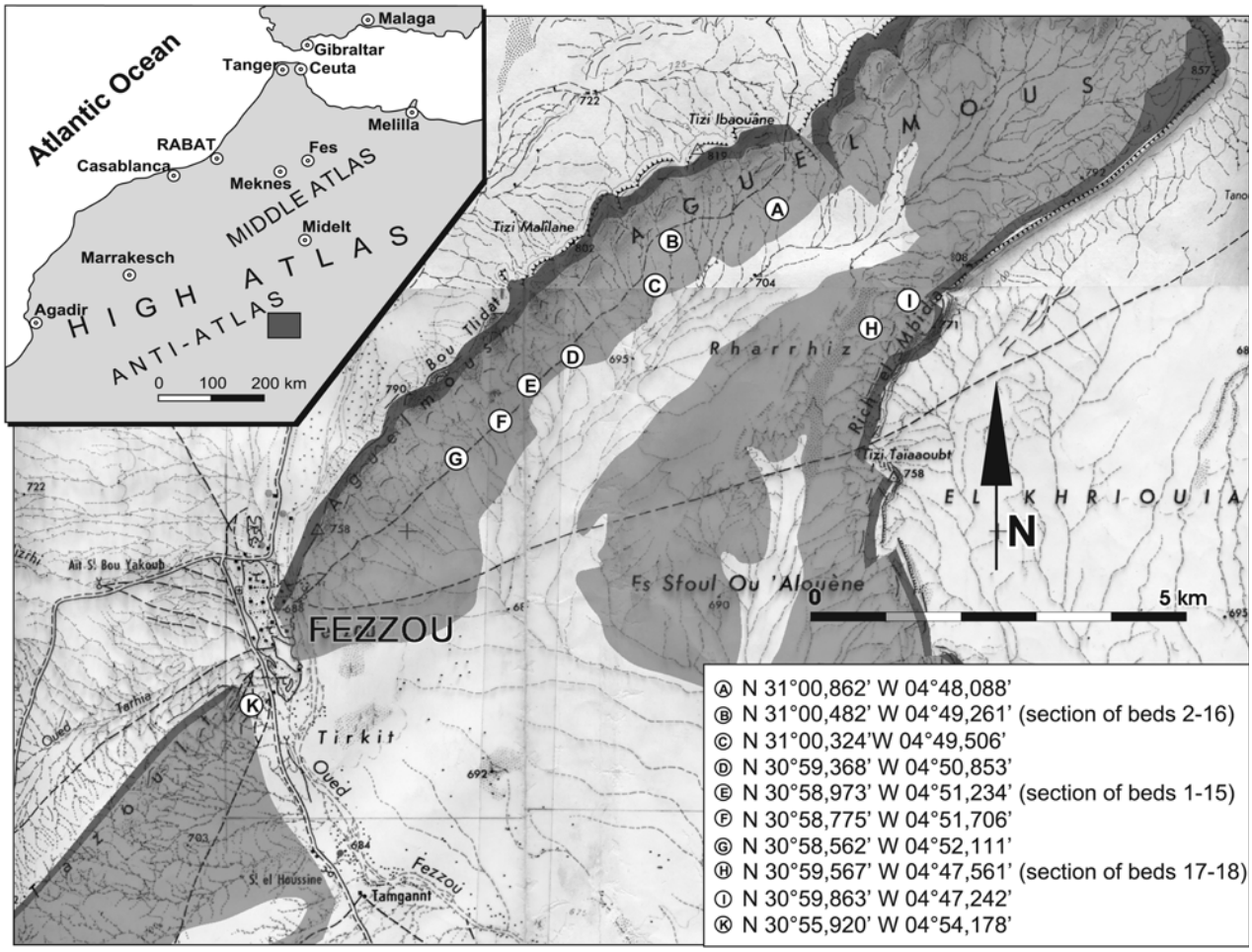


Fig. 1. The position of the Tournaisian ammonoid localities in the vicinity of Fezzou; Tizi Ibaouâne (A, B), Tizi Malilane (C), Bou Tlidat (D–G), Rich el Mbidia (H, I), Tazoult (K).

The Early Carboniferous sediments of the Aguelmous are mainly composed of siliciclastics (shales, siltstones) with few carbonatic intercalations. The rock succession is deeply weathered and widely covered by debris. Sections can be measured only in few areas, and therefore, a combination of several sections led to the synthesis given in Fig. 2. Lateral facies changes could not be observed in the study area. Although the faunas described in this study have been surface collected, a mixing of horizons can be ruled out. All assemblages are located in considerable distances from each other and are separated by sandstone ridges. A detailed description of the section was provided in an unpublished thesis by Kaiser (2005).

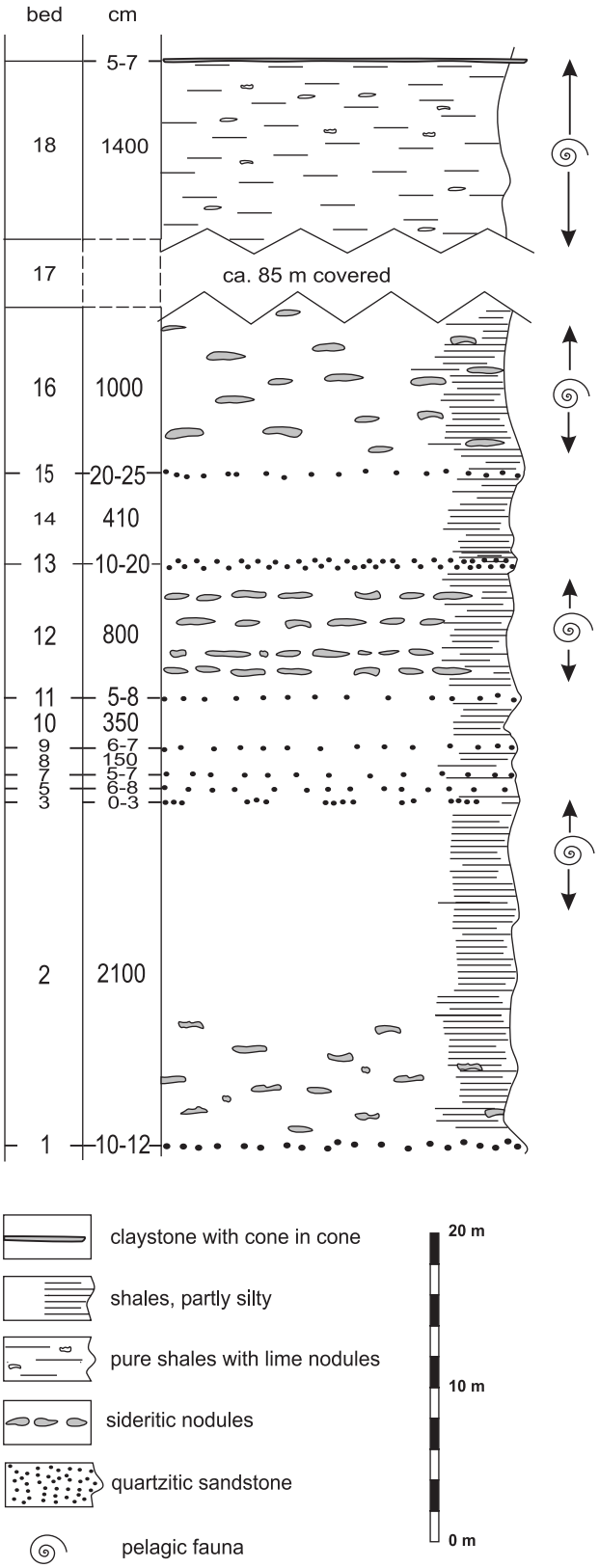


Fig. 2. Lithostratigraphy of the Late Devonian to Early Tournaisian beds at the Aguelmous, Ma'der, Morocco.

Age of the ammonoid fauna

Ammonoid faunas were recorded from beds 2, 12, 16, and 18 (Figs 2, 3). The ammonoid assemblages of beds 2 and 12 show close similarities with the fauna described by Bockwinkel & Ebbighausen (2006) from Mfis in the southern Tafilalt of Morocco. The lack of index genera such as *Paprothites* and *Pseudarietites*, as characteristic for the *Gattendorfia* Limestone of the Rhenish Mountains (Vöhringer

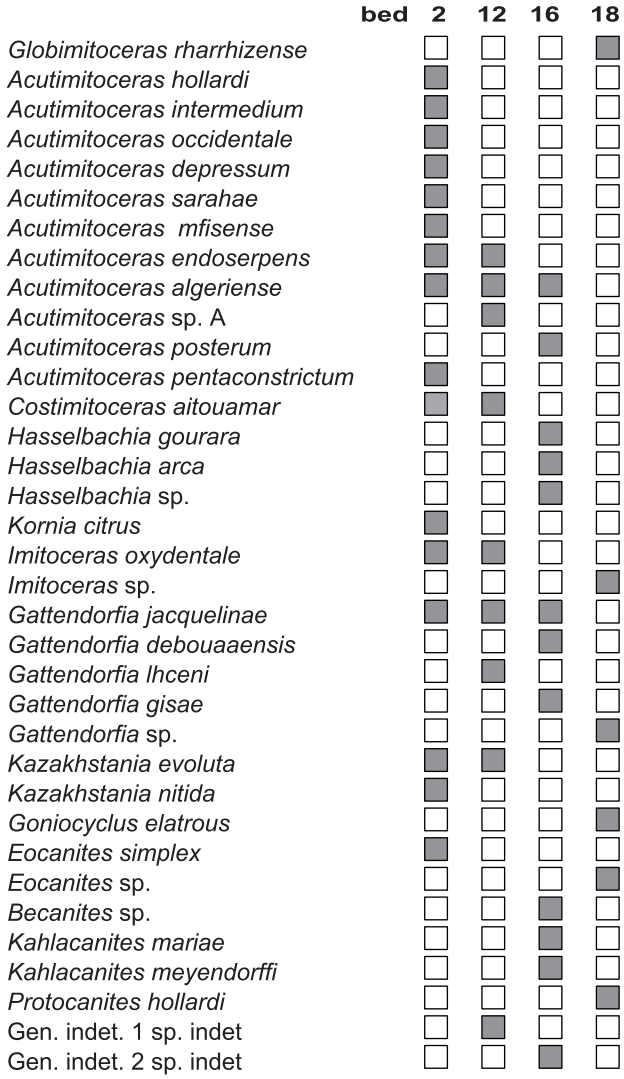


Fig. 3. Distribution of the ammonoid species in the Aguelmous sections.

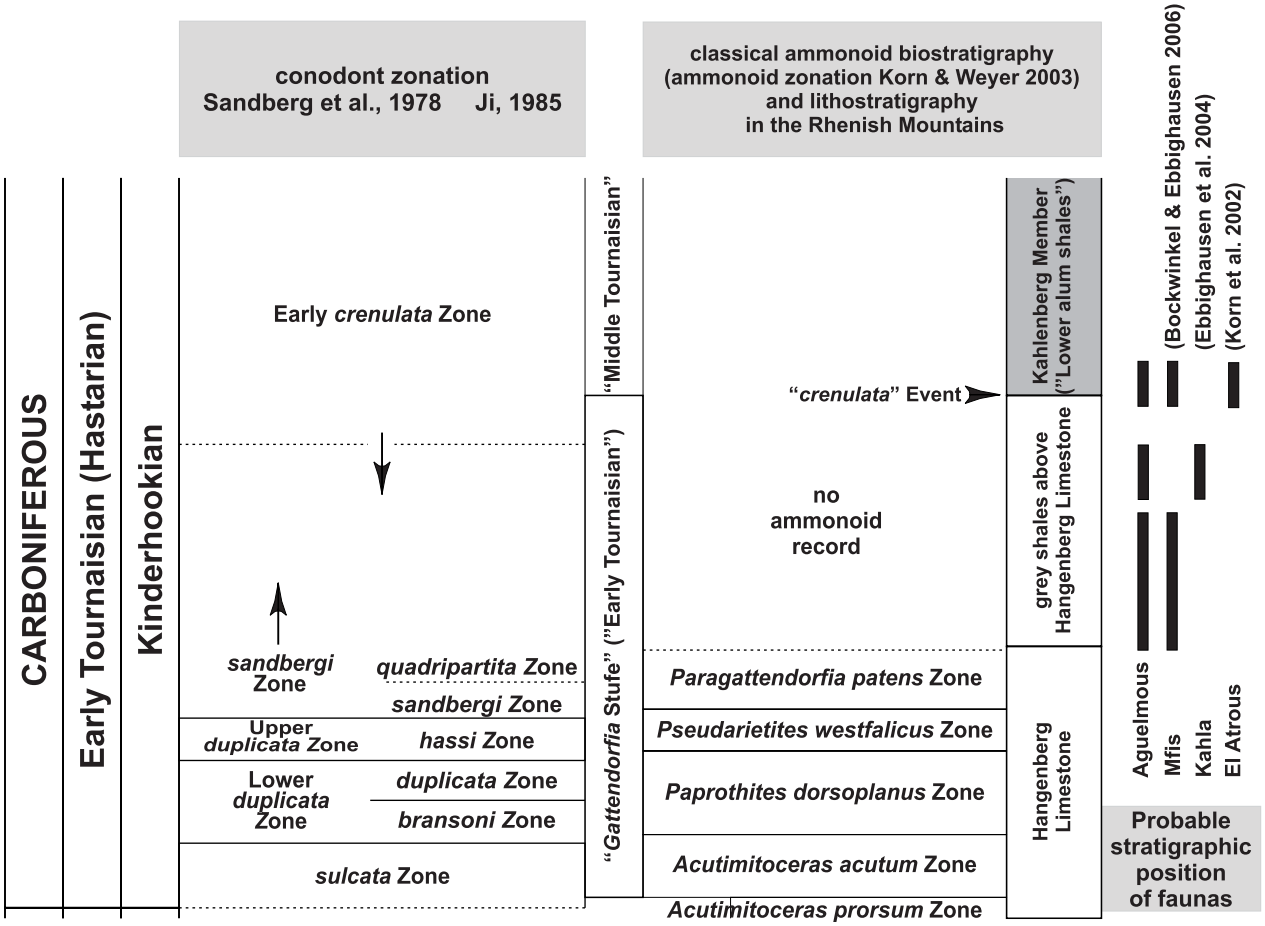


Fig. 4. Chronostratigraphy, ammonoid and conodont zonations in the northern Rhenish Mountains, after Korn & Weyer (2003).

1960) and South China (Ruan 1981), but the presence of advanced forms such as *Imitoceras* speak for a position above the classical *Gattendorfia* Stufe (Fig. 4). Korn et al. (2007) place this fauna in the *Gattendorfia-Eocanites* Assemblage of the North African Carboniferous ammonoid succession. Kaiser (2005) correlated this fauna with the lowest Carboniferous *Acutimitoceras acutum* Zone, based on the occurrence of "*Stockumites*" (= *Acutimitoceras*) and the "*Gattendorfia molaris* Group" (= *Weyerella*), confirmed by *Gattendorfia* and *Eocanites*. However, *Weyerella* has not been recorded from Aguelmous, and the other elements do not exclude a younger stratigraphic assignment.

Bed 16 is dominated by the genera *Gattendorfia*, *Kahlacanites*, and *Hasselbachia*. A very similar fauna is known from the Grès supérieur de Kahla from the Gara el Kahla near Timimoun in north-western Algeria (Ebbighausen et al. 2004). This fauna is placed in the *Gattendorfia-Kahlacanites* Assemblage (Korn et al. 2007).

The poorly preserved fauna from bed 18 is almost identical with the fauna known from a locality 75 km east of the Aguelmous in the Amessoui Syncline (Korn et al. 2002). It belongs to the *Goniocyclus-Protocanites* Assemblage (Korn et al. 2007).

Palaeontological descriptions of the ammonoids

Abbreviations used in the text are dm – conch diameter, ww – whorl width, uw – umbilical width, wh – whorl height, ah – apertural height, IZR – imprint zone rate, calculated (wh-ah)/wh (see Korn & Klug 2002), and WER – whorl expansion rate, calculated $[dm/(dm-ah)]^2$ (Fig. 5A). Described and illustrated specimens are housed in the collection of the Museum für Naturkunde der Humboldt-Universität zu Berlin, with the catalogue numbers MB.C.10151–MB.C.10241. The terminology of the suture line (Fig. 5B) follows Korn et al. (2003). Synonymy lists were partly obtained from the database GONIAT, version 2.60 (Korn & Kullmann 1996).

Order **Goniatitida** Hyatt, 1884
Suborder **Tornoceratina** Wedekind, 1918
Superfamily **Prionoceratoidea** Hyatt, 1884
Family **Prionoceratidae** Hyatt, 1884
Subfamily **Prionoceratinae** Hyatt, 1884

Globimitoceras Korn, 1992

Globimitoceras rharrhizense n. sp.

Figs 6, 7

Derivation of name. After the Rharrhiz crest north-east of Fezzou.

Holotype. Specimen MB.C.10185.1; illustrated here in Fig. 6A.

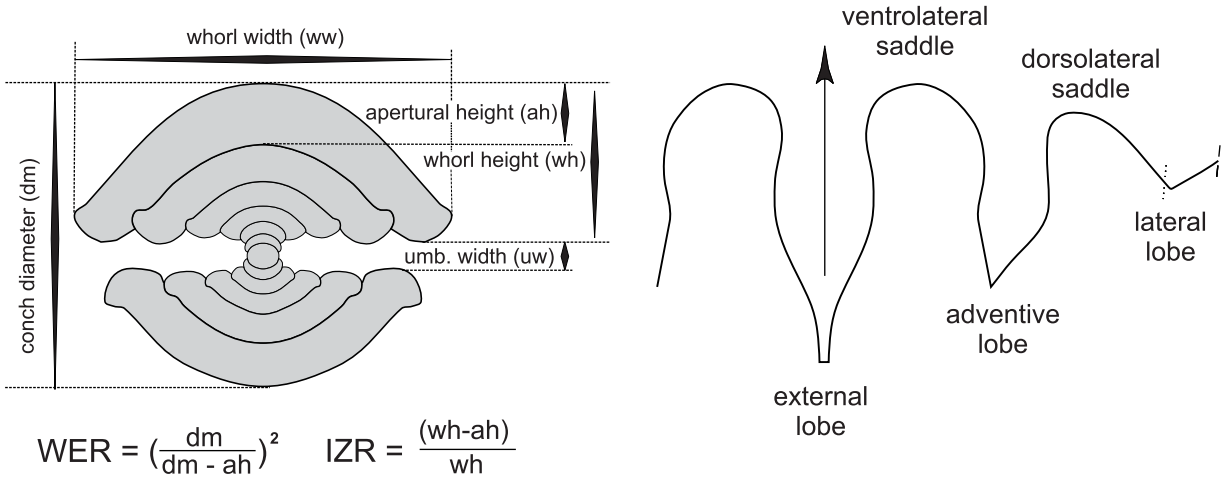


Fig. 5. Conch parameters, calculated ratios and rates; suture nomenclature of the investigated ammonoids, after Korn & Klug (2002).

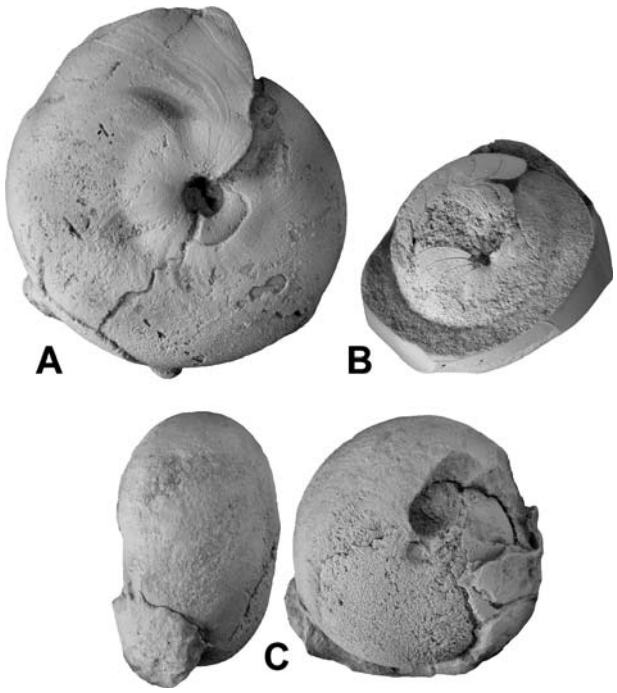


Fig. 6. *Globimitoceras rharrhizense* n. sp. from Rich el Mbidia, bed 18, × 1. **A** – Holotype MB.C.10185.1, lateral view,. **B** – Paratype MB.C.10185.2, latex cast, lateral view. **C** – Paratype MB.C.10185.4, ventral and lateral views.

Type locality and horizon. Rich el Mbidia at the Rharrhiz crest north-east of Fezzou (Ma'der, Anti-Atlas, Morocco); bed 18 (Middle Tournaisian).

Material. Rich el Mbidia (bed 18): 32 specimens.

Diagnosis. Species of *Globimitoceras* with globular conch at 5 mm conch diameter (ww/dm = 1.00), decreasing to a thickly pachyconic conch at 20 mm dm (ww/dm = 0.70–0.80). Umbilicus very narrow throughout ontogeny (uw/dm = 0.15–0.20 in juveniles; 0.10–0.15 in the adult stage). Suture line with asymmetric, lanceolate and very narrow adventive lobe that is deeper than the external lobe. Ornament with fine, strongly convex growth lines; steinkern without constrictions. Umbilicus in the adult stage surrounded by a conspicuous pad.

Description. Paratype MB.C.10185.3 was sectioned and displays the conch ontogeny from 2 to 24 mm diameter (Fig. 7A). The conch has always a similar form lacking conspicuous changes of morphology, but is much wider in the juvenile stage (ww/dm = 1.20–1.30 at 2–3 mm dm) and becomes continuously more slender (ww/dm = 0.70–0.80 at 16–24 mm dm). The umbilicus becomes narrower during this interval; the uw/dm ratio decreases from almost 0.20 to 0.12. All stages show a low aperture with a whorl expansion rate of about 1.50. Holotype MB.C.10185.1 is an adult individual with 47 mm diameter. It shows the adult modification of the conch in possessing a conspicuous tab around the umbilicus (Fig. 6A). Close to the aperture, there is a short radial grooving visible, being backwardly bent. The growth lines of the specimen show a rather high dorsolateral projection and turn back to form a very deep ventral sinus.

Paratype MB.C.10185.5 is a specimen of the same size; it shows the characteristic umbilical pad, and also a deep grooving on the inner flank near the end of the last volution. Smaller specimens such as paratype MB.C.10185.4 (33 mm dm) do not show these adult modifications. They possess a pachyconic to globular conch with continuously rounded flanks. The suture line of paratype MB.C.10185.2 is characterised by a very narrow, lanceolate external and adventive lobe, respectively, and by very wide, broadly arched ventrolateral and dorsolateral saddles (Fig. 7B).

Discussion. It is not easy to attribute the new species to a distinct genus, but, according to the conch geometry and suture line, placement into *Globimitoceras* is most reasonable. The new species differs from the type species *G. globiforme* (Vöhringer, 1960) in the more slender conch shape in the adult stage and, in particular, in the presence of the umbilical pad. This character distinguishes *G. rharrhizense* n. sp. from all other Tournaisian ammonoids.

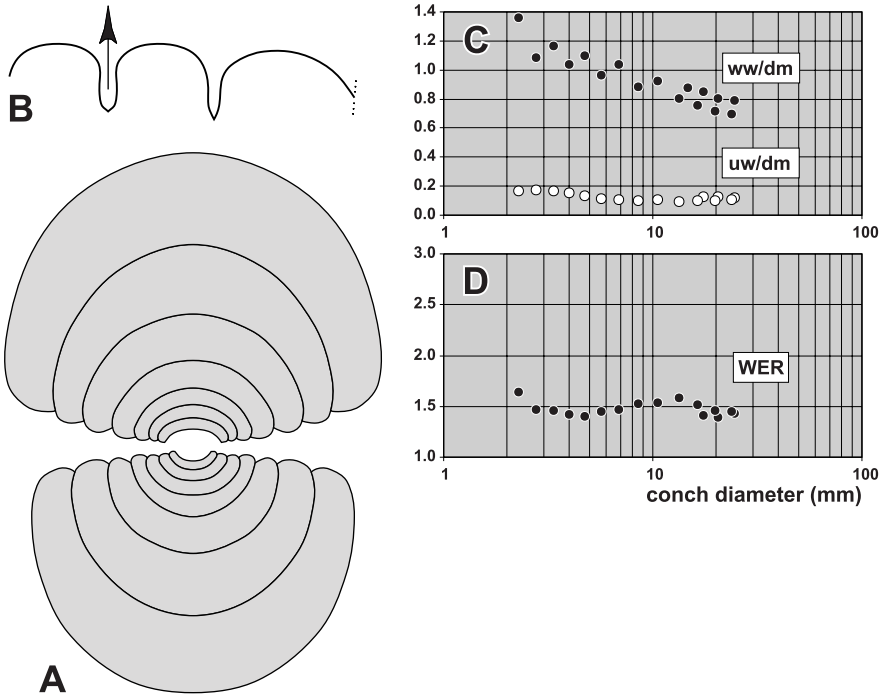


Fig. 7. *Globimitoceras rharrhizense* n. sp. from bed 18 of the Aguelmous. **A** – Cross section, specimen MB.C.10185.3; ×3. **B** – Suture line, specimen MB.C.10185.2, at 16.0 mm ww, 12.2 mm wh; ×2. **C** – Ontogenetic development of the whorl width index (ww/dm) and umbilical width index (uw/dm). **D** – Ontogenetic development of the whorl expansion rate (WER).

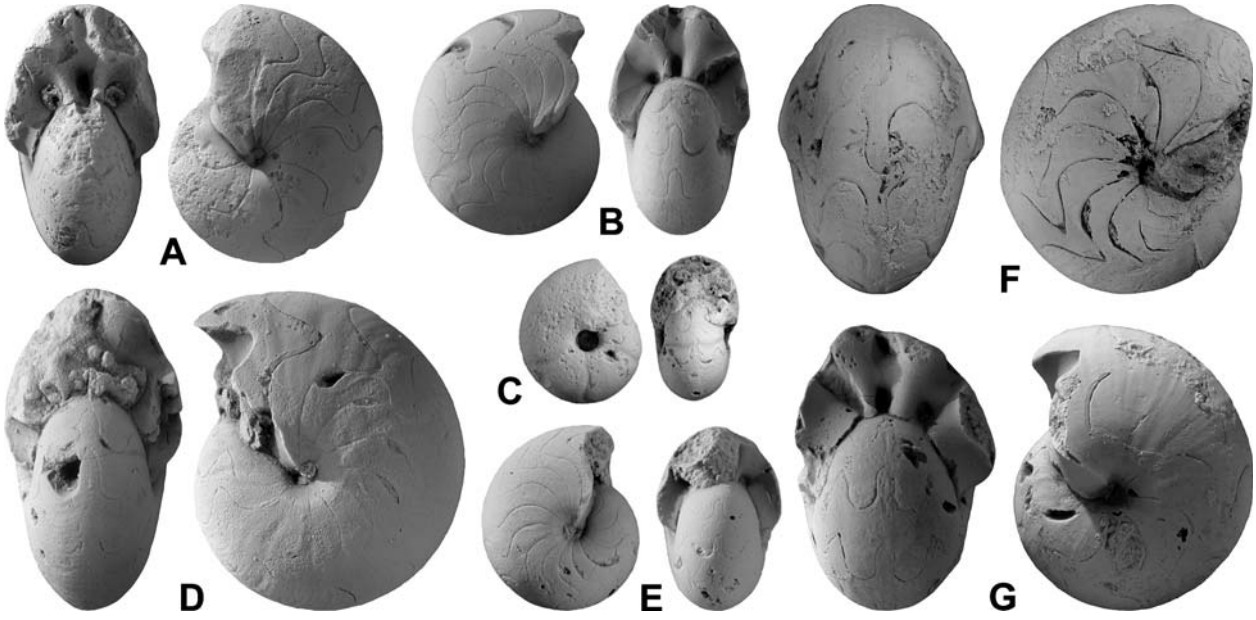


Fig. 8. *Acutimitoceras* from the Aguelmous near Fezzou. **A** – *Acutimitoceras hollardi* Bockwinkel & Ebbighausen, 2006, specimen MB.C.10192.1, from Tazoult, bed 2, dorsal and lateral views, ×2.5. **B** – *Acutimitoceras hollardi* Bockwinkel & Ebbighausen, 2006, specimen MB.C.10192.2 from Tazoult, bed 2, lateral and dorsal views, ×2.5. **C** – *Acutimitoceras hollardi* Bockwinkel & Ebbighausen, 2006, specimen MB.C.10192.3 from Tazoult, bed 2, lateral and dorsal views, ×3. **D** – *Acutimitoceras occidentale* Bockwinkel & Ebbighausen, 2006, specimen MB.C.10196.1 from Tazoult, bed 2, dorsal and lateral views, ×2.5. **E** – *Acutimitoceras occidentale* Bockwinkel & Ebbighausen, 2006, specimen MB.C.10158.1 from Bou Tlidat, lateral and dorsal views, ×3. **F** – *Acutimitoceras intermedium* (Schindewolf, 1923), specimen MB.C.10193.1, from Tazoult, bed 2, ventral and lateral views, ×2. **G** – *Acutimitoceras intermedium* (Schindewolf, 1923), specimen MB.C.10155.1, from Bou Tlidat, bed 2, dorsal and lateral views, ×2.5.

Subfamily **Acutimitoceratinae** Korn, 1994

Acutimitoceras Librovitch, 1957

Type species. *Imitoceras acutum* Schindewolf, 1923.

Acutimitoceras hollardi Bockwinkel & Ebbighausen, 2006

Figs 8A–C, 9

* 2006 *Acutimitoceras hollardi* Bockwinkel & Ebbighausen: 96, figs 11, 12.

Holotype. Specimen MB.C.3827.1.

Type locality and horizon. Northern slope of the Jebel Debouaâ east of Mfis (Anti-Atlas, Morocco); bed 9 (Early Tournaisian).

Material. Bou Tlidat (bed 2): 9 specimens, Tazoult (bed 2): 9 specimens, Tazoult (loose): 3 specimens.

Diagnosis. Species of *Acutimitoceras* with thickly discoidal conch (ww/dm = 0.55 at 12 mm dm). Inner whorls up to 5 mm diameter with open umbilicus (uw/dm = 0.15–0.30), umbilicus slightly open at 12 mm diameter. Aperture low in the juvenile stage but becoming higher during ontogeny; whorl expansion rate higher than 2.00 in stages larger than 10 mm diameter. Steinkern without or with weak constrictions. Suture line with narrow, lanceolate external lobe and Vshaped, very shallow, narrowly rounded adventive lobe.

Remarks. When erecting this peculiar species, Bockwinkel & Ebbighausen (2006) had only two specimens. Now, more than 20 additional specimens are available, and the diagnosis is thus revised. In contrast to the original description, the new specimens such as MB.C.10192.2 (Fig. 8B) have feeble constrictions that extend convexly across the flank and turn back for a shallow ventral sinus. Furthermore, the specimens from Aguelmous show that the apertural height becomes more prominent in stages above 8 mm dm, and hence is characteristic for *Acutimitoceras.*

Acutimitoceras intermedium (Schindewolf, 1923)

Figs 8F, G, 10, 12A, B

* 1923 *Imitoceras intermedium* Schindewolf: 333, pl. 16: fig. 2.
2006 *Acutimitoceras intermedium*. – Bockwinkel & Ebbighausen: 97, text-figs 13, 14 (for more synonymy).

Material. Bou Tlidat (bed 2): 264 specimens, Tazoult (bed 2): 14 specimens, Tazoult (loose): 26 specimens, Rich El Mbidia (bed 2): 5 specimens, Tizi Ibaouâne (bed 2); 9 specimens, Tizi Malilane (bed 2): 4 specimens.

Remarks. The new material allowed the preparation of a series of cross sections, from which the conch ontogeny from the initial stage up to 20 mm diameter can be investigated (Fig. 10A–C). Growth trajectories are characteristic for *Acutimitoceras* with striking ontogenetic changes.

Acutimitoceras occidentale Bockwinkel & Ebbighausen, 2006

Figs 8D–E, 11

* 2006 *Acutimitoceras occidentale* Bockwinkel & Ebbighausen: 103, figs 19, 20.

Material. Bou Tlidat (bed 2): 17 specimens, Tazoult (bed 2): 26 specimens, Tazoult (loose): 28 specimens.

Remarks. The very close resemblance of the new material to the original Mfis material confirms the diagnosis given for that species by Bockwinkel & Ebbighausen (2006).

Acutimitoceras depressum (Vöhringer, 1960)

Figs 12C, D, 13

1960 *Imitoceras depressum* Vöhringer: 130, pl. 3: fig. 5.
1994 *Acutimitoceras depressum*. – Korn: 43, figs 44I, J, 45F, G, 47C, 48E.

Material. Bou Tlidat (bed 2): 13 specimens, Tazoult (bed 2): 2 specimens, Tazoult (loose): 2 specimens, Tizi Ibaouâne (bed 2); 1 specimen.

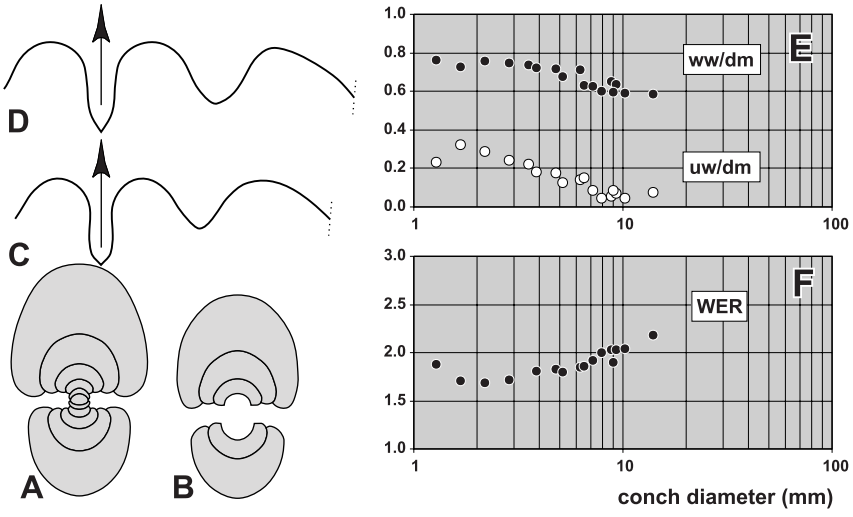


Fig. 9. *Acutimitoceras hollardi* Bockwinkel & Ebbighausen, 2006 from bed 2 of the Aguelmous. **A** – Cross section, specimen MB.C.10192.4; ×3. **B** – Cross section, specimen MB.C.10154.1; ×3. **C** – Suture line (reversed), specimen MB.C.10154.2, at 4.6 mm ww, 3.9 mm wh; ×7. **D** – Suture line (reversed), specimen MB.C.10154.3, at 7.3 mm dm, 4.8 mm ww, 4.3 mm wh; ×7. **E** – Ontogenetic development of the whorl width index (ww/dm) and umbilical width index (uw/dm). **F** – Ontogenetic development of the whorl expansion rate (WER).

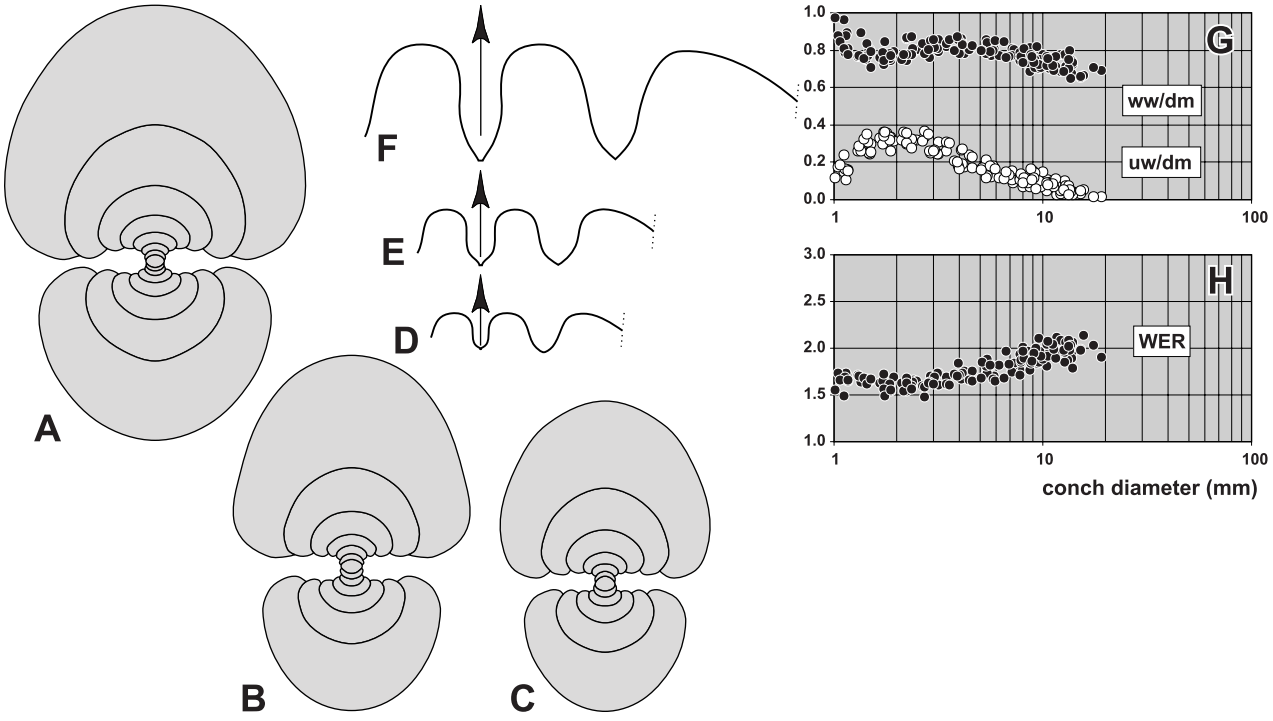


Fig. 10. *Acutimitoceras intermedium* (Schindewolf, 1923) from bed 2 of the Aguelmous. **A** – Cross section, specimen MB.C.10206.1; ×3. **B** – Cross section, specimen MB.C.10155.4; ×3. **C** – Cross section, specimen MB.C.10216.1; ×3. **D** – Suture line (reversed), specimen MB.C.10155.5, at 2.4 mm ww, 1.3 mm wh; ×10. **E** – Suture line specimen MB.C.10155.6, at 5.1 mm dm, 4.2 mm ww, 2.1 mm wh; ×7. **F** – Suture line, specimen MB.C.10155.4, at 10.8 mm dm, 7.9 mm ww, 5.0 mm wh; ×6. **G** – Ontogenetic development of the whorl width index (ww/dm) and umbilical width index (uw/dm). **H** – Ontogenetic development of the whorl expansion rate (WER).

Diagnosis. Species of *Acutimitoceras* with thickly pachyconic conch (ww/dm = 0.70–0.85 at 12 mm dm). Inner whorls up to 5 mm diameter with open umbilicus (uw/dm = 0.20–0.35), umbilicus closed at 12 mm diameter. Aperture low in the juvenile stage and slowly becoming higher during ontogeny; whorl expansion rate higher 1.70–1.90 in stages larger than 10 mm diameter. Steinkern without or with weak constrictions in the adult stage, shallow constrictions in juveniles. Suture line with lanceolate external lobe and V-shaped adventive lobe.

Description. The cross sections of the material shows a rather wide variability, particularly when the umbilical width is studied (Fig. 13). The conchs are widest umbilicate at 2–3 mm dm, where the uw/dm ratio reaches a maximum of 0.30–0.40. This ratio then becomes progressively smaller, and the umbilicus is almost closed at 12 mm dm. The conch width index is stable at 0.75–0.85 between 3 and

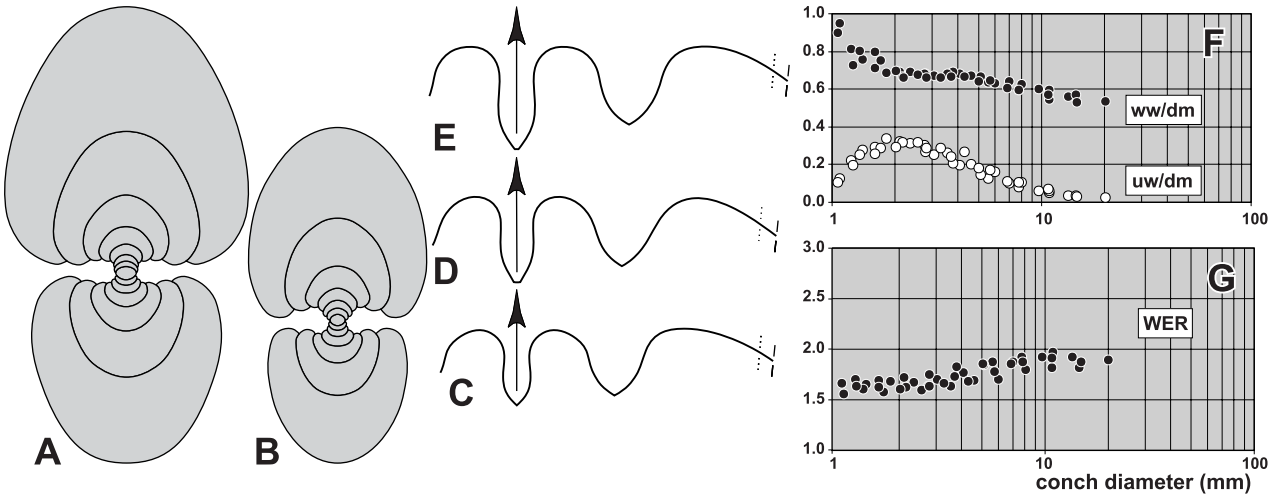


Fig. 11. *Acutimitoceras occidentale* Bockwinkel & Ebbighausen, 2006 from bed 2 of the Aguelmous. **A** – Cross section, specimen MB.C.10196.2; ×3. **B** – Cross section, specimen MB.C.10196.3; ×3. **C** – Suture line, specimen MB.C.10158.3, at 6.0 mm ww, 5.5 mm wh; ×5. **D** – Suture line, specimen MB.C.10158.2, at 8.8 mm dm, 6.3 mm ww, 4.6 mm wh; ×5. **E** – Suture line, specimen MB.C.10158.4, at 6.8 mm ww, 6.4 mm wh; ×5. **F** – Ontogenetic development of the whorl width index (ww/dm) and umbilical width index (uw/dm). **G** – Ontogenetic development of the whorl expansion rate (WER).

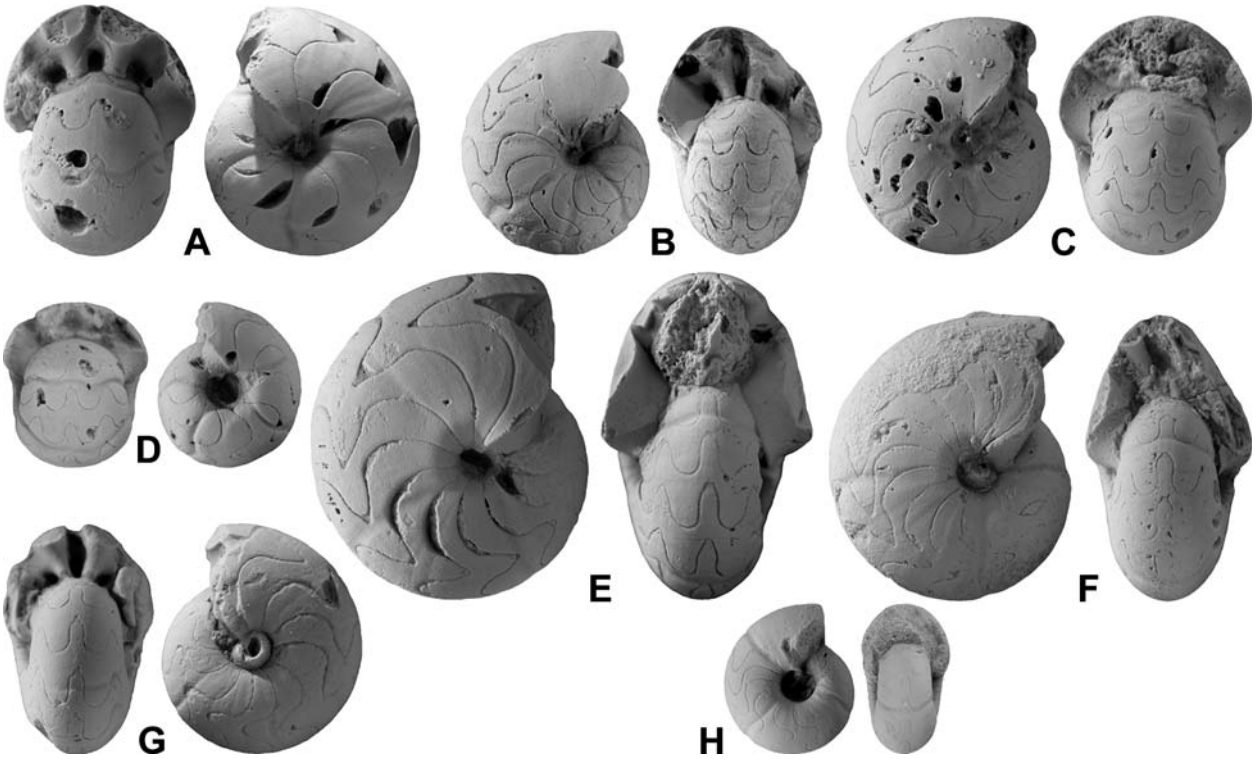


Fig. 12. *Acutimitoceras* from Bou Tlidat, bed 2, all × 3. **A** – *Acutimitoceras intermedium* (Schindewolf, 1923), specimen MB.C.10155.2, dorsal and lateral views. **B** – *Acutimitoceras intermedium* (Schindewolf, 1923), specimen MB.C.10155.3, lateral and dorsal views. **C** – *Acutimitoceras depressum* (Vöhringer, 1960), specimen MB.C.10152.2, lateral and dorsal views. **D** – *Acutimitoceras depressum* (Vöhringer, 1960), specimen MB.C.10152.1, dorsal and lateral views. **E** – *Acutimitoceras sarahae* n. sp. holotype MB.C.10156.1, lateral and dorsal views. **F** – *Acutimitoceras sarahae* n. sp. paratype MB.C.10156.2, lateral and dorsal views. **G** – *Acutimitoceras sarahae* n. sp. paratype MB.C.10156.3, dorsal and lateral views. **H** – *Acutimitoceras sarahae* n. sp. paratype MB.C.10156.4, lateral and dorsal views.

10 mm dm. Between 2 and 12 mm dm, there is a continuous increase of the apertural height (WER increasing from 1.60 to 1.80).

Specimen MB.C.10152.2 is a characteristic specimen that has an 11 mm conch diameter, 12 chambers on the last volution and is fully septate (Fig. 12C). The thickly pachyconic, almost involute specimen has weak steinkern constrictions, which extend with a concavo-convex course across flanks and venter. The smaller specimen MB.C.10152.1 (7 mm dm) has a similar conch, but with a slightly opened umbilicus (Fig. 12D). It possesses rather strong constrictions, which turn forward on the flank and form a shallow ventral sinus. The suture line of specimen

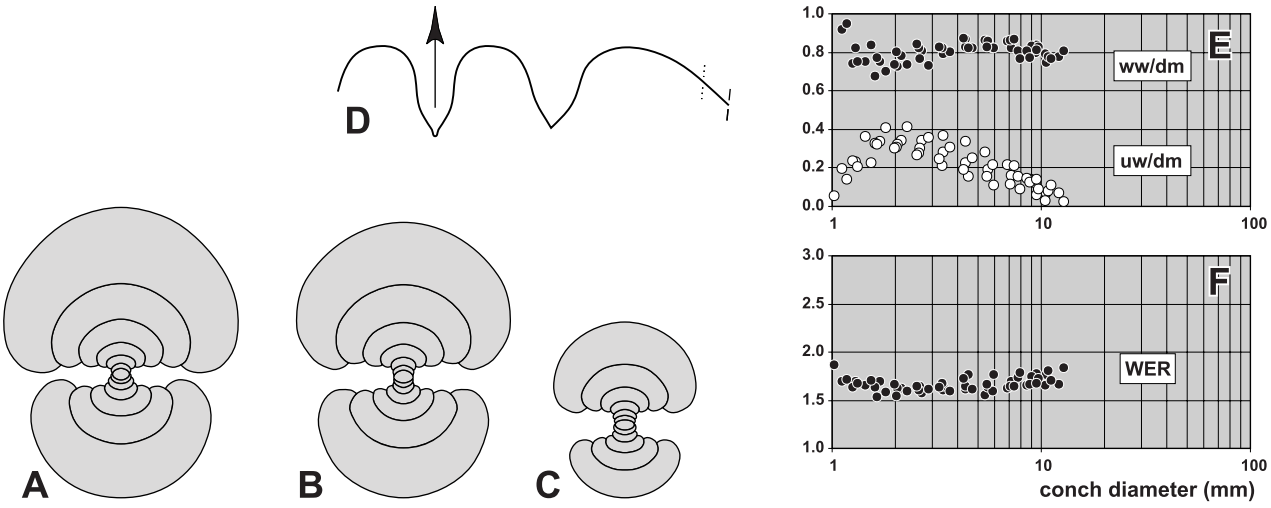


Fig. 13. *Acutimitoceras depressum* (Vöhringer, 1960) from bed 2 of the Aguelmous. **A** – Cross section, specimen MB.C.10190.1; ×3. **B** – Cross section, specimen MB.C.10152.3; ×3. **C** – Cross section, specimen MB.C.10214; ×3. **D** – Suture line, specimen MB.C.10152.3, at 8.8 mm ww, 5.4mm wh; ×5. **E** – Ontogenetic development of the whorl width index (ww/dm) and umbilical width index (uw/dm). **F** – Ontogenetic development of the whorl expansion rate (WER).

MB.C.10152.3 has a lanceolate external lobe with diverging flanks, a wide and broadly rounded ventrolateral saddle, and a V-shaped adventive lobe (Fig. 13D).

Discussion. The new material consists of rather small specimens, which fit well into the morphological spectrum of the Rhenish species. The species resembles *A. kleinerae* Korn, 1984, but can be distinguished by its narrower adventive lobe. *A. intermedium* (Schindewolf, 1923) has a more slender conch.

Acutimitoceras sarahae n. sp

Figs 12E–H, 14

Derivation of name. After Sarah Aboussalam who found the first Carboniferous specimen during our joined field trip to rediscover the Clariond locality.

Holotype. Specimen MB.C.10156.1; illustrated here in Fig. 12E.

Type locality and horizon. Bou Tlidat, Aguelmous (Ma'der, Anti-Atlas, Morocco); bed 2 (Early Tournaisian).

Material. Bou Tlidat (bed 2): 117 specimens, Tazoult (bed 2): 48 specimens, Tazoult (loose): 43 specimens, Rich El Mbidia (bed 2): 1 specimen, Tizi Ibaouâne (bed 2): 5 specimens.

Diagnosis. Species of *Acutimitoceras* with thickly discoidal to pachyconic conch (ww/dm = 0.55–0.65 at 12 mm dm). Inner whorls up to 5 mm diameter with very wide umbilicus (uw/dm = 0.40–0.50), umbilicus slightly open at 10 mm diameter and thereafter closing. Aperture moderate, whorl expansion rate 1.80–2.00 in stages larger than 5 mm diameter. Steinkern with weak linear constrictions. Suture line with narrow, lanceolate external lobe and lanceolate adventive lobe with sinuous flanks.

Description. The general conch ontogeny closely resembles the preceding species, with a serpenticonic juvenile stage followed by a stage, in which the whorl height is enlarged and the umbilicus progressively closes. The whorl cross section is almost circular at 8–11 mm conch diameter but becomes laterally compressed at higher diameters (Fig. 14).

The holotype (MB.C.10156.1) is a medium-sized fully septate specimen (15 mm dm), which has 12 chambers of equal length (Fig. 12E). It is thinly pachyconic (ww/dm = 0.61) and widest near the umbilicus with an almost closed, funnel-shaped umbilicus. The specimen has three irregularly spaced, weak constrictions. The suture line has a narrow, slightly pouched external lobe, a broadly rounded ventrolateral saddle, and a rather wide adventive lobe, in which the flanks are almost parallel in the upper part (Fig. 14F).

The smaller paratypes MB.C.10156.4 (6.5 mm dm), MB.C.10156.3 (10 mm dm), and MB.C.10156.2 (13 mm dm) show the transition from the juvenile to the adult stage, i.e., closing of the umbilicus, widening of the conch, and changing the course of the constrictions from concavo-convex to convex.

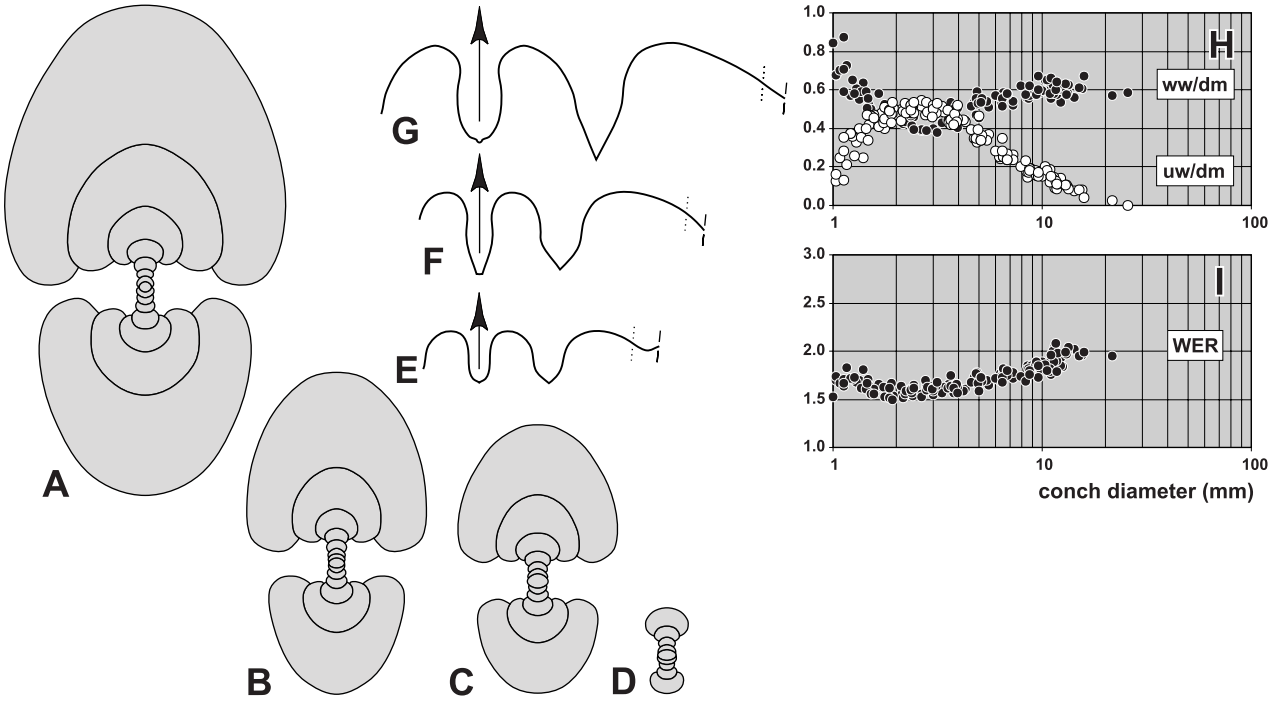


Fig. 14. *Acutimitoceras sarahae* n. sp. from bed 2 of the Aguelmous. **A** – Cross section, paratype MB.C.10207.1; ×3. **B** – Cross section, paratype MB.C.10156.5; ×3. **C** – Cross section, paratype MB.C.10156.6; ×3. **D** – Cross section, paratype MB.C.10156.7; ×3. **E** – Suture line (reversed), paratype MB.C.10156.8, at 4.3 mm ww, 3.1 mm wh; ×5. **F** – Suture line, holotype MB.C.10156.1, at 14.4 mm dm, 8.9 mm ww, 7.6 mm wh; ×3. **G** – Suture line, paratype MB.C.10207.2, at 23.3 mm dm, 14.6 mm ww, 13.4 mm wh; ×2.5. **H** – Ontogenetic development of the whorl width index (ww/dm) and umbilical width index (uw/dm). **I** – Ontogenetic development of the whorl expansion rate (WER).

Discussion. *A. sarahae* differs from the co-occurring *A. endoserpens* n. sp. in having a wider conch, with a ww/wh ratio of 1.40 at 13 mm in *A. sarahae* and 1.00 in *A. endoserpens*. In *A. hilarum* Korn, 2002 similar conch ratios are seen, but the aperture is much lower in this species (WER = 1.70 at 15 mm dm). Other species of *Acutimitoceras*, such as *A. intermedium* (Schindewolf, 1923) may possess similar adult conchs, but differ in the much less widely umbilicate juvenile stage.

Acutimitoceras mfisense Bockwinkel & Ebbighausen, 2006

Figs 15A–C, 16

* 2006 *Acutimitoceras mfisense* Bockwinkel & Ebbighausen: 101, figs 16I, J, K, L, 18.

Material. Bou Tlidat (bed 2): 5 specimens, Tazoult (bed 2): 2 specimens, Tizi Ibaouâne (bed 2): 2 specimens.

Remarks. There is very close resemblance between the specimens from the type locality at Mfis and the material from Aguelmous, visible in the cross section (Fig. 16A), the suture line (Fig. 16B), and the ontogenetic trends of the conch geometry (Fig. 16C, D). An emendation of the original diagnosis is hence not required.

Acutimitoceras endoserpens n. sp.

Figs 15D–G, 17

Derivation of name. Named after the serpenticonic internal whorls.

Holotype. Specimen MB.C.10153.1; illustrated here in Fig. 15E.

Type locality and horizon. Bou Tlidat, Aguelmous (Ma'der, Anti-Atlas, Morocco); bed 2 (Early Tournaisian).

Material. Bou Tlidat (bed 2): 99 specimens, Bou Tlidat (bed 12): 1 specimen, Tazoult (bed 2): 11 specimens, Tazoult (loose): 20 specimens, Rich El Mbidia (bed 2): 2 specimens, Tizi Ibaouâne (bed 2): 7 specimens, Tizi Malilane (bed 2): 2 specimens.

Diagnosis. Species of *Acutimitoceras* with thickly discoidal conch (ww/dm = 0.45–0.55 at 12 mm dm). Inner whorls up to 6 mm diameter with very wide umbilicus (uw/dm = 0.40–0.55), umbilicus slightly open at 10 mm diameter and thereafter rapidly closing. Aperture moderate, whorl expansion rate 1.80–2.00 in stages larger than 5 mm diameter. Steinkern with wellpreserved linear constrictions. Suture line with very narrow, lanceolate external lobe and very narrow, V-shaped adventive lobe.

Description. A number of cross sections were prepared (Fig. 17A–F); these permitted the detailed study of ontogenetic changes of the species. Variability within the material is limited but as can be seen in the growth curves, there are significant ontogenetic changes (Fig. 17I, J). There is a serpenticonic juvenile stage up to about 6 mm conch diameter, and thereafter, rapid overlapping of whorls takes place with the result of an involute, discoidal conch with laterally compressed whorl cross section. This development is paralleled by a continuous increase of the apertural height; the whorl expansion rate ranges between 1.50 and 1.60 at 6 mm dm and then increases to 1.75–2.00 at 15 mm dm.

Holotype MB.C.10153.1 is a well preserved, fully septate preadult specimen with a nearly13 mm

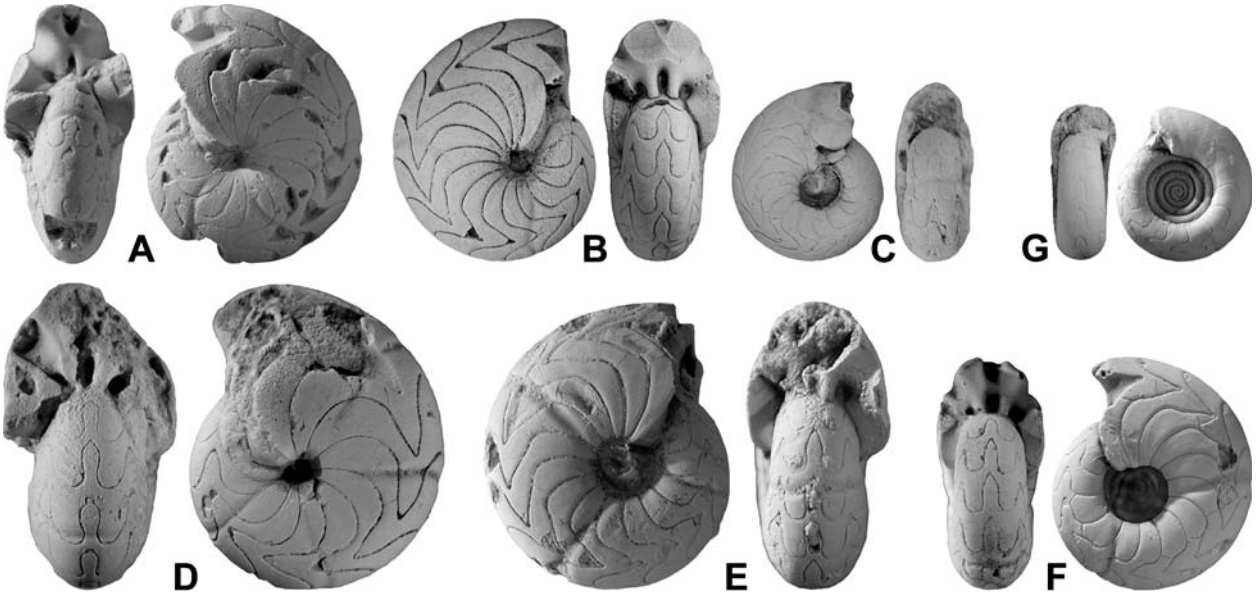


Fig. 15. *Acutimitoceras* from Fezzou, all × 3. **A** – *Acutimitoceras mfisense* Bockwinkel & Ebbighausen, 2006, specimen MB.C.10157.2 from Bou Tlidat, bed 2, dorsal and lateral views. **B** – *Acutimitoceras mfisense* Bockwinkel & Ebbighausen, 2006, specimen MB.C.10217 from Tizi Ibaouâne, bed 2, lateral and dorsal views. **C** – *Acutimitoceras mfisense* Bockwinkel & Ebbighausen, 2006, specimen MB.C.10195.1 from Tazoult, bed 2, lateral and dorsal views. **D** – *Acutimitoceras endoserpens* n. sp. paratype MB.C.10215.1 from Bou Tlidat, bed 2, dorsal and lateral views. **E** – *Acutimitoceras endoserpens* n. sp. holotype MB.C.10153.1 from Bou Tlidat, bed 2, lateral and dorsal views. **F** – *Acutimitoceras endoserpens* n. sp. paratype MB.C.10153.2 from Bou Tlidat, bed 2, dorsal and lateral views. **G** – *Acutimitoceras endoserpens* n. sp. paratype MB.C.10191.1 from Tazoult, dorsal and lateral views.

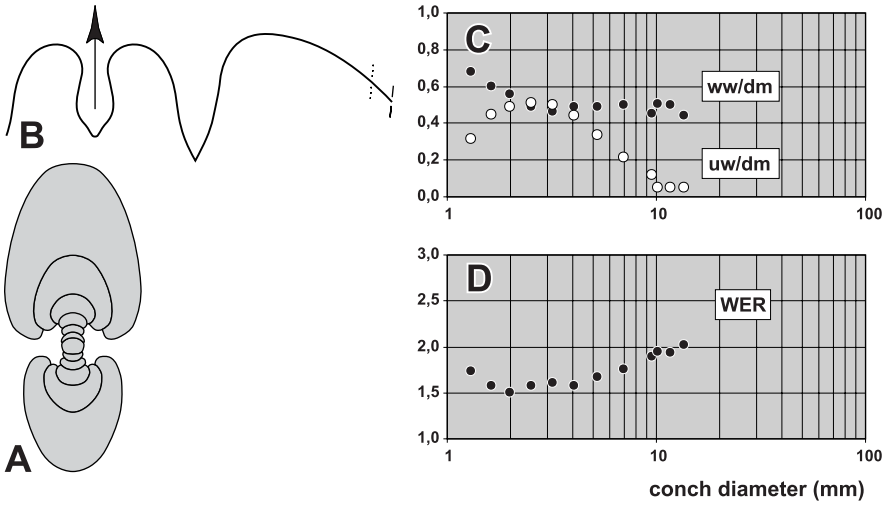


Fig. 16. *Acutimitoceras mfisense* Bockwinkel & Ebbighausen, 2006 from bed 2 of the Aguelmous. **A** – Cross section, specimen MB.C.10157.1; ×3. **B** – Suture line, specimen MB.C.10157.2, at 10.6 mm dm, 5.1 mm ww, 5,7 mm wh; ×6. **C** – Ontogenetic development of the whorl width index (ww/dm) and umbilical width index (uw/dm). **D** – Ontogenetic development of the whorl expansion rate (WER).

conch diameter (Fig. 15E). It has 15 chambers with almost equal distances on the last preserved whorl. Conch proportions are: ww/dm = 0.48, uw/dm = 0.15, but the specimen shows the almost complete closure of the umbilicus on the following whorl, of which the umbilical wall is impressed in the matrix that is preserved in the umbilicus. The specimen has four constrictions at variable distances; these constrictions extend linearly over the flanks and turn back to create a very shallow ventral sinus. The suture line has a narrow and deep, lanceolate external lobe, an asymmetric, ventrally inclined ventrolateral saddle, and a slightly asymmetric, V-shaped adventive lobe (Fig. 17H).

The umbilicus is almost completely closed in specimens above 13 mm dm, such as MB.C.10215.1 (Fig. 15D). Smaller specimens, e.g. MB.C.10153.2 (10 mm dm) and MB.C.10191.1 (7 mm dm) display a very different morphology with open umbilicus and an almost circular whorl cross section. They show rather deep, protracted steinkern constrictions which have a well-developed ventral sinus (Fig. 15F, G).

Discussion. The new form belongs to the group of open-umbilicate species within *Acutimitoceras*. *A. hilarum* Korn, 2002 is similar in this respect with a pachyconic conch (ww/dm = 0.65 at 15 mm dm) and a lower aperture (WER = 1.70). *A. antecedens* (Vöhringer, 1960) appears to be identical in conch shape and suture line, but differs in the absence of steinkern constrictions. *A. mfisense* Bockwinkel & Ebbighausen, 2006 also differs in the shorter external lobe. *A. sarahae* n. sp. has a wider conch (ww/dm = 0.55–0.65) and a wider adventive lobe. *Nicimitoceras heterolobatum* (Vöhringer, 1960) has a shorter adventive lobe, an asymmetric adventive lobe, and lacks constrictions.

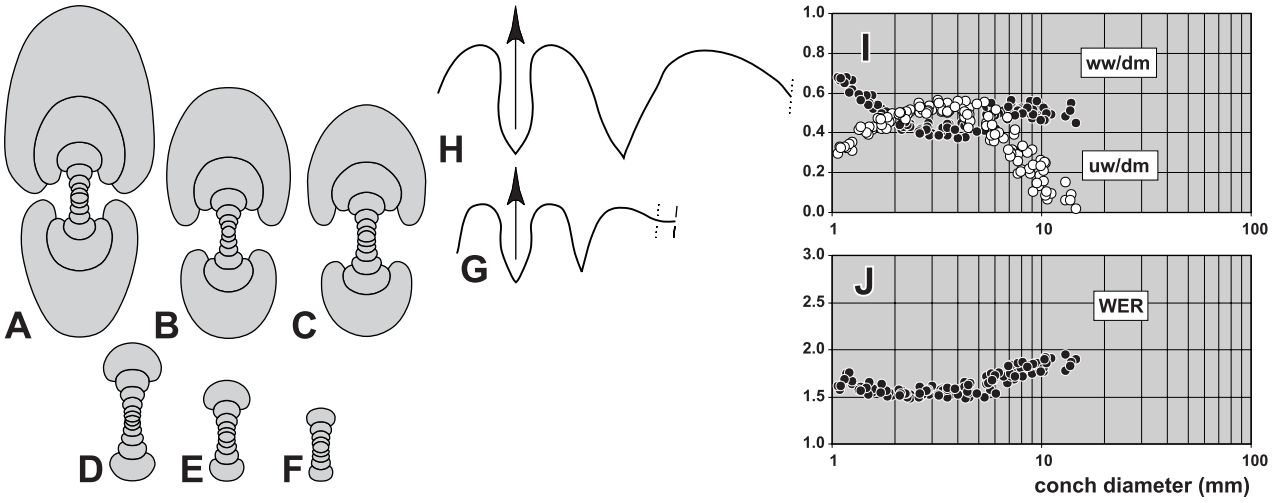


Fig. 17. *Acutimitoceras endoserpens* n. sp. from bed 2 of the Aguelmous. **A** – Cross section, paratype MB.C.10153.3; ×3. **B** – Cross section, paratype MB.C.10191.2; ×3. **C**. Cross section, paratype MB.C.10153.4; ×3. **D** – Cross section, paratype MB.C.10153.5; ×3. **E** – Cross section, paratype MB.C.10191.3; ×3. **F** – Cross section, paratype MB.C.10153.6; ×3. **G** – Suture line, paratype MB.C.10173.1, at 6.4 mm dm, 2.9 mm ww, 1.7 mm wh; ×5. **H** – Suture line (reversed), holotype MB.C.10153.1, at 12.5 mm dm, 5.9 mm ww, 6.4 mm wh; ×5. **I** – Ontogenetic development of the whorl width index (ww/dm) and umbilical width index (uw/dm). **J** – Ontogenetic development of the whorl expansion rate (WER).

***Acutimitoceras algeriense* Ebbighausen, Bockwinkel, Korn & Weyer, 2004**
Figs 18A–C, 19

* 2004 *Acutimitoceras algeriense* Ebbighausen, Bockwinkel, Korn & Weyer: 136, fig. 3A–F.

Material. Bou Tlidat (bed 2): 1 specimen, Rich El Mbidia (bed 16): 3 specimens, Tizi Ibaouâne (bed 12): 17 specimens, Tizi Ibaouâne (bed 16): 5 specimens.

Remarks. The smaller individuals from bed 16 closely resemble Algerian material, and there is no doubt that they belong to the same species. They possess the discoidal conch with the punctiform umbilicus, the short evolute juvenile stage, and the biconvex constrictions of the steinkern. Larger specimens such as MB.C.10228.5 (30 mm dm), MB.C.10228.2 (64 mm dm; Fig. 19A), and MB.C.10228.1 (86 mm dm; Fig. 18A) are preserved

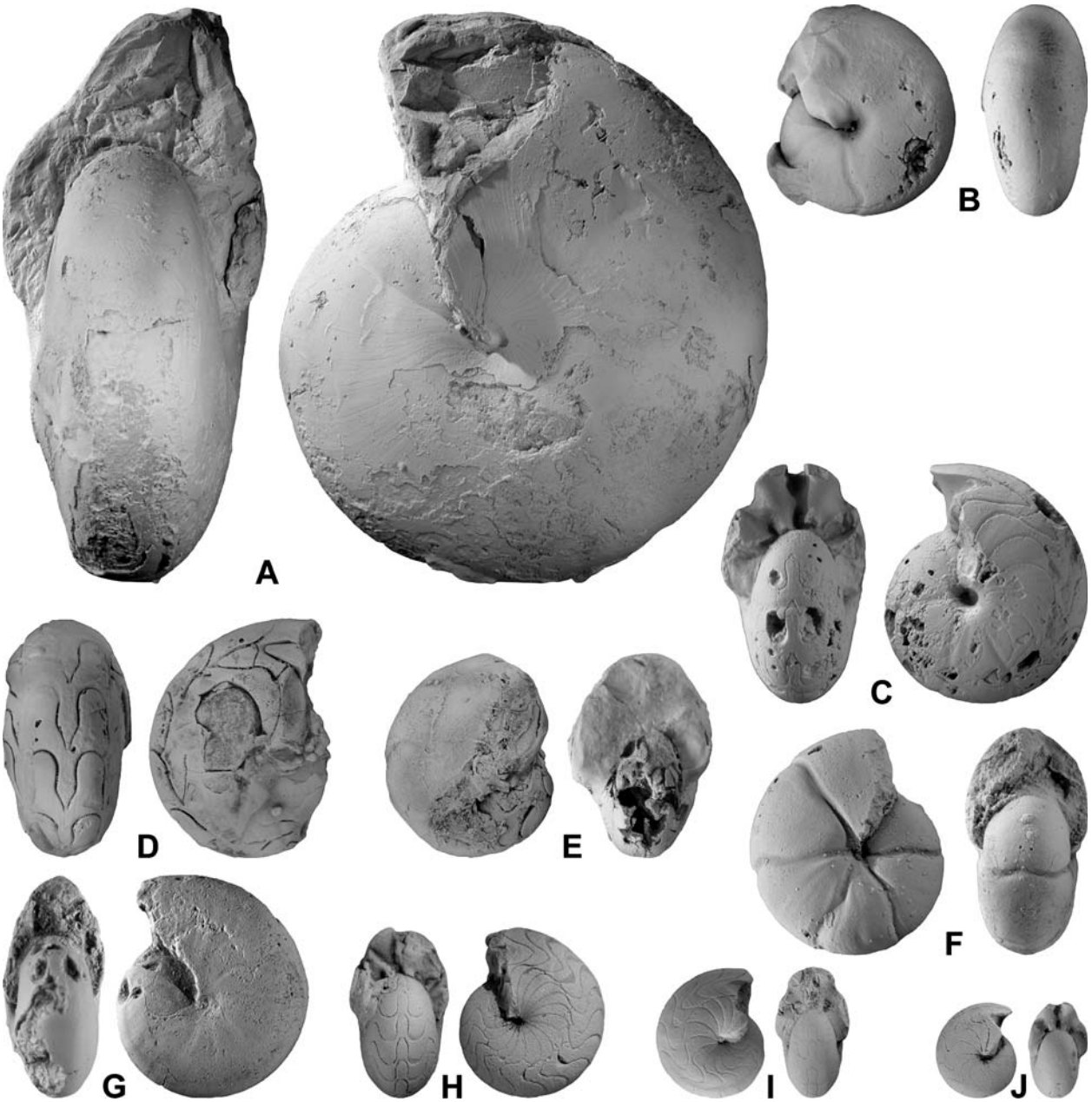


Fig. 18. *Acutimitoceras* and *Costimitoceras* from Fezzou. **A** – *Acutimitoceras algeriense* Ebbighausen et al. 2004, specimen MB.C.10228.1 from Tizi Ibaouâne, bed 16, dorsal and lateral views, ×1. **B** – *Acutimitoceras algeriense* Ebbighausen et al. 2004, specimen MB.C.10222.1 from Tizi Ibaouâne, bed 12, lateral and dorsal views, ×1.5. **C** – *Acutimitoceras algeriense* Ebbighausen et al. 2004, specimen MB.C.10151 from Bou Tlidat, bed 2, dorsal and lateral views, ×2.5. **D** – *Acutimitoceras* sp. A, specimen MB.C.10223.1 from Tizi Ibaouâne, bed 12, dorsal and lateral views, ×1. **E** – *Acutimitoceras* sp. A, specimen MB.C.10223.2 from Tizi Ibaouâne, bed 12, dorsal and lateral views, ×1. **F** – *Acutimitoceras pentaconstrictum* n. sp., holotype from Tizi Ibaouâne, bed 2, lateral and dorsal views, ×3. **G** – *Costimitoceras aitouamar* n. sp., holotype MB.C.10159.1 from Bou Tlidat, bed 2, dorsal and lateral views, ×3. **H** – *Costimitoceras aitouamar* n. sp., paratype MB.C.10159.2 from Bou Tlidat, bed 2, dorsal and lateral views, ×3. **I** – *Costimitoceras aitouamar* n. sp., paratype MB.C.10210.1 from Tazoult, bed unknown, lateral and dorsal views, ×3. **J** – *Costimitoceras aitouamar* n. sp., paratype MB.C.10159.5 from Bou Tlidat, bed 2 lateral and dorsal views, ×3.

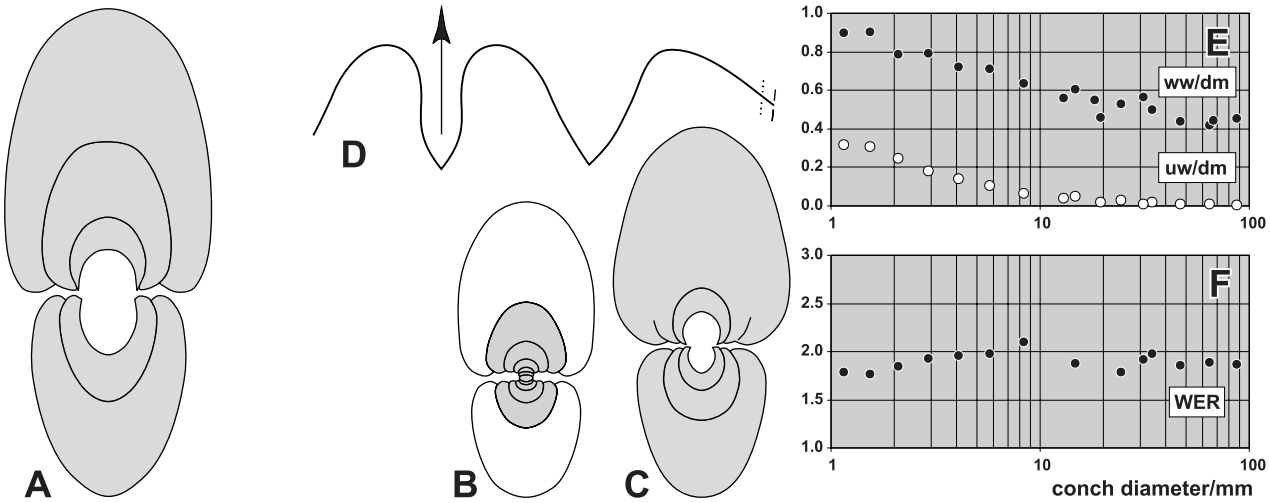


Fig. 19. *Acutimitoceras algeriense* Ebbighausen et al., 2004 from bed 12 and 16 of the Aguelmous. **A** – Cross section, specimen MB.C.10228.2 from bed 16, ×1. **B** – Cross section, specimen MB.C.10228.3 from bed 16, ×2. **C** – Cross section, specimen MB.C.10222.2 from bed 12, ×2. **D** – Suture line, specimen MB.C.10228.4 from bed 16, at 10.5 mm dm, 6.2 mm ww, 5.9 mm wh; ×8. **E** – Ontogenetic development of the whorl width index (ww/dm) and umbilical width index (uw/dm). **F** – Ontogenetic development of the whorl expansion rate (WER).

in sideritic nodules; they have a similar conch morphology but possess convex growth lines and lack constrictions.

Acutimitoceras sp. A
Figs 18D, E, 20

Material. Bou Tlidat (bed 12): 1 specimen, Tizi Ibaouâne (bed 12): 18 specimens.

Remarks. It is not certain that every specimen belongs to the same species, but they all show a thickly discoidal conch above 10 mm dm, a closed umbilicus, and a steinkern with concavo-convex constrictions. They differ each other in their conch width; some specimens including MB.C.10223.1 resemble *A. subbilobatum* (ww/dm = 0.50), whereas others, such as MB.C.10223.2 are closer to *A. intermedium* (ww/dm = 0.65). The cross sections MB.C.10223.3 and MB.C.10223.4 (Fig. 20A, B) show tegoid conchs with a closed umbilicus, an oblique umbilical wall, and rather strongly converging flanks.

Acutimitoceras sp. B
Fig. 21

Material. Tazoult (loose): 2 specimens.

Remarks. Two specimens preserved as siderite have been sectioned, and, based on conch differ-

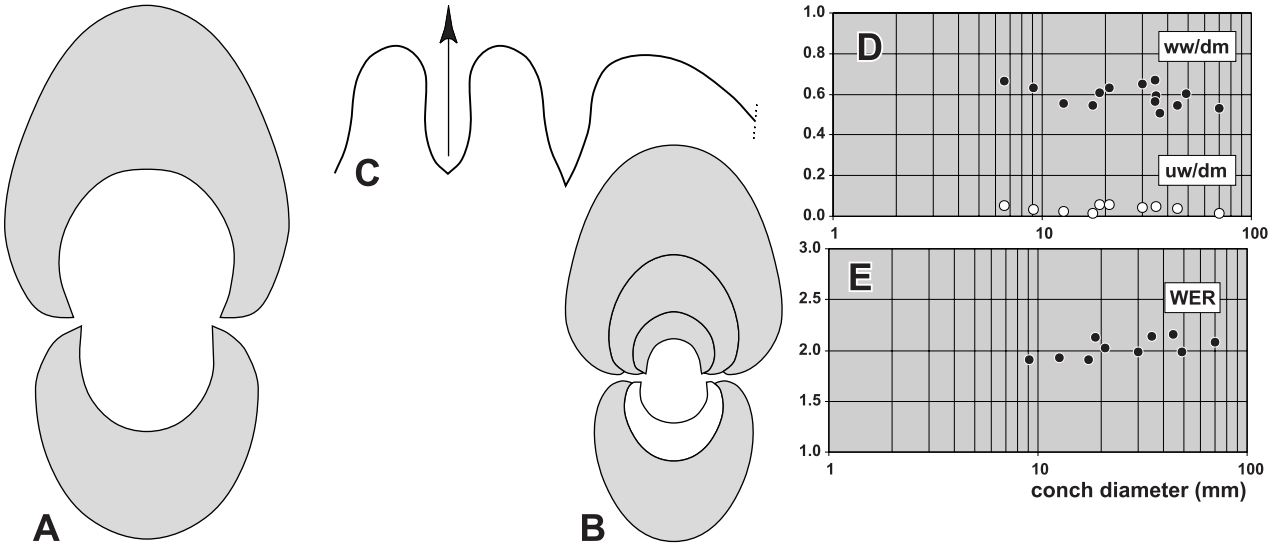


Fig. 20. *Acutimitoceras* sp. A from bed 12 of the Aguelmous. **A** – Cross section, specimen MB.C.10223.3; ×1. **B** – Cross section, specimen MB.C.10223.4; ×3. **C** – Suture line, specimen MB.C.10223.5, at 18.9 mm wh; ×2. **D** – Ontogenetic development of the whorl width index (ww/dm) and umbilical width index (uw/dm). **E** – Ontogenetic development of the whorl expansion rate (WER).

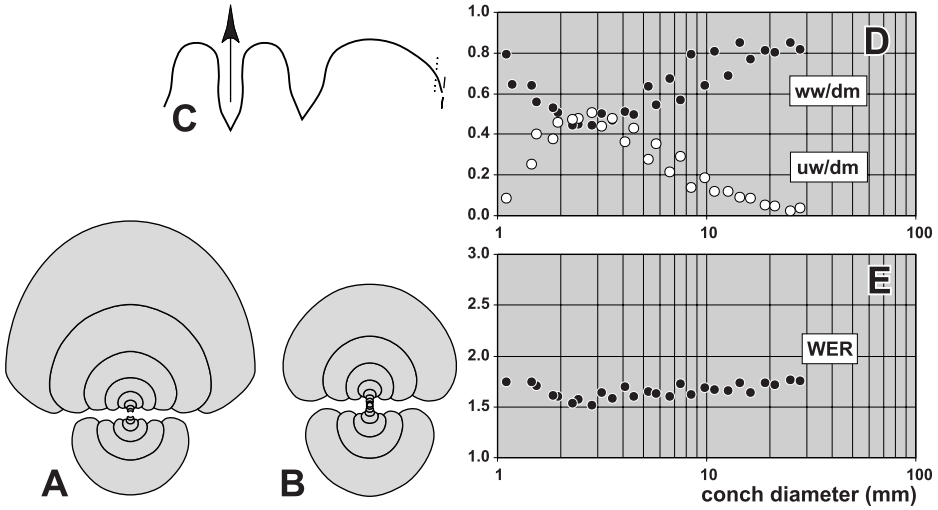


Fig. 21. *Acutimitoceras* sp. B from bed 2 of the Aguelmous. **A** – Cross section, specimen MB.C.10209.1; ×1. **B** – Cross section, specimen MB.C.10209.2; ×1. **C** – Suture line, specimen MB.C.10209.1, at 33.0 mm ww, 19.5 mm wh; ×1. **D** – Ontogenetic development of the whorl width index (ww/dm) and umbilical width index (uw/dm). **E** – Ontogenetic development of the whorl expansion rate (WER).

ences, it is not clear if they belong to the same species (Fig. 21A, B). Both have very evolute inner whorls with a maximum uw/dm ratio of 0.40–0.50 at 2–4 mm conch diameter. The umbilicus is closed at 20 mm dm. The ww/dm ratio is lowest when the umbilicus is widest, followed by an increase of the ww ratio. The conchs are thickly pachyconic (ww/dm = 0.80) at 20 mm dm.

The suture line of specimen MB.C.10209.1 possesses a deep and narrow lanceolate external lobe, which is slightly pouched. A broadly rounded ventrolateral saddle and a V-shaped adventive lobe is present on the flank (Fig. 21C).

Acutimitoceras posterum Bockwinkel & Ebbighausen, 2006

Fig. 22

* 2006 *Acutimitoceras posterum* Bockwinkel & Ebbighausen: 100, figs 16E–H, 17A–F.

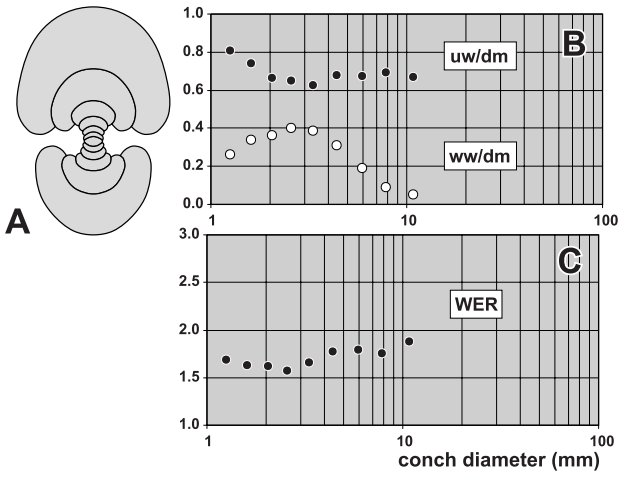


Fig. 22. *Acutimitoceras posterum* Bockwinkel & Ebbighausen, 2006 from bed 16 of the Aguelmous. **A** – Cross section, specimen MB.C.10229; ×3. **B** – Ontogenetic development of the whorl width index (ww/dm) and umbilical width index (uw/dm). **C** – Ontogenetic development of the whorl expansion rate (WER).

Material. Tizi Ibaouâne (bed 16): 1 specimen.

Remarks. The single specimen MB.C.10229 (Fig. 22) confirms the description of the original material from Mfis.

Acutimitoceras pentaconstrictum n. sp.

Figs 18F, 23

Derivation of name. Named after the five steinkern constrictions.

Holotype. Specimen MB.C.10218; illustrated here in Fig. 18F. Type locality and horizon. Tizi Ibaouâne, Aguelmous (Ma'der, Anti-Atlas, Morocco); bed 2 (Early Tournaisian).

Material. Holotype.

Diagnosis. Species of *Acutimitoceras* with thickly discoidal conch (ww/dm = 0.50–0.55 at 12 mm dm), umbilicus closed. Aperture moderate, whorl expansion rate 1.75. Steinkern with strong biconvex constrictions. Suture line with V-shaped external lobe and tongue-shaped, rounded adventive lobe.

Description. The holotype has a diameter of almost 12 mm, and the last whorl largely represents the body chamber (Fig. 18F). It is discoidal (ww/dm = 0.52) with a punctiform umbilicus. Flanks and venter are continuously rounded, and the umbilical wall is oblique. The steinkern has strong constrictions, which are almost exactly arranged in distances of 60°. Their course is biconvex with a very low dorsolateral and a more pronounced ventrolateral projection. The ventral sinus is shallow and slightly chevron-shaped. The suture lines shows juvenile aspects, e.g. the external lobe is V-shaped and the adventive lobe is rounded (Fig. 23).

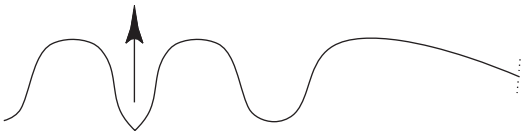


Fig. 23. *Acutimitoceras pentaconstrictum* n. sp. from bed 2 of the Aguelmous. Suture line (reversed), holotype MB.C.10218, at 4.1 mm ww, 3.7 mm wh; ×10.

Discussion. *A. pentaconstrictum* has a somewhat isolated position within the genus. Strong steinkern constrictions are present in some other species, such as *A. prorsum* (Schmidt, 1925) and *A. stockumense* Korn, 1984, but these species possess an open umbilicus at the stage when the new species is already completely involute. The most similar species is obviously "*Mimimitoceras crestaverde* Korn, 1992" from the *Gattendorfia* Stufe of the Carnic Alps (Korn 1992b), of which only one small specimen is known.

Costimitoceras Vöhringer, 1960

Type species. *Costimitoceras ornatum* Vöhringer, 1960

Composition of the genus.
Costimitoceras ornatum Vöhringer, 1960; *Gattendorfia* Stufe, Rhenish Mountains.
Costimitoceras epichare (Ruan, 1981); *Gattendorfia* Fauna, Guizhou.
Costimitoceras aitouamar n. sp.; *Gattendorfia-Eocanites* assemblage; Anti-Atlas.

Genus definition. Acutimitoceratinae with biconvex growth lines, which form a pronounced ventrolateral salient. Spiral lines and/or ventrolateral grooves may be present.

Discussion. Only two species are thus far included in the genus *Costimitoceras*, and these may even be synonyms. With the new form described below, another species that most likely belongs to the genus is introduced. Unfortunately, there is no shell preserved in this new material and thus the generic assignment is not completely certain. The strikingly biconvex growth lines, the periodically strengthened growth lines, and the weak spirals impressed on the steinkern in the new species however, make such an assignment most likely.

Costimitoceras aitouamar n. sp.
Figs 18G–J, 24

Derivation of name. After the village and family of Ait Ouamar, owing to their hospitality.

Holotype. Specimen MB.C.10159.1; illustrated here in Fig. 18G.

Type locality and horizon. Bou Tlidat, Aguelmous (Ma'der, Anti-Atlas, Morocco); bed 2 (Early Tournaisian).

Material. Bou Tlidat (bed 2): 34 specimens, Bou Tlidat (bed 12): 1 specimen, Tazoult (bed 2): 15 specimens, Tazoult (loose): 11 specimens.

Diagnosis. Species of *Costimitoceras* with thickly discoidal conch (ww/dm = 0.55 at 10 mm dm). Inner whorls up to 2 mm diameter with moderate umbilicus (uw/dm = 0.20). Aperture low in the juvenile stage and becoming higher during ontogeny; whorl expansion rate higher than 2.00 at 10 mm diameter. Steinkern without constrictions, shallow ventrolateral groove. Suture line with narrow, lanceolate external lobe and V-shaped, subacute adventive lobe.

Description. The bivariate plots show that within the sectioned specimens, there is rather little variability in conch width and umbilical width ratios, but the whorl expansion rate has a wider range (Fig. 24H, I). The cross section of specimen MB.C.10197.1 shows a short, widely umbilicate juvenile stage, and already the third whorl embraces the preceding to a large degree (Fig. 24A). The umbilicus is closed by the fourth whorl at about 2 mm conch diameter. The conch becomes continuously thinner during ontogeny, and the umbilicus remains closed.

Holotype MB.C.10159.1 is, at a diameter of 11.5 mm, the largest of the specimens (Fig. 18G). Its last whorl belongs almost completely to the body chamber that shows some impressions of the shell surface. The conch is slightly distorted, being lenticular with an almost closed umbilicus. A shallow ventrolateral groove is fairly well visible; it

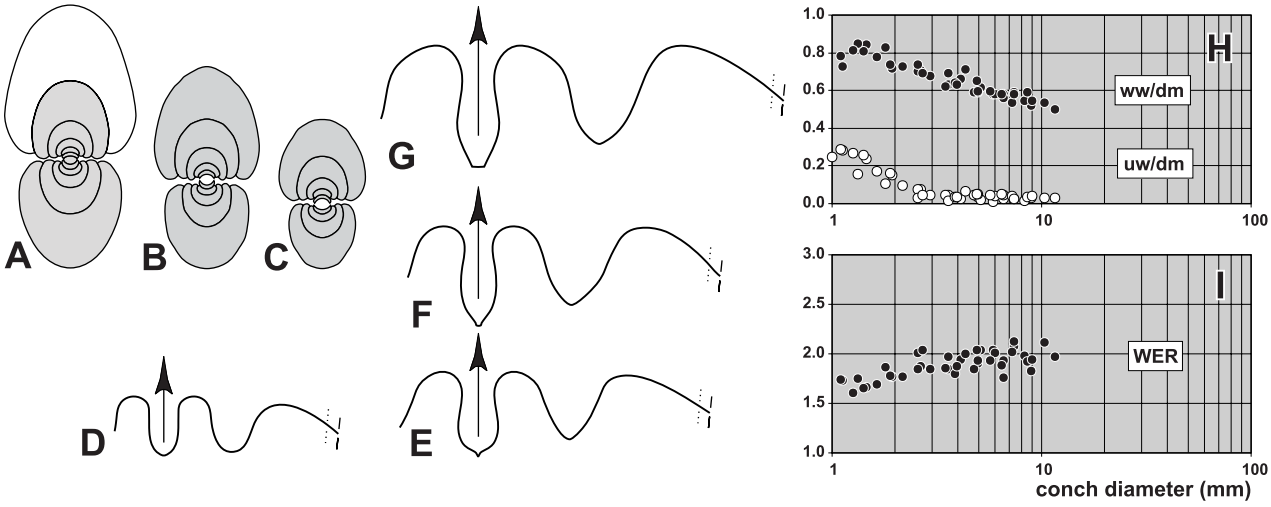


Fig. 24. *Costimitoceras aitouamar* n. sp. from Bed 2 of the Aguelmous. **A** – Cross section, paratype MB.C.10197.1; ×3. **B** – Cross section, paratype MB.C.10159.3; ×3. **C** – Cross section, paratype MB.C.10197.2; ×3. **D** – Suture line, paratype MB.C.10159.4, at 2.5 mm dm, 1.7 mm ww, 1.4 mm wh; ×14. **E** – Suture line (reversed), paratype MB.C.10159.5, at 4.7 mm dm, 3.0 mm ww, 2.5 mm wh; ×10. **F** – Suture line, paratype MB.C.10159.6, at 7.3 mm dm, 3.9 mm ww, 4.1 mm wh; ×7. **G** – Suture line, paratype MB.C.10159.7, at 9.2 mm dm, 5.0 mm ww, 5.3 mm wh; ×7. **H** – Ontogenetic development of the whorl width index (ww/dm) and umbilical width index (uw/dm). **I** – Ontogenetic development of the whorl expansion rate (WER).

separates the flanks from the narrow venter. The body chamber shows impressions of periodically strengthened growth lines, which extend with biconvex course on flanks and venter, forming a prominent ventrolateral projection and a rather deep ventral sinus. At the terminal end, impressions of a spiral ornament are visible in the ventrolateral region.

Smaller specimens such as paratype MB.C.10210.1 show a very similar conch morphology and a similar ornament impression, but without traces of spiral lines (Fig. 18I). The umbilicus is punctiform in these specimens.

The ontogeny of the suture line shows a narrowing of the external lobe, which is U-shaped in the early juvenile stage and deep and lanceolate in later growth stages (Fig. 24D–G). The ventrolateral saddle is strikingly asymmetric and highest on the ventral side, and the adventive lobe is subacute and V-shaped.

Discussion. The new species has a conch geometry that closely resembles *C. ornatum* Vöhringer, 1960, but with a narrower umbilicate juvenile stage. Shell ornament is not preserved in the new species, and hence it is not clear if the species has a dense spiral ornament such as the type species of the genus. However, both species are very similar In the strength of the biconvex growth lines.

Hasselbachia Korn & Weyer, 2003

Type species. *Imitoceras multisulcatum* Vöhringer, 1960.

Hasselbachia gourara Ebbighausen, Bockwinkel, Korn & Weyer, 2004

Figs 25A, B, 26

* 2004 *Hasselbachia gourara* Ebbighausen, Bockwinkel, Korn & Weyer: 140, fig. 8A–F

Material. Rich El Mbidia (bed 16): 1 specimen, Tizi Ibaouâne (bed 16): 3 specimens.

Diagnosis. Species of *Hasselbachia* with discoidal conch (ww/dm = 0.50–0.55 at 10 mm dm). Inner whorls up to 5 mm diameter widely umbilicate (uw/dm 0.40), umbilicus narrower in later stages (uw/dm = 0.30 at 18 mm dm). Aperture very low, whorl expansion rate 1.50. Steinkern without or with weak constrictions that become more pronounced in the adult stage. Suture line with wide, parallel-sided external lobe and parallel-sided adventive lobe.

Description. The new material is much better preserved than the Algerian type material and allows an upgrade of the Diagnosis. Specimen MB.C.10234.1 with 18 mm conch diameter is the largest of the specimens (Fig. 25A); it has a body chamber with some strongly weathered shell. The conch is lenticular (ww/dm = 0.47) with an open umbilicus (uw/dm = 0.30). Flanks and venter are rounded, and the umbilical edge is subangular. The last volution has three irregularly spaced steinkern constrictions, which turn backward from the umbilicus and then extend almost linearly across flanks and venter. Traces of radial ornament are visible on the steinkern, possibly caused by rhythmically strengthened growth lines. These lines turn more strongly backward than the constrictions and form a deep ventral sinus.

Smaller specimens such as MB.C.10233.8 (11 mm dm) and MB.C.10234.2 (9 mm dm) show a similar

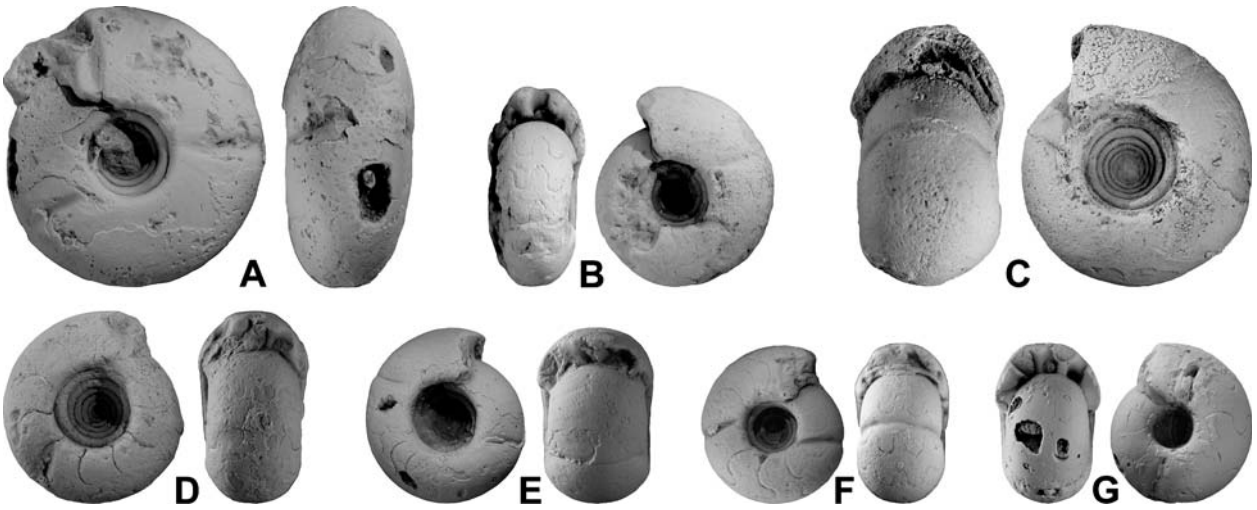


Fig. 25. *Hasselbachia* from Tizi Ibaouâne, bed 16. **A** – *Hasselbachia gourara* Ebbighausen et al., 2004, specimen MB.C.10234.1, lateral and ventral views, ×2. **B** – *Hasselbachia gourara* Ebbighausen et al., 2004, specimen MB.C.10234.2, dorsal and lateral views, ×3. **C** – *Hasselbachia arca* n. sp., paratype MB.C.10233.2, dorsal and lateral views, ×2.5. **D** – *Hasselbachia arca* n. sp., paratype MB.C.10233.4, lateral and dorsal views, ×2.5. **E** – *Hasselbachia arca* n. sp., holotype MB.C.10233.1, ×2.5. **F** – *Hasselbachia arca* n. sp., paratype MB.C.10233.3, lateral and dorsal views, ×2.5. **G** – *Hasselbachia* sp., specimen MB.C.10235.1, dorsal and lateral views, ×2.5.

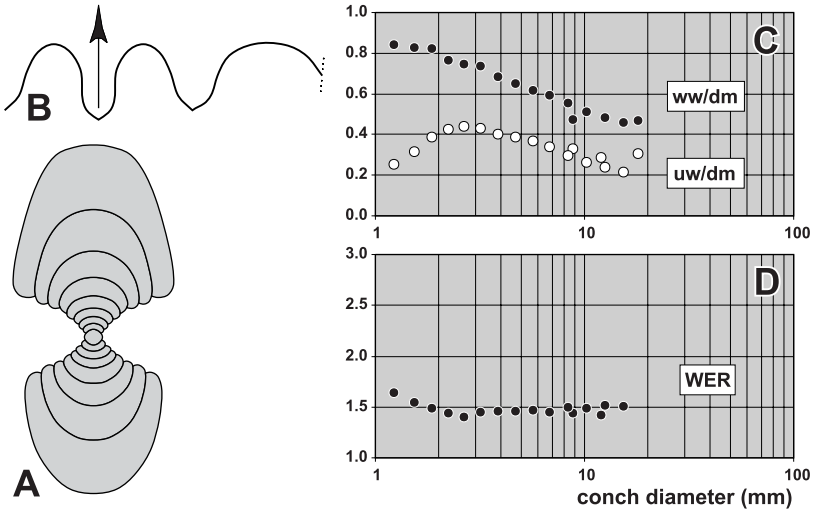


Fig. 26. *Hasselbachia gourara* Ebbighausen et al., 2004 from bed 16 of the Aguelmous. **A** – Cross section, specimen MB.C.10179; ×3. **B** – Suture line (reversed), specimen MB.C.10234.2, at 8.6 mm dm, 4.1 mm ww, 3.2 mm wh; ×5. **C** – Ontogenetic development of the whorl width index (ww/dm) and umbilical width index (uw/dm). **D** – Ontogenetic development of the whorl expansion rate (WER).

conch geometry, but possess much weaker steinkern constrictions. The suture line is similar to the type specimens; it has an adventive lobe that resembles the external lobe, but is slightly less deep.

Hasselbachia arca n. sp.

Figs 25C–F, 27

Derivation of name. After the arc-shaped whorl cross section.

Holotype. Specimen MB.C.10233.1; illustrated here in Fig. 25E.

Type locality and horizon. Tizi Ibaouâne, Aguelmous (Ma'der, Anti-Atlas, Morocco); bed 16 (Early Tournaisian).

Material. Tizi Ibaouâne (bed 16): 25 specimens.

Diagnosis. Species of *Hasselbachia* with thinly pachyconic conch (ww/dm = 0.60–0.65 at 10 mm dm). Inner whorls up to 5 mm diameter widely umbilicate (uw/dm 0.40), umbilicus narrower in later stages. Aperture very low, whorl expansion rate 1.50. Steinkern with weak constrictions. Suture line with wide, parallel-sided external lobe and parallel-sided adventive lobe.

Description. The three cross sections MB.C.10233.5 – MB.C.10233.7 show very similar growth trajectories without remarkable variability in all growth stages (Fig. 27A–C). The conch becomes almost continuously slender during ontogeny, with a ww/dm ratio of 0.80 at 1–3 mm dm to 0.60 at 10–12 mm dm. Distinct growth stages can not be separated. In contrast, the umbilicus shows a more complex development, with an opening from 0.20 in the initial stage to 0.40 at 3 mm dm, and thereafter a slight decrease to 0.35–0.40 at 10 mm dm. The conch has a crescent-shaped whorl cross section throughout ontogeny, and a very low aperture (WER 1.45–1.50).

Specimen MB.C.10233.1 was chosen for holotype. It is a specimen with a 9 mm conch diameter and is a fully septate steinkern with some attached but strongly corroded shell remaining (Fig. 25E). It is thinly pachyconic (ww/dm = 0.65) with an umbilicus that has almost 0.40 of the conch diameter. Umbilical wall and umbilical margin are rounded. The specimen has two constrictions standing vis-à-vis; they turn slightly back from the umbilicus and form a wide and shallow ventral sinus. The constrictions are faint on the shell surface but much more pronounced on the steinkern.

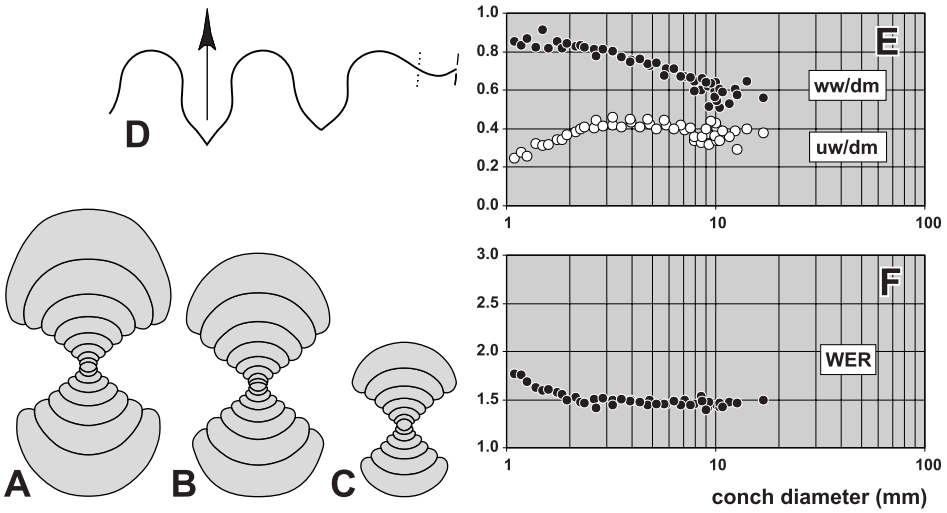


Fig. 27. *Hasselbachia arca* n. sp. from bed 16 of the Aguelmous. **A** – Cross section, paratype MB.C.10233.5; ×3. **B** – Cross section, paratype MB.C.10233.6; ×3. **C** – Cross section, paratype MB.C.10233.7; ×3. **D** – Suture line, paratype MB.C.10233.4, at 9.6 mm dm, 5.8 mm ww, 3.0 mm wh; ×6. **E** – Ontogenetic development of the whorl width index (ww/dm) and umbilical width index (uw/dm). **F** – Ontogenetic development of the whorl expansion rate (WER).

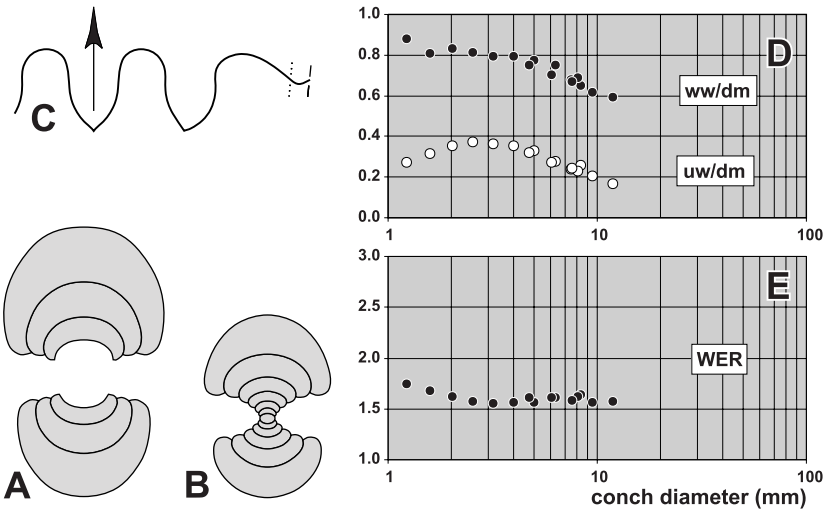


Fig. 28. *Hasselbachia* sp. from bed 16 of the Aguelmous. **A** – Cross section, specimen MB.C.10235.2; ×3. **B** – Cross section, specimen MB.C.10235.3; ×3. **C** – Suture line, specimen MB.C.10180, at 6.7 mm dm, 4.6 mm ww, 2.9 mm wh; ×7. **D** – Ontogenetic development of the whorl width index (ww/dm) and umbilical width index (uw/dm). **E** – Ontogenetic development of the whorl expansion rate (WER).

All other specimens possess irregularly spaced, weak steinkern constrictions, which turn back on the flanks and extend with a very wide and shallow sinus across the venter. The course of the suture line is almost identical with that of *H. gourara*; there is a rather wide external lobe with parallel flanks in the upper half, a symmetric and broadly rounded ventrolateral saddle, and an adventive lobe that has almost the same shape as the external lobe (Fig. 27D).

Discussion. The new species closely resembles *H. gourara* but differs in the pachyconic conch that is 0.10 wider than in the latter species. Small individuals of *H. arca* always possess constrictions that appear not to be restricted to the steinkern. The two Rhenish species *H. multisulcatum* (Vöhringer, 1960) and *H. gracile* (Vöhringer, 1960) differ in the presence of deep and short constrictions on the flanks.

Hasselbachia sp.

Figs 25G, 28

Material. Tizi Ibaouâne (bed 16): 3 specimens.

Remarks. The material is too incomplete for a distinct attribution to species. It has a somewhat intermediate position between *H. gourara* and *H. arca*, possessing a wider conch than the first and a narrower umbilicus than the second (Fig. 28D, E).

Kornia n. gen.

Type species. *Kornia citrus* n. sp.

Composition of the genus.
Kornia citrus n. sp.; *Gattendorfia-Eocanites* assemblage; Anti-Atlas.
Imitoceras sphaeroidale Vöhringer, 1960; *Gattendorfia* Stufe, Rhenish Mountains.
"*Paragattendorfia* n. sp. 1" Korn & Weyer, 2003; *Gattendorfia* Stufe, Rhenish Mountains.

Genus definition. Genus of the subfamily Acutimitoceratinae with pachyconic to globular conch. Innermost whorls evolute, umbilicus rapidly closing during ontogeny. Aperture always low, WER usually between 1.50 and 1.60.

Discussion. Korn & Weyer (2003) included "*Imitoceras sphaeroidale* Vöhringer, 1960" in their new genus *Hasselbachia*, because of its low aperture as is seen in the two more characteristic species *H. multisulcata* (Vöhringer, 1960) and *H. gracilis* (Vöhringer, 1960). A characteristic of *Hasselbachia* is the constantly low aperture and the strong overlap of adult whorls, a feature that is not as well developed in "*Imitoceras sphaeroidale* Vöhringer, 1960". This species, which has the general conch shape of *Acutimitoceras*, but with a markedly lower aperture, possesses growth trajectories rather similar to the new species, and is therefore included here.

Kornia citrus n. sp.

Figs 29, 30

Derivation of name. After the genus Citrus, because of the lemon-shaped conch in the juvenile stage.

Holotype. Specimen MB.C.10165.1; illustrated here in Fig. 29B.

Type locality and horizon. Bou Tlidat, Aguelmous (Ma'der, Anti-Atlas, Morocco); bed 2 (Early Tournaisian).

Material. Bou Tlidat (bed 2): 4 specimens, Tazoult (bed 2): 3 specimens.

Diagnosis. Species of *Kornia* with conch spindle-shaped in the juvenile stage and globular in the adult stage. Umbilicus almost closed in stages larger than 7 mm conch diameter; conspicuous umbilical pad. Suture line with lanceolate external lobe and asymmetric adventive lobe. Steinkern without constrictions.

Description. The two sectioned specimens MB.C.10165.2 and MB.C.10202.1 (Fig. 30A, B) offer an insight into the conspicuous conch ontogeny up to 8 mm diameter. Growth starts with a short serpenticonic stage that ends at about 2 mm conch

Fig. 29. *Kornia citrus* n. sp. from Bou Tlidat, bed 2. **A** – Paratype MB.C.10165.4, lateral and dorsal views, ×3. **B** – Holotype MB.C.10165.1, lateral and dorsal views, ×5.

diameter, followed by a rapid increase of the whorl width (ww/dm = 1.20–1.30 at 5 mm dm), followed by a decrease in whorl width (Fig. 30E). Three whorls, from 3 to at least 8 mm conch diameter, are C-shaped with a pronounced umbilical rim, which separates the semicircular umbilical wall from the wide venter. The aperture is very low in all stages and results in a rather stable whorl expansion rate of approximately 1.50 (Fig. 30F).

Paratype MB.C.10165.4 has a 16 mm diameter and is the largest specimen of the species (Fig. 29A). It is globular (ww/dm = 0.90) with a nearly closed umbilicus, which exhibits the characteristic umbilical rim to a lesser degree than the sectioned smaller paratypes. The specimen is fully septate and encrusted by limonite; therefore, no details of the steinkern surface are visible. The suture line has a deep, lanceolate external lobe, a symmetric and rounded ventrolateral saddle, and a rather narrow, asymmetric adventive lobe with steep ventral and curved dorsal flank.

Holotype MB.C.10165.1 (Fig. 29B) is a spindle-shaped steinkern of 6.5 mm dm and has a very low aperture. The umbilical rim is very well visible and forms a thick round pad. The steinkern is smooth. Suture lines were drawn from paratypes MB.C.10165.3 and MB.C.10202.2 (Fig. 30C, D), both at approximately 6.5 mm conch diameter. They differ somewhat in the width of the lobes but possess like the holotype, a lanceolate external lobe, a continuously rounded, symmetric ventrolateral saddle, and an asymmetric adventive lobe.

Discussion. The new species can easily be separated from any other ammonoid from the *Gattendorfia* faunas by its umbilical pad. Similar growth trajectories can be seen only in "*Imitoceras sphaeroidale* Vöhringer, 1960" which however, has a wider umbilicate juvenile stage. An ammonoid similar to *Kornia citrus* was figured by Korn & Weyer (2003, pl. 2: fig. 20, 21) as "*Paragattendorfia* n. sp. 1". This specimen from Oese in the Rhenish Mountains has a globe shape with a very low aperture and a very narrow umbilicus. It has growth lines which turn strongly back from the slightly elevated umbilical margin. In conch shape and form of the umbilicus, the taxon in open nomenclature resembles the new species and may belong to the genus *Kornia*.

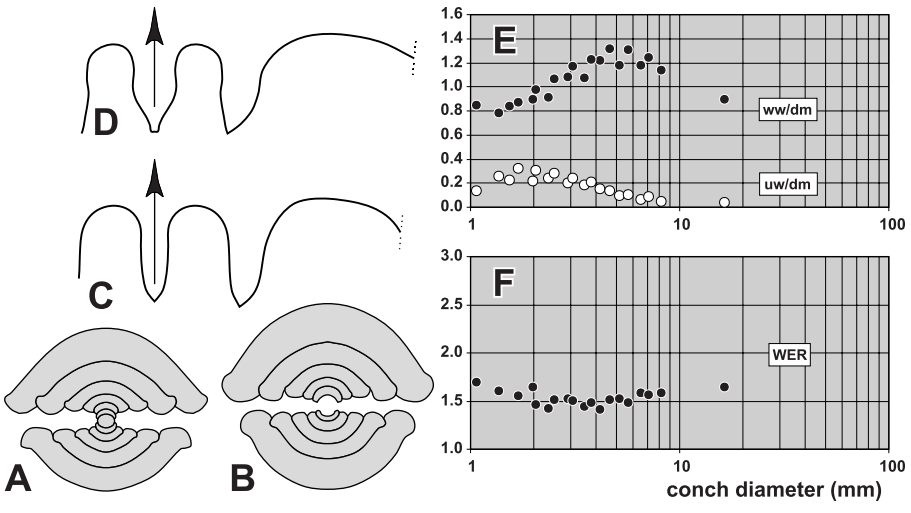


Fig. 30. *Kornia citrus* n. sp. from bed 2 of the Aguelmous. **A** – Cross section, paratype MB.C.10165.2; ×3. **B** – Cross section, paratype MB.C.10202.1; ×3. **C** – Suture line, paratype MB.C.10165.3, at 6.3 mm dm, ca. 3.4 mm wh; ×7. **D** – Suture line, paratype MB.C.10202.2, at 7.1 mm ww, 3.0 mm wh; ×7. **E** – Ontogenetic development of the whorl width index (ww/dm) and umbilical width index (uw/dm). **F** – Ontogenetic development of the whorl expansion rate (WER).

Subfamily **Imitoceratinae** Ruzhencev, 1950

Imitoceras Schindewolf, 1923

Type species. *Goniatites Ixion* Hall, 1860.

Imitoceras oxydentale Bockwinkel & Ebbighausen, 2006

Figs 31A–D, 32

* 2006 *Imitoceras oxydentale* Bockwinkel & Ebbighausen: 108, figs 24C, D, G, H, 25.

Material. Bou Tlidat (bed 2): 17 specimens, Bou Tlidat (bed 12): 1 specimen, Tazoult (bed 2): 2 specimens, Tazoult (loose): 6 specimens, Tizi Ibaouâne (bed 2): 13 specimens, Tizi Malilane (bed 2): 2 specimens.

Remarks. Little can be added to the original description of the species. The new material differs from the material from the type locality in the slightly less evolute inner whorls, but this difference is regarded as intraspecific variability. The suture line of specimen MB.C.10242 has a rather strongly pouched external lobe with sinuous flanks (Fig. 32D), and differs in this respect from a paratype of about the same size from Mfis.

Imitoceras sp.

Figs 31E, 33

Material. Rich El Mbidia (bed 18): 21 specimens.

Description. The cross section of specimen MB.C.10187.2 displays six whorls, which permit the study of ontogeny up to 38 mm conch diameter (Fig. 33A). During this interval, there is an almost continuous decrease in the ww/dm ratio from 0.95 to 0.40. The umbilicus opens in the juvenile stage to one fifth of the conch diameter at 2–3 mm dm, but then closes rather rapidly and remains punctiform. Flanks and venter are rounded at 38 mm dm, and the conch there is widest in the midflank area. The aperture becomes higher during ontogeny; the whorl expansion rate is rather low up to 4 mm dm (WER = 1.80), then increases to a value of 2.20 at 10 mm dm, and then remains at this level. The suture line of the specimen has a small, pouched external lobe, a 1.5 times deeper, asymmetric adventive lobe, and a broadly rounded ventrolateral saddle in between them.

Discussion. The material is too poor to be described as a distinct species. It is clear from conch shape and suture line, however, that it belongs to *Imitoceras*.

Family **Gattendorfiidae** Bartzsch & Weyer, 1987
Subfamily **Gattendorfiinae** Bartzsch & Weyer, 1987

Gattendorfia Schindewolf, 1920

Type species. *Goniatites subinvolutus* Münster, 1832.

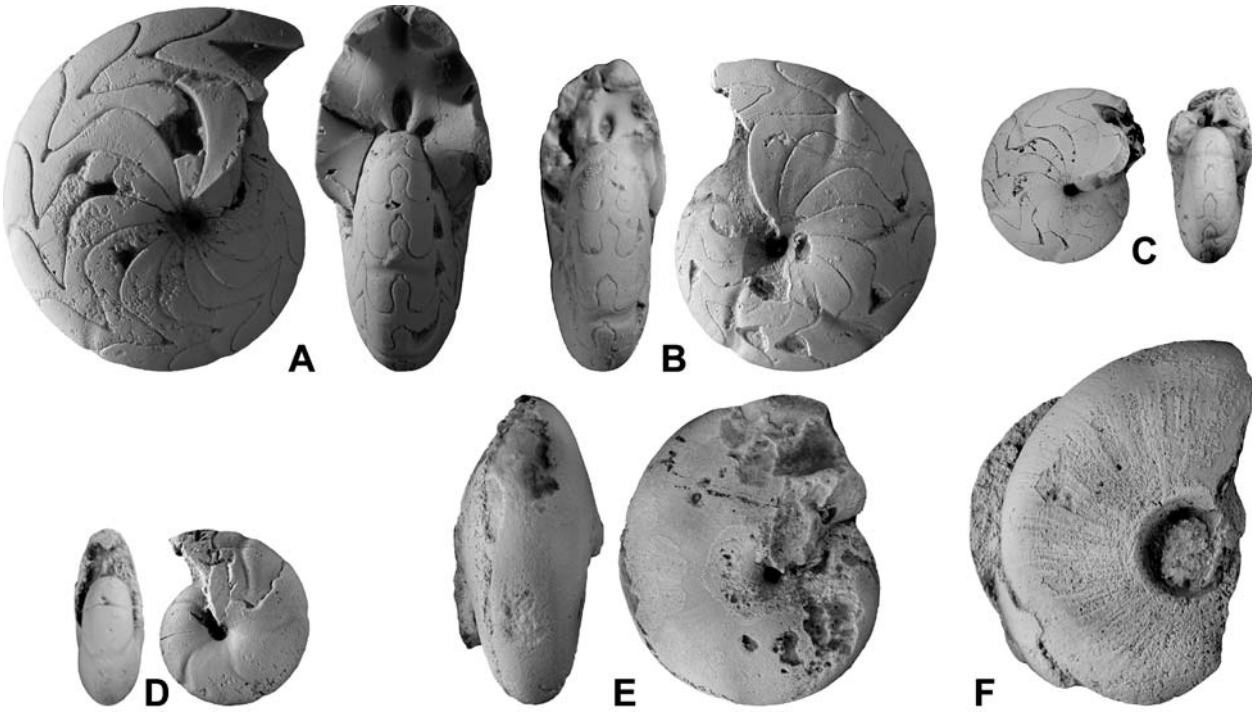


Fig. 31. *Imitoceras* and *Gattendorfia* from Fezzou. **A** – *Imitoceras oxydentale* Bockwinkel & Ebbighausen, 2006, specimen MB.C.10162.1 from Bou Tlidat, bed 2, lateral and dorsal views, ×4. **B** – *Imitoceras oxydentale* Bockwinkel & Ebbighausen, 2006, specimen MB.C.10162.2 from Bou Tlidat, bed 2, dorsal and lateral views, ×3. **C** – *Imitoceras oxydentale* Bockwinkel & Ebbighausen, 2006, specimen MB.C.10162.3 from Bou Tlidat, bed 2, lateral and dorsal views, ×3. **D** – *Imitoceras oxydentale* Bockwinkel & Ebbighausen, 2006, specimen MB.C.10162.1 from Bou Tlidat, bed 2, dorsal and lateral views, ×4. **E** – *Imitoceras* sp., specimen MB.C.10187.1 from Rich el Mbidia, bed 18, ventral and lateral views, ×1.25. **F** – *Gattendorfia* sp., specimen MB.C.10189 from Rich el Mbidia, bed 18, lateral view, ×1.

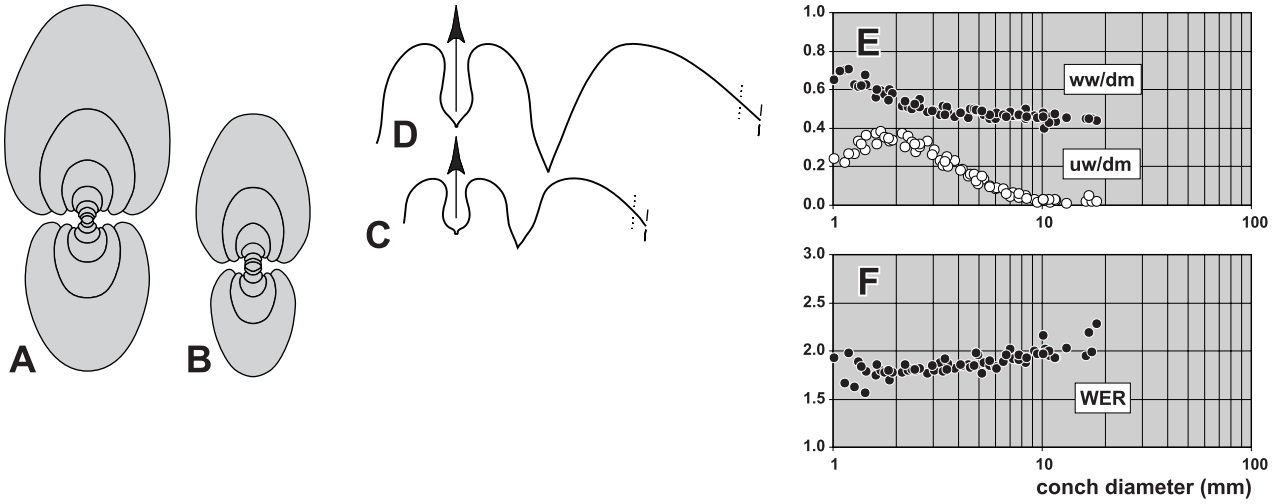


Fig. 32. *Imitoceras oxydentale* Bockwinkel & Ebbighausen, 2006 from bed 2 of the Aguelmous. **A** – Cross section, specimen MB.C.10200.1; ×3. **B** – Cross section, specimen MB.C.10162.4; ×3. **C** – Suture line, specimen MB.C.10220, at 9.9 mm dm, 4.7 mm ww, 5.5 mm wh; ×4. **D** – Suture line, specimen MB.C.10242, at 16.4 mm dm, 8.3 mm ww, 9.5 mm wh; ×4. **E** – Ontogenetic development of the whorl width index (ww/dm) and umbilical width index (uw/dm). **F** – Ontogenetic development of the whorl expansion rate (WER).

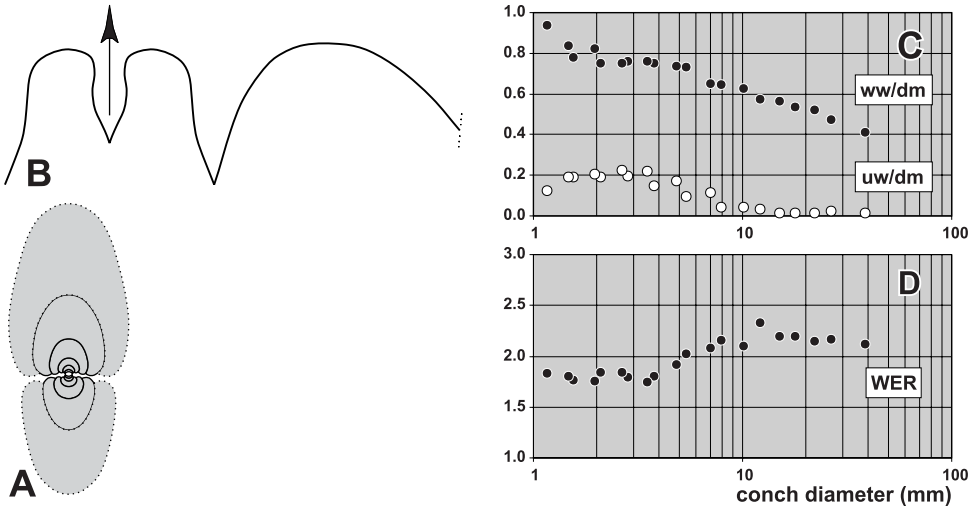
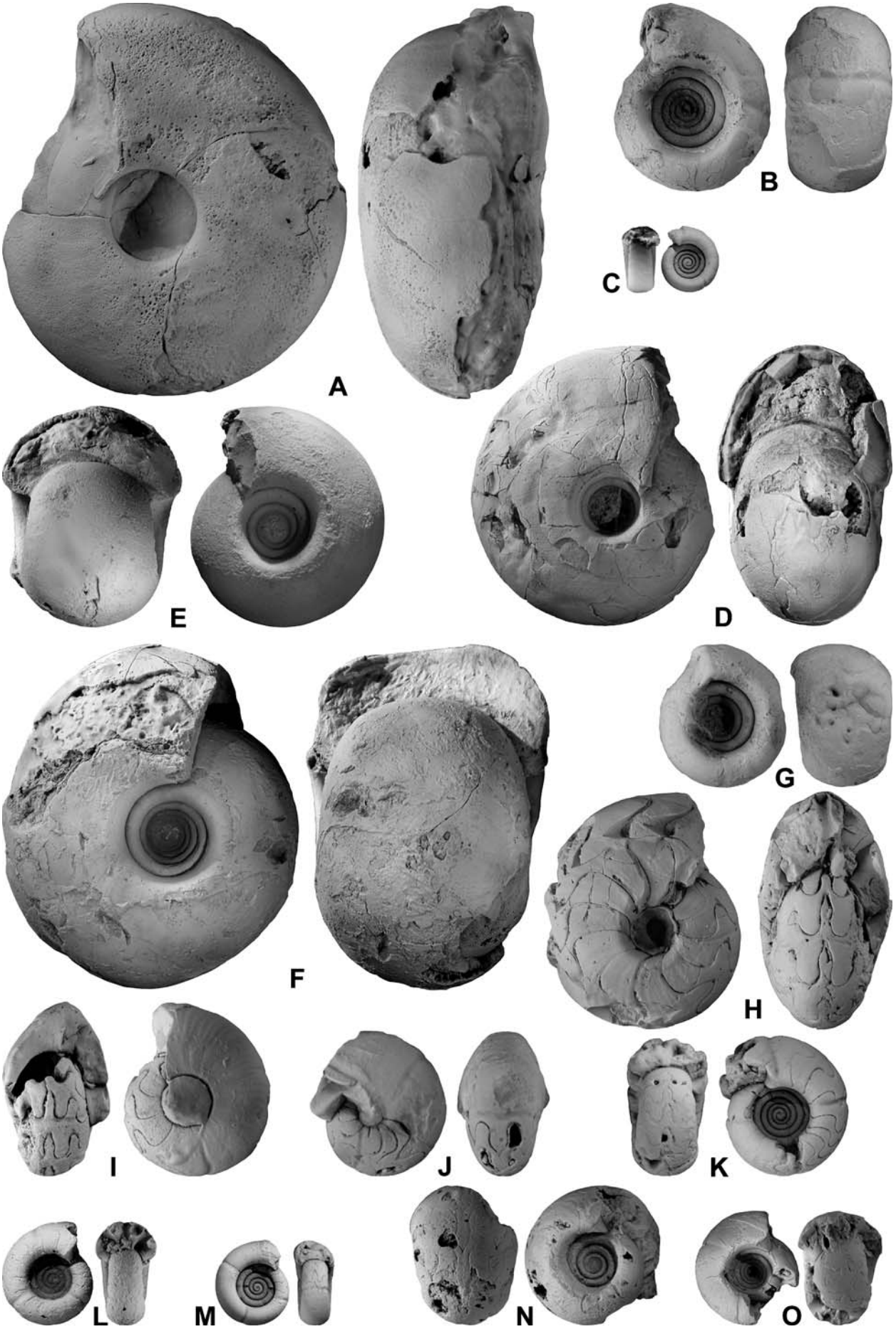


Fig. 33. *Imitoceras* sp. from bed 18 of the Aguelmous. **A** – Cross section, specimen MB.C.10187.2; ×1. **B** – Suture line (reversed), specimen MB.C.10187.3, at 29.1 dm, 13.3 mm ww, 17.3 mm wh; ×3. **C** – Ontogenetic development of the whorl width index (ww/dm) and umbilical width index (uw/dm). **D** – Ontogenetic development of the whorl expansion rate (WER).

►

Fig. 34. *Gattendorfia* from Fezzou. **A** – *Gattendorfia jacquelinae* Ebbighausen et al. 2004, specimen MB.C.10232.1 from Tizi Ibaouâne, bed 16, lateral and ventral views, ×1. **B** – *Gattendorfia jacquelinae* Ebbighausen et al. 2004, specimen MB.C.10232.2 from Tizi Ibaouâne, bed 16, lateral and ventral views, ×3. **C** – *Gattendorfia jacquelinae* Ebbighausen et al. 2004, specimen MB.C.10224.1 from Tizi Ibaouâne, bed 12, dorsal and lateral views, ×3. **D** – *Gattendorfia jacquelinae* Ebbighausen et al. 2004, specimen MB.C.10232.3 from Tizi Ibaouâne, bed 12, lateral and dorsal views, ×1. **E** – *Gattendorfia debouaaensis* (Bockwinkel & Ebbighausen, 2006), specimen MB.C.10175.4 from Rich el Mbidia, bed 16, dorsal and lateral views, ×1. **F** – *Gattendorfia debouaaensis* (Bockwinkel & Ebbighausen, 2006), specimen MB.C.10230.1 from Tizi Ibaouâne, bed 16, lateral and dorsal views, ×1. **G** – *Gattendorfia debouaaensis* (Bockwinkel & Ebbighausen, 2006), specimen MB.C.10230.2 from Tizi Ibaouâne, bed 16, lateral and ventral views, ×2.5. **H** – *Gattendorfia lhceni* n. sp., holotype MB.C.10225.1 from Tizi Ibaouâne, bed 12, lateral and dorsal views, ×1. **I** – *Gattendorfia lhceni* n. sp., paratype MB.C.10225.2 from Tizi Ibaouâne, bed 12, dorsal and lateral views, ×1.25. **J** – *Gattendorfia lhceni* n. sp., paratype MB.C.10225.3 Tizi Ibaouâne, bed 12, lateral and ventral views, ×1.5. **K** – *Gattendorfia lhceni* n. sp., specimen MB.C.10225.4 Tizi Ibaouâne, bed 12, dorsal and lateral views, ×2.5. **L** – *Gattendorfia lhceni* n. sp., specimen MB.C.10168.1 Bou Tlidat, bed 12, lateral and dorsal views, ×2.5. **M** – *Gattendorfia lhceni* n. sp., specimen MB.C.10168.2 from Bou Tlidat, bed 12, lateral and dorsal views, ×2.5. **N** – *Gattendorfia gisae* n. sp., paratype MB.C.10211 from Tazoult, bed unknown, ventral and lateral views, ×1.25. **O** – *Gattendorfia debouaaensis* (Bockwinkel & Ebbighausen, 2006), specimen MB.C.10175.3 from Rich el Mbidia, bed 16, dorsal and lateral views, ×1.25.



Gattendorfia jacquelinae Ebbighausen, Bockwinkel, Korn & Weyer, 2004

Figs 34A–D, 35

* 2004 *Gattendorfia jacquelinae* Ebbighausen, Bockwinkel, Korn & Weyer: 142, figs 11–13.
2006 *Gattendorfia jacquelinae.* – Bockwinkel & Ebbighausen: 111, figs 27A–F, 28.

Material. Bou Tlidat (bed 2): 4 specimens, Bou Tlidat (bed 12): 2 specimens, Tazoult (bed 2): 1 specimen, Rich El Mbidia (bed 16): 2 specimens, Tizi Ibaouâne (bed 12): 2 specimens, Tizi Ibaouâne (bed 16): 7 specimens.

Description. The new material is composed of small and large specimens, and hence the description can be extended. Cross section MB.C.10232.4 of a specimen with 33 mm diameter shows the transition from the serpenticonic juvenile stage to the cadyconic intermediate and then pachyconic adult stage (Fig. 35A). The umbilicus reaches a maximum of 0.60 at 4–7 mm conch diameter, and a subsequent decrease to 0.35 at 33 mm dm. The absolute width of the umbilicus increases constantly, and the umbilical wall, convexly rounded in juvenile and intermediate stages, turns to become flattened and steep on the last volution.

MB.C.10232.3 is a corroded specimen of 52 mm conch diameter; it is thinly pachyconic (ww/dm = 0.63) with an umbilicus of one fourth of the conch diameter (Fig. 34D). Flanks and venter are broadly rounded, and the umbilical margin appears to be subangular. The specimen has fine convex growth lines which form a deep sinus on the venter. Specimen MB.C.10232.1 (73 mm dm) is the largest among the material; it is a corroded fragment but shows that the umbilicus, 16.5 mm wide, is opened in the adult stage (Fig. 34A).

Discussion. The conch of *G. jacquelinae* is similar to that of *G. costata* Vöhringer, 1960, but lacks the ribbing of that species. *G. crassa* is another similar species, but the size of its umbilicus stagnates in its opening in the adult stage, whereas it slowly but constantly opens in *G. jacquelinae*. Furthermore, *G. crassa* has juvenile whorls with slightly flattened venter, unlike the rounded venter of *G. jacquelinae*. The ontogenetic trajectories of both species differ in respect to conch width and umbilical width indices. *G. crassa* has a much thinner juvenile stage (ww/dm = 0.30–0.40 at 4 mm dm; see Korn & Vöhringer 2004) compared to *G. jacquelinae* (ww/dm = 0.45–0.55 at 4 mm dm), and a wider umbilicus (uw/dm > 0.60).

Gattendorfia debouaaensis (Bockwinkel & Ebbighausen, 2006)

Figs 34E–G, O, 36

* 2006 *Zadelsdorfia debouaaensis* Bockwinkel & Ebbighausen: 115, figs 30I–N, 33.

Material. Rich El Mbidia (bed 16): 11 specimens, Tizi Ibaouâne (bed 16): 24 specimens.

Diagnosis. Species of *Gattendorfia* with thickly pachyconic conch in the adult stage (ww/dm = 0.75–0.85). Inner whorls up to 6 mm diameter widely umbilicate (uw/dm 0.50–0.60), umbilicus slightly narrower (uw/dm 0.40) at 15 mm diameter. Aperture low, whorl expansion rate 1.50–1.60 without an increase in the adult stage. Umbilical margin subangular. Steinkern without constrictions, smooth. Suture line with moderately wide, slightly pouched external lobe and symmetric lanceolate adventive lobe.

Description. The diagnosis can be emended on the basis of more and better preserved material.

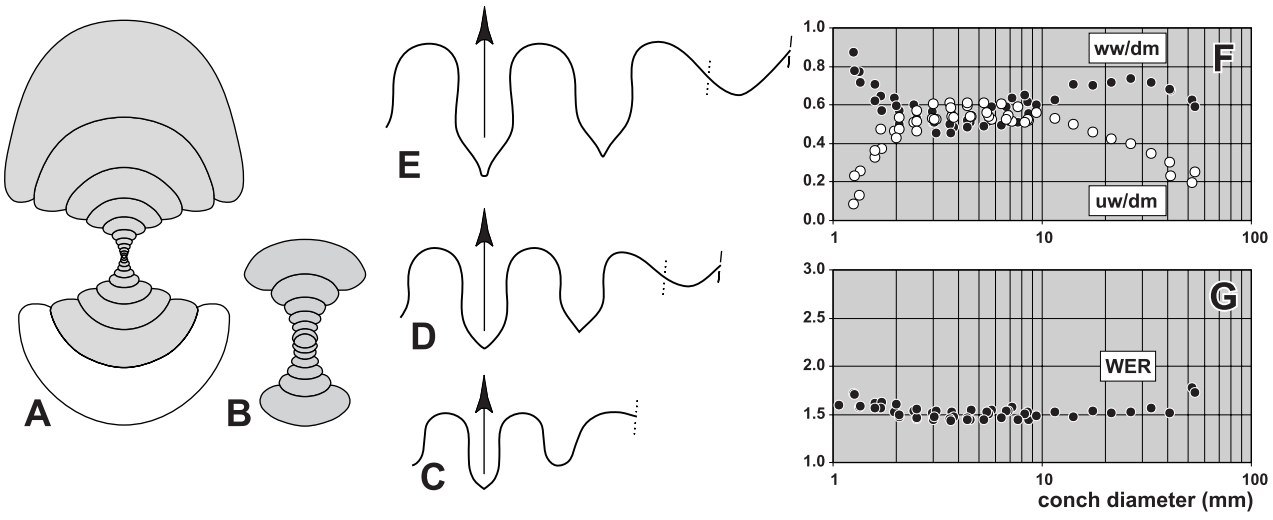


Fig. 35. *Gattendorfia jacquelinae* Ebbighausen et al., 2004 from bed 2 and bed 16 of the Aguelmous. **A** – Cross section, specimen MB.C.10232.4; bed 16; ×1. **B** – Cross section, specimen MB.C.10177.1; bed 2; ×3. **C** – Suture line, specimen MB.C.10177.2, at 8.5 mm dm, 5.2 mm ww, 2.1 mm wh; ×7; bed 2. **D** – Suture line, specimen MB.C.10161.1, at 3.8 mm ww, 2.3 mm wh; ×7; bed 2. **E** – Suture line, specimen MB.C.10161.2, at 7.3 mm ww, 2.6 mm wh; ×7; bed 2. **F** – Ontogenetic development of the whorl width index (ww/dm) and umbilical width index (uw/dm). **G** – Ontogenetic development of the whorl expansion rate (WER).

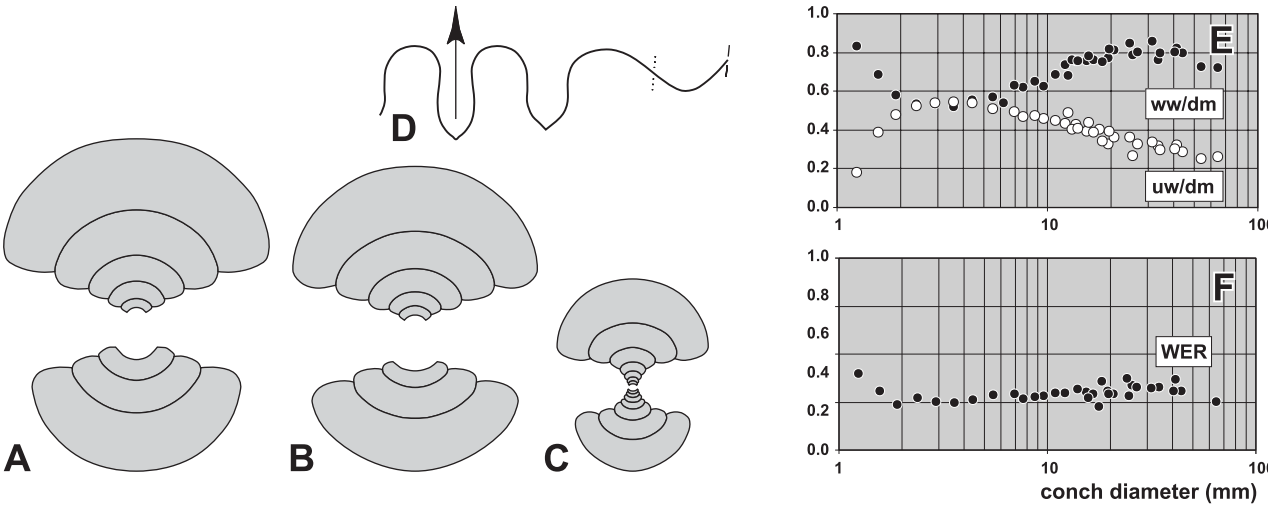


Fig. 36. *Gattendorfia debouaaensis* (Bockwinkel & Ebbighausen, 2006) from bed 16 of the Aguelmous. **A** – Cross section, specimen MB.C.10175.1; ×1. **B** – Cross section, specimen MB.C.10230.3; ×1. **C** – Cross section, specimen MB.C.10175.2; ×1. **D** – Suture line, specimen MB.C.10175.3, at 15.1 mm dm, 10.8 mm ww, 4.1 mm wh; ×4. **E** – Ontogenetic development of the whorl width index (ww/dm) and umbilical width index (uw/dm). **F** – Ontogenetic development of the whorl expansion rate (WER).

The cross sections MB.C.10175.1, MB.C.10230.3, and MB.C.10175.2 provide insight into the ontogenetic development that as is characteristic for the genus *Gattendorfia*, shows rather distinct growth intervals (Fig. 36A–C), beginning with a serpenticonic early juvenile stage (ending at 8–10 mm dm), and then transforming into a pachyconic stage. The aperture is low throughout ontogeny, with a slow increase of the whorl expansion rate from 1.50 at 2 mm dm to 1.60 at 20–40 mm dm.

Large specimens such as MB.C.10175.4 (40 mm conch diameter) appear to be smoothshelled without constrictions or strengthened growth lines (Fig. 34E). The specimen is a thickly pachyconic conch (ww/dm = 0.82) with a moderately narrow umbilicus (uw/dm = 0.32) that is bordered on the flanks by a subangular umbilical edge.

The suture line of specimen MB.C.10175.3 shows a lanceolate, slightly pouched external lobe, which is deeper than the similar adventive lobe (Fig. 36D). Both lobes are separated by an almost symmetric, broadly arched ventrolateral saddle.

Discussion. *G. debouaaensis* belongs to a species of the genus in which the adult stage is obviously not becoming slender, and in this trait differs from species such as *G. crassa* Vöhringer, 1960, *G. lhaceni* n. sp., and *G. jacquelinae* Ebbighausen, Bockwinkel, Korn & Weyer, 2004. *G. gisae* n. sp. has also a thickly pachyconic adult stage, but differs in the rounded umbilical margin and the higher aperture (WER = 2.00 at 40 mm dm) from *G. debouaaensis.*

Korn & Feist (2007) showed that the genera *Gattendorfia* Schindewolf, 1920 and *Zadelsdorfia* Weyer, 1972 cannot be separated, and that the latter has to be treated as a junior synonym. The putative difference between them has been the shape of the external lobe, which is lanceolate in *Gattendorfia* and pouched in *Zadelsdorfia*. The North African material, however, provides firm evidence that a pouched lobe is present in most of the *Gattendorfia* species.

Gattendorfia lhceni n. sp.

Figs 34H–M, 37

Derivation of name. After our friend Lhcen Mahraz from Fezzou, to honour his contribution during field work.

Holotype. Specimen MB.C.10225.1; illustrated here in Fig. 34H.

Type locality and horizon. Tizi Ibaouâne (A), Aguelmous (Ma'der, Anti-Atlas, Morocco); bed 12 (Early Tournaisian).

Material. Bou Tlidat (bed 12): 3 specimens, Tizi Ibaouâne (bed 12): 28 specimens.

Diagnosis. Species of *Gattendorfia* with discoidal to pachyconic conch. Inner whorls up to 8 mm diameter widely umbilicate (uw/dm 0.55–0.60), umbilicus narrower (uw/dm 0.25–0.30) at 15 mm diameter. Aperture low, whorl expansion rate 1.50–1.60, increasing to 1.90 in the adult stage. Umbilical margin subangular. Steinkern with rursiradiate constrictions and faint riblets. Suture line with very narrow, slightly pouched external lobe and symmetric adventive lobe.

Description. The growth trajectories show a complex picture, and the conch parameters are correlated to some degree (Fig. 37G, H). The conch is globular in the initial stage (ww/dm = 0.80–0.95 at 1 mm dm), rapidly becoming discoidal (ww/dm = 0.40–0.50 at 3–4 mm dm), then becoming thicker again (ww/dm = 0.55–0.65 at 10 mm dm), and finally, being thickly discoidal in the adult stage (ww/dm = 0.50 at 45 mm dm). This development is paralleled by changes in the umbilical width, with a uw/dm ratio of 0.55–0.65 at 3–6 mm dm, a subsequent reduction to a value of 0.20 at 16 mm dm, and maintenance of this ratio in the adult stage. The aperture is low in early growth stages (WER = 1.50–1.60 up to 4 mm dm), and thereafter almost continuously increases to 1.90 in adults.

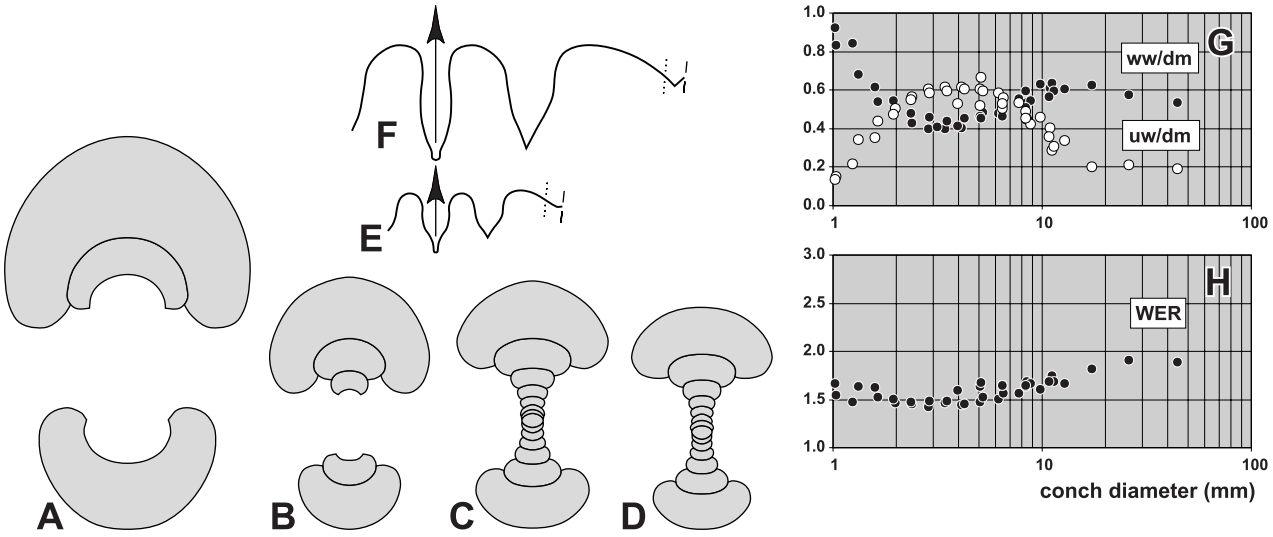


Fig. 37. *Gattendorfia lhceni* n. sp. from bed 12 of the Aguelmous. **A** – Cross section, paratype MB.C.10225.5; ×3. **B** – Cross section, paratype MB.C.10225.6; ×3. **C** – Cross section, paratype MB.C.10225.7; ×3. **D** – Cross section, paratype MB.C.10225.8; ×3. **E** – Suture line, paratype MB.C.10225.6, at 6.2 mm ww, 3.5 mm wh; ×3. **F** – Suture line, holotype MB.C.10225.1, at 16.5 mm ww, 13.3 mm wh; ×2. **G** – Ontogenetic development of the whorl width index (ww/dm) and umbilical width index (uw/dm). **H** – Ontogenetic development of the whorl expansion rate (WER).

Holotype MB.C.10225.1 is a rather well-preserved steinkern of 44 mm dm; it is fully chambered with 12 septa, which do not show crowding (Fig. 34H). The conch is thickly discoidal (ww/dm = 0.53) and widest at the pronounced subangular umbilical edge. The umbilical width is one fifth of the conch diameter. The steinkern has a few feeble constrictions, which turn backwards from the umbilicus. Between them, a faint ribbing is visible on the inner flanks. In the suture line of the holotype, the very narrow, slightly inflated external lobe is most conspicuous on the flank, followed by an almost symmetric ventrolateral saddle and an almost symmetric adventive lobe with subparallel flanks in the upper half (Fig. 37F).

Paratype MB.C.10225.2 is smaller (26 mm dm) but resembles the holotype in conch shape and steinkern ornament (Fig. 34I). The riblets are stronger in this specimen.

The juvenile specimens show a completely different conch morphology, as visible in the cross sections and the plots of the growth trajectories. Paratype MB.C.10225.4 (10.5 mm dm), for instance, has an open umbilicus (uw/dm = 0.37) and ventrally depressed whorls. It has four rather strong steinkern constrictions, which extend almost linearly across the flanks and form a shallow sinus on the venter (Fig. 34K).

Discussion. *Gattendorfia lhceni* n. sp. resembles *G. crassa* Vöhringer, 1960 in its conch dimensions and ontogenetic development. The main difference is the much narrower external lobe in the new species which serves as a distinguishing criterion with most other species of *Gattendorfia*. *G. asiatica* Librovitch, 1940 has a similar conch morphology and external lobe, but possesses a strikingly asymmetric adventive lobe and linear constrictions.

Gattendorfia gisae n. sp.

Figs 34N, 38

Derivation of name. After Gisa Bockwinkel, who participated in some of the field campaigns to Morocco, and encouraged the present study.

Holotype. Specimen MB.C.10176.1; illustrated here in 38A, D.

Type locality and horizon. Tizi Ibaouâne (A), Aguelmous (Ma'der, Anti-Atlas, Morocco); bed 12 (Early Tournaisian).

Material. Tazoult (loose): 1 specimen, Rich El Mbidia (bed 16): 8 specimens, Tizi Ibaouâne (bed 16): 13 specimens.

Diagnosis. Species of *Gattendorfia* with thickly pachyconic conch in the adult stage (ww/dm = 0.75–0.85). Inner and intermediate whorls up to 12 mm diameter moderately widely umbilicate (uw/dm 0.35–0.40), umbilicus slightly narrower (uw/dm 0.30) at 15–30 mm diameter. Aperture low in the juvenile stage, whorl expansion rate 1.50–1.60, increasing in the adult stage to 2.00. Umbilical margin rounded. Steinkern without constrictions, smooth. Suture line with narrow, slightly pouched external lobe and symmetric lanceolate adventive lobe.

Description. Cross sections MB.C.10176.1 and MB.C.10231.1 display the development of conch geometry, which is normal for a species of *Gattendorfia* (Fig. 38A, B). A distinct serpenticonic stage does not exist; the inner whorls are slightly more evolute than the outer, but the uw/dm ratio does not exceed a value of 0.40. The conch is pachyconic in all stages, with a ww/dm ratio of 0.70 at 6 mm conch diameter, increasing to 0.80 in later stages. All growth stages show a similar kidney-shaped whorl cross section, but the apertural height increases rather quickly from 1.60 at 10 mm dm to 2.00 at 30 mm dm. The umbilical wall is rounded throughout ontogeny.

The sectioned specimen MB.C.10176.1 was chosen for the holotype; it shows the conch development

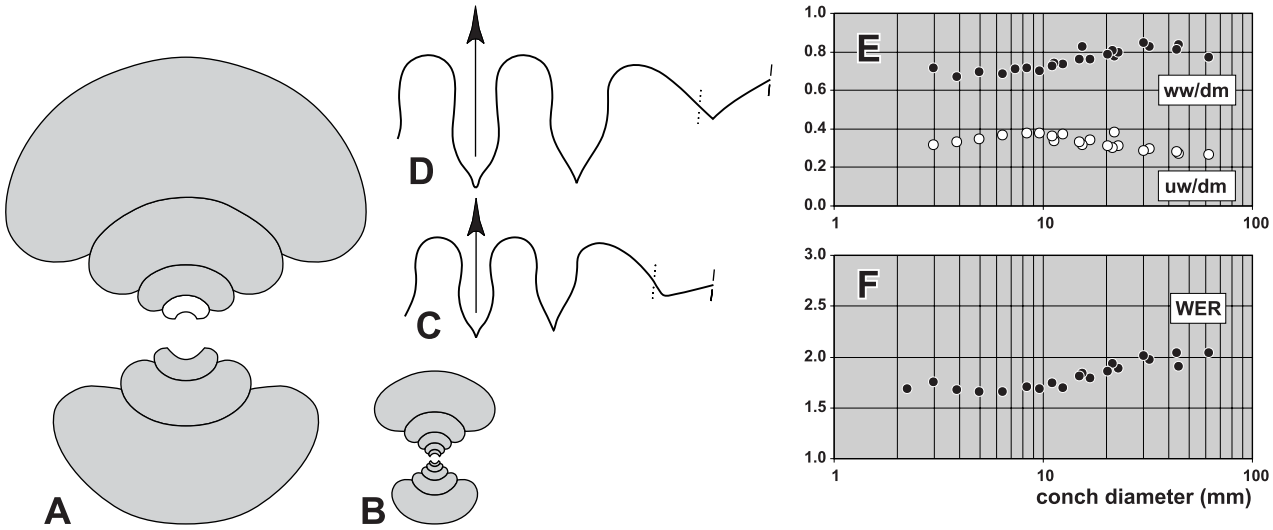


Fig. 38. *Gattendorfia gisae* n. sp. from bed 16 of the Aguelmous. **A** – Cross section, holotype MB.C.10176.1; ×1. **B** – Cross section, paratype MB.C.10231.1; ×1. **C** – Suture line, paratype MB.C.10211, at 20.9 mm dm, 16.3 mm ww, 7.2 mm wh; ×2. **D** – Suture line, holotype MB.C.10176.1, at 47.8 mm dm, 37.6 mm ww, 25.3 mm wh; ×1. **E**. Ontogenetic development of the whorl width index (ww/dm) and umbilical width index (uw/dm). **F** – Ontogenetic development of the whorl expansion rate (WER).

as well as the suture line. Its diameter is almost 62 mm and is thickly pachyconic (ww/dm = 0.77) with a moderate umbilicus (uw/dm = 0.27). The specimen is somewhat corroded but it appears that there are no details of ornament visible, and constrictions are lacking. The suture line shows a narrow, lanceolate and slightly pouched external lobe and a narrowly rounded ventrolateral saddle. The lanceolate adventive lobe is wider than the external lobe; both lobes have the same depth (Fig. 38D).

Paratype MB.C.10231.2 with a 128 mm conch diameter is the largest specimen of the material from Aguelmous. At this diameter, the conch is still thinly pachyconic (uw/dm = 0.60) with a narrow umbilicus (uw/dm = 0.21). The corroded shell surface shows strongly rursiradiate growth lines.

Discussion. *G. gisae* n. sp. differs from the other pachyconic species of *Gattendorfia* in the absence of a truly serpenticonic juvenile stage and by the rounded umbilical margin. A further distinguishing character is the adult heightening of the aperture, leading to a whorl expansion rate of 2.00.

Gattendorfia sp.

Fig. 31F

* 2002 *Zadelsdorfia* sp. Korn, Klug, Ebbighausen & Bockwinkel: fig. 5G, H.

Material. Rich El Mbidia (bed 18): 10 specimens.

Remarks. Only insufficiently preserved specimens are available for study, and therefore, the material is described in open nomenclature. Specimens such as MB.C.10189 (50 mm dm) have a thickly discoidal to pachyconic conch with an umbilicus of approximately one fifth of the conch diameter. They possess faint riblets, which extend almost linearly or convexly across the flanks and turn back to a wide and shallow ventral sinus. A faint spiral ornament is visible in some of the specimens. The suture line has a slightly pouched external lobe, slightly inflated ventrolateral saddle, and an asymmetric adventive lobe with steep ventral flank.

Kazakhstania Librovitch, 1940

Type species. *Gattendorfia* (*Kazakhstania*) *karagandensis* Librovitch, 1940.

Kazakhstania evoluta (Vöhringer, 1960)

Figs 39A, B, 40

* 1960 *Gattendorfia evoluta* Vöhringer: 159, fig. 34a–b, pl. 5: fig. 4a–b.
2006 *Kazakhstania evoluta*. – Bockwinkel & Ebbighausen: 112, figs 29, 30E–H.

Material. Bou Tlidat (bed 2): 2 specimens, Bou Tlidat (bed 12): 2 specimens, Tizi Ibaouâne (bed 2): 3 specimens.

Remarks. The material from Aguelmous consists of small specimens which reach only 7 mm in conch diameter. A suture line is shown in Fig. 40; it shows a very deep, lanceolate external sinus and a U-shaped adventive lobe that is much shallower. This lateral lobe lies on the umbilical wall.

Kazakhstania nitida Bockwinkel & Ebbighausen, 2006

Figs 39C, D, 41

* 2006 *Kazakhstania nitida* Bockwinkel & Ebbighausen: 113, figs 30A, B, 32.

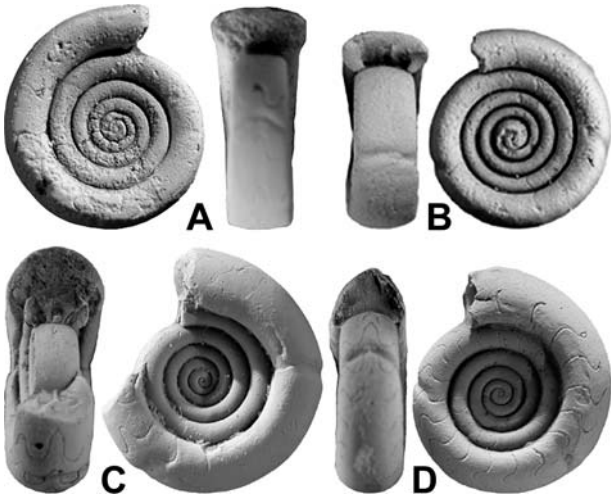


Fig. 39. *Kazakhstania* from Fezzou, all ×5. **A** – *Kazakhstania evoluta* (Vöhringer, 1960), specimen MB.C.10163.1 from Bou Tlidat, bed 2, lateral and dorsal views. **B** – *Kazakhstania evoluta* (Vöhringer, 1960), specimen MB.C.10221.1 from Tizi Ibaouâne, bed 2, dorsal and lateral views. **C** – *Kazakhstania nitida* Bockwinkel & Ebbighausen, 2006, specimen MB.C.10213 from Tazoult, dorsal and lateral views. **D** – *Kazakhstania nitida* Bockwinkel & Ebbighausen, 2006, specimen MB.C.10164.1 from Bou Tlidat, bed 2, dorsal and lateral views.

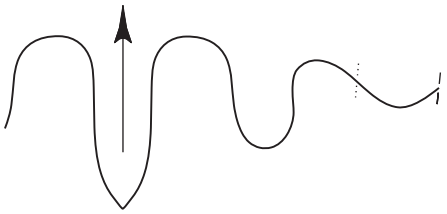


Fig. 40. *Kazakhstania evoluta* (Vöhringer, 1960) from bed 2 of the Aguelmous. Suture line, specimen MB.C.10163.1, at 5.3 mm dm, 2.2 mm ww, 1.0 mm wh; ×20.

Material. Bou Tlidat (bed 2): 11 specimens, Tazoult (bed 2): 2 specimens, Tazoult (loose): 1 specimen.

Remarks. The new material consists of specimens smaller than those of the suite from Mfis (Bockwinkel & Ebbighausen 2006). They confirm the original description, and information on the juvenile suture can be added: the adventive lobe is rounded at 4.8 mm conch diameter and only half as deep as the external lobe, which has subparallel flanks.

Suborder **Goniatitina** Hyatt, 1884
Superfamily **Pericycloidea** Hyatt, 1900
Family **Pericyclidae** Hyatt, 1900

Goniocyclus Gordon, 1986

Type species. *Goniatites blairi*, Miller & Gurley, 1896.

Goniocyclus elatrous Korn, Klug, Ebbighausen & Bockwinkel, 2002

Figs 42A, B, 43

* 2002 *Goniocyclus elatrous* Korn, Klug, Ebbighausen & Bockwinkel: 82, fig. 6A, B, C.

Material. Rich El Mbidia (bed 18): 9 specimens.

Remarks. Only fragmentarily preserved specimens are available, but these contribute additional information about the species. The new material consists of larger specimens than the original suite, but the specimens are very similar in conch form and ornament. In Particular specimens MB.C.10186.1 and MB.C.10186.2 possess sharp rursiradiate ribs and delicate spiral ornament in the rib interspaces. Specimen MB.C.10186.3 was sectioned but only allows the study of the last 2. whorls. The whorl outline is strongly affected by the sharp ribs (Fig. 43).

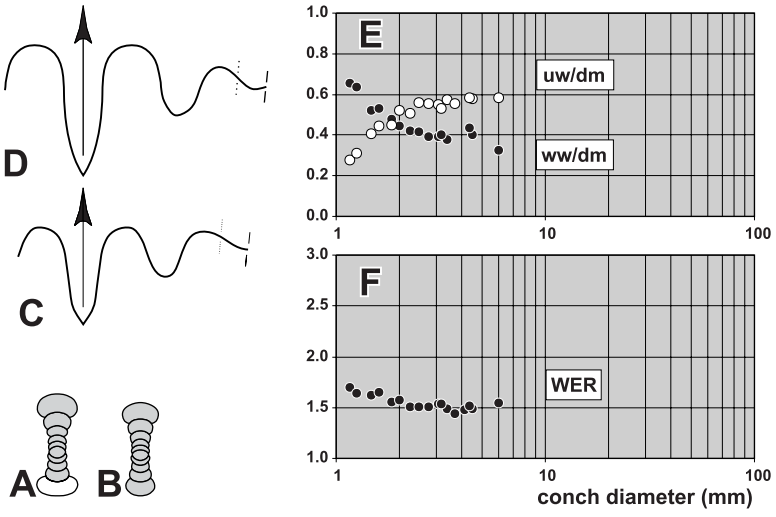


Fig. 41. *Kazakhstania nitida* Bockwinkel & Ebbighausen, 2006 from bed 2 of the Aguelmous. **A** – Cross section, specimen MB.C.10164.2; ×3. **B** – Cross section, specimen MB.C.10164.3; ×3. **C** – Suture line, specimen MB.C.10164.3, at ca. 3.9 mm dm, 1.6 mm ww, 1.0 mm wh; ×15. **D** – Suture line (reversed), specimen MB.C.10164.4, at 4.8 mm dm, 1.6 mm ww, 1.1 mm wh; ×15. **E** – Ontogenetic development of the whorl width index (ww/dm) and umbilical width index (uw/dm). **F** – Ontogenetic development of the whorl expansion rate (WER).

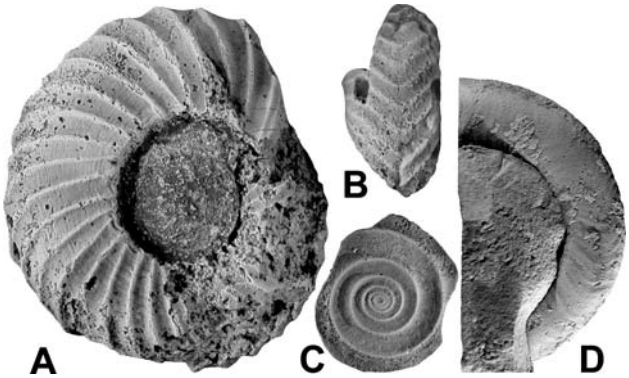


Fig. 42. *Goniocyclus* and *Eocanites* from Fezzou, all ×1. **A** – *Goniocyclus elatrous* Korn et al., 2002, specimen MB.C.10186.1 from Rich el Mbidia, bed 18, lateral view. **B** – *Goniocyclus elatrous* Korn et al., 2002, Specimen MB.C.10186.1 from Rich el Mbidia, bed 18, ventral view. **C** – *Eocanites* sp., specimen MB.C.10183.1, from Rich el Mbidia, bed 18, lateral view. **D** – *Eocanites* sp., specimen MB.C.10183.2, from Rich el Mbidia, bed 18, lateral view.

Order **Prolecanitida** Miller & Furnish, 1954
Superfamily **Prolecanitoidea** Hyatt, 1884
Family **Prolecanitidae** Hyatt, 1884
Subfamily **Prolecanitinae** Hyatt, 1884

Eocanites Librovitch, 1957

Type species. *Protocanites supradevonicus* (Schindewolf, 1926).

Eocanites simplex Bockwinkel & Ebbighausen, 2006

Figs 44A, 45

* 2006 *Eocanites simplex* Bockwinkel & Ebbighausen: 120, figs 37, 38I–K.

Material. Bou Tlidat (bed 2): 10 specimens, Tazoult (bed 2): 3 specimens, Tizi Ibaouâne (bed 2): 1 specimen.

Description. The new material permits the description of conch ontogeny, which, however, is rather unspectacular. The conch, beginning pachyconic in the initial stage, becomes rapidly thinner and has a ww/dm ratio of 0.40 at 4 mm diameter. At the same time, the umbilicus is opened to a uw/dm ratio of 0.50. The whorl expansion rate is stable throughout ontogeny, being 1.75–1.80 (Fig. 45D, E).

Specimen MB.C.10160.1 is the best preserved of the newly collected material (Fig. 44A). It has 13 mm diameter and is fully chambered with 13 septa on the last volution. The whorl cross section is almost circular, and the rate at which the whorls embrace is low. Faint riblets are visible on outer flanks and venter, they form a shallow ventral sinus. The suture line of the specimen possesses an external lobe that is much deeper than the asymmetric adventive lobe. Both are separated by an inflated ventrolateral saddle.

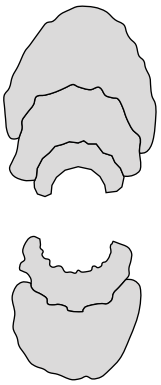


Fig. 43. *Goniocyclus elatrous* Korn et al., 2002, cross section of specimen MB.C.10286.3 from Rich el Mbidia, bed 18, ×3.

Eocanites sp.

Fig. 42C, D

* 2002 *Eocanites* sp. Korn, Klug, Ebbighausen & Bockwinkel: fig. 5E, F, K.

Material. Rich El Mbidia (bed 18): 2 specimens.

Remarks. The material is too poor for a distinct interpretation. The assignment to *Eocanites* is based on a close similarity to specimens figured by Korn et al. (2002), which show the characteristic suture line.

Becanites Korn, 1997

Type species. *Protocanites algarbiensis* Pruvost, 1914.

Becanites sp.

Figs 44B, 46

Material. Rich El Mbidia (bed 16): 1 specimen.

Remarks. The single specimen MB.C.10174 allows the attribution to a distinct genus, but nothing further. The conch is at 12.5 mm diameter, discoidal (ww/dm = 0.30) and widely umbilicate (uw/dm = 0.43). The whorls embrace only to a very low degree, and the whorl cross section is compressed and oval. In the penultimate whorl, there are some faint ribs visible, which turn back on the flanks. The suture line of the specimen possesses a lanceolate external lobe, a pouched and blunt adventive lobe, and a small lateral lobe that is similar to the adventive lobe.

Kahlacanites Ebbighausen, Bockwinkel, Korn & Weyer, 2004

Type species. *Kahlacanites mariae* Ebbighausen, Bockwinkel, Korn & Weyer, 2004.

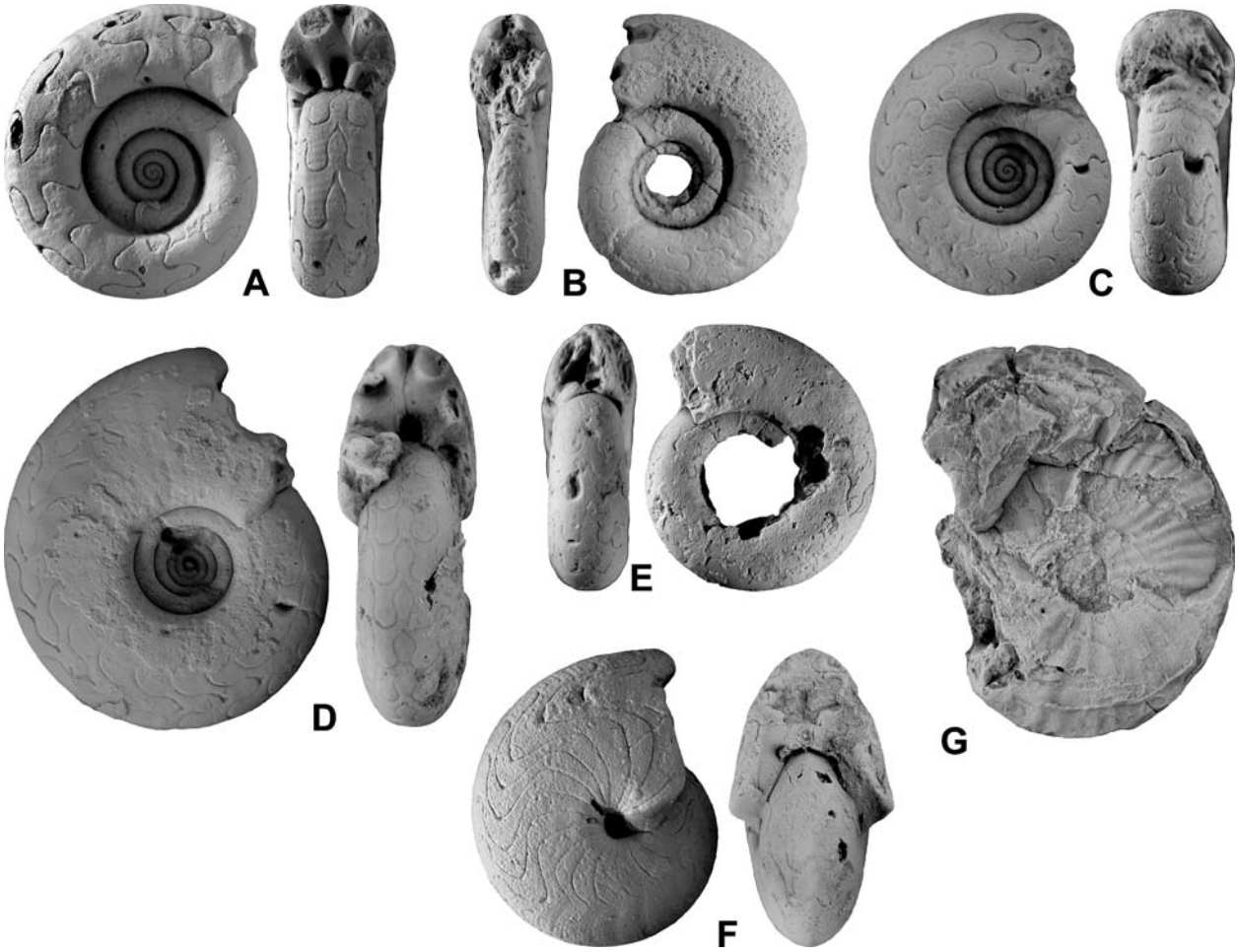


Fig. 44. *Eocanites*, *Becanites*, *Kahlacanites*, and gen. indet. from Fezzou. **A** – *Eocanites simplex* Bockwinkel & Ebbighausen, 2006, specimen MB.C.10160.1 from Bou Tlidat, bed 2, lateral and dorsal views, ×3. **B** – *Becanites* sp., specimen MB.C.10174 from Rich el Mbidia, bed 16, dorsal and lateral views, ×2.5. **C** – *Kahlacanites mariae* Ebbighausen et al. 2004, specimen MB.C.10236.1 from Tizi Ibaouâne, bed 16, lateral and dorsal views, ×2.5. **D** – *Kahlacanites mariae* Ebbighausen et al. 2004, specimen MB.C.10181.1 from Tizi Ibaouâne, bed 16, dorsal and lateral views, ×2.5. **E** – *Kahlacanites meyendorffi* Ebbighausen et al., 2004, specimen MB.C.10237 from Tizi Ibaouâne, bed 16, dorsal and lateral views, ×2.5. **F** – gen. indet. 1 sp. indet, specimen MB.C.10226 from Tizi Ibaouâne, bed 12, lateral and dorsal views, ×5. **G** – gen. indet. 2 sp. indet, specimen MB.C.10178 from Rich el Mbidia, bed 16, ×1.

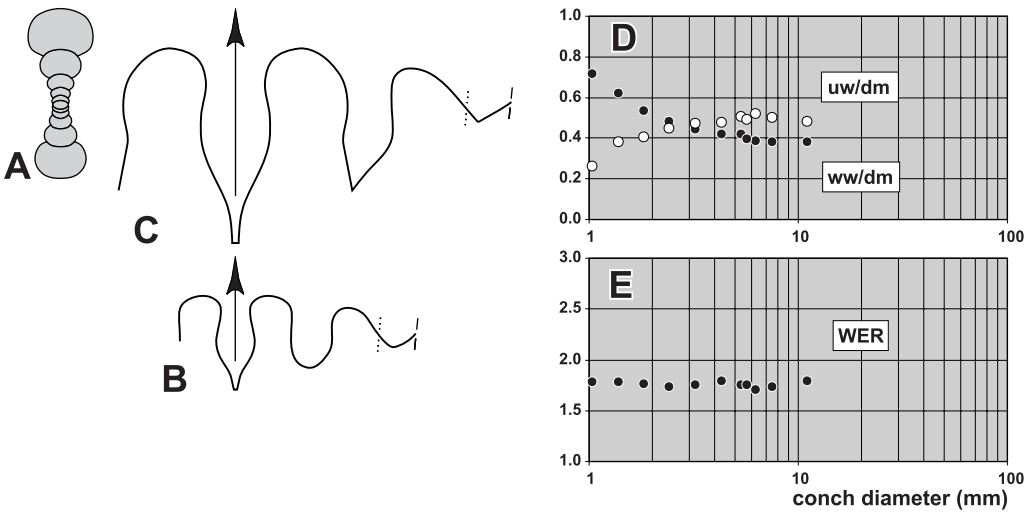


Fig. 45. *Eocanites simplex* Bockwinkel & Ebbighausen, 2006 from bed 2 of the Aguelmous. **A** – Cross section, specimen MB.C.10160.2; ×3. **B** – Suture line, specimen MB.C.10160.3, at 1.9 mm ww, 1.2 mm wh; ×14. **C** – Suture line, specimen MB.C.10160.1, at 10.9 mm dm, 4.1 mm ww, 3.2 mm wh; ×8. **D** – Ontogenetic development of the whorl width index (ww/dm) and umbilical width index (uw/dm). **E** – Ontogenetic development of the whorl expansion rate (WER).

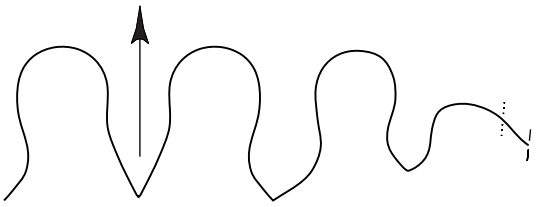


Fig. 46. *Becanites* sp., suture line, specimen MB.C.10174, at 10.3 mm dm, 3.4 mm ww, 3.4 mm wh; ×3.

Kahlacanites mariae Ebbighausen, Bockwinkel, Korn & Weyer, 2004

Figs 44C, D, 47A–F

* 2004 *Kahlacanites mariae* Ebbighausen, Bockwinkel, Korn & Weyer: 147, figs 15C–E, 17A.

Material. Rich El Mbidia (bed 16): 3 specimens, Tizi Ibaouâne (bed 16): 49 specimens.

Description. The specimens from Aguelmous are much better preserved than the original material from the Gara el Kahla, and thus the description of the species can be updated (Fig. 47A, B). Cross sections MB.C.10236.2 and MB.C.10236.3 show the ontogenetic development of conch geometry, which in turn shows the transformation of ventrally depressed, semilunate innermost whorls to laterally compressed whorls in the adult stage. The ww/dm ratio decreases from 0.60 to 0.30 between 1.5 and 20 mm conch diameter, but the uw/dm ratio remains rather stable around 0.40. A slight opening of the umbilicus (uw/dm = 0.40–0.50) can be seen between 2 and 5 mm dm (Fig. 47E, F).

The suture lines of specimens MB.C.10218 and MB.C.10181.1 have a pouched external lobe which is widest near its base. On the flank an almost symmetric, inflated ventrolateral saddle, a lanceolate adventive lobe, an inflated dorsolateral saddle, and a lateral lobe follows. A shallow umbilical lobe lies on the umbilical wall (Fig. 47C, D). The two figured suture lines differ in the width of their elements: the ventrolateral saddle is wider in the larger specimen, and the adventive lobe is narrower. By contrast, the lateral lobe is wider in the larger specimen.

Specimen MB.C.10181.1 is the best preserved within the material. It has 20 mm diameter and is fully septate with 18 chambers on the last volution. The steinkern is smooth except for a barely visible radial folding on the surface. Specimen MB.C.10236.5 (19 mm dm) is preserved with attached shell remains. These show rather coarse growth lines, extending with a lateral sinus and a ventrolateral projection across the flanks.

Kahlacanites meyendorffi Ebbighausen, Bockwinkel, Korn & Weyer, 2004

Figs 44E, 47G

* 2004 *Kahlacanites meyendorffi* Ebbighausen, Bockwinkel, Korn & Weyer: 147, fig. 15A, B.

Material. Tizi Ibaouâne (bed 16): 1 specimen.

Remarks. Only one specimen (MB.C.10237; 14 mm dm) is available; it confirms the original Description. The conch is discoidal (ww/dm = 0.37) with a wide umbilicus (uw/dm = 44), and the whorl cross section is oval with slightly converging flanks. The suture line is characteristic for the genus with a pouched external lobe, a similarly shaped adventive lobe, a smaller lateral lobe, and a very shallow umbilical lobe on the umbilical wall (Fig. 47G).

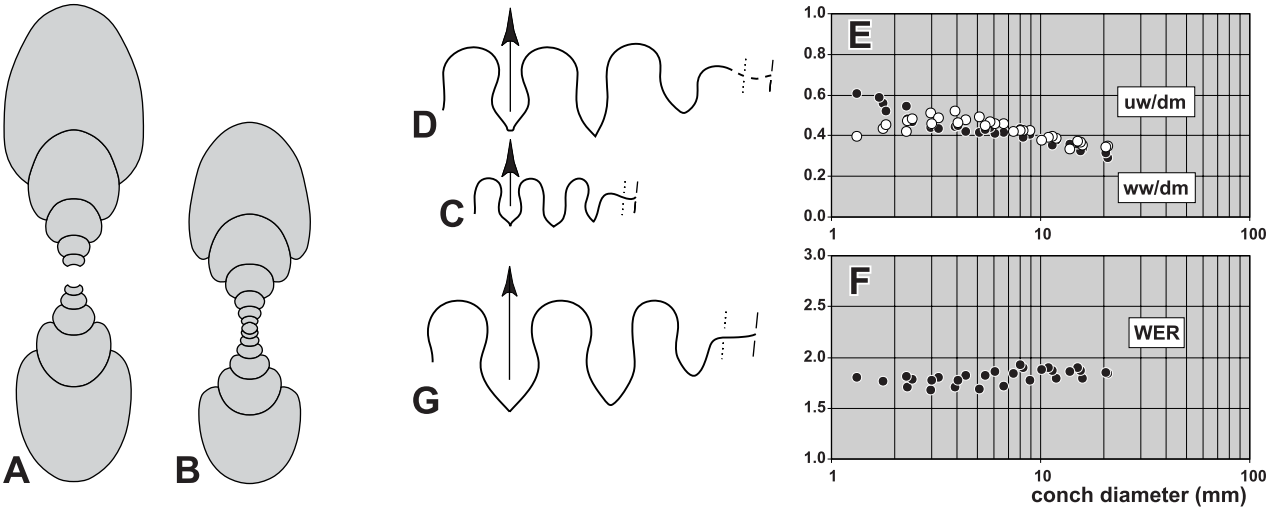


Fig. 47. *Kahlacanites mariae* Ebbighausen et al., 2004 (A–F) and *Kahlacanites meyendorffi* Ebbighausen et al., 2004 (G) from bed 16 of the Aguelmous. **A** – Cross section, specimen MB.C.10236.2; ×3. **B** – Cross section, specimen MB.C.10236.3; ×3. **C** – Suture line, specimen MB.C.10218, at ca. 10.2 mm dm, ca. 3.7 mm ww, 3.4 mm wh; ×10. **D** – Suture line, specimen MB.C.10181.1, at 19.3 mm dm, 6.8 mm ww, 8.4 mm wh; ×10. **E** – Ontogenetic development of the whorl width index (ww/dm) and umbilical width index (uw/dm). **F** – Ontogenetic development of the whorl expansion rate (WER). **G** – Suture line, specimen MB.C.10237, at 3.6 mm ww, 3.1 mm wh; ×10.

Fig. 48. *Protocanites hollardi* Korn et al., 2002 from Rich el Mbidia, bed 18. **A** – Specimen MB.C.10188.2, lateral view, ×1. **B** – Specimen MB.C.10188.1, dorsal and lateral views, ×2.

Subfamily **Protocanitinae** Weyer, 1972

Protocanites Schmidt, 1922

Type species. *Goniatites lyoni* Meek & Worthen, 1860.

Protocanites hollardi Korn, Klug, Ebbighausen & Bockwinkel, 2002

Figs 48, 49

* 2002 *Protocanites hollardi* Korn, Klug, Ebbighausen & Bockwinkel: 82, fig. 5A–C.

Material. Rich El Mbidia (bed 18): 64 specimens.

Remarks. Only poor material is available. The two specimens MB.C.10188.2 and MB.C.10188.3 preserve parts of the suture line (Fig. 49B), which permits an assignment to the genus *Protocanites*, and MB.C.10188.2 possesses a radial ornament consisting of fine but rhythmically strengthened growth lines. These extend in rectiradiate direction across the flanks.

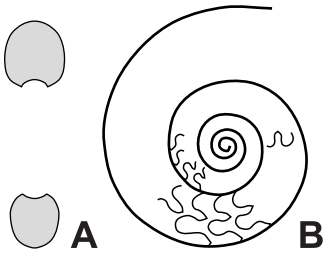


Fig. 49. *Protocanites hollardi* Korn et al., 2002 from bed 18 of the Aguelmous. **A** – Cross section, specimen MB.C.10188.3; ×1. **B** – Side view of a cast with suture lines, specimen MB.C.10188.2; ×2.

gen. indet. 1
gen. indet. 1 sp. indet.

Figs 44F, 50

Material. Tizi Ibaouâne (bed 12): 1 specimen.

Description. The single specimen MB.C.10226 with 8 mm diameter is fully septate with approximately 16 chambers (Fig. 44F). It is a lenticular conch (ww/dm = 0.55) with an almost closed umbilicus and a keeled narrow venter. The aperture is high (WER = 2.28). Apart from the conch shape, the specimen is particularly peculiar because of its suture line, which is so far notknown from any other ammonoid. It may be a juvenile suture, in which some distinctive characters are not yet developed, but the very small, broadly V-shaped external lobe and the very large, asymmetric and rounded adventive lobe are very striking (Fig. 50).

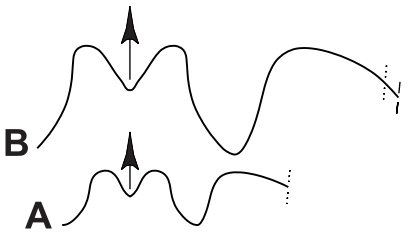


Fig. 50. gen. indet. 1 sp. indet., suture lines of specimen MB.C.10226 from Tizi Ibaouâne, bed 12, ×7. **A** – At 2.6 mm ww, 2.2 mm wh. **B** – At 7.9 mm dm, 3.9 mm ww, 4.4 mm wh.

gen. indet. 2
gen. indet. 2 sp. indet.

Fig. 44G

Material. Rich El Mbidia (bed 16): 1 specimen.

Remarks. The single specimen MB.C.10178 with 54 mm diameter is fragmentary, and unfortunately, many aspects of conch and septum morphology are unknown. It is obvious that the conch is thinly discoidal, but caused by erosion, it cannot be stated whether the venter is rounded, tabular, or acute. The conch is ornamented with shallow sinuous ribs, some of them intercalated in the midflank area. In its general appearance, the specimen resembles the genus *Qiannanites* Ruan, 1981, but more material is required for an assignment to this genus.

Acknowledgements

We thank Dieter Weyer (Berlin) for his support during measurement and interpretation of the section and for making his material available. We are particularly indebted to Dieter Korn (Berlin) for discussions and his patient support in all stages of writing the article. Lhcen Mahraz (Fezzou) contributed much in the field and collected some of the material. Evelin Stenzel (Berlin) did the careful preparation of some specimens. We acknowledge the reviews of Christian Klug (Zürich) and John Malinky (Escondido, CA). The authors express their thanks to Ralf Thomas Becker (Münster) for critically reading the manuscript.

References

Bartzsch, K. & Weyer, D. 1987. Das unterkarbonische Ammonoidea-Tribus Pseudarietini. – Abhandlungen und Berichte für Naturkunde und Vorgeschichte **13**: 59–68.

Becker, R. T., House, M. R., Bockwinkel, J., Ebbighausen, V. & Aboussalam, S. 2002. Famennian ammonoid zones of

the eastern Anti-Atlas (southern Morocco). – Münstersche Forschungen zur Geologie und Paläontologie **93**: 159–205.

Bockwinkel, J. & Ebbighausen V. 2006. A new ammonoid fauna from the *Gattendorfia-Eocanites* Genozone of the Anti-Atlas (Early Carboniferous, Morocco). – Fossil Record **9** (1): 87–129.

Clariond, L. 1935. Etude stratigraphique sur les terrains du sud marocain : La série Primaire du Sarro, du Maïder et du Tafilalet. – Association pour l'étude géologique de la Méditerranée occidentale **5**: 3–10.

Destombes, J. & Hollard, H. 1988. Todrha – Ma'der, échelle 1:200,000. – *In* Fetah, S. E. M., Bensaïd, M. M. & Dahmani, M. M. (eds): Carte Géologique du Maroc. – Notes et Mémoires du Service Géologique du Maroc, **243**; Rabat.

Ebbighausen, V., Bockwinkel, J., Korn, D. & Weyer, D. 2004. Early Tournaisian ammonoids from Timimoun (Gourara, Algeria). – Mitteilungen aus dem Museum für Naturkunde in Berlin, Geowissenschaftliche Reihe **7**: 133–152.

Ebbighausen, V. & Korn, D. 2007. Conch geometry and ontogenetic trajectories in the Late Devonian triangularly coiled ammonoid *Wocklumeria*. – Neues Jahrbuch für Geologie und Paläontologie.

Gordon, M. jr. 1986. Late Kinderhookian (Early Mississippian) Ammonoids of the Western United States. – Journal of Paleontology, Memoir **19**: 1–36.

Hall, J. 1860. Notes and observations upon fossils of the Goniatite Limestone in the Marcellus shale of the Hamilton group, in the eastern and central parts of the State of New York, and those of the Goniatite beds of Rockford, Indiana; with some analogous forms from the Hamilton group proper. – Annual Reports of the Regents of the University of the State New York, on the condition of the State Cabinet of Natural History, and the Historical and Antiquarian Collection annexed thereto **13**: 59–112.

Hollard, H. 1958. Découverte des Goniatites tournaisiennes dans le Maider (Province du Tafilalet, Maroc). – Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences **247**: 789–792.

Hyatt, A. 1883–1884. Genera of the fossil cephalopods. – Proceedings of the Boston Society of Natural History **22**: 253–338 (253–272 publ. 1883, 237–238 publ. 1884).

– 1900. Tetrabranchiate Cephalopoda. – *In* Zittel-Eastman: Text-book of palaeontology, 1st edition: 502–604, London.

Ji Qiang 1985. Study on the Phylogeny, Taxonomy, Zonation and Biofacies of *Siphonodella* (Conodonta). – Bulletin of the Institute of Geology, Chinese Academy of Geological Sciences **11**: 51–75.

Kaiser, S. I. 2005. Mass extinction, climatic and oceanographic changes at the Devonian/Carboniferous boundery. – Dissertation zur Erlangung des akademischen Grades eines Doktors der Naturwissenschaften an der Fakultät für Geowissenschaften der Ruhr-Universität Bochum (Germany), 156 pp; Bochum. (unpublished)

Korn, D. 1984. Die Goniatiten der Stockumer *Imitoceras*-Kalklinsen (Ammonoidea; Devon/Karbon-Grenze). – Courier Forschungsinstitut Senckenberg **67**: 71–89.

– 1992a. Heterochrony in the evolution of Late Devonian Ammonoids. – Acta Palaeontologica Polonica **37** (1): 21–36.

– 1992b. Ammonoideen aus dem Devon/Karbon-Grenzprofil an der Grünen Schneid (Karnische Alpen, Österreich). – Jahrbuch der Geologischen Bundesanstalt **135**: 7–19.

– 1994. Oberdevonische und unterkarbonische Prionoceraten aus dem Rheinischen Schiefergebirge. – Geologie und Paläontologie in Westfalen **30**: 1–85.

– 1997. The Palaeozoic ammonoids of the South Portuguese Zone. – Memórias do Instituto Geológico e Mineiro de Portugal **33**: 1–132.

– 1999. Famennian Ammonoid Stratigraphy of the Ma'der and Tafilalt (Eastern Anti-Atlas, Morocco). – Abhandlungen der Geologischen Bundesanstalt **54**: 147–179.

Korn, D., Bockwinkel, J. & Ebbighausen, V. 2007. Tournaisian and Viséan ammonoid stratigraphy in North Africa. – Neues Jahrbuch für Geologie und Paläontologie **242**: 127–148

Korn, D., Ebbighausen, V., Bockwinkel, J. & Klug, C. 2003. The A-mode sutural ontogeny in prolecanitid ammonoids. – Palaeontology **46** (6): 1123–1132.

Korn, D. & Feist, R. (2007): Early Carboniferous ammonoid faunas and stratigraphy of the Montagne Noire (France). – Fossil Record **10** (2): 99–124

Korn, D. & Klug, C. 2002. Ammoneae Devonicae. In: W. Riegraf (Ed.), Fossilium Catalogus, Animalia I, 138: xviii + 375 pp., Backhuys, Leiden.

Korn, D., Klug, C., Ebbighausen, V. & Bockwinkel, J. 2002. Palaeogeographical meaning of a Middle Tournaisian ammonoid fauna from Morocco. – Geologica et Palaeontologica **36**: 79-86.

Korn, D. & Kullmann, J. 1996. GONIAT-Paleozoic Ammonoid Database System, Version 2.60. – Geologisch-Paläotologisches Institut, Tübingen.

Korn, D. & Weyer, D. 2003. High resolution stratigraphy of the Devonian-Carboniferous transitional beds in the Rhenish Mountains. – Mitteilungen aus dem Museum für Naturkunde in Berlin, Geowissenschaftliche Reihe **6**: 79– 124.

Korn, D. & Vöhringer, E. 2004. Allometric growth and intraspecific variability in the basal Carboniferous ammonoid *Gattendorfia crassa* Schmidt, 1924. – Paläontologische Zeitschrift **78** (2): 419–426.

Librovitch, L. S. 1957. O nekotorykh novykh gruppakh goniatitov iz kamennougolnykh otlozheniy SSSR. – Ezhegodnik Vsesoyuznogo Paleontologicheskogo Obshchestva **16**: 246–272.

Meek, F. B. & Worthen A. H. 1860. Descriptions of new Carboniferous fossils from Illinois and other western States. – Proceedings of the Acadademy of Natural Science Philadelphia **1860**: 471.

Miller, A. K. & Furnish, W. M. 1954. The classification of the Paleozoic ammonoids. – Journal of Paleontology **28**: 685–692.

Miller, S. A. & Gurley, W. F. E. 1896. New species of Palaeozoic invertebrates from Illinois and other states. – Bulletin of the Illinois State Museum of Natural History **11**: 1–50.

Münster, G. Graf zu 1832. Über die Planuliten und Goniatiten im Uebergangs-Kalk des Fichtelgebirges. – 38 pp, Birner, Bayreuth

Petter, G. 1959. Goniatites Dévoniennes du Sahara. – Publications du Service de la Carte Géologique de l'Algérie, Nouvelle Série, Paléontologie **2**: 1–313.

– 1960 Clymènies du Sahara. – Publications du Service de la Carte Géologique de l'Algérie, Nouvelle Série, Paléontologie **6**: 1–58.

Pruvost, P. 1914. Observations sur les terrains Dévoniens et Carbonifères du Portugal et leur faune. – Comunicações da Commissão do Serviço Geológico de Portugal **10** (1): 1–21.

Ruan, Yi-ping 1981. Devonian and earliest Carboniferous ammonoids from Guangxi and Guizhou. – Memoirs of Nanjing Institute of Geology and Palaeontology, Academia Sinica **15**: 1–152.

Ruzhencev, V. E. 1950. Verkhnekamennougol'nye ammonity Urala. – Trudy Paleontologicheskogo Instituta Akademiya Nauk SSSR **29**: 1–223.

Sandberg, C. A., Ziegler, W., Leuteritz, K. & Brill, S. M. 1978. Phylogeny, speciation, and zonation of *Siphonodella* (Conodonta, Upper Devonian and Lower Carboniferous). – Newsletters on Stratigraphy **7** (2): 102–120.

Schindewolf, O. H. 1920. Neue Beiträge zur Kenntnis der Stratigraphie und Paläontologie des deutschen Oberdevons. – Senckenbergiana **2** (3/4): 114–129.

– 1923. Beiträge zur Kenntnis des Paläozoikums in Oberfranken, Ostthüringen und dem Sächsischen Vogtlande. I. Stratigraphie und Ammoneenfauna des Oberdevons von Hof a. S. – Neues Jahrbuch für Mineralogie, Geologie und Paläontologie, Beilageband **49**: 250–357, 393–509.

– 1926. Zur Kenntnis der Devon-Karbon-Grenze in Deutschland. – Zeitschrift der Deutschen Geologischen Gesellschaft **78**: 88–133.
Schmidt, H. 1922. Das Oberdevon-Culm-Gebiet von Warstein i. W. und Belecke. – Jahrbuch der Preußischen Geologischen Landesanstalt **41** (for 1920): 254–339.
– 1925. Die carbonischen Goniatiten Deutschlands. – Jahrbuch der Preußischen Geologischen Landesanstalt **45** (for 1924): 489–609.
Vöhringer, E. 1960. Die Goniatiten der unterkarbonischen *Gattendorfia*-Stufe im Hönnetal (Sauerland). – Fortschritte in der Geologie von Rheinland und Westfalen **3** (1): 107–196.
Wedekind, R. 1918. Die Genera der Palaeoammonoidea (Goniatiten). Mit Ausschluß der Mimoceratidae, Glyphioceratidae und Prokecanitidae. – Palaeontographica **62**: 85–184.
Weyer, D. 1972. Zum Alter der Ammonoideen-Fauna des Marshall-Sandsteins (Unterkarbon; Michigan, USA). – Berichte der deutschen Gesellschaft für geologische Wissenschaften, A, Geologie, Paläontologie **17** (3): 325–350.

Appendix

Conch dimensions and ratios of ammonoids from the Aguelmous.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
Globimitoceras rharrhizense n. sp.										
MB.C.10185.6	24.57	19.38	11.66	2.98	4.00	0.79	1.66	0.12	1.43	0.66
	17.44	14.89	7.99	2.17	2.78	0.85	1.86	0.12	1.42	0.65
MB.C.10185.3	23.80	16.61	11.41	2.48	4.04	0.70	1.46	0.10	1.45	0.65
	16.36	12.35	7.87	1.62	3.06	0.75	1.57	0.10	1.51	0.61
	10.56	9.75	5.22	1.13	2.05	0.92	1.87	0.11	1.54	0.61
	6.89	7.13	3.44	0.72	1.21	1.03	2.07	0.10	1.47	0.65
	4.72	5.19	2.31	0.64	0.73	1.10	2.25	0.14	1.40	0.68
	3.35	3.91	1.61	0.56	0.58	1.17	2.43	0.17	1.46	0.64
	2.29	3.12	1.09	0.39	0.50	1.36	2.86	0.17	1.64	0.54
Acutimitoceras hollardi Bockwinkel & Ebbighausen, 2006										
MB.C.10154.4	13.98	8.18	7.42	1.08	4.52	0.59	1.10	0.08	2.18	0.39
MB.C.10154.1	8.96	5.34	4.99	0.79	2.45	0.60	1.07	0.09	1.90	0.51
	4.77	3.42	2.35	0.84	1.24	0.72	1.45	0.18	1.82	0.47
MB.C.10192.4	10.22	6.01	5.84	0.47	3.07	0.59	1.03	0.05	2.04	0.47
	5.16	3.50	2.62	0.66	1.32	0.68	1.34	0.13	1.80	0.50
	2.86	2.14	1.27	0.69	0.68	0.75	1.69	0.24	1.72	0.46
	1.68	1.22	0.65	0.54	0.39	0.73	1.87	0.32	1.71	0.40
	0.94	0.90	0.50	0.06	0.25	0.96	1.79	0.07	1.84	0.51
Acutimitoceras occidentale Bockwinkel & Ebbighausen, 2006										
MB.C.10196.3	20.11	10.74	11.35	0.53	5.49	0.53	0.95	0.03	1.89	0.52
	10.84	6.45	5.88	0.68	2.80	0.60	1.10	0.06	1.82	0.52
	5.99	3.78	2.90	0.96	1.40	0.63	1.30	0.16	1.70	0.52
	3.53	2.40	1.53	0.93	0.77	0.68	1.57	0.26	1.63	0.50
	2.16	1.44	0.85	0.69	0.47	0.66	1.69	0.32	1.62	0.45
	1.36	1.09	0.58	0.35	0.29	0.80	1.87	0.25	1.61	0.51
MB.C.10196.4	14.79	7.85	8.38	0.48	4.00	0.53	0.94	0.03	1.88	0.52
	7.81	4.65	4.08	0.83	2.11	0.60	1.14	0.11	1.88	0.48
	4.27	2.84	1.83	1.14	0.98	0.67	1.56	0.27	1.68	0.47
	2.56	1.73	1.03	0.81	0.54	0.68	1.67	0.32	1.60	0.48
	1.60	1.28	0.71	0.41	0.34	0.80	1.79	0.26	1.62	0.52
	0.98	0.94	0.54	0.06	0.27	0.96	1.76	0.06	1.93	0.49
Acutimitoceras intermedium (Schindewolf, 1923)										
MB.C.10206.1	19.18	13.26	11.21	0.34	5.26	0.69	1.18	0.02	1.90	0.53
	10.42	7.97	5.89	0.50	2.68	0.76	1.35	0.05	1.81	0.55
	5.91	5.03	2.88	0.97	1.31	0.85	1.75	0.16	1.65	0.55
	3.59	3.08	1.48	1.10	0.75	0.86	2.08	0.31	1.60	0.49
	2.22	1.92	0.83	0.79	0.48	0.86	2.32	0.36	1.62	0.42
	1.43	1.19	0.52	0.50	0.31	0.83	2.30	0.35	1.62	0.41
	0.92	0.91	0.44	0.13	0.21	0.98	2.07	0.14	1.66	0.53
MB.C.10155.4	15.66	10.44	8.91	0.82	4.95	0.67	1.17	0.05	2.14	0.44
	7.76	5.98	3.91	1.01	1.93	0.77	1.53	0.13	1.77	0.51
	4.47	3.61	1.99	1.04	1.01	0.81	1.82	0.23	1.67	0.49
	2.71	2.18	0.97	0.91	0.48	0.80	2.25	0.34	1.48	0.50
	1.79	1.33	0.65	0.64	0.37	0.74	2.06	0.36	1.58	0.43
	1.11	1.07	0.49	0.17	0.26	0.96	2.20	0.15	1.68	0.48

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
MB.C.10216.1	13.68	9.25	7.80	0.52	3.84	0.68	1.19	0.04	1.93	0.51
	7.24	5.62	3.82	0.67	1.84	0.78	1.47	0.09	1.80	0.52
	4.10	3.43	1.91	0.78	0.99	0.84	1.80	0.19	1.73	0.48
	2.37	1.92	0.95	0.74	0.52	0.81	2.03	0.31	1.63	0.46
	1.47	1.17	0.55	0.37	0.33	0.80	2.12	0.25	1.65	0.41
Acutimitoceras depressum (Vöhringer, 1960)										
MB.C.10190.1	12.80	10.33	7.29	0.31	3.36	0.81	1.42	0.02	1.84	0.54
	7.07	6.13	3.69	0.84	1.57	0.87	1.66	0.12	1.65	0.58
	4.27	3.73	2.10	0.82	1.02	0.87	1.78	0.19	1.73	0.51
	2.54	2.15	1.10	0.68	0.56	0.85	1.95	0.27	1.65	0.49
	1.53	1.29	0.62	0.35	0.36	0.84	2.09	0.23	1.71	0.42
	0.90	0.86	0.44	0.02	0.23	0.96	1.94	0.02	1.78	0.49
MB.C.10152.3	12.14	9.42	6.48	0.88	2.74	0.78	1.45	0.07	1.67	0.58
	7.20	5.94	3.48	1.18	1.67	0.83	1.71	0.16	1.69	0.52
	4.32	3.58	1.92	0.99	0.95	0.83	1.86	0.23	1.64	0.51
	2.63	2.03	1.02	0.80	0.58	0.77	1.99	0.30	1.65	0.43
	1.61	1.09	0.57	0.53	0.35	0.68	1.90	0.33	1.64	0.39
	0.98	0.91	0.45	0.13	0.21	0.93	2.02	0.14	1.63	0.53
Acutimitoceras sarahae										
MB.C.10156.1	15.01	9.18	7.95	1.18	4.25	0.61	1.15	0.08	1.95	0.47
MB.C.10207.2	25.55	15.02	15.52	0.04	–	0.59	–	0.00	–	–
MB.C.10156.2	13.05	7.52	6.40	1.39	3.75	0.58	1.18	0.11	1.97	0.41
MB.C.10207.1	21.61	12.38	12.34	0.58	6.13	0.57	1.00	0.03	1.95	0.50
	11.06	6.85	5.57	1.68	2.73	0.62	1.23	0.15	1.76	0.51
	6.43	3.30	2.58	2.23	1.46	0.51	1.28	0.35	1.67	0.43
	3.95	1.60	1.05	2.05	0.79	0.40	1.53	0.52	1.56	0.25
	2.44	0.97	0.64	1.31	0.52	0.40	1.52	0.54	1.61	0.18
	1.57	0.73	0.40	0.71	0.31	0.46	1.81	0.45	1.55	0.23
MB.C.10156.5	14.19	7.92	7.90	1.08	4.19	0.56	1.00	0.08	2.02	0.47
	7.27	3.91	3.29	1.74	1.82	0.54	1.19	0.24	1.78	0.45
	4.19	1.87	1.37	1.86	0.86	0.45	1.36	0.45	1.59	0.37
	2.66	1.05	0.65	1.45	0.50	0.40	1.60	0.55	1.52	0.23
	1.75	0.88	0.54	0.75	0.38	0.50	1.62	0.43	1.63	0.31
	1.08	0.76	0.43	0.27	0.24	0.70	1.77	0.25	1.67	0.43
Acutimitoceras mfisense Bockwinkel & Ebbighausen, 2006										
MB.C.10157.2	11.58	5.85	6.48	0.61	3.26	0.51	0.90	0.05	1.94	0.50
MB.C.10157.3	10.16	5.14	5.69	0.52	2.88	0.51	0.90	0.05	1.95	0.49
MB.C.10157.1	13.55	6.00	7.73	0.75	4.03	0.44	0.78	0.06	2.03	0.48
	6.91	3.46	3.31	1.49	1.70	0.50	1.05	0.22	1.76	0.49
	4.02	1.98	1.33	1.79	0.83	0.49	1.48	0.44	1.59	0.38
	2.51	1.24	0.69	1.29	0.52	0.49	1.79	0.51	1.59	0.25
	1.62	0.98	0.48	0.73	0.33	0.60	2.05	0.45	1.58	0.30
Acutimitoceras endoserpens n. sp.										
MB.C.10153.1	12.93	6.23	6.44	1.97	3.67	0.48	0.97	0.15	1.95	0.43
MB.C.10215.1	13.78	7.62	7.51	1.18	3.71	0.55	1.01	0.09	1.87	0.51
MB.C.10153.2	9.93	4.61	4.68	2.32	2.47	0.46	0.99	0.23	1.77	0.47
MB.C.10153.3	14.60	6.60	8.28	0.28	3.99	0.45	0.80	0.02	1.89	0.52
	7.69	4.02	3.88	1.51	2.03	0.52	1.04	0.20	1.84	0.48
	4.30	1.97	1.29	2.05	0.96	0.46	1.53	0.48	1.66	0.25
	2.65	1.11	0.69	1.41	0.49	0.42	1.61	0.53	1.51	0.29
	1.73	0.90	0.57	0.72	0.35	0.52	1.58	0.42	1.57	0.39
	1.09	0.72	0.37	0.36	0.22	0.67	1.96	0.33	1.58	0.40
MB.C.10191.2	11.05	5.45	6.08	1.06	3.06	0.49	0.90	0.10	1.91	0.50
	5.94	3.06	2.34	2.13	1.38	0.52	1.31	0.36	1.69	0.41
	3.56	1.59	1.01	1.80	0.72	0.45	1.58	0.50	1.57	0.28
	2.27	1.06	0.64	1.15	0.44	0.47	1.66	0.51	1.53	0.32
	1.49	0.81	0.47	0.59	0.29	0.54	1.70	0.39	1.53	0.40
	0.91	0.66	0.36	0.21	0.22	0.72	1.84	0.23	1.75	0.38
Acutimitoceras algeriense Ebbighausen, Bockwinkel & Korn, 2004										
MB.C.10228.1	87.22	39.75	50.06	0.49	23.39	0.46	0.79	0.01	1.87	0.53
MB.C.10228.5	31.10	17.55	19.69	0.30	8.63	0.56	0.89	0.01	1.92	0.56
MB.C.10151	14.65	8.89	8.05	0.77	3.97	0.61	1.10	0.05	1.88	0.51
MB.C.10228.2	64.48	27.36	37.49	0.44	17.58	0.42	0.73	0.01	1.89	0.53
	34.36	17.11	19.65	0.68	9.97	0.50	0.87	0.02	1.98	0.49

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
MB.C.10228.3	19.53	9.00	11.51	0.36	6.63	0.46	0.78	0.02	–	0.42
	8.31	5.27	4.69	0.54	2.58	0.63	1.12	0.07	2.11	0.45
	4.07	2.94	2.04	0.58	1.17	0.72	1.44	0.14	1.96	0.43
	2.09	1.65	0.92	0.52	0.55	0.79	1.79	0.25	1.85	0.40
	1.16	1.04	0.42	0.37	0.29	0.90	2.49	0.32	1.79	0.30
Acutimitoceras sp. A										
MB.C.10223.3	70.57	37.60	41.31	1.09	21.68	0.53	0.91	0.02	2.08	0.48
MB.C.10223.8	44.17	24.05	22.64	1.59	14.13	0.54	1.06	0.04	2.16	0.38
MB.C.10223.9	35.19	20.94	19.97	1.68	11.12	0.60	1.05	0.05	2.14	0.44
MB.C.10223.2	30.20	19.65	17.68	1.24	8.77	0.65	1.11	0.04	1.99	0.50
MB.C.10223.7	20.84	13.16	10.52	1.17	6.18	0.63	1.25	0.06	2.02	0.41
MB.C.10223.6	18.84	11.46	10.34	1.05	5.93	0.61	1.11	0.06	2.13	0.43
MB.C.10223.4	17.47	9.55	10.11	0.28	4.83	0.55	0.94	0.02	1.91	0.52
	9.10	5.74	5.28	0.32	2.52	0.63	1.09	0.04	1.91	0.52
Acutimitoceras sp. B										
MB.C.10209.2	28.03	22.93	15.43	1.02	6.85	0.82	1.49	0.04	1.75	0.56
	16.15	12.42	8.54	1.38	3.55	0.77	1.45	0.09	1.64	0.58
	9.78	6.29	4.86	1.83	2.26	0.64	1.29	0.19	1.69	0.54
	5.73	3.12	2.22	2.03	1.24	0.55	1.40	0.35	1.63	0.44
	3.55	1.66	1.09	1.69	0.73	0.47	1.52	0.48	1.59	0.33
	2.29	1.02	0.62	1.09	0.44	0.44	1.65	0.48	1.54	0.28
	1.45	0.93	0.57	0.37	0.35	0.64	1.65	0.25	1.74	0.38
MB.C.10209.1	25.17	21.39	14.32	0.65	6.20	0.85	1.49	0.03	1.76	0.57
	14.38	12.26	7.75	1.33	3.47	0.85	1.58	0.09	1.74	0.55
	8.45	6.69	4.30	1.17	1.82	0.79	1.56	0.14	1.62	0.58
	5.24	3.34	2.24	1.46	1.16	0.64	1.50	0.28	1.65	0.48
	3.13	1.57	1.05	1.38	0.69	0.50	1.50	0.44	1.64	0.35
	1.95	0.99	0.57	0.89	0.41	0.51	1.72	0.46	1.60	0.29
Acutimitoceras posterum Bockwinkel & Ebbighausen, 2006										
MB.C.10229	10.73	7.20	6.00	0.55	2.91	0.67	1.20	0.05	1.88	0.51
	5.90	3.98	2.92	1.14	1.50	0.67	1.36	0.19	1.80	0.49
	3.30	2.07	1.19	1.27	0.74	0.63	1.74	0.39	1.66	0.38
	2.04	1.36	0.70	0.74	0.44	0.66	1.94	0.36	1.63	0.37
	1.25	1.01	0.46	0.33	0.29	0.81	2.20	0.26	1.69	0.37
Acutimitoceras pentaconstrictum n. sp.										
MB.C.10218	11.53	6.23	6.17	0.40	3.20	0.54	1.01	0.03	1.91	0.48
Costimitoceras aitouamar n. sp.										
MB.C.10159.1	11.70	5.10	6.83	0.00	3.24	0.44	0,75	0.00	1.91	0.52
MB.C.10159.8	10.31	5.50	5.80	0.32	3.12	0.53	0.95	0.03	2.05	0.44
MB.C.10159.7	9.04	4.94	5.29	0.38	2.55	0.55	0.93	0.04	1.94	0.52
MB.C.10159.5	4.95	2.96	2.67	0.24	1.39	0.60	1.11	0.05	1.93	0.48
MB.C.10159.4	2.70	1.87	1.52	0.12	0.81	0.69	1.23	0.04	2.04	0.47
MB.C.10159.3	8.90	4.62	4.96	0.25	2.31	0.52	0.93	0.03	1.83	0.53
	4.74	2.81	2.61	0.23	1.26	0.59	1.08	0.05	1.85	0.52
	2.56	1.80	1.42	0.19	0.67	0.70	1.26	0.07	1.84	0.53
	1.42	1.14	0.64	0.36	0.31	0.81	1.80	0.26	1.65	0.51
MB.C.10197.2	6.57	3.81	3.57	0.15	1.62	0.58	1.06	0.02	1.76	0.55
	3.59	2.26	1.93	0.17	0.95	0.63	1.17	0.05	1.84	0.51
	1.93	1.38	0.95	0.29	0.48	0.72	1.45	0.15	1.77	0.50
	1.13	0.82	0.42	0.32	0.27	0.73	1.95	0.28	1.73	0.36
Hasselbachia gourara Ebbighausen, Bockwinkel & Korn, 2004										
MB.C.10234.2	8.77	4.17	3.10	2.9	1.46	0.48	1.35	0.33	1.44	0.53
MB.C.10179	15.36	7.08	6.72	3.30	2.84	0.46	1.05	0.21	1.51	0.58
	10.17	5.19	4.17	2.68	1.83	0.51	1.24	0.26	1.49	0.56
	6.82	4.04	2.53	2.32	1.16	0.59	1.60	0.34	1.45	0.54
	4.67	3.03	1.60	1.80	0.81	0.65	1.90	0.39	1.46	0.49
	3.19	2.36	1.03	1.38	0.54	0.74	2.29	0.43	1.45	0.47
	2.24	1.72	0.71	0.95	0.37	0.77	2.43	0.42	1.44	0.47
	1.53	1.27	0.56	0.48	0.30	0.83	2.27	0.31	1.55	0.46
Hasselbachia arca n. sp.										
MB.C.10233.1	9.18	5.70	3.24	3.41	1.46	0.62	1.76	0.37	1.41	0.55
MB.C.10233.2	16.93	9.52	5.7	6.36	3.11	0.56	1.67	0.38	1.50	0.45
MB.C.10233.4	10.12	5.57	3.11	4.09	1.69	0.55	1.79	0.40	1.44	0.46

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
MB.C.10233.3	8.48	5.10	3.12	2.77	1.64	0.60	1.63	0.33	1.54	0.47
MB.C.10233.5	12.65	7.27	5.08	3.71	2.20	0.58	1.43	0.29	1.46	0.57
	8.63	5.70	3.08	3.10	1.54	0.66	1.85	0.36	1.48	0.50
	5.80	4.13	1.84	2.43	0.99	0.71	2.25	0.42	1.46	0.46
	3.93	2.98	1.23	1.70	0.71	0.76	2.43	0.43	1.49	0.42
	2.64	2.14	0.86	1.07	0.49	0.81	2.48	0.41	1.50	0.44
	1.74	1.48	0.62	0.60	0.36	0.85	2.39	0.34	1.58	0.43
	1.09	0.93	0.42	0.27	0.27	0.85	2.21	0.25	1.77	0.36
MB.C.10233.6	10.73	6.31	3.58	4.16	1.74	0.59	1.76	0.39	1.42	0.51
	7.60	5.08	2.43	3.07	1.27	0.67	2.09	0.40	1.44	0.48
	5.20	3.86	1.72	2.08	0.88	0.74	2.25	0.40	1.45	0.49
	3.55	2.74	1.15	1.45	0.66	0.77	2.38	0.41	1.50	0.43
	2.35	1.94	0.75	0.97	0.41	0.82	2.58	0.41	1.47	0.45
	1.59	1.30	0.58	0.50	0.33	0.82	2.23	0.32	1.60	0.43
	0.96	0.86	0.43	0.15	0.23	0.90	2.01	0.15	1.71	0.47
Hasselbachia sp.										
MB.C.10235.3	8.05	5.56	3.54	1.85	1.73	0.69	1.57	0.23	1.62	0.51
	4.98	3.86	1.90	1.65	1.00	0.78	2.03	0.33	1.57	0.47
	3.18	2.52	1.14	1.16	0.63	0.79	2.21	0.37	1.56	0.45
	2.03	1.69	0.72	0.72	0.43	0.83	2.33	0.35	1.62	0.40
	1.23	1.08	0.50	0.33	0.30	0.88	2.15	0.27	1.74	0.41
MB.C.10235.2	11.88	7.06	5.63	1.98	2.41	0.59	1.25	0.17	1.58	0.57
	7.56	5.08	3.24	1.86	1.55	0.67	1.57	0.25	1.58	0.52
	4.74	3.56	1.90	1.51	1.01	0.75	1.88	0.32	1.62	0.47
Kornia citrus n. sp.										
MB.C.10165.4	16.31	14.70	8.02	0.62	3.63	0.90	1.83	0.04	1.65	0.55
MB.C.10202.1	8.18	9.31	4.32	0.38	1.68	1.14	2.15	0.05	1.58	0.61
	5.16	6.09	2.60	0.51	0.98	1.18	2.35	0.10	1.52	0.62
	3.51	3.76	1.48	0.66	0.59	1.07	2.55	0.19	1.44	0.60
	2.37	2.16	0.96	0.57	0.39	0.91	2.24	0.24	1.43	0.60
MB.C.10165.2	7.07	8.80	3.70	0.62	1.42	1.25	2.38	0.09	1.57	0.61
	4.63	6.11	2.32	0.64	0.86	1.32	2.64	0.14	1.51	0.63
	3.10	3.62	1.31	0.76	0.57	1.17	2.76	0.25	1.50	0.56
	2.05	2.00	0.79	0.63	0.36	0.98	2.54	0.31	1.47	0.55
	1.36	1.06	0.52	0.35	0.29	0.78	2.05	0.26	1.61	0.44
Imitoceras oxydentale Bockwinkel & Ebbighausen, 2006										
MB.C.10162.1	16.66	7.57	9.09	0.78	5.41	0.45	0.83	0.05	2.19	0.41
MB.C.10200.1	16.13	7.28	9.24	0.33	4.58	0.45	0.79	0.02	1.95	0.50
	8.32	4.18	4.66	0.41	2.24	0.50	0.90	0.05	1.87	0.52
	4.51	2.25	2.26	0.72	1.17	0.50	0.99	0.16	1.82	0.48
	2.50	1.33	1.12	0.69	0.64	0.53	1.18	0.28	1.80	0.43
	1.43	0.97	0.56	0.41	0.29	0.68	1.73	0.29	1.56	0.49
	0.88	0.77	0.43	0.16	0.24	0.87	1.77	0.19	1.88	0.45
MB.C.10162.5	13.09	5.95	7.62	0.12	3.91	0.45	0.78	0.01	2.03	0.49
	6.50	3.05	3.56	0.55	1.77	0.47	0.86	0.08	1.89	0.50
	3.48	1.78	1.57	0.87	0.89	0.51	1.13	0.25	1.81	0.43
	1.92	1.12	0.72	0.65	0.48	0.58	1.54	0.34	1.78	0.34
Imitoceras sp.										
MB.C.10187.2	38.42	15.86	22.82	0.58	12.04	0.41	0.70	0.02	2.12	0.47
	17.90	9.60	10.69	0.24	5.83	0.54	0.90	0.01	2.20	0.45
	7.91	5.12	4.68	0.33	2.53	0.65	1.09	0.04	2.16	0.46
	3.78	2.84	1.96	0.55	0.96	0.75	1.45	0.15	1.80	0.51
	2.10	1.58	0.99	0.40	0.55	0.75	1.60	0.19	1.84	0.44
	1.17	1.10	0.54	0.15	0.30	0.94	2.02	0.12	1.83	0.44
MB.C.10187.4	21.99	11.47	12.84	0.29	6.98	0.52	0.89	0.01	2.15	0.46
	10.12	6.36	5.94	0.43	3.13	0.63	1.07	0.04	2.10	0.47
	4.85	3.58	2.44	0.84	1.35	0.74	1.47	0.17	1.92	0.45
	2.65	2.00	1.16	0.59	0.70	0.75	1.72	0.22	1.84	0.40
	1.48	1.24	0.65	0.28	0.38	0.84	1.90	0.19	1.81	0.42
Gattendorfia jacquelinae Ebbighausen, Bockwinkel & Korn, 2004										
MB.C.10232.3	52.21	32.75	23.04	10.27	13.1	0.63	1.42	0.20	1.78	0.43
MB.C.10232.4	53.52	31.58	24.06	13.43	12.81	0.59	1.31	0.25	1.73	0.47
	33.12	23.82	12.45	11.61	6.65	0.72	1.91	0.35	1.57	0.47
	21.45	15.37	6.90	9.11	4.04	0.72	2.23	0.42	1.52	0.41
	14.03	9.93	3.96	7.04	2.49	0.71	2.51	0.50	1.48	0.37
	9.35	5.60	2.37	5.24	1.69	0.60	2.36	0.56	1.49	0.29

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
	6.37	3.16	1.40	3.85	1.12	0.50	2.26	0.60	1.47	0.20
	4.38	2.13	0.93	2.68	0.73	0.49	2.30	0.61	1.44	0.21
	3.04	1.56	0.74	1.59	0.54	0.51	2.12	0.52	1.48	0.27
	2.01	1.19	0.63	0.86	0.42	0.59	1.89	0.43	1.60	0.33
	1.27	0.99	0.50	0.30	0.30	0.78	1.99	0.23	1.71	0.40
MB.C.10177.2	8.57	4.76	2.19	4.46	1.43	0.55	2.17	0.52	1.44	0.35
	5.70	3.38	1.53	2.98	1.11	0.59	2.20	0.52	1.54	0.28
	3.70	2.05	0.93	2.01	0.71	0.56	2.20	0.54	1.53	0.24
	2.43	1.46	0.64	1.24	0.47	0.60	2.27	0.51	1.54	0.27
	1.59	1.12	0.49	0.52	0.34	0.71	2.28	0.33	1.62	0.31
Gattendorfia debouaaensis (Bockwinkel & Ebbighausen, 2006)										
MB.C.10230.1	64.17	46.26	21.45	16.77	11.91	0.72	2.16	0.26	1.51	0.44
MB.C.10175.4	41.19	33.91	14.92	13.25	9.90	0.82	2.27	0.32	1.73	0.34
MB.C.10175.1	43.68	34.89	17.54	12.48	9.33	0.80	1.99	0.29	1.62	0.47
	26.69	21.46	10.41	8.81	5.95	0.80	2.06	0.33	1.66	0.43
	16.47	12.55	5.72	6.37	3.41	0.76	2.19	0.39	1.59	0.40
MB.C.10230.3	40.06	32.14	15.99	12.19	8.52	0.80	2.01	0.30	1.61	0.47
	24.59	20.86	9.06	9.00	4.91	0.85	2.30	0.37	1.56	0.46
	15.63	12.23	5.39	6.85	3.04	0.78	2.27	0.44	1.54	0.43
MB.C.10230.4	18.28	13.73	7.16	6.29	4.32	0.75	1.92	0.34	1.71	0.40
	10.93	7.52	3.43	4.90	2.27	0.69	2.19	0.45	1.59	0.34
	6.96	4.38	1.97	3.43	1.44	0.63	2.22	0.49	1.59	0.27
	4.39	2.44	1.13	2.37	0.84	0.56	2.15	0.54	1.52	0.26
	2.91	1.56	0.73	1.57	0.54	0.53	2.14	0.54	1.50	0.26
	1.91	1.11	0.51	0.91	0.34	0.58	2.16	0.48	1.47	0.35
	1.23	1.03	0.48	0.23	0.32	0.83	2.15	0.18	1.80	0.34
Gattendorfia lhceni n. sp.										
MB.C.10225.1	44.21	23.64	21.44	8.39	12.02	0.53	1.10	0.19	1.89	0.44
MB.C.10225.2	25.89	14.88	11.17	5.45	7.17	0.57	1.33	0.21	1.91	0.36
MB.C.10225.5	17.58	10.45	8.46	3.65	4.42	0.59	1.24	0.21	1.78	0.48
MB.C.10225.6	11.11	7.05	5.11	3.17	2.70	0.63	1.38	0.29	1.75	0.47
	6.47	3.17	1.82	3.27	1.42	0.49	1.74	0.51	1.64	0.22
	3.95	1.63	1.05	2.10	0.82	0.41	1.55	0.53	1.59	0.22
MB.C.10225.7	10.89	6.66	3.86	4.42	2.53	0.61	1.73	0.41	1.70	0.34
	6.53	3.38	1.65	3.66	1.31	0.52	2.05	0.56	1.57	0.20
	4.23	1.92	0.89	2.57	0.73	0.45	2.16	0.61	1.46	0.18
	2.88	1.32	0.64	1.68	0.52	0.46	2.07	0.58	1.49	0.19
	1.94	1.06	0.50	0.93	0.36	0.55	2.13	0.48	1.50	0.28
	1.24	1.05	0.51	0.27	0.22	0.85	2.06	0.22	1.47	0.57
Gattendorfia gisae n. sp.										
MB.C.10176.1	61.72	47.65	27.08	16.39	18.53	0.77	1.76	0.27	2.04	0.32
	30.24	25.65	12.81	8.73	8.92	0.85	2.00	0.29	2.01	0.30
	15.32	12.71	6.12	4.87	4.03	0.83	2.08	0.32	1.84	0.34
MB.C.10176.2	44.45	37.33	19.01	12.09	12.32	0.84	1.96	0.27	1.91	0.35
	22.86	18.25	9.26	7.20	6.21	0.80	1.97	0.31	1.89	0.33
	12.43	9.15	4.50	4.62	2.89	0.74	2.03	0.37	1.70	0.36
MB.C.10231.1	20.21	15.93	7.97	6.38	5.40	0.79	2.00	0.32	1.86	0.32
	11.00	7.98	4.04	4.02	2.68	0.73	1.98	0.37	1.75	0.34
	6.37	4.38	2.25	2.34	1.42	0.69	1.95	0.37	1.66	0.37
	3.84	2.58	1.46	1.28	0.88	0.67	1.77	0.33	1.68	0.40
Kazakhstania nitida Bockwinkel & Ebbighausen, 2006										
MB.C.10164.2	4.49	1.80	1.03	2.59	0.80	0.40	1.74	0.58	1.48	0.22
	3.07	1.20	0.77	1.69	0.59	0.39	1.57	0.55	1.54	0.23
	2.02	0.90	0.48	1.06	0.41	0.45	1.87	0.52	1.58	0.15
	1.25	0.80	0.41	0.39	0.27	0.64	1.93	0.31	1.64	0.33
MB.C.10164.3	4.11	1.59	0.92	2.42	0.73	0.39	1.73	0.59	1.48	0.20
	2.77	1.09	0.66	1.54	0.51	0.39	1.65	0.56	1.51	0.22
	1.84	0.88	0.54	0.83	0.36	0.48	1.63	0.45	1.55	0.33
	1.16	0.76	0.41	0.32	0.27	0.66	1.86	0.28	1.70	0.34
Eocanites simplex Bockwinkel & Ebbighausen, 2006										
MB.C.10160.1	11.05	4.23	3.29	5.36	2.80	0.38	1.29	0.49	1.79	0.15
MB.C.10160.2	7.48	2.87	2.10	3.77	1.80	0.38	1.37	0.50	1.73	0.14
	4.29	1.81	1.26	2.06	1.09	0.42	1.43	0.48	1.80	0.14
	2.41	1.17	0.71	1.09	0.58	0.48	1.64	0.45	1.74	0.18
	1.38	0.86	0.47	0.53	0.35	0.62	1.81	0.38	1.78	0.27
	0.77	0.76	0.38	0.08	0.23	0.98	1.99	0.10	2.04	0.39

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
Kahlacanites mariae Ebbighausen, Bockwinkel & Korn, 2004										
MB.C.10181.1	20.33	6.96	8.36	5.97	5.68	0.34	0.83	0.29	1.93	0.32
MB.C.10236.2	21.02	6.15	7.91	7.33	5.52	0.29	0.78	0.35	1.84	0.30
	11.33	4.01	3.98	4.51	3.04	0.35	1.01	0.40	1.87	0.24
	6.01	2.47	1.93	2.75	1.61	0.41	1.28	0.46	1.86	0.17
	3.26	1.42	0.96	1.59	0.83	0.44	1.48	0.49	1.80	0.13
MB.C.10236.3	15.92	5.34	6.04	5.63	4.04	0.34	0.89	0.35	1.80	0.33
	8.86	3.62	2.99	3.78	2.21	0.41	1.21	0.43	1.78	0.26
	5.08	2.12	1.51	2.50	1.17	0.42	1.40	0.49	1.69	0.22
	2.99	1.31	0.80	1.54	0.68	0.44	1.64	0.51	1.68	0.15
	1.77	0.99	0.56	0.77	0.44	0.56	1.76	0.44	1.77	0.22
	0.99	0.73	0.36	0.26	0.27	0.73	1.99	0.26	1.89	0.26
Kahlacanites meyendorffi Ebbighausen, Bockwinkel & Korn, 2004										
MB.C.10174	14.78	4.45	4.83	6.43	4.56	0.30	0.92	0.44	2.09	0.06
MB.C.10237	14.02	5.19	4.71	6.10	3.90	0.37	1.10	0.44	1.92	0.17

