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The Early Carboniferous (Mississippian) ammonoids from the Chebket el Hamra (Jerada Basin, Morocco)

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Abstract

Five Late Viséan ammonoid assemblages of North Variscan provenance are described from the locality Chebket el Hamra (Jerada Basin, north-eastern Morocco). These assemblages are composed of 27 species of the genera *Eoglyphioceras*, *Girtyoceras*, *Sulcogirtyoceras*, *Metadimorphoceras*, *Goniatites*, *Arnsbergites*, *Hibernicoceras*, *Paraglyphioceras*, *Lusitanoceras*, *Sudeticeras*, *Neoglyphioceras*, *Lusitanites*, *Ferganoceras*, *Praedaraelites*, and *Pronorites*. The new subfamily Arnsbergitinae is described, as well as the thirteen new species *Eoglyphioceras minutum* n. sp., *Girtyoceras ibnkhaldouni* n. sp., *Metadimorphoceras anguinosum* n. sp., *Arnsbergites ferrus* n. sp., *Arnsbergites proiecturus* n. sp., *Arnsbergites rufus* n. sp., *Hibernicoceras touissitense* n. sp., *Hibernicoceras artilobatum* n. sp., *Paraglyphioceras celeris* n. sp., *Lusitanoceras zirari* n. sp., *Sudeticeras ibnbajjahi* n. sp., *Sudeticeras horoni* n. sp., and *Pronorites owodenkoi* n. sp.

Introduction

North-western Africa is a key region for the understanding of Carboniferous ammonoid evolution and biogeography. Although the occurrences in Morocco and Algeria do not belong to the 'classical'areas of Palaeozoic ammonoid palaeontology, they can be regarded now as one of the most promising sites for future investigations.

Carboniferous ammonoids from North Africa were discovered at the beginning of the 20th century and were described in a short article by Dollé (1912), much later than occurrences from other regions such as North England (e.g. Phillips 1836, 1841), Belgium (e.g. de Koninck 1844, 1880), the Rhenish Mountains (e.g. Sandberger & Sandberger 1850–1856), and the American Midcontinent (e.g. Hall 1860). A more extensive description of ammonoids from north-western Algeria was provided by Menchikoff (1930), before Delépine (1941) summarised the knowledge of that time in his monograph on the Carboniferous ammonoids from North Africa. His descriptions are mainly based on material assembled in the 1930s by the field investigators Clariond, Owodenko, Menchikoff, Neltner, and particularly H. Termier (1936a, 1936b). The material available to Delépine was collected in various places in Morocco and north-western Algeria, and was mostly composed of rather species-poor assemblages of which the precise stratigraphy was not known.

Pareyn (1961) used sections in the area of Béni-Abbès and Béchar to establish a stratigraphy that was based on lithological as well as palaeontological data. He showed that the Viséan rocks of his study area are rather rich in ammonoids, and pointed out close similarities of their faunas with the occurrences in the South Urals. It was mainly the study by Pareyn that placed North Africa among the important Carboniferous ammonoid-yielding regions.

The coal basin of Jerada in north-eastern Morocco was discovered in the late 1920s (Harroy & Brichant 1928) and was intensely studied and subsequently mapped (Owodenko 1946, 1976; Horon 1952). Owodenko was able to find a number of fossil horizons, which permitted dating and subdivision of the succession. Based on ammonoids, an interval from the late Viséan up to the late Westphalian could be correlated with the successions in Central and North-western Eu-

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rope. He investigated the area of the Chebket el Hamra in the vicinity of Touissit during field excursions in 1933 and 1934 and collected ammonoid material, which he sent to Delépine for interpretation. Few specimens were described and figured by Delépine (1941), but the fossil list gives an impression of the rather diverse fauna from that locality.

We investigated the area of the Chebket el Hamra during a field trip in 2006 supplemented by another in 2007. Our focus was the separation of distinct ammonoid-bearing horizons and the collection of rich assemblages, which allow a comparison with the time equivalents from other North African occurrences (such as the Anti-Atlas and the area around Béchar) and from the Subvariscan occurrences in Europe (such as South Portugal and Ireland).

With this report, we introduce a monograph on the ammonoid faunas from the Chebket el Hamra as a tool to discuss Carboniferous biogeography of Iberia and North Africa. It is a continuation of the monographic descriptions of the Carboniferous ammonoid faunas from north-western Africa (Ebbighausen et al. 2004; Bockwinkel & Ebbighausen 2006; Klug et al. 2006; Ebbighausen & Bockwinkel 2007).

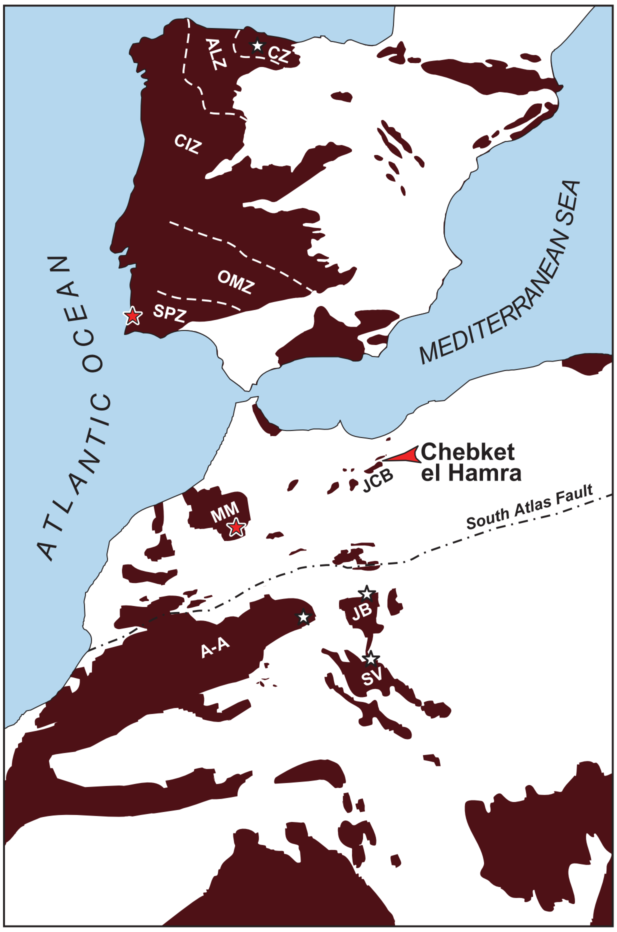


Figure 1. The outcrop of Palaeozoic rocks in North-western Africa and Iberia, the occurrences of Late Viséan ammonoid faunas (marked by asterisks), and the geographic position of the Chebket el Hamra. [CZ, Cantabrian Zone; ALZ, Asturo-Leonese Zone; CIZ, Central Iberian Zone; OMZ, Ossa-Morena Zone; SPZ, South Portuguese Zone; MM, Moroccan Meseta; JCB, Jerada Basin; A-A, Anti-Atlas; JB, Jebel Béchar; SV, Saoura Valley]. This figure is available in colour online at museum-fossilrecord.wiley-vch.de

Geographic and geological setting

The Chebket el Hamra (Chebikat el Hamra on modern maps) is a low butte, capped by Liassic sediments, on the east-northeastern extension of the Jerada Basin of east-northeast Morocco, 50 km south of the province capital Oujda, and immediately west of the mining town of Touissit (Figs 1–2). It was studied by a number of researchers (e.g. Brichant 1932, 1935; Clariond 1933; Clariond & Termier 1933) and intensely investigated and mapped by Owodenko (1946), who used the age determination of the fossil-bearing rocks previously given by Delépine (1941).

The Carboniferous rock succession in the Jerada Basin consists of rhyolites, cherts, shallow-water carbonates, shales, and sandstones; it is exposed there in an asymmetric syncline with a WSW–ENE axis. It possesses a steep southern flank (80–90° inclination) and gently dipping strata in the northern flank (20–30°). The N–S extension reaches 17 km in length, and the W–E extension to approximately 50 km. Portions of the Carboniferous rocks are covered by Mesozoic sediments, particularly towards the east where the Jerada Syncline dips below a Triassic and Jurassic cover. Stratigraphically the rock succession in the Jerada Basin extends from the Viséan into the Moscovian, as demonstrated by ammonoids (Delépine 1941; Owodenko 1946; Horon 1952; Owodenko & Horon 1952; Bouckaert & Owodenko 1965) and foraminifers (Vachard & Berkhli 1992; Berkhli et al. 1993, 1999a).

Following the earlier study by Owodenko, the Viséan rocks were re-investigated by Horon (1952) and Berkhli et al. (1993, 1999a, 1999b). In these articles, the succession of the Jerada Coal Basin was described in detail in the context of biostratigraphy and sequence stratigraphy. Formation names were proposed for the distinctive rock units by Berkhli et al. The Viséan interval, on the northern flank of the syncline, was subdivided into two major cycles, of which the lower was placed in the late Asbian, and the upper in the Brigantian (both Late Viséan).

As will be shown below, both formations are obviously identical.

The Carboniferous rocks of the Chebket el Hamra form the north-easternmost extension of the Jerada Basin. The small occurrence crops out in a tectonic horst structure, in an area of approximately 3 × 8 km was uplifted and subsequently opened due to the erosion of the covering Mesozoic rocks. Structurally, the occurrence at the Chebket el Hamra belongs to the northern flank of the Jerada Syncline, with the beds dipping at 20–30° to the south-southeast. The section begins with approximately 20 m of tuffites and turquoise-coloured cherts, followed by a sequence of more than 50 m of

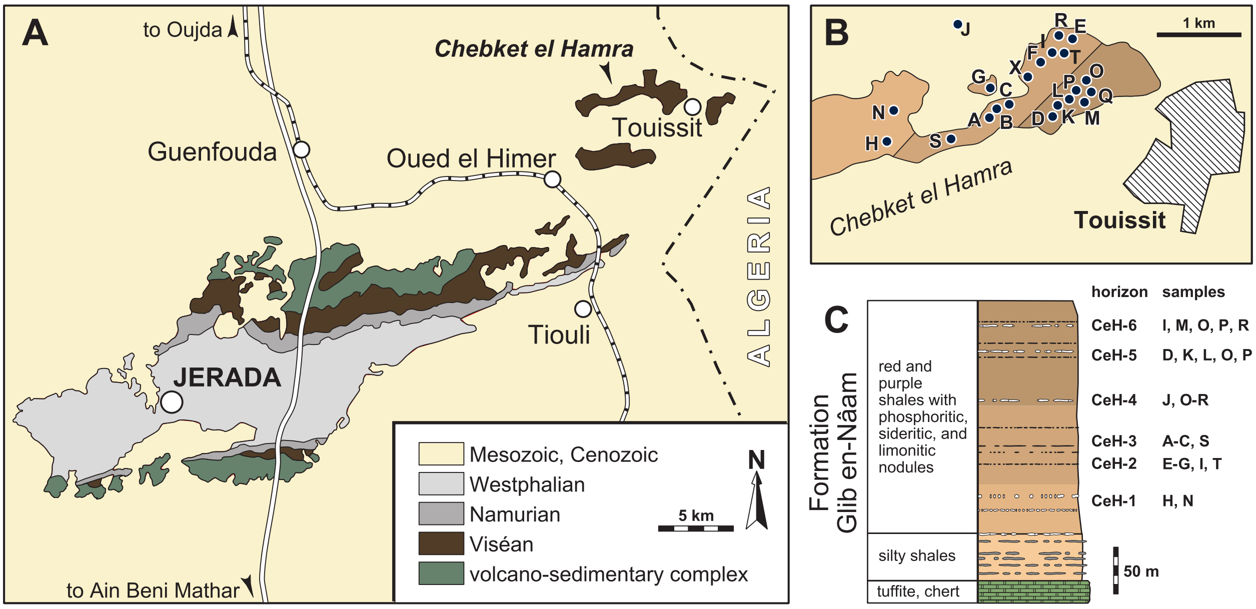


Figure 2. A. The geology of the Jerada Basin (mostly after Berkhli et al. 1999b) showing the location of the Chebket el Hamra. **B.** Detailed map of the Chebket el Hamra with position of the collected samples. **C.** Schematic columnar section with the position of the fossiliferous units and the collected samples. This figure is available in colour online at museum-fossilrecord.wiley-vch.de

silty shales with thin beds of sandstone and hard cherty nodules. These non-fossiliferous units are overlain by approximately 200 m of intensely weathered red and purple dark shales with phosphoritic, sideritic, and limonitic nodules and very thin limestone intercalations. This monotonous but fossiliferous succession yielded ammonoids from six clearly distinguishable units (here named CeH-1–CeH-6), in ascending order:

CeH-1 – Hard sideritic nodules with large specimens of *Goniatites crenistria* Phillips, 1836 and *Goniatites globostriatus* (Schmidt, 1925).

CeH-2 – Intensely weathered red to purple shales with a limonitic ammonoid fauna composed of the genera *Girtyoceras*, *Sulcogirtyoceras*, *Metadimorphoceras*, *Arnsbergites*, *Hibernicoceras*, *Paraglyphioceras*, *Sudeticeras*, *Neoglyphioceras*, *Praedaraelites*, and *Pronorites*.

CeH-3 – Red shales with limonitic specimens of *Eoglyphioceras*, *Metadimorphoceras*, and *Sudeticeras*.

CeH-4 – Red to purple sideritic nodules with *Sudeticeras*.

CeH-5 – Red shales with limonitic and phosphatic nodules containing *Lusitanoceras*, *Sudeticeras*, and *Lusitanites*.

CeH-6 – Red shales with sideritic nodules containing *Sudeticeras splendens* (Bisat, 1928).

Stratigraphy of the assemblages

Stratigraphy of the Viséan ammonoid faunas from the Jerada Basin is based on the investigations by Owodenko (1946). He discovered three succeeding assemblages which based on the determinations by Delépine, he attributed to the German ammonoid zonation proposed by Schmidt (1925). The three zones are '*Goniatites crenistria*', '*Goniatites striatus*' (= various species of *Arnsbergites*), and '*Goniatites granosus*' (= *Lusitanoceras zirari*). Though the identification of the latter two species is incorrect in the current state of knowledge, it can be said that the principal succession of ammonoid faunas was correctly identified and correlation with the Central European stratigraphy is corroborated by with the new study.

Owodenko (1946) mentioned two ammonoid assemblages from the Chebket el Hamra,

(1) from a locality more to the north:
'*Beyrichoceras obtusum* Phill.' = probably *Hibernicoceras* sp.
'*Beyrichoceras micronotum* Phill.' = probably *Sudeticeras* sp.
'*Paraprolecanites mixolobus* Sandberger' = probably *Praedaraelites culmiensis*

(2) from a locality more to the south:
'*Goniatites falcatus* Roemer.' = probably *Lusitanoceras zirari*
'*Beyrichoceras truncatum* Phill.' = probably *Sudeticeras splendens.*
Additionally, he mentioned one putatively Namurian specimen of '*Stenopronorites uralensis* Karpinsky' not found in situ, which most probably is the Late Viséan *Pronorites owodenkoi.*

The spectrum of genera within the samples from the Chebket el Hamra permits an interpretation of the age of the fossiliferous horizons from the late Asbian to the late Brigantian (Late Viséan). The material is composed of genera well-known from occurrences in the Rhenohercynian and Subvariscan, represented by *Eoglyphio-*

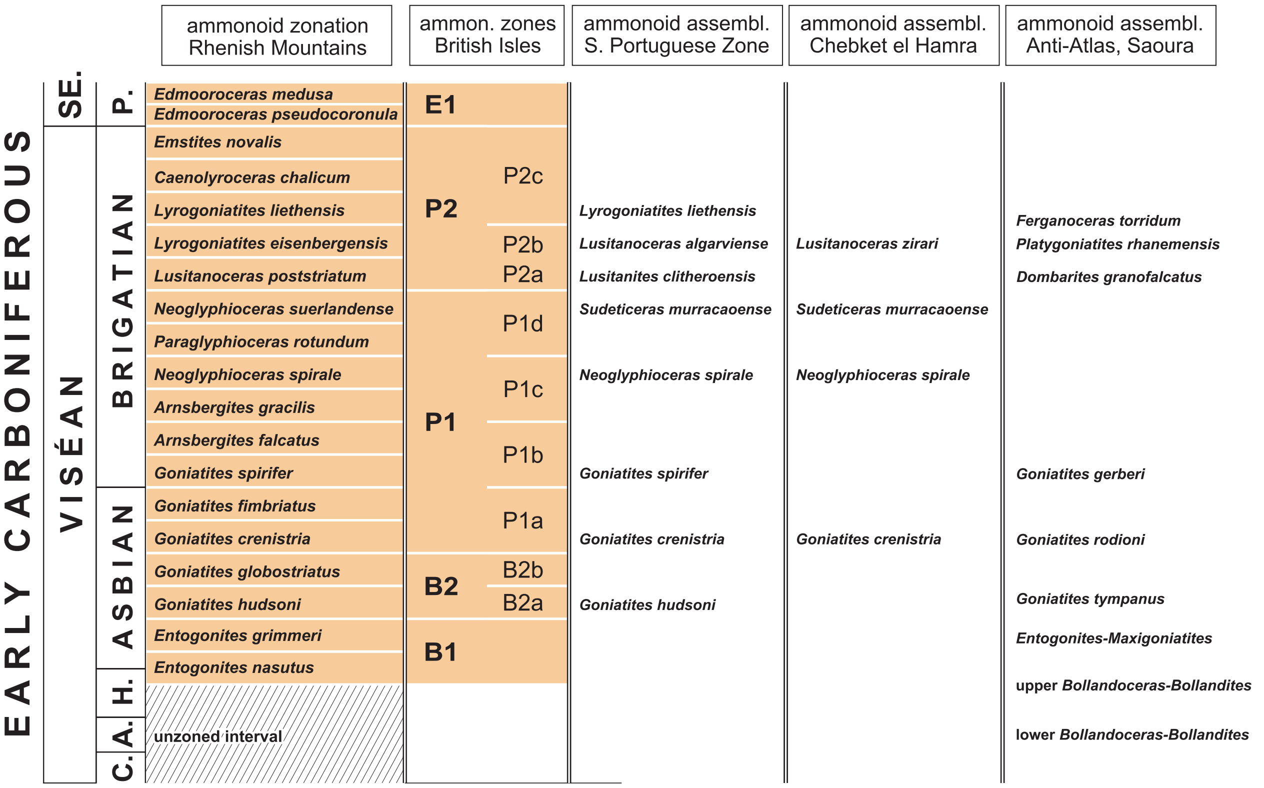


Figure 3. Stratigraphic scheme of the Late Viséan ammonoid zonation of the Rhenish Mountains and the British Isles, with correlation of the ammonoid assemblages from the South Portuguese Zone, Chebket el Hamra, and the Anti-Atlas as well as Saoura Valley. [C., Chadian; A., Arundian; H., Holkerian; SE., Serpukhovian; P., Pendleian]. This figure is available in colour online at museum-fossilrecord.wiley-vch.de

ceras, Girtyoceras, Sulcogirtyoceras, Metadimorphoceras, Goniatites, Arnsbergites, Hibernicoceras, Paraglyphioceras, Lusitanoceras, Sudeticeras, Neoglyphioceras, Lusitanites, Praedaraelites, and *Pronorites*. Close relationships can be detected with the ammonoid succession in the South Portuguese Zone (Korn 1997), but relationships to the ammonoid succession in places south of the High Atlas Fault are poorly known (Korn et al. 2007). The six ammonoid units of the Chebket el Hamra can be correlated as follows with the North Variscan zonations (Fig. 3):

CeH-1 – Based on the co-occurrence of *Goniatites crenistria* and *G. globostriatus*, a stratigraphic age of the basal *Goniatites crenistria* Zone (late Asbian) of the Rhenish Mountains is most likely (Korn 1996). Both species co-occur only at the base of this zone; *G. globostriatus* is not known from the widespread *Crenistria* Limestone at the top of the zone.

CeH-2 – The diverse assemblage with *Neoglyphioceras spirale*, *Praedaraelites culmiensis, Hibernicoceras* spp., *Arnsbergites* spp. etc. is known from the South Portuguese Zone (Korn 1997), north-western Ireland (Moore & Hodson 1958), the Rhenish Mountains (Korn 1988), and the Harz (Kobold 1933). It is a very distinctive fauna of the *Neoglyphioceras spirale* Zone (late early Brigantian) that, within the Jerada Basin and the South Portuguese Zone, is even very similar in preservation with the pyritized or limonitic steinkern specimens.

CeH-3 – The assemblage with limonitic *Sudeticeras murracaoense* closely resembles the *Sudeticeras murracaoense* horizon in the South Portuguese Zone (Korn 1997), where that species is very abundant in one single horizon. In terms of Central European ammonoid stratigraphy (Korn 1996), it may be placed in the *Neoglyphioceras suerlandense* Zone (late early Brigantian).

CeH-4 – The species-poor fauna with S*udeticeras horoni* was discovered a few metres above the previous assemblage, and mixing is seen in some places. An equivalent is not known from other regions. It may belong in the *Neoglyphioceras suerlandense* Zone of the Rhenish Mountains (late early Brigantian).

CeH-5 – The co-occurrence of *Lusitanoceras* and *Lusitanites* speaks for an attribution in the *Lusitanoceras poststriatum* Zone of the Rhenish Mountains that corresponds to the P2a Zone of the British Isles (late Brigantian). The specific composition of unit 5 allows a correlation with the South Portuguese Zone, where both genera occur, if not together then in an interval of two metres.

CeH-6 – *Sudeticeras splendens* (Bisat, 1928) suggests an attribution in the *Lyrogoniatites liethensis* Zone of the Rhenish Mountains that corresponds to the higher P2 (late Brigantian).

Faunas from the late Asbian (*Goniatites crenistria*), the early Brigantian (*Neoglyphioceras spirale* together with species of *Arnsbergites* and *Hibernicoceras*), and the late Brigantian (*Lusitanoceras zirari*) occur in the same rock unit, thus raising strong doubts concerning the interpretation of separate major cycles, as done by Berkhli et al. (1999b).

Material

More than 1,200 specimens from 21 different localities (each representing one sample) at the Chebket el Hamra were available for study. Principally, two different modes of preservation are represented in the material:

- Sideritic nodules (stratigraphic units CeH-1, CeH-3, CeH-6). Ammonoids from these nodules reach sizes of almost 10 cm, and are usually preserved as steinkerns with shell remains sometimes attached. Inner whorls are rarely preserved; usually only the body chamber was filled by sediment whereas the phragmocone imploded during diagenesis.
- Limonitic (or goethitic) preservation (stratigraphic units CeH-2, CeH-4, CeH-5). These ammonoid conchs are usually much smaller with a maximum diameter of 40 mm; normally only the phragmocone is preserved.

About 100 cross sections of most of the species were produced to allow the investigation of the inner whorls as well as separation and attribution of the juvenile specimens.

Systematic descriptions

Descriptive terms of the conch features are adopted from Korn (1988); abbreviations of the conch dimensions (Fig. 4) are: conch diameter (dm), whorl width (ww), whorl height (wh), umbilical width (uw), and aperture height (ah).

Conch shapes are described as follows:

- thinly discoidal: ww/dm < 0.36;
- discoidal: ww/dm $= 0.36$–0.60;
- pachyconic: ww/dm $= 0.61$–0.85;
- globular: ww/dm $= 0.86$–1.10.

Conch dimensions are subdivided as follows:

- small: dm < 30 mm
- moderate: dm $= 31$–70 mm;
- moderately large: dm $= 71$–120 mm;
- large: dm > 120 mm.

The width of the umbilicus, relative to the diameter of the conch, is termed as follows:

- very narrow: uw/dm < 0.16;
- narrow: uw/dm $= 0.16$–0.30;
- moderately wide: uw/dm $= 0.31$–0.45;
- wide: uw/dm $= 0.46$–0.60;
- very wide: uw/dm > 0.60.

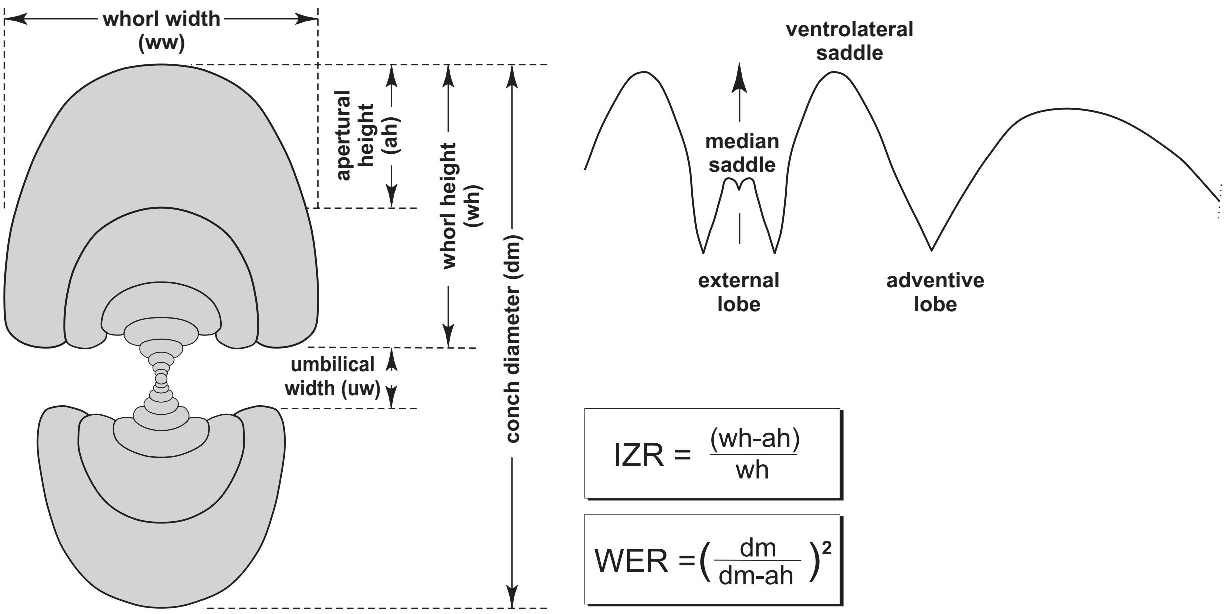
A very important conch parameter is the whorl expansion rate (WER). It can be calculated by the algorithm used by Korn (2000): $\mathrm{WER} = [\mathrm{dm}/(\mathrm{dm} - \mathrm{ah})]^2$. The imprint zone rate (IZR) is a ratio that characterises the whorl overlap. It can be calculated by the following equation: $\mathrm{IZR} = (\mathrm{wh} - \mathrm{ah})/\mathrm{wh}$.

The direction and the course of the growth lines are defined as:

- rursiradiate: turning back on the flanks;
- rectiradiate: running approximately radially;
- prorsiradiate: projecting on the flanks;
- linear: without remarkable projections and sinuses;
- convex: with only one lateral projection and a ventral sinus;
- concavo-convex: with a lateral sinus, a ventrolateral projection, and a ventral sinus;
- biconvex: with a dorsolateral and a ventrolateral projection, and a lateral as well as a ventral sinus.

Sutural terminology (Fig. 4) is according to Wedekind (1918), and Korn et al. (2003):

- external lobe (E lobe);
- median saddle (M saddle);



$$\mathrm{IZR} = \frac{(\mathrm{wh}-\mathrm{ah})}{\mathrm{wh}}$$

$$\mathrm{WER} = \left(\frac{\mathrm{dm}}{\mathrm{dm}-\mathrm{ah}}\right)^2$$

Figure 4. Conch and suture line parameters and ratios as used in the descriptions of the ammonoid species.

- ventrolateral saddle (E/A saddle; between external lobe and adventive lobe);
- adventive lobe (A lobe);
- dorsolateral saddle (A/L saddle; between adventive lobe and lateral lobe);
- lateral lobe (L lobe);
- umbilical lobe (U lobe);
- internal lobe (I lobe).

Especially in Carboniferous ammonoids, the shape of the external lobe is an important criterion for distinguishing higher-rank ammonoid taxa and also for species of one genus. Its general shape is described as follows:

- rectangular: with largely parallel, almost uncurved flanks;
- pouched or inflated: with more or less parallel, convexly curved flanks;
- V-shaped: with diverging, almost straight flanks;
- Y-shaped: with flanks parallel in the lower part, but diverging in the upper part.

The width of the external lobe, which is an important criterion for the separation of species and genera particularly of the Goniatitina, can be described (1) by the ratio of the width (at half depth) of the external lobe and the adventive lobe (E/A as used by Korn 1988), or (2) by the ratio of width (measured at half depth) and total depth of the external lobe (EL/h as used by Korn 1997).

The width of the external lobe is classified follows:

- very narrow: E/A < 0.50
- narrow: E/A = 0.50–0.75
- moderately narrow: E/A = 0.75–1.00
- moderate: E/A = 1.00–1.25
- moderately wide: E/A = 1.25–1.50
- wide: E/A = 1.50–1.75
- very wide: E/A > 1.75

The height of the median saddle is measured by its ratio with the depth of the external lobe (MS/h):

- very low: MS/h < 0.20
- low: MS/h = 0.20–0.35
- moderate: MS/h = 0.35–0.50
- moderately high: MS/h = 0.50–0.65
- high: MS/h = 0.65–0.80
- very high: MS/h > 0.80

The material described and figured in the following account is stored in the following collections:

Museum für Naturkunde der Humboldt-Universität zu Berlin (MB.C.prefix), British Museum (Natural History), London (NHM prefix), Geological Survey Museum, Keyworth, Nottinghaum (GSM prefix), Instituto Geológico e Mineiro, Lisboa (IGML prefix), Westfälisches Museum für Naturkunde, Münster (WMN prefix).

Order **Goniatitida** Hyatt, 1884
Suborder **Goniatitina** Hyatt, 1884
Superfamily **Muensteroceratoidea** Librovitch, 1957
Family **Muensteroceratidae** Librovitch, 1957

Eoglyphioceras Brüning, 1923

Type species. *Goniatites truncatus* Phillips, 1836.

Discussion. The problem regarding the taxonomic validity of the two genera *Eoglyphioceras* Brüning, 1923 and *Beyrichoceratoides* Bisat, 1924 is not fully resolved. Korn (1988) treated *Eoglyphioceras* as valid, whereas Riley (1996) regarded it as an invalid genus. This latter opinion was mainly based on the arguments that no type species was given for *Eoglyphioceras*, and that this genus was defined by amalgamation of *Beyrichoceras* and *Muensteroceras*.

Currently, nine species can be attributed with more or less certainty to *Eoglyphioceras* (Korn & Ilg, 2007). Several of these require revision to make clear that they really belong to this genus.

The better known Western and Central European species of *Eoglyphioceras* can be grouped as follows:

A – species with a large conch (reaching 50 mm in diameter or more):

E. truncatum (Phillips, 1836): with delicate radial ornament;
E. redesdalense (Hind, 1918): with coarse radial ornament and pachyconic conch;
E. fournieri (Delépine, 1940): with coarse radial ornament and discoidal conch.

B – species with a small conch (reaching 30 mm in diameter or less):

E. serotinum Korn, 1997: with few constrictions and delicate radial ornament;
E. minutum n. sp.: with numerous constrictions.

Eoglyphioceras minutum n. sp.

Figures 5–6

Derivation of name. After Latin *minutus* = minute, because of the small conch.

Holotype. Specimen MB.C.13269.1 (Ebbighausen & Weyer 2007 Coll.); illustrated in Figure 5A.

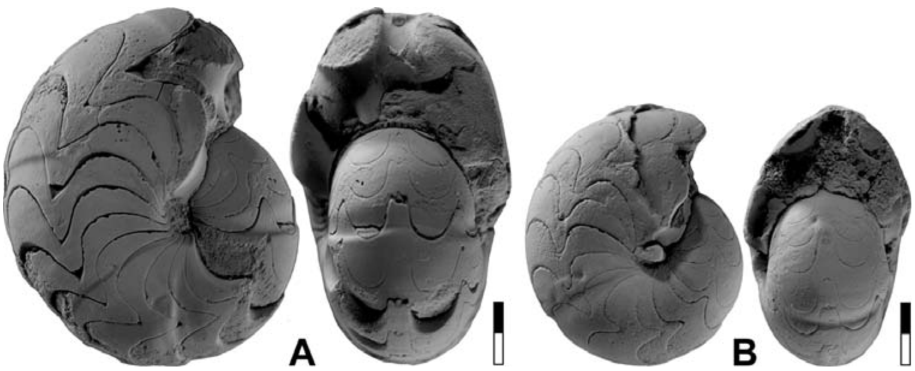


Figure 5. *Eoglyphioceras minutum* n. sp. **A.** Holotype MB.C.13269.1 from locality Chebket el Hamra-S; ×4.0. **B.** Paratype MB.C.13269.3 from locality Chebket el Hamra-S; ×4.0.

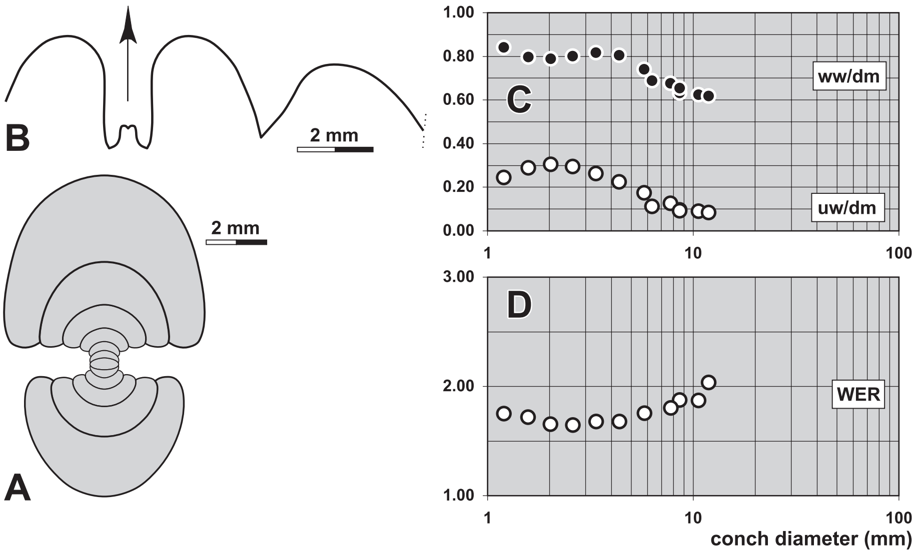


Figure 6. *Eoglyphioceras minutum* n. sp. **A.** Cross section of paratype MB.C.13269.2 from locality Chebket el Hamra-S; ×4.0. **B.** Suture line of paratype MB.C.13269.1 from locality Chebket el Hamra-S, at 11.5 mm dm, 7.0 mm ww, 6.5 mm wh; ×5.0. **C**, **D.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm) and whorl expansion rate (WER) of all available specimens.

Type locality and horizon. Chebket el Hamra-S (Jerada Basin, NE-Morocco); horizon CeH-4 (middle Brigantian, Early Carboniferous).

Material. Three limonitic steinkern specimens of phragmocones between 8.5 and 12 mm conch diameter from horizon CeH-4 at locality Chebket el Hamra-S.

Diagnosis. Small *Eoglyphioceras* with thinly pachyconic conch at 6 mm diameter (ww/dm = 0.70) and thickly discoidal to thinly pachyconic conch at 12 mm diameter (ww/dm = 0.60). Umbilicus very narrow between 8 mm and 12 mm dm (uw/dm = 0.10); umbilical margin broadly rounded. Internal mould with numerous constrictions, which extend almost straight across the flanks and form a shallow ventral sinus. Suture line with slightly pouched, very narrow external lobe (0.40 of the external lobe depth, 0.90 of the adventive lobe), and very low median saddle (0.20 of the external lobe depth). Ventrolateral saddle broadly rounded, adventive lobe V-shaped with almost uncurved flanks.

Description. The ontogenetic development is displayed by the sectioned paratype MB.C.13269.2 (10.6 mm dm; Fig. 6A), which shows the thickly pachyconic inner whorls (ww/dm = 0.80 at 1.5–4.5 mm dm) with opened umbilicus (uw/dm = 0.30 at 2 mm dm) and the trend toward a slender conch (ww/dm = 0.62 at 10.6 mm dm) with very narrow umbilicus (uw/dm = 0.09). The conch is laterally compressed at this stage with subparallel flanks and a broadly rounded venter; the umbilical margin is rounded. During ontogeny, there is a slight increase in apertural height (WER = 1.65 at 2 mm dm and 1.87 at 10.6 mm dm).

Holotype MB.C.13269.1 is the largest of the three specimens; it has a thinly pachyconic shape (ww/dm = 0.62) and a very narrow umbilicus (uw/dm = 0.08) at 12 mm diameter (Fig. 5A). Its umbilical margin is broadly rounded, and the flanks converge slowly towards the broadly rounded venter. It is a fully septate specimen with nearly 20 chambers on the last volution and does not show any details of ornament. The internal mould is decorated with five almost regularly positioned constrictions; they run almost linearly across the flanks and turn back for a shallow ventral sinus.

The smaller specimen MB.C.13269.3 (8.5 mm dm) has a slightly thicker conch (ww/dm = 0.63) and also otherwise closely resembles the larger specimen (Fig. 5B). The smaller one has only three irregularly arranged constrictions with almost straight course.

The suture line of the largest specimen, holotype MB.C.13269.1 (drawn at 11.5 mm conch diameter), has a narrow rectangular, slightly pouched external lobe with flanks that are almost parallel in the lower three quarters, and diverge then strongly to form a broadly rounded ventrolateral saddle (Fig. 6B). This appears inclined toward the venter and continues into the simple V-shaped adventive lobe, which has weakly curved flanks.

Discussion. *E. serotinum* Korn, 1997 is a similar, small-sized species with a slightly wider umbilicus at comparable stages. However, the numerous constrictions of *E. minutum* clearly separate this new species from *E. serotinum*.

Superfamily **Girtyoceratoidea** Wedekind, 1918
Family **Girtyoceratidae** Wedekind, 1918

Girtyoceras Wedekind, 1918

Type species. Adelphoceras meslerianum Girty, 1909.

Discussion. *Girtyoceras* is a genus with a nearly global distribution and 28 possibly valid species are listed in the AMMON database (Korn & Ilg 2007). Some of these species are based on insufficiently preserved material and may not belong to this genus. Sixteen of the species were erected on material from Europe, and only few of these were described with respect to ontogenetic development of conch geometry and ornament. The various species of *Girtyoceras* however, can only be defined when ontogenetic series are available; separation of the species requires the comparison of specimens of the same size. The following key to the European species must remain incomplete because of the lack of information for some species.

The better known Western and Central European species of *Girtyoceras* can be grouped as follows:

A – species with a discoidal conch (ww/dm = less than 0.50 at 15 mm conch diameter):

G. ibergense Korn, 1992 (in Gischler & Korn 1992): slender form (ww/dm = 0.45, uw/dm = 0.13 at 16 mm dm) with weakly biconvex constrictions, sharpening of the venter above 35 mm conch diameter;

G. brueningianum (Schmidt, 1925): very slender form (ww/dm = 0.37, uw/dm = 0.18 at 16 mm dm) with biconvex constrictions and feeble ribs around the umbilicus, sharpening of the venter above 24 mm conch diameter;

G. luscinia Korn, 1988: slender form (ww/dm = 0.45, uw/dm = 0.20 at 15 mm dm) with biconvex constrictions and with faint riblets around the umbilicus, sharpening of the venter above 20 mm conch diameter;

G. ibnkhaldouni n. sp.: slender form (ww/dm = 0.45, uw/dm = 0.15 at 15 mm dm) with biconvex constrictions and with faint riblets around the umbilicus, sharpening of the venter above 15 mm conch diameter;

G. goii Korn, 1988: slender form (ww/dm = 0.50, uw/dm = 0.12 at 16 mm dm) with biconvex constrictions and without ribs, sharpening of the venter above 18 mm conch diameter;

G. deani Moore, 1946: very slender form (ww/dm = 0.27, uw/dm = 0.14 at 22 mm dm) without constrictions and without ribs, sharpening of the venter above 22 mm conch diameter;

G. simplex Moore, 1946: slender form (ww/dm = 0.38, uw/dm = 0.14 at 29 mm dm) with concavo-convex constrictions and without ribs, sharpening of the venter above 24 mm conch diameter;

G. premeslerianum Moore, 1946: slender form (ww/dm = 0.44; uw/dm = 0.18 at 18 mm dm) with concavo-convex constrictions and without ribs, sharpening of the venter above 25 mm conch diameter, fine spiral lines.

B – species with a thickly discoidal or pachyconic conch (ww/dm = more than 0.50 at 15 mm conch diameter):

G. duekemoerense Korn, 1988: rather stout form (ww/dm = 0.53, uw/dm = 0.20 at 16 mm dm) with concavo-convex constrictions and rather strong ribs on the flanks, sharpening of the venter above 16 mm conch diameter;

G. margaritatum Korn, 1988: rather stout form (ww/dm = 0.55, uw/dm = 0.14 at 16 mm dm) with very weak constrictions and without ribs, sharpening of the venter above 15 mm conch diameter;

G. aeulkei Korn, 1988: rather stout form (ww/dm = 0.58, uw/dm = 0,07 at 16 mm dm) with biconvex constrictions and rather strong ribs on the flanks;

G. edwinae Korn, 1988: stout form (ww/dm = 0.65, uw/dm = 0.26 at 14 mm dm) with concavo-convex constrictions and without ribs;

G. shorrocksi Moore, 1946: rather stout form (ww/dm = 0.54, uw/dm = 0.21 at 17 mm dm) with sharp ribs;

G. waitei Moore, 1946: stout form (ww/dm = 0.63, uw/dm = 0.16 at 16 mm dm) with sharp ribs, sharpening of the venter above 20 mm conch diameter.

Girtyoceras luscinia **Korn, 1988**
Figures 7–8

1988 *Girtyoceras luscinia* Korn, p. 52, pl. 7, figs 5–8.
1997 *Girtyoceras luscinia*. – Korn, p. 44, pl. 3, figs 5, 6.

Holotype. Specimen WMN 10028 (Rademacher Coll.); figured by Korn (1988, pl. 7, figs 5, 6).

Type locality and horizon. Large quarry north of Deinstrop near Holzen (Rhenish Mountains); *Arnsbergites gracilis* Zone (Late Viséan).

Material. Five limonitic steinkern specimens of phragmocones between 8.5 and 20.5 mm conch diameter from horizon CeH-2 at localities Chebket el Hamra-F and G.

Diagnosis. *Girtyoceras* with thickly discoidal, moderately umbilicate conch at 10 mm diameter (ww/dm = 0.55; uw/dm = 0.30) and thinly discoidal, narrowly umbilicate conch at 20 mm diameter (ww/

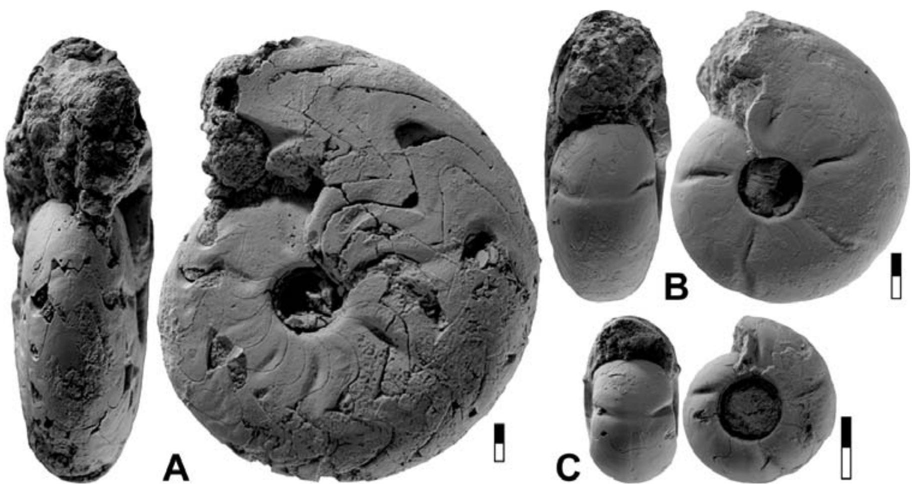


Figure 7. *Girtyoceras luscinia* Korn, 1988. **A.** Specimen MB.C.13213.1 from locality Chebket el Hamra-F; ×2.5. **B.** Specimen MB.C.13213.2 from locality Chebket el Hamra-F; ×3.0. **C.** Specimen MB.C.13213.3 from locality Chebket el Hamra-F; ×4.0.

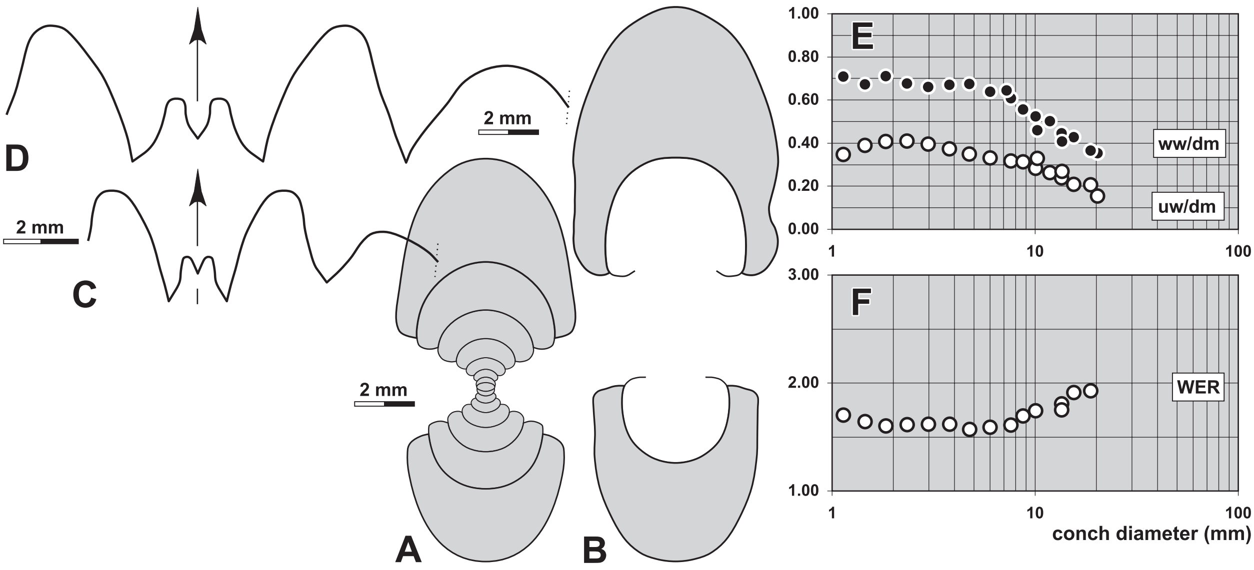


Figure 8. *Girtyoceras luscinia* Korn, 1988. **A.** Cross section of specimen MB.C.13213.4 from locality Chebket el Hamra-F; ×4.0. **B.** Cross section of specimen MB.C.13228 from locality Chebket el Hamra-G; ×4.0. **C.** Suture line of specimen MB.C.13213.2 from locality Chebket el Hamra-F, at 13.6 mm dm, 5.8 mm ww, 6.2 mm wh; ×5.0. **D.** Suture line of specimen MB.C.13213.1 from locality Chebket el Hamra-F, at 21.7 mm dm, 7.6 mm ww, 11.5 mm wh; ×5.0. **E, F.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm) and whorl expansion rate (WER) of all available specimens.

dm = 0.35; uw/dm = 0.15). Umbilical wall angular. Venter rounded up to 15 mm dm; sharpening of the venter begins at 20 mm dm. Internal mould in the immature stage with biconvex and rectiradiate constrictions with low dorsolateral projection and higher ventrolateral projection; external sinus shallow. Juveniles with faint, short riblets around the umbilicus.

Description. The sectioned specimen MB.C.13213.4 shows the development of all whorls up to 13.5 mm conch diameter (Fig. 8A). Two growth stages can be separated, the first (up to 8 mm dm) in which growth of the conch is almost isometric, being thinly pachyconic (ww/dm = 0.65–0.70) with a moderately wide umbilicus (uw/dm = 0.33–0.41) with a crescent-shaped whorl cross section. The aperture is low in this growth interval (WER = 1.60–1.65). In the second stage, the conch becomes continuously more slender, with a ww/dm ratio of 0.44 at 13.5 mm dm, parallel to narrowing of the umbilicus (uw/dm = 0.24) and heightening of the aperture (WER = 1.80). The umbilical margin is rounded in the first stage and becomes subangular in the second.

Specimen MB.C.13213.1 is a somewhat corroded but otherwise well preserved steinkern specimen of 20 mm diameter (Fig. 7A). It is fully chambered and demonstrates the transition from the immature stage with distinct constrictions to the adult oxyconic stage. The conch is thinly discoidal and narrowly umbilicate (ww/dm = 0.35; uw/dm = 0.16) with slowly converging flanks towards a narrow and later slightly keeled venter. The umbilicus is angular on the first half of the last whorl and becomes rounded in the second half. The first three quarters of the last volution display eight radial constrictions, which become continuously shallower with increasing size of the specimen. They are restricted to the flanks and form a shallow lateral sinus and a rather high ventrolateral salient. Faint and rounded riblets can be seen between the constrictions.

The characteristic morphology of the species is better expressed by specimen MB.C.13213.2 (15 mm dm), in which the conch is discoidal (ww/dm = 0.43) with a narrow umbilicus (uw/dm = 0.21) that is separated from the flanks by an angular margin (Fig. 7B). The last volution shows five regularly arranged steinkern constrictions, which begin in a short distance from the umbilical margin. The last three volutions form a low dorsolateral projection, a higher ventrolateral projection, and a rather shallow ventral sinus. A dorsolateral projection is not developed in the early two constrictions.

Specimen MB.C.13213.3 (8.5 mm dm) shows the juvenile morphology with a thickly discoidal, moderately umbilicate conch (ww/dm = 0.56; uw/dm = 0.31). It has a rather sharp umbilical edge on which faint short riblets occur. Three steinkern constrictions are present; these run in prorsiradiate direction across flanks and venter and form a wide ventral projection (Fig. 7C).

The suture line of specimen MB.C.13213.1 (21.7 mm dm) can be regarded as typical for an adult specimen of *Girtyoceras* (Fig. 8D). It possesses a very wide V-shaped external lobe, subdivided by a moderately high median saddle, with asymmetric prongs. The ventrolateral saddle is asymmetric and dorsally inclined, and the adventive lobe is as deep as the external lobe and V-shaped.

The smaller specimen MB.C.13213.2 (13.6 mm dm) has a suture line that is characteristic of the premature stage (Fig. 8C). Its external lobe is V-shaped with strongly diverging flanks, the ventrolateral saddle is asymmetric and rounded, and the small adventive lobe is V-shaped.

Discussion. The material is very similar to that described by Korn (1988, 1997) from the Rhenish Mountains and the South Portuguese Zone. Probably owing to the same type of preservation the latter can be regarded identical in conch morphology and ornament.

The co-occurring *G. ibnkhaldouni* is generally similar but differs in the narrower umbilicus at the same conch diameters (uw/dm = 0.28 in *G. luscinia* but 0.20 in *G. ibnkhaldouni* at 10 mm conch diameter). Furthermore, *G. luscinia* has more strongly curved constrictions and develops an acute venter at larger diameters (at 20 mm in *G. luscinia* but 15 mm in *G. ibnkhaldouni*).

Some of the stratigraphically older species of *Girtyoceras* are rather similar, such as *G. brueningianum* (but with a more slender conch and stronger curved constrictions), *G. ibergense* (but with a much narrower umbilicus and a much later beginning oxyconic stage), and *G. deani* as well as *G. simplex* (but with a much more slender conch).

Girtyoceras ibnkhaldouni **n. sp.**
Figures 9–10

Derivation of name. After Ibn Khaldoun (1332–1406), one of the most influential Arab philosophers of medieval times.

Holotype. Specimen MB.C.13214.1 (Korn & Ebbighausen 2006 Coll.); illustrated in Figure 9A.

Type locality and horizon. Chebket el Hamra-F (Jerada Basin, NE-Morocco); horizon CeH-2, probably *Neoglyphioceras spirale* Zone (middle Brigantian, Early Carboniferous).

Material. Nine limonitic steinkern specimens with conch diameters between 5 and 18 mm from horizon CeH-2 at localities Chebket el Hamra-F and G.

Diagnosis. *Girtyoceras* with discoidal, narrowly umbilicate conch at 10 mm diameter (ww/dm = 0.50; uw/dm = 0.20) and thinly discoidal conch, narrowly umbilicate conch at 15 mm diameter (ww/dm = 0.45; uw/dm = 0.15). Umbilical wall subangular. Venter rounded up to 12 mm dm; sharpening of the venter begins at 15 mm dm. Internal mould in the immature stage with slightly biconvex and rectiradiate constrictions with low dorsolateral projection and low ventrolateral projection; external sinus very shallow. Juveniles with faint short riblets around the umbilicus.

Description. The sectioned paratype MB.C.13214.4 shows ontogenetic changes consisting of a first growth stage that ends at 6 mm and a second ranging from 6 to 18 mm conch diameter (Fig. 10B). The first stage is characterised by an almost stable ww/dm ratio (0.60–0.70) and a low aperture (WER = 1.55–1.68). At 6 mm dm, there is a continuous heightening of the aperture (WER higher than 2.00 at 10 mm dm), paralleled by a lowering of the whorl width/conch diameter ratio (ww/dm = 0.42 at 18 mm dm). The development of the umbilicus is uncoupled from the other two characters; it is widest at 2 mm dm (uw/dm = 0.45) and becomes narrower towards a value of only 0.13 at 18 mm dm. The early stage shows semilunate whorl cross sections, becoming laterally compressed at 6 mm dm, with the development of a subangular umbilical margin.

Holotype MB.C.13214.1, with a diameter of 21 mm, is the largest specimen of this species, but the last quarter of its whorl is crushed (Fig. 9A). It is discoidal at 15 mm dm (ww/dm = 0.45) with a narrow umbilicus (uw/dm = 0.15), a subangular umbilical wall, and a narrowly rounded venter. The last volution has five shallow steinkern constrictions, of which the last two are only elongate notches on the inner flank. The constrictions at the beginning of the last volution are biconvex with a rather high ventrolateral projection and a rather deep ventral sinus.

The immature morphology can be studied in paratype MB.C.13214.2 (10 mm dm; Fig. 9B). It is discoidal (ww/dm = 0.50) with a narrow umbilicus (uw/dm = 0.17). The flanks converge slowly towards the narrowly rounded venter and the umbilical margin is subangular. The steinkern shows four constrictions standing 90° apart. They begin a short distance from the umbilicus, extend in linear direction across the inner flanks, bending forward to form a low ventrolateral projection and a very shallow ventral sinus.

The suture line of holotype MB.C.13214.1 has, at almost 16 mm conch diameter, a wide external lobe subdivided by a moderately high median saddle (Fig. 10C). The flanks of the external lobe are concavely incurved and continue into the asymmetric ventrolateral saddle, followed by a small V-shaped adventive lobe. In this outline, the suture line is characteristic for a *Girtyoceras* species.

Discussion. For a comparison with the co-occurring *G. luscinia*, see under that species. The new species be-

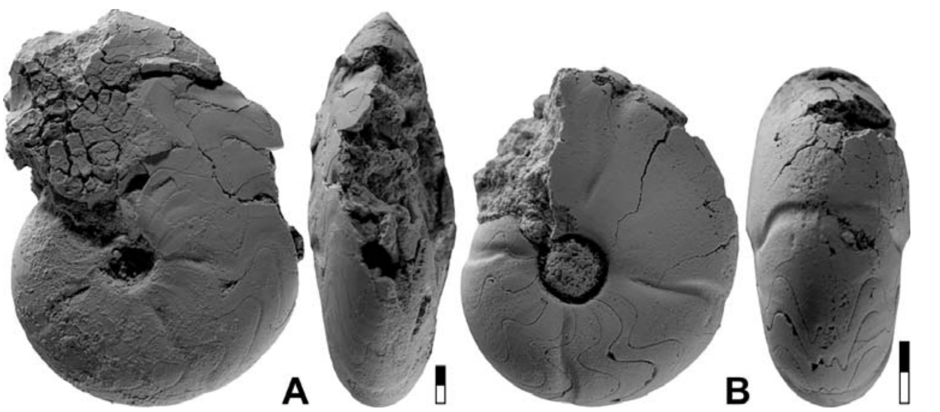


Figure 9. *Girtyoceras ibnkhaldouni* n. sp. **A.** Holotype MB.C.13214.1 from locality Chebket el Hamra-F; ×2.5. **B.** Paratype MB.C.13214.2 from locality Chebket el Hamra-F; ×4.0.

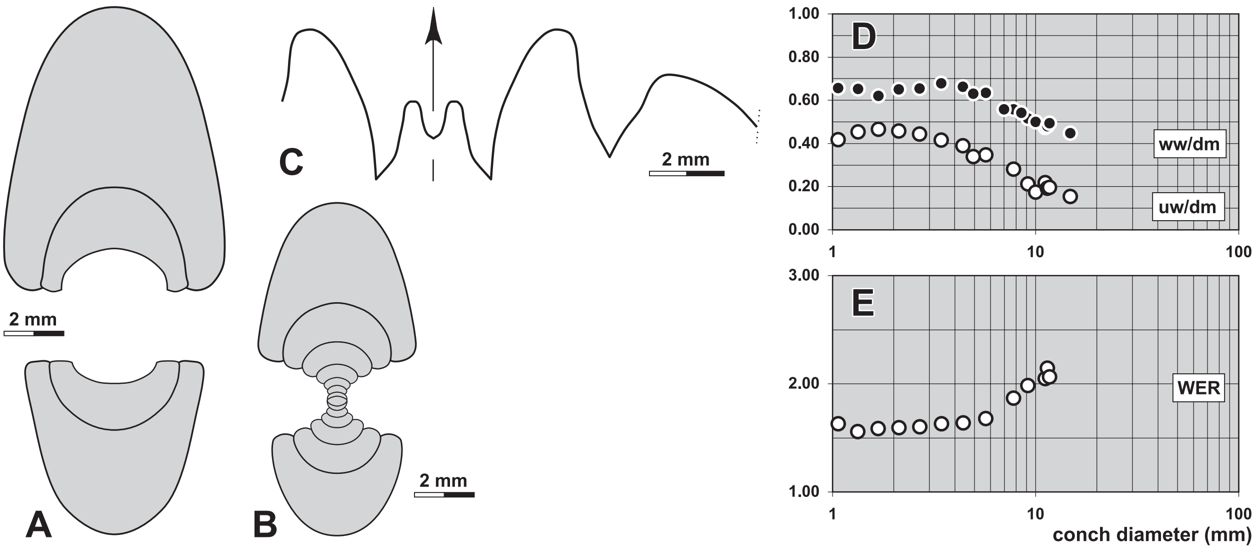


Figure 10. *Girtyoceras ibnkhaldouni* n. sp. **A.** Cross section of paratype MB.C.13214.3 from locality Chebket el Hamra-F; ×4.0. **B.** Cross section of paratype MB.C.13214.4 from locality Chebket el Hamra-F; ×4.0. **C.** Suture line of holotype MB.C.13214.1 from locality Chebket el Hamra-F, at 14.8 mm dm, 6.0 mm ww, 8.1 mm wh; ×5.0. **D**, **E.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm) and whorl expansion rate (WER) of all available specimens.

longs to the narrowly umbilicate species of the genus, and comparable are only *G. ibergense* (but with an oxyconic stage that starts much later).

Sulcogirtyoceras Ruzhencev, 1960

Type species. Eumorphoceras burhennei Brüning, 1923.

Sulcogirtyoceras sp.
Figure 11

Material. Three limonitic steinkern specimens between 5 and 16 mm conch diameter from horizon CeH-2 at locality Chebket el Hamra-F.

Description. The larger specimen MB.C.13215.1 is a fragment of a specimen with an original diameter of 16 mm; it shows the transformation from the widely umbilicate juvenile stage with faint riblets to the narrowly umbilicate preadult stage with strong constrictions. Less than one third is preserved of the last whorl, which shows a pronounced umbilical rim and concavo-convex constrictions that begin on the inner flanks. They form a shallow lateral sinus, a very high ventrolateral projection, and a shallow ventral sinus. Remains of rather coarse growth lines are visible on the steinkern. The inner whorl, corresponding to a diameter of 8 mm, possesses a ventrally depressed whorl cross section and a wide umbilicus. The flanks bear numerous forwardly directed faint riblets and deep constrictions with the same course; they are deepest on the flanks and almost disappear on the venter, where they form a high projection.

The small specimen MB.C.13215.3 (5 mm dm) represents the early juvenile calyx stage with a very wide umbilicus, a sharp umbilical margin that is occupied by short and sharp riblets, and an almost smooth, flattened venter.

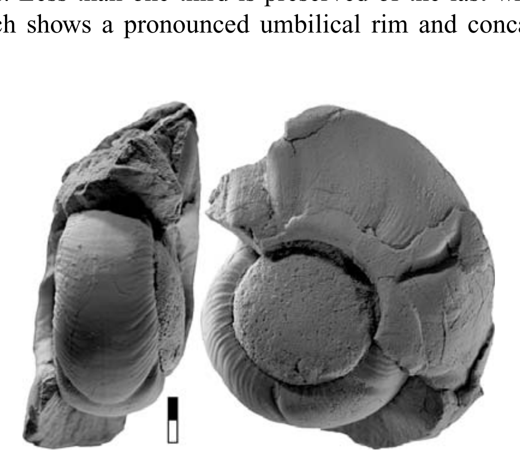


Figure 11. *Sulcogirtyoceras* sp., specimen MB.C.13215.1 from locality Chebket el Hamra-F; ×3.0.

Superfamily **Dimorphoceratoidea** Hyatt, 1884
Family **Dimorphoceratidae** Wedekind, 1918

Metadimorphoceras Moore, 1958

Type species. Goniatites splendidus Brown, 1841.

Discussion. *Metadimorphoceras* has a near-global distribution with 22 valid species listed in the AMMON database (Korn & Ilg 2007). Separation of species is almost completely based on suture line characters. Twelve of the species were erected on material from Europe; these derive from a wide stratigraphic interval ranging from the middle Late Viséan *Goniatites crenistria* interval to the Kinderscoutian R1 Zone in Europe (Moore 1939) and even in the Yeadonian G1 Zone in Arkansas (Manger 1988).

On the basis of their suture lines, the Western and Central European species of *Metadimorphoceras* can be grouped as follows (for a phylogenetic concept of the genus, see Manger 1988):

A – species with simple subdivision of the adventive lobe:

- *M. pseudodiscrepans* (Moore, 1939): with incipient subdivision of the E1 lobe;
- *M. hodsoni* (Moore, 1958): with bifid, narrow E1 lobe;
- *M. wiswellense* (Moore, 1939): with denticulation of the E1 lobe;
- *M. moorei* (Hodson, 1954): with bifid, wide E1 lobe.

B – species with secondary subdivision of the adventive lobe and simple subdivision of the E2 lobe:

- *M. denticulatum* (Schmidt, 1925): with weak secondary subdivision of the adventive lobe and multiple denticulation of the E1 lobe;
- *M. saleswheelense* (Moore, 1939): with weak secondary subdivision of the adventive lobe and bifid E1 lobe;
- *M. ribblense* (Moore, 1936): with weak secondary subdivision of the adventive lobe and simple E1 lobe;
- *M. splendidum* (Brown, 1841): with strong secondary subdivision of the adventive lobe and denticulation of the E1 lobe.

C – species with secondary subdivision of the adventive lobe and secondary subdivision of the E2 lobe:

- *M. anguinosum* n. sp.: with incipient secondary denticulation of the adventive lobe and denticulation of the E1 lobe;
- *M. inflatum* (Moore, 1939): with weak secondary subdivision of the adventive lobe and bifid E1 and E2 lobes;
- *M. pix* Korn, 1997: with strong secondary denticulation of the adventive lobe and weak denticulation of the E1 lobe;
- *M. complex* (Moore, 1939): with strong secondary denticulation of the adventive lobe and clear denticulation of the E1 lobe;
- *M. varians* (Moore, 1939): with strong secondary denticulation of the adventive lobe and strong denticulation of the E1 lobe.

***Metadimorphoceras anguinosum* n. sp.**
Figures 12–13

Derivation of name. After Latin *anguinosus, -um* = like a snake, because of the narrow and subdivided median saddle.

Holotype. Specimen MB.C.13233.1 (Korn & Ebbighausen 2006 Coll.); illustrated in Figure 12A.

Type locality and horizon. Chebket el Hamra-I (Jerada Basin, NE-Morocco); horizon CeH-2, probably *Neoglyphioceras spirale* Zone (middle Brigantian, Early Carboniferous).

Material. 26 limonitic steinkern specimens of phragmocones between 4 and 19 mm conch diameter from horizon CeH-2 at localities Chebket el Hamra-F, I, and T.

Diagnosis. *Metadimorphoceras* with thinly pachyconic conch at 5 mm diameter (ww/dm = 0.65–0.70) and thickly discoidal conch at 12–15 mm diameter (ww/dm = 0.50–0.60). Umbilicus funnel-shaped and almost closed in all stages. Suture line with tertiary subdivision of the external lobe, of which the dorsal side shows delicate denticulation, and primarily subdivided adventive lobe, of which the dorsal branch shows incipient secondary notching.

Description. The ontogenetic development (Figs 13D, E) is simple with a continuously decreasing ww/dm ratio (ww/dm = 0.80 at 2 mm dm; 0.45 at 19 mm dm) and a continuously increasing apertural height (WER = 1.80 at 2 mm dm; 2.65 at 19 mm dm). The umbilicus is almost closed in all stages above 1.5 mm dm.

The sectioned paratype MB.C.13272.1 shows five whorls at a maximum diameter of 12 mm (Fig. 13A). At this diameter, the conch is thickly discoidal (ww/dm = 0.56) with an almost completely closed, funnel-shaped umbilicus and a rather high aperture (WER = 2.45). The conch is widest at the rounded umbilical margin, from which the flanks converge towards the narrowly rounded venter. Early whorls have, at 3 mm dm, continuously rounded flanks and venter as well as a very narrow umbilicus (uw/dm = 0.06).

The suture line of the largest specimen, holotype MB.C.13233.1 (approximately 17 mm conch diameter) demonstrates that *M. anguinosum* belongs to the more advanced species of the genus (Fig. 13C). It has a strikingly subdivided external lobe, in which a very narrow, high median saddle is raised. Both secondary lobes of the external lobe are further denticulate, with the ven-

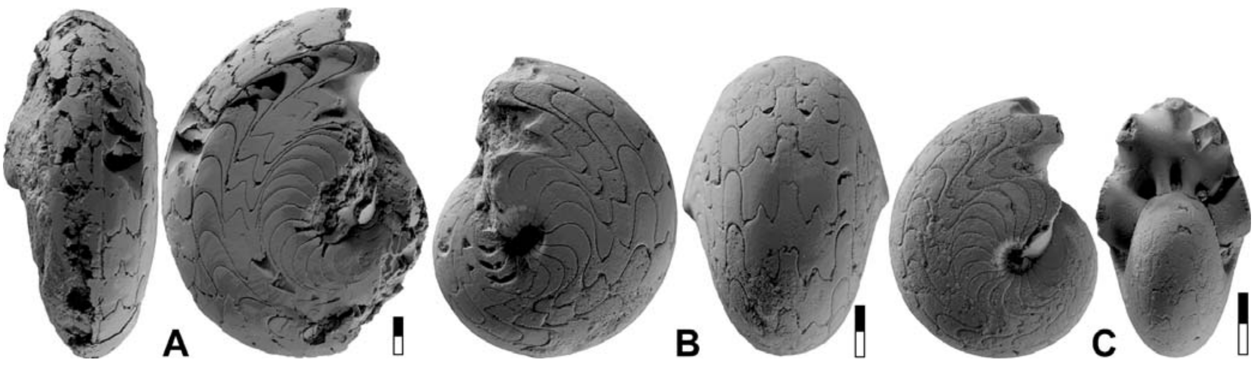


Figure 12. *Metadimorphoceras anguinosum* n. sp. **A.** Holotype MB.C.13233.1 from locality Chebket el Hamra-I; ×2.5. **B.** Paratype MB.C.13216.1 from locality Chebket el Hamra-F; ×3.5. **C.** Paratype MB.C.13216.2 from locality Chebket el Hamra-F; ×4.0.

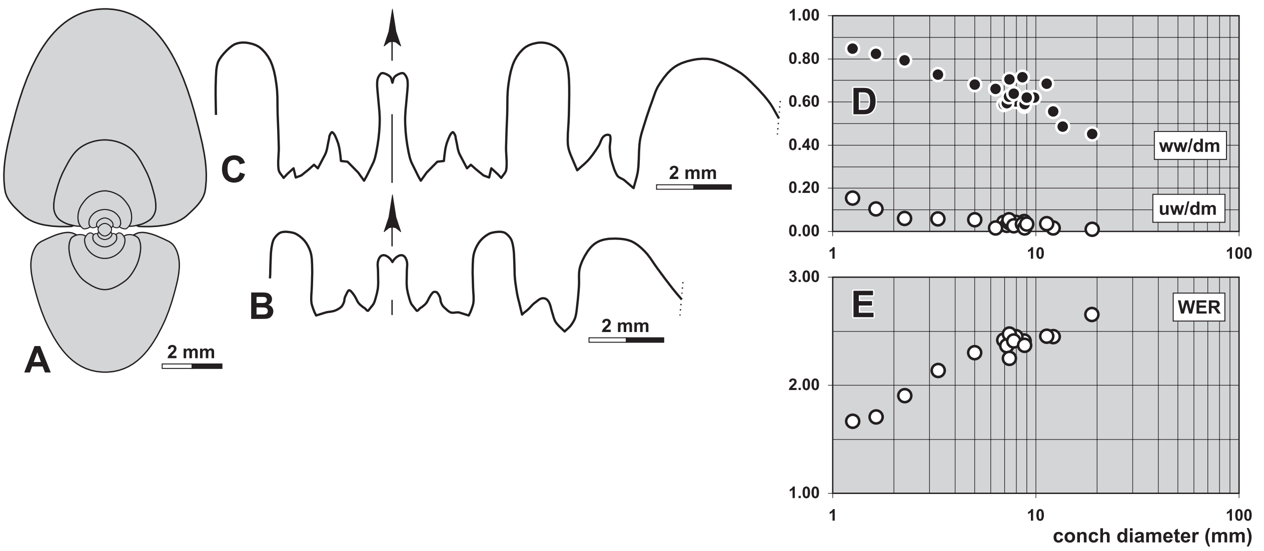


Figure 13. *Metadimorphoceras anguinosum* n. sp. **A.** Cross section of paratype MB.C.13272.1 from locality Chebket el Hamra-T; ×4.0. **B.** Suture line of paratype MB.C.13216.1 from locality Chebket el Hamra-F, at 10.8 mm dm, 7.2 mm ww, 6.0 mm wh; ×5.0. **C.** suture line of holotype MB.C.13233.1 from locality Chebket el Hamra-I, at 9.7 mm wh; ×5.0. **D**, **E.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm) and whorl expansion rate (WER) of all available specimens.

tral side (E2) possessing a large dorsal prong and a very small ventral notch. The dorsal side (E1), which is separated from the E2 lobe by a narrow and acute saddle, is subdivided into three small notches. Behind the narrow, tongue-shaped ventrolateral saddle follows the bifid adventive lobe, of which the dorsal prong shows the indication of further subdivision.

A less advanced suture line can be studied in the smaller paratype MB.C.13216.1 (11 mm dm), in which the subdivision of the lobes is less striking (Fig. 13B). The external lobe shows only secondary subdivision, resulting in unequal E1 and E2 lobes, of which the E1 lobe is the deeper and wider element. The adventive lobe shows only primary subdivision with two prongs.

Discussion. Most species of *Metadimorphoceras* with a similarly advanced sutural subdivision are stratigraphically younger. *M. anguinosum* has, in the suture line, some resemblance to *M. denticulatum*, which has a similar pattern of sutural subdivision. Both are also similar in conch morphology, but in *M. anguinosum*, the E2 lobe has an incipient further subdivision.

M. hodsoni from the slightly younger horizon at Chebket el Hamra has a less advanced suture line, with a bifid adventive lobe, a bifid E1 lobe, and a simple E2 lobe.

Metadimorphoceras hodsoni Moore, 1958
Figures 14–15

1958 *Dimorphoceras* (*Metadimorphoceras*) *hodsoni* Moore, p. 223, pl. 14, figs 1, 2.
1988 *Metadimorphoceras hodsoni*. – Manger, textfig. 2B.

Holotype. Specimen GSM ZI4020 (Moore Coll.); figured by Moore (1958, pl. 14, fig. 2).

Type locality and horizon. Townland of Carraun, two miles south-southwest of Kiltyclogher (Co. Leitrim, Ireland); P1c Subzone, associated with *Neoglyphioceras spirale* (Late Viséan).

Material. 16 limonitic steinkern specimens of phragmocones with conch diameters ranging from 7 and 13 mm, from horizon CeH-4 at localities Chebket el Hamra-A, B, C, and S.

Diagnosis. *Metadimorphoceras* with thinly pachyconic conch at 5 mm diameter (ww/dm = 0.65–0.70) and thickly discoidal conch at 12–15 mm diameter (ww/dm = 0.50–0.60). Umbilicus funnel-shaped and almost closed in all stages. Suture line with secondarily subdivided

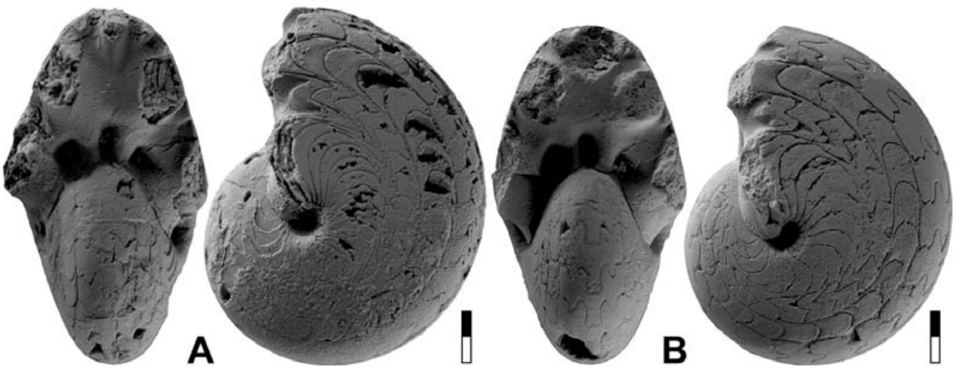


Figure 14. *Metadimorphoceras hodsoni* Moore, 1958. **A.** Specimen MB.C.13201.1 from locality Chebket el Hamra-A; ×3.5. **B.** Specimen MB.C.13270.1 from locality Chebket el Hamra-S; ×3.5.

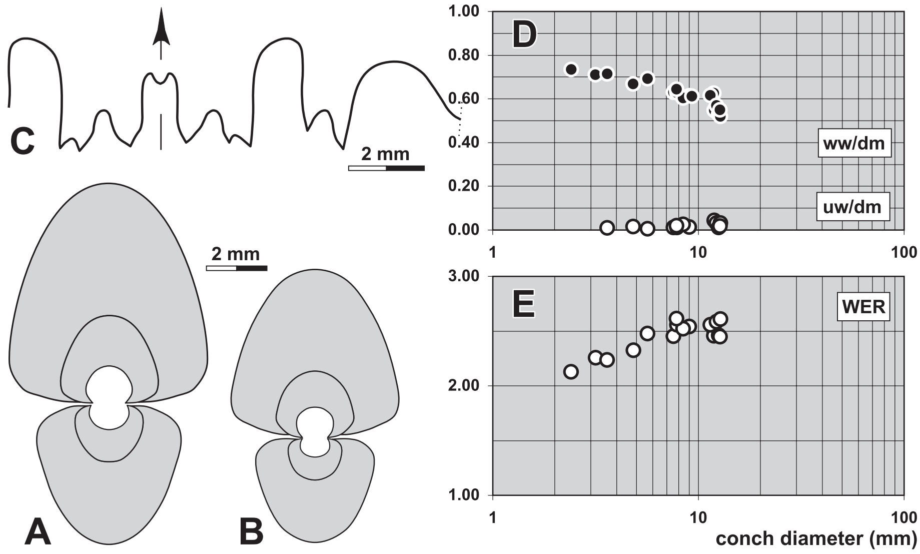


Figure 15. *Metadimorphoceras hodsoni* Moore, 1958. **A.** Cross section of specimen MB.C.13270.2 from locality Chebket el Hamra-S; ×4.0. **B.** Cross section of specimen MB.C.13270.3 from locality Chebket el Hamra-S; ×4.0. **C.** Suture line of specimen MB.C.13270.1 from locality Chebket el Hamra-S, at 12.0 mm dm, 6.9 mm ww, 7.5 mm wh; ×5.0. **D**, **E.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm) and whorl expansion rate (WER) of all available specimens.

external lobe, of which the dorsal side shows tertiary denticulation, and primarily subdivided adventive lobe.

Description. Ontogenetic changes of the conch can be seen in the ww/dm ratio and also in the whorl expansion rate (Figs 15D, E). As characteristic for dimorphoceratids, the ww/dm ratio decreases continuously and the whorl expansion rate is heightened. Intraspecific variability is low within the investigated material.

The two sectioned specimens MB.C.13270.2 and MB.C.13270.3 do not show the inner whorls, but provide insight into the conch development between 2.5 and 12 mm diameter (Figs 15A, B). The general form is similar in these stages, with the exception of the ww/dm ratio that decreases from 0.74 at 2.4 mm dm to 0.55 at 12 mm dm. The umbilical margin becomes pronounced at 4 mm conch diameter, and separates the converging flanks from the almost closed, funnel-shaped umbilicus. The aperture becomes rapidly higher during ontogeny, leading to a whorl expansion rate of almost 2.50 at 12 mm dm.

Specimen MB.C.13270.1 is well preserved and fully chambered at 12.5 mm diameter (Fig. 14B). In terms of conch ratios, it closely resembles cross section MB.C.13270.2, and also shows the funnel-shaped umbilicus, the strongly conversing flanks, and the narrowly rounded venter.

The suture line of specimen MB.C.13270.1 (drawn at 12 mm dm) shows an insignificant amount of asymmetry in the serration of the external lobe (Fig. 15C). Secondary and tertiary subdivision of the external lobe leads to a V-shaped to lanceolate and acute E2 prong and a bifid E1 prong, both with the same width. The adventive lobe is bifid with a deeper dorsal notch.

Discussion. The material closely resembles, in conch shape and degree of suture line subdivision, the Irish specimens. The faint keel of the type material from Carraun, however is not visible in the steinkern specimens from Chebket el Hamra.

M. hodsoni belongs to the less advanced species of the genus. The other species from Chebket el Hamra, *M. anguinosum* for instance, has a much more advanced suture line, although it is stratigraphically older.

Superfamily **Goniatitoidea** Hyatt, 1884
Family **Goniatitidae** de Haan, 1825

Included subfamilies.
- Goniatitinae de Haan, 1825 – with narrowly umbilicate inner whorls, a narrow external lobe, and usually acute ventrolateral saddle,
- Arnsbergitinae n. subfam. – with widely umbilicate inner whorls, a moderately wide external lobe, and usually subacute or rounded ventrolateral saddle,
- Sygambritinae Korn, 1988 – with a narrow external lobe, and tectiform ventrolateral saddle,
- Sudeticeratinae Korn & Ebbighausen, 2006 in Klug et al. 2006 – with moderately umbilicate inner whorls, a wide external lobe, a concave median saddle, and a rounded ventrolateral saddle.

Subfamily **Goniatitinae** de Haan, 1825

Included genera.
- *Progoniatites* Korn, Bockwinkel, Ebbighausen & Klug, 2003.
- *Goniatites* de Haan, 1825.
- *Hypergoniatites* Ruzhencev & Bogoslovskaya, 1970.
- *Goniatitella* Korn, 1988.

Goniatites **de Haan, 1825**

Type species. Conchiliolithus Nautilites (*sphaericus*) Martin, 1809 [nomen nudum], = *Ammonites sphaericus* Sowerby, 1814 (Opinion 420 ICZN, 1956).

Discussion. *Goniatites* is a broad genus encompassing 30 species, of which 12 were erected on North Variscan material, listed in the AMMON database (Korn & Ilg 2007). Many of the species are only briefly described, and some are based on poorly preserved material.

The well-known North-western and Central European species of *Goniatites* can be grouped as follows:

A – species with spiral ornament:

G. globostriatus (Schmidt, 1925): type material crushed, with coarse falcate ornament in the adult stage;

G. moorei Weyer, 1972: without falcate ornament in the adult stage;

G. spirifer Roemer, 1850: with weak falcate ornament in the adult stage;

G. wedberensis Bisat, 1934: an insufficiently described species, possibly a junior synonym of *G. spirifer* Roemer, 1850.

B – species without spiral ornament:

G. hudsoni Bisat, 1934: with highly variable, thickly pachyconic to globular conch (ww/dm = 0.75–0.95 between 20 and 40 mm dm), distinct dorsolateral projection of the growth lines, a very narrow external lobe, and a low median saddle;

G. crenistria Phillips, 1836: with thinly to thickly pachyconic conch (ww/dm = 0.70–0.80 at 20 and 0.60–0.70 at 40 mm dm), low dorsolateral projection of the growth lines, a moderate external lobe, and a moderate median saddle;

G. sphaericus (Sowerby, 1814): only known from the holotype, possibly senior synonym of *G. fimbriatus*, but with lower median saddle;

G. fimbriatus (Foord & Crick, 1897): with variable, thickly pachyconic to globular conch (ww/dm = 0.70–0.90 between 20 and 40 mm dm), moderate dorsolateral projection of the growth lines, a moderate external lobe, and a moderate median saddle;

G. fuhrmanni Schindewolf, 1951: a problematic species, horizon not precisely known;

G. involutus de Koninck, 1880: a problematic species;

G. interruptus de Koninck, 1844: a problematic species;

G. antiquatus Bisat, 1934: an insufficiently described species, possibly a synonym of *G. hudsoni* Bisat, 1934.

Goniatites crenistria Phillips, 1836
Figures 16–21

1836 *Goniatites crenistria* Phillips, p. 234, pl. 19, figs 7–9.

1925 *Glyphioceras crenistria*. – Schmidt, p. 565, pl. 21, figs 1–3, pl. 23, figs 13–14.

1925 *Glyphioceras crenistria* var. *globoides* Schmidt, p. 566, pl. 21, fig. 1.

1928 *Goniatites crenistria dinckleyense* Bisat, p. 132, pl. 6A, fig. 1.

1963 *Goniatites crenistria*. – Nicolaus, p. 96, pl. 1, figs 1, 3.

1988 *Goniatites crenistria*. – Korn, p. 83, pl. 17, figs 1, 4, pl. 18, figs 1–11.

Holotype. Specimen NHM c282 (Gilbertson Coll.); figured by Phillips (1836, pl. 19, figs 7–9), refigured here in Figure 16.

Type locality and horizon. 'Bolland' (West Yorkshire); 'Mountain Limestone' (Late Viséan).

Material. 76 specimens from horizon CeH-1 of the locality Chebket el Hamra-N; they range in their size from 25 and 120 mm diameter. All are preserved as sideritic nodules in which usually only the body chamber is preserved. Inner whorls, if present at all, are preserved only as fragments.

Diagnosis. *Goniatites* with globular conch at 10 mm diameter (ww/dm = 0.90–1.00), pachyconic conch at 30 mm diameter (ww/dm = 0.65–0.75), and thickly discoidal to thinly pachyconic conch at 50 mm diameter (ww/dm = 0.55–0.65). Umbilicus very narrow in all stages larger than 10 mm dm (uw/dm = 0.05–0.10), in the adult stage slightly opening; umbilical wall rounded. Ornamentation with crenulated biconvex and rectiradiate growth-lines with low dorsolateral projection and higher ventrolateral projection; external sinus deep. No spiral lines. Suture line with V-shaped, moderately narrow external lobe (0.50 of the external lobe depth, 0.90–1.00 of the adventive lobe), and moderate median saddle (0.40 of the external lobe depth); E lobe Y-shaped in very large stages. Flanks of the external lobe almost straight, ventrolateral saddle acute, adventive lobe V-shaped with almost straight flanks.

Description. Growth stages between 18 and 120 mm are represented in the material from Chebket el Hamra, and cross sections of material from the Rhenish Mountains and Harz are shown for comparison. Intraspecific variability within the material from Chebket el Hamra is very low, all specimens plot within a very narrow range (Figs 18D, E). The ww/dm ratio decreases almost continuously within the observable growth interval, being 0.70–0.80 at 20 mm, 0.60–0.70 at 50 mm dm, and approximately 0.50 at 90 mm dm. At the same time, the umbilicus opens slightly from a uw/dm ratio of 0.10 at 20 mm dm to 0.15 at 90 mm dm. The aperture becomes significantly higher during this interval, with a WER that increases from 1.50 at 30 mm dm to almost 2.00 at 90 mm dm.

The two sectioned specimens from Germany (Figs 19–20) closely fit the conch geometry of the Moroccan material. Differences can only be seen in the whorl expansion rate, which is somewhat higher in the

Figure 16. *Goniatites crenistria* Phillips, 1836, holotype NHM c282 from 'Bolland', West Yorkshire (Gilbertson Coll.); ×1.50.

Figure 17. *Goniatites crenistria* Phillips, 1836. **A.** Specimen MB.C.13254.1 from locality Chebket el Hamra-N; × 1.0. **B.** Specimen MB.C.13254.2 from locality Chebket el Hamra-N; × 1.0. **C.** Specimen MB.C.13254.3 from locality Chebket el Hamra-N; × 1.0.

German specimens. However, these two specimens show differences in this character, with the specimen from the Harz possessing a much higher aperture in intermediate growth stages.

Specimen MB.C.13256.3 is the largest available specimen; it is, with 120 mm conch diameter, possibly the largest known individual of the genus *Goniatites*. The body chamber is slightly crushed, but it can be seen

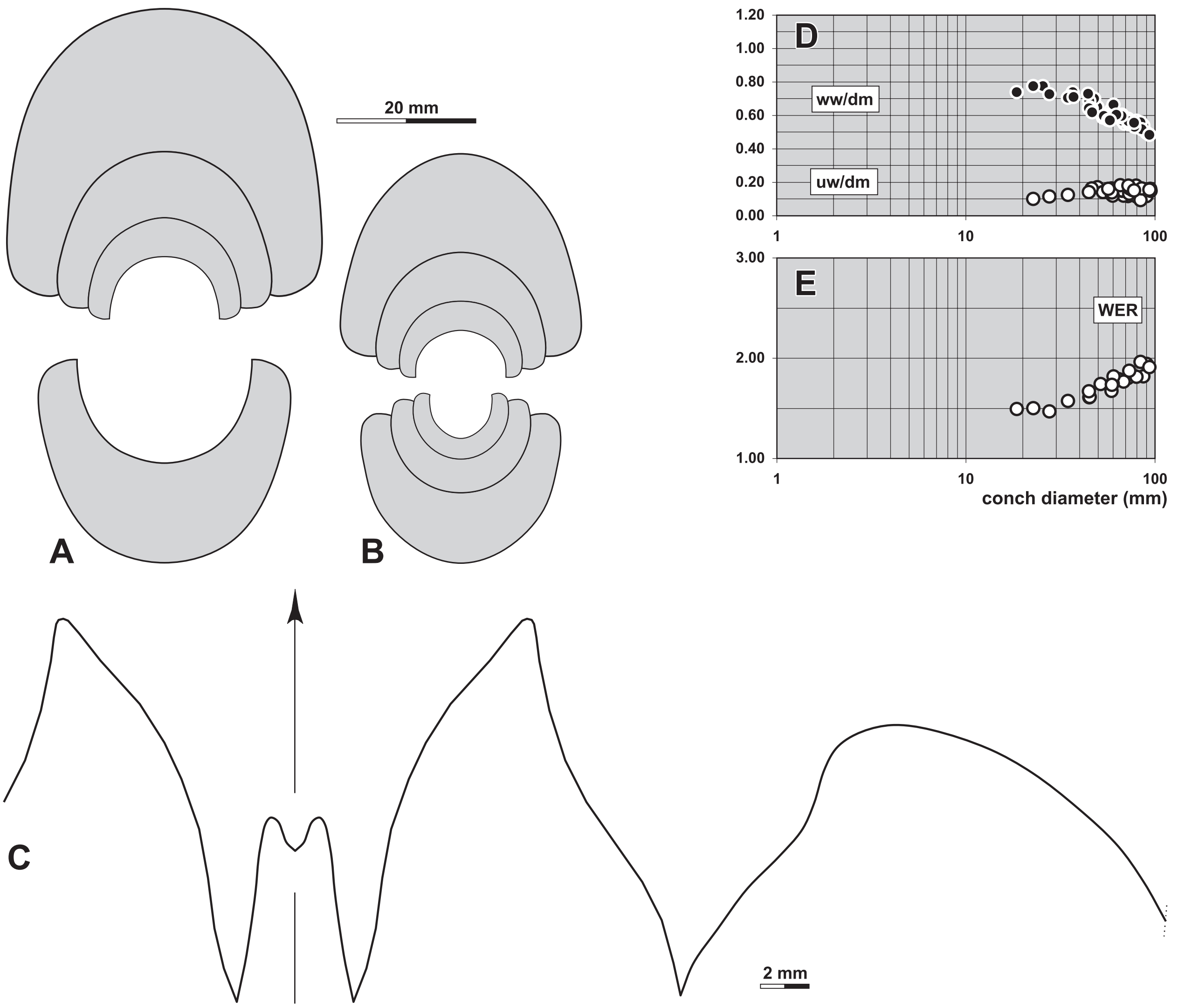


Figure 18. *Goniatites crenistria* Phillips, 1836. **A.** Cross section of specimen MB.C.13254.4 from locality Chebket el Hamra-N; ×1.0. **B.** Cross section of specimen MB.C.13256.1 from locality Chebket el Hamra-N; ×1.0. **C.** Suture line of specimen MB.C.13256.2 from locality Chebket el Hamra-N, at 38 mm ww, 26 mm wh; ×3.5. **D**, **E.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm) and whorl expansion rate (WER) of all available specimens.

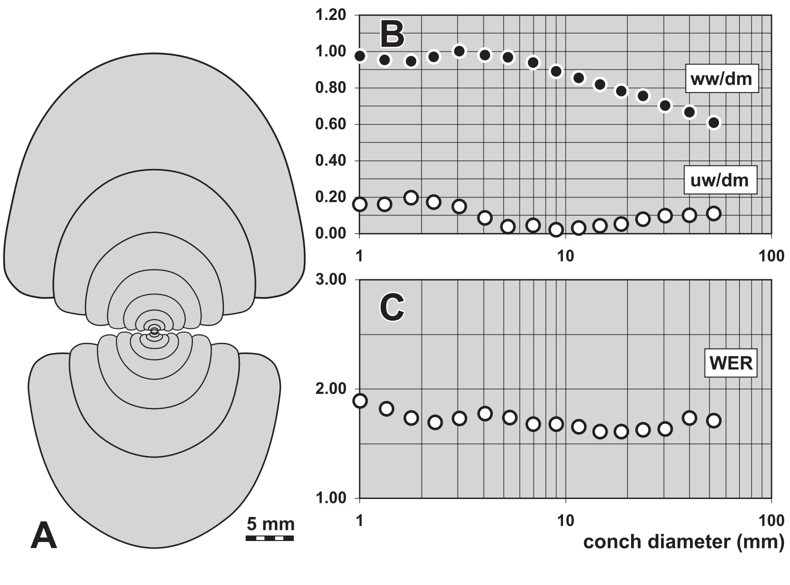


Figure 19. *Goniatites crenistria* Phillips, 1836 from Oese, Rhenish Mountains (Paproth Coll.). **A.** Cross section of specimen MB.C.13297; ×1.25. **B**, **C.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm) and whorl expansion rate (WER) of specimen MB.C.13297.

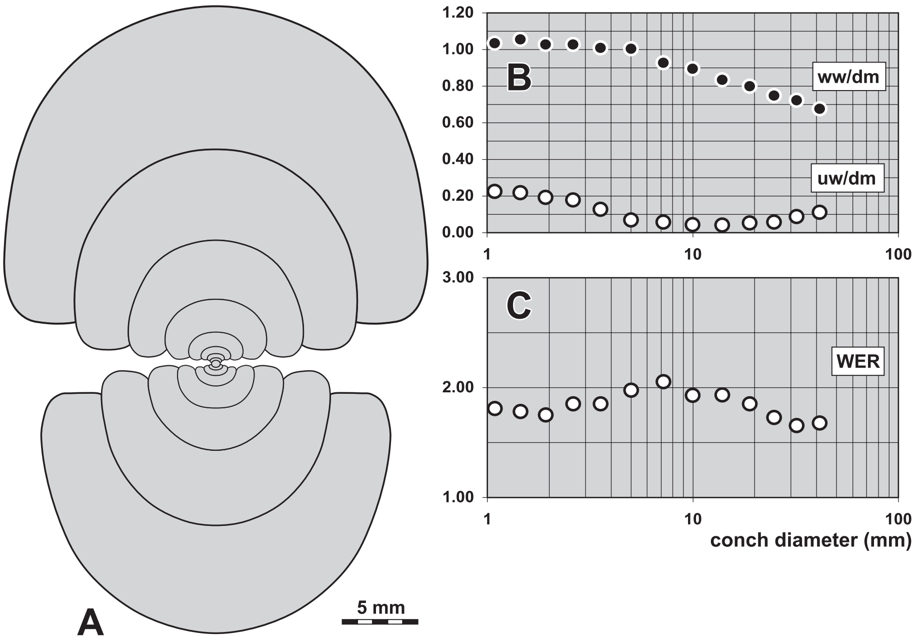


Figure 20. *Goniatites crenistria* Phillips, 1836 from the Iberg near Bad Grund, Harz. **A.** Cross section of specimen MB.C.13308; ×2.00. **B**, **C.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm) and whorl expansion rate (WER) of specimen MB.C.13308.

that the conch is discoidal in this stage (ww/dm = 0.48) with a narrow umbilicus (uw/dm = 0.16). It is probably fully mature, possessing a well-visible pairwise thickening of the internal shell in front of the last septum.

MB.C.13254.1 is also one of the larger, nearly complete specimens (Fig. 17A). It has a diameter of 86 mm and is thickly discoidal (ww/dm = 0.54) with a very narrow umbilicus (uw/dm = 0.15) and a low aperture (WER = 1.82). It is a smooth steinkern specimen that possesses, in the dorsal region, shell remains with crenulated growth lines these extend in a rectiradiate direction and with biconvex course across flanks and venter. The lateral sinus of these is very shallow, the ventrolateral projection is low, and the ventral sinus is very deep.

The two smaller specimens MB.C.13254.2 and MB.C.13254.3 (68 and 64 mm in dm) are similar in their preservation with a smooth steinkern and well-preserved shell remains in the dorsal area (Figs 17B, C). They differ in the course of the growth lines, being slightly biconvex with shallow lateral sinus in MB.C.13254.3 though the lateral sinus is lacking in specimen MB.C.13254.2.

The material from Chebket el Hamra permits study of the suture line in a very large individual (Fig. 18C). Specimen MB.C.13256.2 (38 mm whorl width, corresponding to a conch diameter of about 64 mm) shows a Y-shaped external lobe with incurved flanks, a moderate median saddle (0.48 of the E lobe depth), an acute and asymmetric ventrolateral saddle, and a V-shaped, dorsally inclined adventive lobe. The external lobe is moderately narrow, being less wide than the adventive lobe, measured at half depth. Its width/depth ratio is only 0.54.

Discussion. *Goniatites crenistria* can easily be separated from other crenistriate species of *Goniatites*. The

Figure 21. *Goniatites crenistria* Phillips, 1836 (holotype of '*Goniatites crenistria dinckleyense* Bisat, 1928'), specimen NHM c33150 from Dinckley, Lancashire (Moore Coll.); × 1.50. This figure is available in colour online at museum-fossilrecord.wiley-vch.de

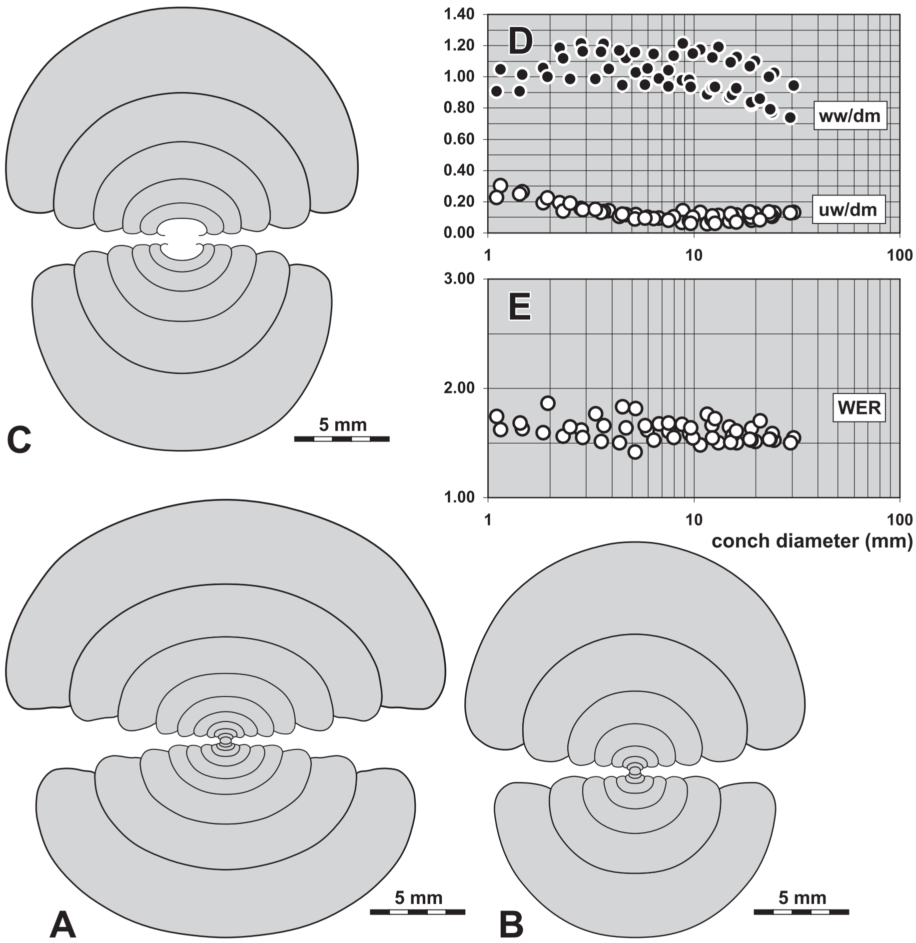


Figure 22. *Goniatites hudsoni* Bisat, 1934 from bed 100 of the Praia de Murração section (Korn & Horn 1995 Coll.). **A.** Cross section of specimen MB.C.13310.1; ×2.5 (cuboid variant). **B.** Cross section of specimen MB.C.13310.2 (non-cuboid variant with high aperture); ×2.5. **C.** Cross section of specimen MB.C.13310.3 (non-cuboid variant with low aperture); ×2.5. **D**, **E.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm) and whorl expansion rate (WER) of the four sectioned specimens MB.C.13310.1–MB.C.13310.4.

stratigraphically slightly older species *G. hudsoni* Bisat, 1934 (Fig. 22) has a distinct dorsolateral projection of the growth lines; *G. americanus* Gordon, 1971 from the Chainman Shale of Utah has a pronounced dorsolateral projection of the growth lines and also spiral lines around the umbilicus. The African species *G. lazarus* Korn, Klug & Mapes, 2005 has an almost closed umbilicus in the adult stage and a narrowly rounded ventrolateral saddle, and *G. rodioni* Korn & Ebbighausen, 2006 is globular in the adult stage and possesses a very narrow external lobe.

Goniatites fimbriatus (Foord & Crick, 1897) is a variable species (Fig. 23), of which the more slender representatives are similar to *G. crenistria*. *G. fimbriatus* has a less pronounced ventrolateral projection of the growth lines, a wider external lobe, a wider umbilicus, and spindle-shaped juvenile conchs.

Remarks. *Goniatites crenistria* is a very common species at many places in central Europe, being the most celebrated index fossil because of its mass occurrence in the *Crenistria* Limestone of the Rhenish Mountains and Harz (Nicolaus 1963; Korn 1988; Mestermann 1998). It is also abundant at places in North England (Bisat 1924; Moore 1936), but has not been discovered in the fossiliferous sections of Ireland (Brandon & Hodson 1985). Occurrences in the South Portuguese Zone are quite rare (Korn 1997). Reports from North America are doubtful. They may mostly belong to *G. americanus* Gordon, 1971.

Goniatites globostriatus **(Schmidt, 1925)**
Figures 24–25

1851 *Goniatites crenistria*. – Sandberger & Sandberger, p. 74, pl. 5, figs 1b, c.
1925 *Glyphioceras crenistria* var. *globostriata* Schmidt, p. 566, pl. 23, fig. 13.
1963 *Goniatites striatus spirifer*. – Nicolaus, p. 107, pl. 4, figs 8–9, pl. 5, figs 8–10.
1988 *Goniatites* (?) *globostriatus*. – Korn, p. 94, pl. 19, figs 2–5, pl. 59, figs 1–4.
1990a *Goniatites* (?) *globostriatus*. – Korn, p. 34, pl. 10, figs 6–9.
1997 *Goniatites* (?) *globostriatus*. – Korn, p. 50, pl. 4, fig. 9.

Holotype. Specimen GÖT 480-47 (H. Schmidt Coll.); figured by Schmidt (1925, pl. 23, fig. 13) and Korn (1988, pl. 19, figs 1–2).

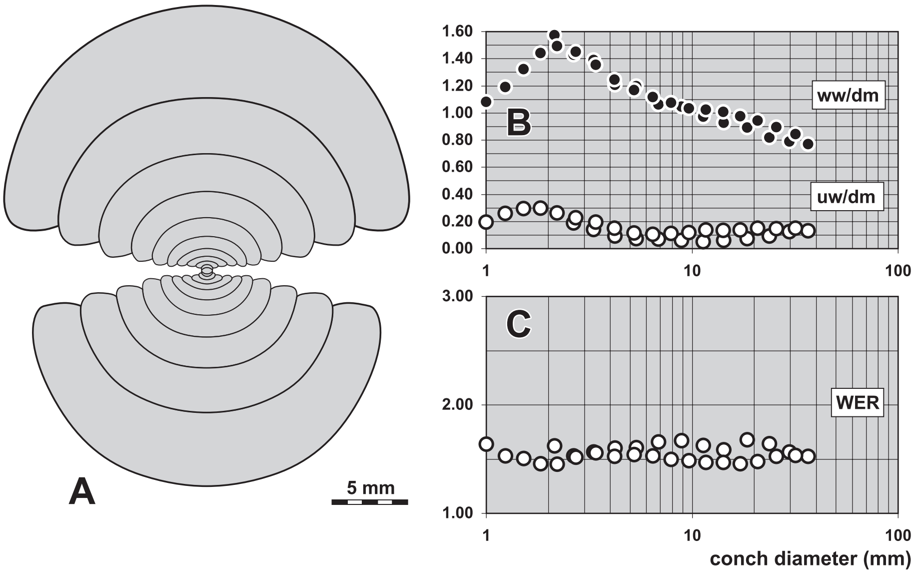


Figure 23. *Goniatites fimbriatus* (Foord & Crick, 1897) from Nehden, Rhenish Mountains (Korn 1986 Coll.). **A.** Cross section of specimen MB.C.13299; ×2.0. **B**, **C.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm) and whorl expansion rate (WER) of the two sectioned specimens MB.C.13299.1 and MB.C.13299.2.

Type locality and horizon. Oese near Menden (Rhenish Mountains); '*crenistria* Zone' (most probably *Goniatites globostriatus* Zone, Late Viséan).

Material. Three sideritic specimens between 63 and 98 mm conch diameter from horizon CeH-1 of the locality Chebket el Hamra-N.

Diagnosis. *Goniatites* with thickly discoidal to thinly pachyconic conch at 100 mm diameter (ww/dm = 0.50–0.55). Umbilicus very narrow (uw/dm = 0.15); umbilical wall rounded. Ornamentation with crenulated biconvex and rectiradiate growth-lines with high dorsolateral projection and lower ventrolateral projection; external sinus deep. Approximately 180 spiral lines. Adult stage with coarse falcatoid ornament. Deep biconvex constrictions. Suture line with V-shaped (in juveniles) or Y-shaped (in adults), moderately narrow external lobe (0.60 of the external lobe depth, 1.20 of the adventive lobe), and moderate median saddle (0.45 of the external lobe depth). Flanks of the external lobe sharply incurved, ventrolateral saddle acute, adventive lobe V-shaped with almost straight flanks.

Description. Specimen MB.C.13255.1 is a beautiful individual with almost 100 mm diameter (Fig. 24). It is thickly discoidal (ww/dm = 0.53) with a very narrow umbilicus (uw/d = 0.14) and a low aperture (WER = 1.53). The conch appears to be laterally compressed with subparallel flanks that converge slowly toward the broadly rounded venter. The umbilical margin and the umbilical wall are rounded. Almost the entire

Figure 24. *Goniatites globostriatus* (Schmidt, 1925). Specimen MB.C.13255.1 from locality Chebket el Hamra-N; ×1.0.

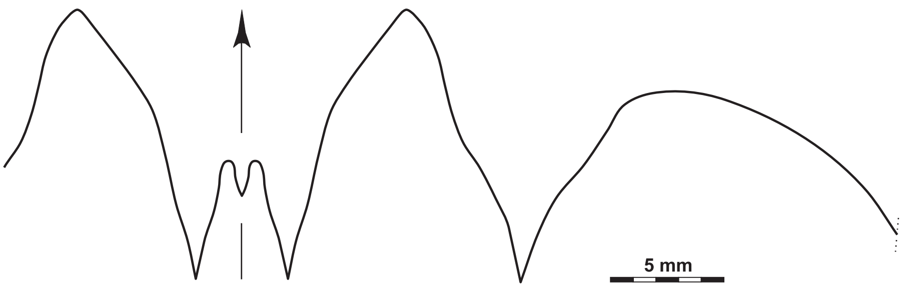


Figure 25. *Goniatites globostriatus* (Schmidt, 1925). Suture line of specimen MB.C.13255.2 from locality Chebket el Hamra-N, at 20 mm wh; ×3.0.

specimen is preserved as an internal mould with little shell remains. Impressions of the coarse ornament can be seen on the surface of the steinkern; they show that there is a combination of about 180 spiral lines with fine growth lines, which are periodically strengthened and produce a falcate ornament. The growth lines are strongly biconvex in their course with a rather prominent dorsolateral projection, a lower ventrolateral projection, and a rather deep ventral sinus. Deep constrictions with distances of approximately 75° are visible on the steinkern; they do not run parallel to the growth lines but extend almost straight with a low dorsolateral projection across flanks and venter.

The suture line of specimen MB.C.13255.2 (20 mm whorl height) is typical for an adult specimen of *Goniatites*. It has an external lobe that shows the transformation from the V-shape into the Y-shape, with flanks possessing a conspicuous bend at two thirds of its height, and above which they strongly diverge (Fig. 25). The median saddle reaches 0.45 of the E lobe depth, and the secondary prongs of the E lobe are symmetric and narrowly V-shaped. The ventrolateral saddle is almost symmetric and acute, and the adventive lobe is V-shaped with slightly curved flanks.

Discussion. With this new discovery, the first representative of an adult specimen of *Goniatites globostriatus* can be shown. It clearly shows the differences with the probably contemporaneous species *G. moorei* Weyer, 1972 from the British Isles, which does not possess a falcatoid ornament in the adult stage (Korn & Tilsley 2006).

Other species of *Goniatites* with a falcatoid ornament are *G. spirifer* Roemer, 1850, in which this type of ornament is not as strongly developed, and *G. crenifalcatus* Bogoslovskaya, 1966, in which the growth lines have a course with much higher ventrolateral projection.

Subfamily **Arnsbergitinae** n. subfam.

Included genera.

Arnsbergites Korn, 1988.
Hibernicoceras Moore & Hodson, 1958.
Paraglyphioceras Brüning, 1923.
Neogoniatites Ruzhencev & Bogoslovskaya, 1970.
Xainzalites Sheng, 1983 [synonym of *Neogoniatites* Ruzhencev & Bogoslovskaya, 1970].
Lusitanoceras Pereira de Sousa, 1923.
Mesoglyphioceras Pareyn 1961 [synonym of *Lusitanoceras* Pereira de Sousa, 1923].
Junggarites Liang & Wang, 1991.

Discussion. The new subfamily is erected here for goniatitids with advanced conch morphology, displaying an ontogenetic development including a widely umbilicate stage for at least three whorls. Another separating criterion is the course of the growth lines in the late juvenile to preadult stage of many of the species, with a high ventral projection of the growth lines, which in representatives of the Goniatitinae is restricted to early juveniles.

Arnsbergites **Korn, 1988**

Type species. Goniatites falcatus Roemer, 1850.

Discussion. Seven valid species of *Arnsbergites* are listed in the AMMON database (Korn & Ilg 2007). One of these, *A. quinquagenarius* (Hoeck, 1929) is based on crushed, poorly preserved material and thus very difficult to interpret. Of the remaining species, the three German species *A. falcatus* (Roemer, 1850), *A. arnsbergensis* (Brüning, 1923), and *A. gracilis* Korn, 1988 have been described with respect to their conch ontogeny (Korn 1988). For the three British and Irish species, the description of the inner whorls is still lacking.

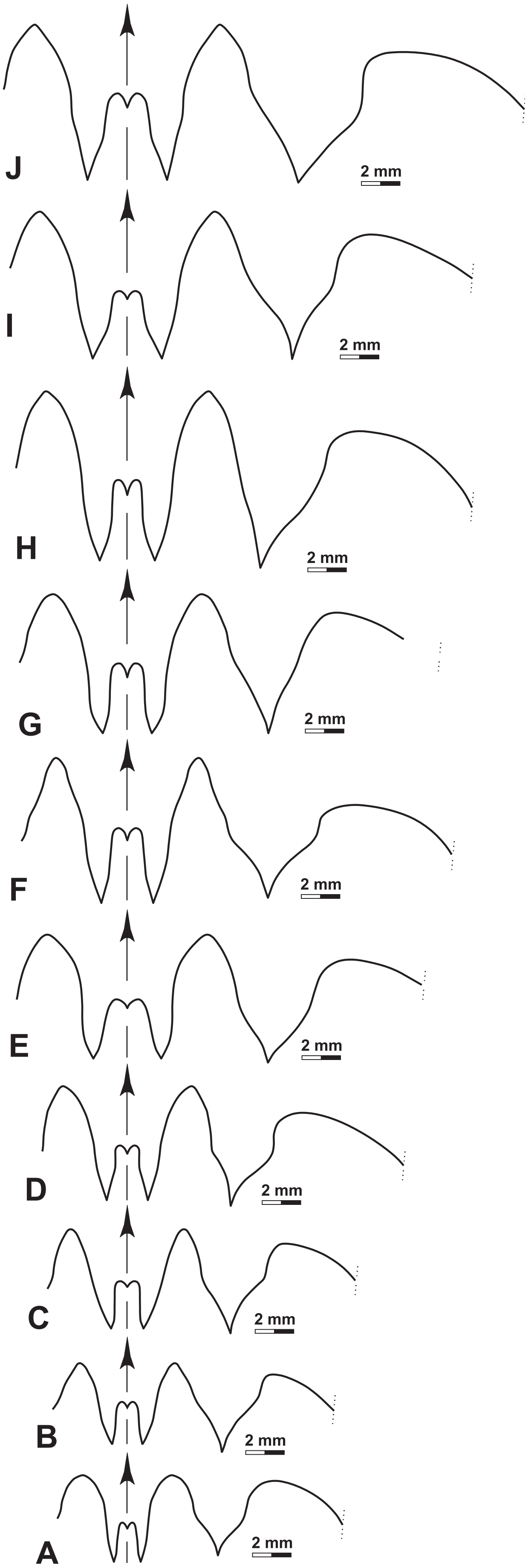
The species of *Arnsbergites* can be grouped as follows:

A – species with falcate radial ornament:

- *A. falcatus* (Roemer, 1850): with a thickly pachyconic conch (ww/dm = 0.75 at 25 mm dm) and a coarse falcate ornament beginning at 25 mm dm;
- *A. sphaericostriatus* (Bisat, 1924): with a thickly pachyconic conch (ww/dm = 0.75–0.85 at 25 mm dm), a weak falcate ornament beginning at 30 mm dm, and a V-shaped external lobe that is very narrow at its base (0.30–0.35 of external lobe depth).

B – species without falcate radial ornament and a narrow external lobe (Fig. 26):

- *A. warslowensis* (Bisat, 1957): with a thickly pachyconic to globular conch (ww/dm = 0.85 at 25 mm dm) and a V-shaped external lobe that is very narrow at its base (0.30–0.35 of external lobe depth), ventrolateral saddle subacute;
- *A. robustus* (Moore & Hodson, 1958): with a thickly pachyconic to globular conch (ww/dm = 0.85 at 25 mm dm) and a V-shaped external lobe that is narrow at its base (0.35–0.40 of external lobe depth), ventrolateral saddle subacute;



A. rufus n. sp.: with a thinly pachyconic conch (ww/dm = 0.60–0.65 at 25 mm dm) and a V-shaped external lobe that is narrow at its base (0.35–0.40 of external lobe depth), ventrolateral saddle subacute;

A. proiecturus n. sp.: with a globular conch (ww/dm = 0.85–0.95 at 25 mm dm) and a V-shaped external lobe that is very narrow at its base (0.30–0.35 of external lobe depth), ventrolateral saddle rounded.

C – species without falcate radial ornament and a rather wide external lobe (Fig. 26):

A. arnsbergensis (Brüning, 1923): with a thickly pachyconic conch (ww/dm = 0.75 at 25 mm dm) and a Y-shaped external lobe;

A. gracilis Korn, 1988: with a thickly pachyconic conch (ww/dm = 0.75 at 25 mm dm) and a V-shaped external lobe that is moderately wide at its base (0.45–0.50 of external lobe depth);

A. ferrus n. sp.: with a thickly pachyconic conch (ww/dm = 0.75–0.85 at 25 mm dm) and a V-shaped to Y-shaped external lobe that is moderately wide at its base (0.50 of external lobe depth).

***Arnsbergites sphaericostriatus* (Bisat, 1924)**
Figures 27–29

1924 *Goniatites sphaerico-striatus* Bisat, p. 75.
1928 *Goniatites waddingtoni* Bisat, p. 131.
1936 *Goniatites sphaerico-striatus*. – Moore, p. 181, pl. 1, figs 6, 7.
1958 *Goniatites sphaericostriatus*. – Moore & Hodson, p. 99, pl. 10, figs 6, 7.

Lectotype. Specimen GSM 71406 (Holmes Coll.).

Type locality and horizon. Dinckley Ferry, River Ribble (Lancashire, Great Britain); P1c Subzone (Late Viséan).

◀

Figure 26. Suture lines of representatives of *Arnsbergites*, all ×3.0. **A.** *A. proiecturus* n. sp., holotype MB.C.13219.1 from locality Chebket el Hamra-F, at 17.6 mm dm, 15.9 mm ww, 6.5 mm wh. **B.** *A. robustus* (Moore & Hodson, 1958), specimen GSM ZI5751 from Dough Mountain near Kiltyclogher (Ireland), at 16.3 mm dm, 14.0 mm ww, 6.8 mm wh. **C.** *A. warslowensis* (Bisat, 1957), specimen GSM ZI5230 from Warslow Brook (Staffordshire), at 15.5 mm dm, 15.2 mm ww, 6.7 mm wh. **D.** *Arnsbergites ferrus* n. sp., paratype MB.C.13291.2 from Chebket el Hamra, at 19.2 mm dm, 18.3 mm ww, 9.6 mm wh. **E.** *A. arnsbergensis* (Brüning, 1923), specimen MBG 4080 from Arnsberg (Rhenish Mountains), at 23.8 mm dm, 20.1 mm ww, 12.1 mm wh. **F.** *Arnsbergites rufus* n. sp., paratype MB.C.13285.2 from Chebket el Hamra, at 28.2 mm dm, 18.6 mm ww, 6.5 mm wh. **G.** *A. sphaericostriatus* (Bisat, 1924), specimen GSM ZI2623 from Dough Mountain near Kilticlogher (Ireland), at 28.7 mm dm, 21.8 mm ww, 13.0 mm wh. **H.** *Arnsbergites sphaericostriatus* (Bisat, 1924) n. sp., specimen MB.C.13290.1 from Chebket el Hamra, at 31.7 mm dm, 25.3 mm ww, 15.5 mm wh. **I.** *A. gracilis* Korn, 1988, specimen WMN 10122 from Holzen-Deinstrop (Rhenish Mountains), at 26.8 mm dm, 19.5 mm ww, 11.6 mm wh. **J.** *Arnsbergites ferrus* n. sp., holotype MB.C.13291.1 from Chebket el Hamra, at 30.0 mm dm, 24.7 mm ww, 16.4 mm wh.

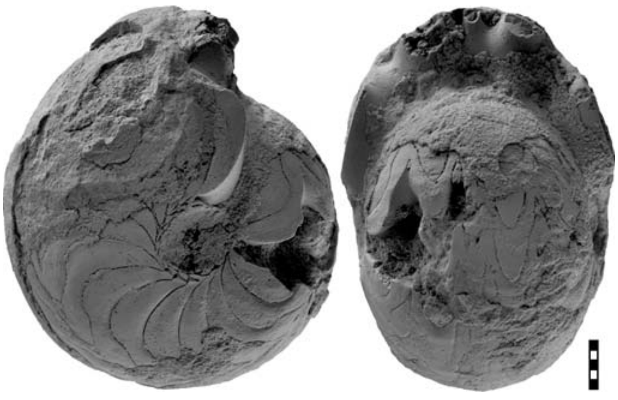


Figure 27. *Arnsbergites sphaericostriatus* (Bisat, 1924). Specimen MB.C.13290.1 from Chebket el Hamra; ×1.5.

Material. 22 limonitic steinkern specimens ranging from 8 to 38 mm in conch diameter, from horizon CeH-2 at localities Chebket el Hamra-F, I, T, and an unspecified locality.

Diagnosis. *Arnsbergites* with globular conch at 5 mm diameter (ww/dm = 0.85–0.95), globular conch at 10 mm diameter (ww/dm = 0.90–1.00), and thickly pachyconic conch at 25 mm diameter (ww/dm = 0.75–0.85). Umbilicus moderately wide to wide in early juveniles (uw/dm = 0.40–0.45 at 2–5 mm dm) and continuously closing in later stages (uw/dm = 0.10–0.15 at 20 mm dm); umbilical margin and umbilical wall rounded. Ornamentation with 180 fine and granulated spiral lines. Suture line with V-shaped, moderately wide external lobe (0.50–0.55 of the external lobe depth; 1.00–1.10 of the adventive lobe width), and moderate median saddle (0.45 of the external lobe depth). Flanks of the external lobe almost straight, ventrolateral saddle subacute to acute, adventive lobe with sinuous flanks.

Description. A cross section could only be produced from the small specimen MB.C.13234 (10 mm dm), but this displays the significant ontogenetic changes characteristic for the species (Fig. 28A). The early whorls have a wide umbilicus (uw/dm is more than 0.45 between 1.5 and 3.5 mm dm), which opens only slightly in the following whorls and thus leads to a rather rapid decrease of the uw/dm ratio (uw/dm = 0.23 at 10 mm dm). The aperture is low in all stages (WER = 1.50).

The largest specimen MB.C.13290.1 is a complete phragmocone specimen with 37 mm diameter but largely covered with an iron crust and bearing only few poorly preserved shell remains (Fig. 27). The conch is thinly pachyconic (ww/dm = 0.71) with a very narrow umbilicus (uw/dm = 0.14) and a very low aperture (WER = 1.53). The umbilical margin is rounded. On the internal mould and the iron crust, traces of a periodic strengthening of the growth lines are visible in the ventral and ventrolateral area; they suggest a falcate ornament.

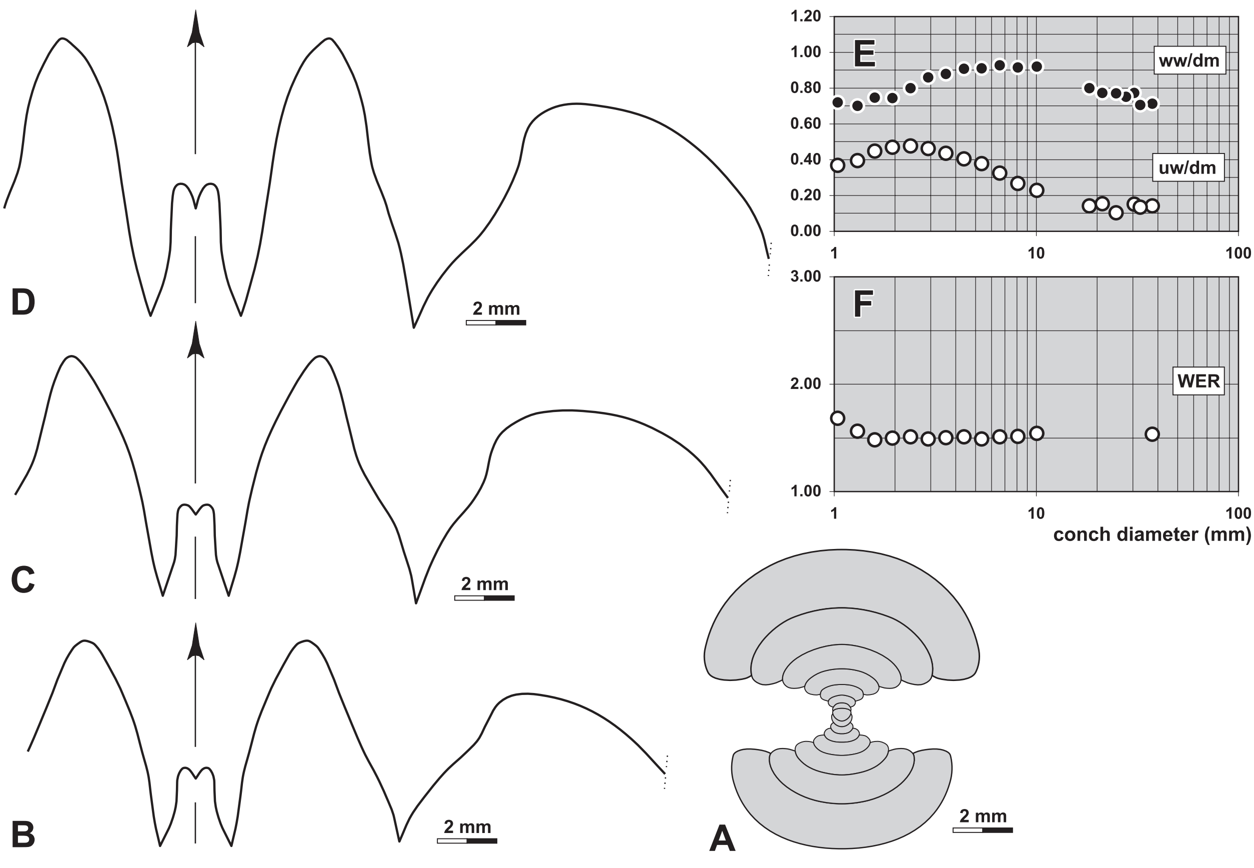


Figure 28. *Arnsbergites sphaericostriatus* (Bisat, 1924). **A.** Cross section of specimen MB.C.13234 from locality Chebket el Hamra-I; ×4.0. **B.** Suture line of specimen MB.C.13290.2 from Chebket el Hamra, at 22.0 mm dm, 17.1 mm ww, 12.0 mm wh; ×4.0. **C.** Suture line of specimen MB.C.13283 from Chebket el Hamra, at 27.5 mm dm, 22.9 mm ww, 14.6 mm wh; ×4.0. **D.** Suture line of specimen MB.C.13290.1 from Chebket el Hamra, at 31.7 mm dm, 25.3 mm ww, 15.5 mm wh; ×4.0. **E, F.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm) and whorl expansion rate (WER) of all available specimens.

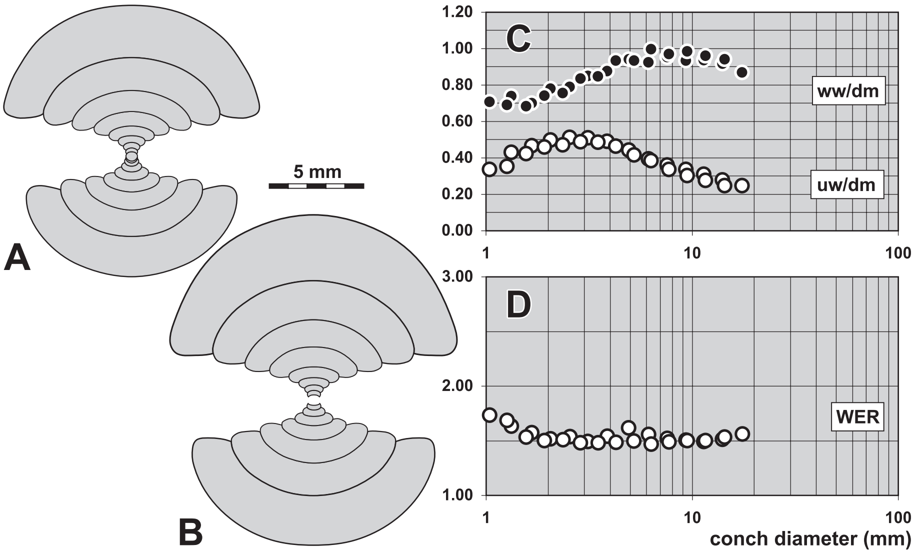


Figure 29. *Arnsbergites sphaericostriatus* (Bisat, 1924) from the highest of three horizons with *Arnsbergites* spp. at the base of the first shale member in the Carraun Shale Formation, north-western slope of Dough Mountain 3 km south-west of Kiltyclogher, Co. Leitrim, Ireland (Korn & Ebbighausen 2007 Coll.). **A.** Cross section of specimen MB.C.13309.1; ×2.5. **B.** Cross section of specimen MB.C.13309.2; ×2.5. **C**, **D.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm) and whorl expansion rate (WER) of the two sectioned specimens.

The suture lines of the specimens are characterised by a narrow V-shaped external lobe, which has stronger diverging flanks in smaller specimens such as MB.C.13290.2 (22 mm dm; Fig. 28B). In the larger specimens MB.C.13283 (27.5 mm dm) and MB.C.13290.1 (31.7 mm dm), the flanks tend to stand more parallel (Figs 28C, D). The ventrolateral saddle is almost symmetric in the three specimens, changing ontogenetically from subacute to acute. At the same time, the adventive lobe becomes narrower. This lobe has a weakly curved ventral and a more strongly curved dorsal flank.

Discussion. *A. sphaericostriatus* differs from similar species, such as *A. gracilis*, *A. robustus*, *A. warslowensis*, *A. arnsbergensis*, and *A. ferrus* in the presence of a weak falcate ornament at a conch diameter of 35 mm. *A. sphaericostriatus* belongs with the other species of the genus that have a narrow external lobe, which is a good criterion for separating it from species with a similar conch geometry, such as *A. gracilis* and *A. ferrus*.

Arnsbergites ferrus **n. sp.**
Figures 30–31

Derivation of name. After Latin *ferrus* = sword, because of the shape of the prongs of the external lobe.

Holotype. Specimen MB.C.13291.1 (Ebbighausen & Weyer 2007 Coll.); illustrated in Figure 30A.

Type locality and horizon. Chebket el Hamra (Jerada Basin, NE-Morocco); horizon CeH-2, *Arnsbergites gracilis* or *Neoglyphioceras spirale* Zone (middle Brigantian, Early Carboniferous).

Material. 38 limonitic steinkern specimens between 8 and 31 mm conch diameter from horizon CeH-2 at localities Chebket el Hamra-F, I, T, and an unspecified locality.

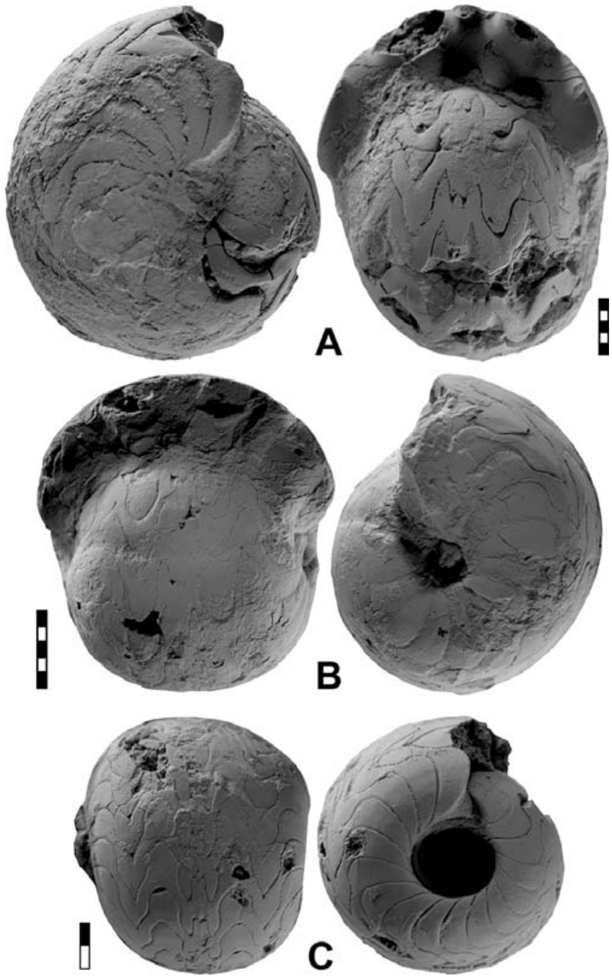


Figure 30. *Arnsbergites ferrus* n. sp. **A.** Holotype MB.C.13291.1 from Chebket el Hamra; ×1.5. **B.** Specimen MB.C.13291.2 from Chebket el Hamra; ×2.0. **C.** Paratype MB.C.13218.1 from locality Chebket el Hamra-F; ×3.0.

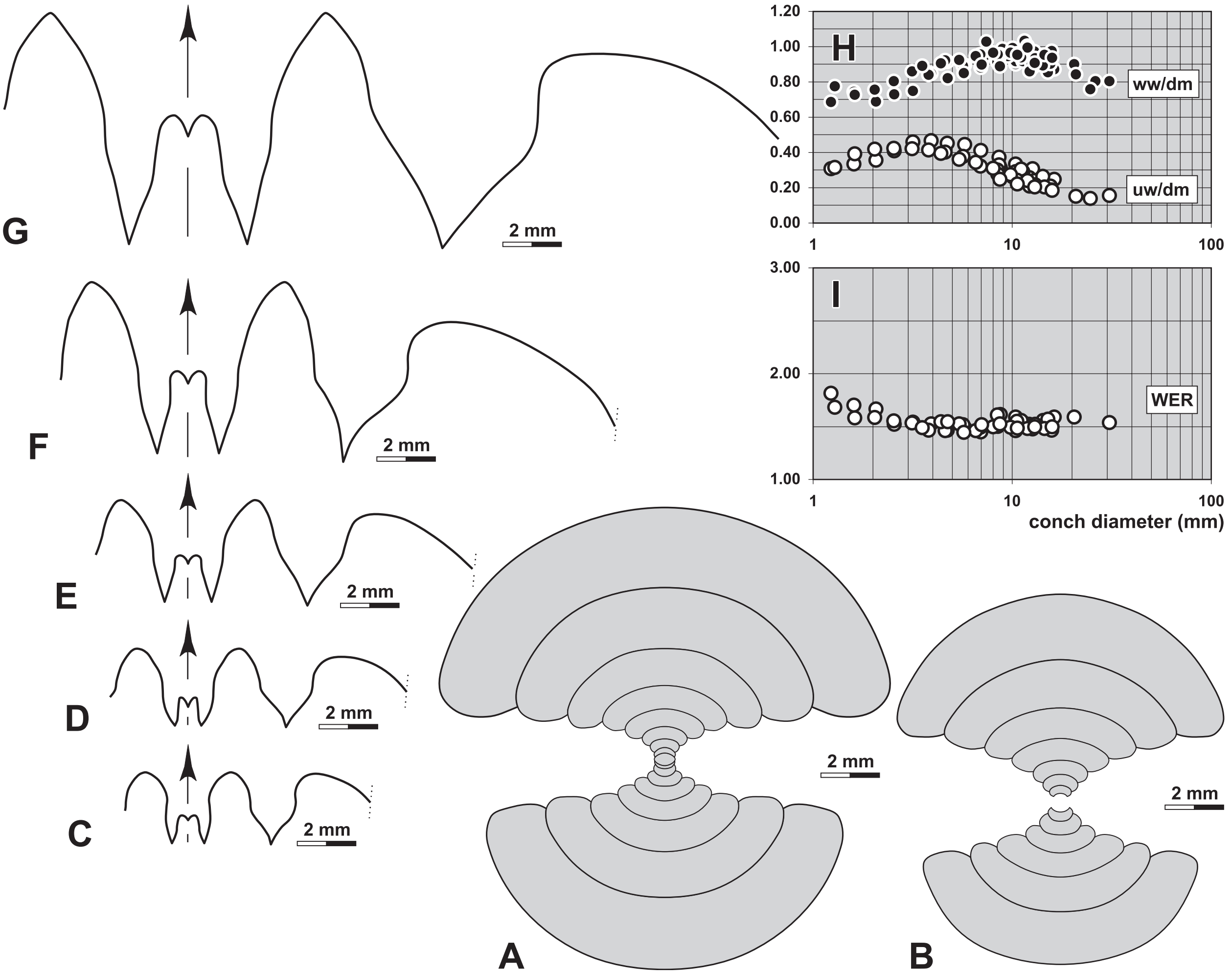


Figure 31. *Arnsbergites ferrus* n. sp. **A.** Cross section of paratype MB.C.13274.1 from locality Chebket el Hamra-T; ×4.0. **B.** Cross section of paratype MB.C.13218.2 from locality Chebket el Hamra-F; ×4.0. **C.** Suture line of paratype MB.C.13218.1 from locality Chebket el Hamra-F, at 10.2 mm dm, 9.2 mm ww, 4.2 mm wh; ×4.0. **D.** Suture line of paratype MB.C.13218.3 from locality Chebket el Hamra-F, at 11.1 mm dm, 11.2 mm ww, 4.3 mm wh; ×4.0. **E.** Suture line of paratype MB.C.13218.4 from locality Chebket el Hamra-F, at 14.9 mm dm, 13.1 mm ww, 6.3 mm wh; ×4.0. **F.** Suture line of paratype MB.C.13291.2 from Chebket el Hamra, at 19.2 mm dm, 18.3 mm ww, 9.6 mm wh; ×4.0. **G.** Suture line of holotype MB.C.13291.1 from Chebket el Hamra, at 30.0 mm dm, 24.7 mm ww, 16.4 mm wh; ×4.0. **H, I.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm) and whorl expansion rate (WER) of all available specimens.

Diagnosis. *Arnsbergites* with globular conch at 5 mm diameter (ww/dm = 0.85–0.95), globular conch at 10 mm diameter (ww/dm = 0.90–1.00), and thickly pachyconic conch at 25 mm diameter (ww/dm = 0.75–0.85). Umbilicus moderately wide to wide in early juveniles (uw/dm = 0.40–0.50 at 2–5 mm dm) and continuously closing in later stages (uw/dm = 0.20–0.25 at 15 mm dm); umbilical margin and umbilical wall rounded. Ornamentation with 180 fine and granulated spiral lines. Suture line with V-shaped to Y-shaped, moderately wide external lobe (0.60–0.70 of the external lobe depth; 1.10 of the adventive lobe width), and moderate median saddle (0.50 of the external lobe depth). Flanks of the external lobe slightly sinuous, ventrolateral saddle subacute, adventive lobe with sinuous flanks.

Description. The plot displaying the ontogeny of the cardinal conch parameters shows that the ontogenetic trends of the ww/dm ratio and the uw/dm ratio are unrelated, and that it is thus not possible to distinguish between distinct growth stages (Fig. 31H). The development of the conch width shows two phases. In the first growth interval, ranging up to about 11 mm dm, a continuous increase of the ww/dm ratio can be seen from 0.70–0.75 at 2 mm dm to 0.90–1.00 at 11 mm. A reverse development, i.e. a decrease of the ww/dm ratio to ww/dm = 0.80 occurs the second growth interval. In the uw/dm ratio, also two growth intervals can be seen, but the first one is much shorter. The uw/dm ratio increases up to 4 mm conch diameter (uw/dm = 0.42–0.47); thereafter, an almost continuous decrease to approximately 0.15 at 20 mm dm can be seen. The aperture is very low in all stages above 2 mm conch diameter; the whorl expansion rate ranges between 1.50 and 1.60 (Fig. 31I).

A number of cross sections were produced to outline the ontogenetic changes, the intraspecific variability, and the differences with the co-occurring species of *Arnsbergites* (Figs 31A, B). The most complete of these is paratype MB.C.13274.1 with a maximum diameter

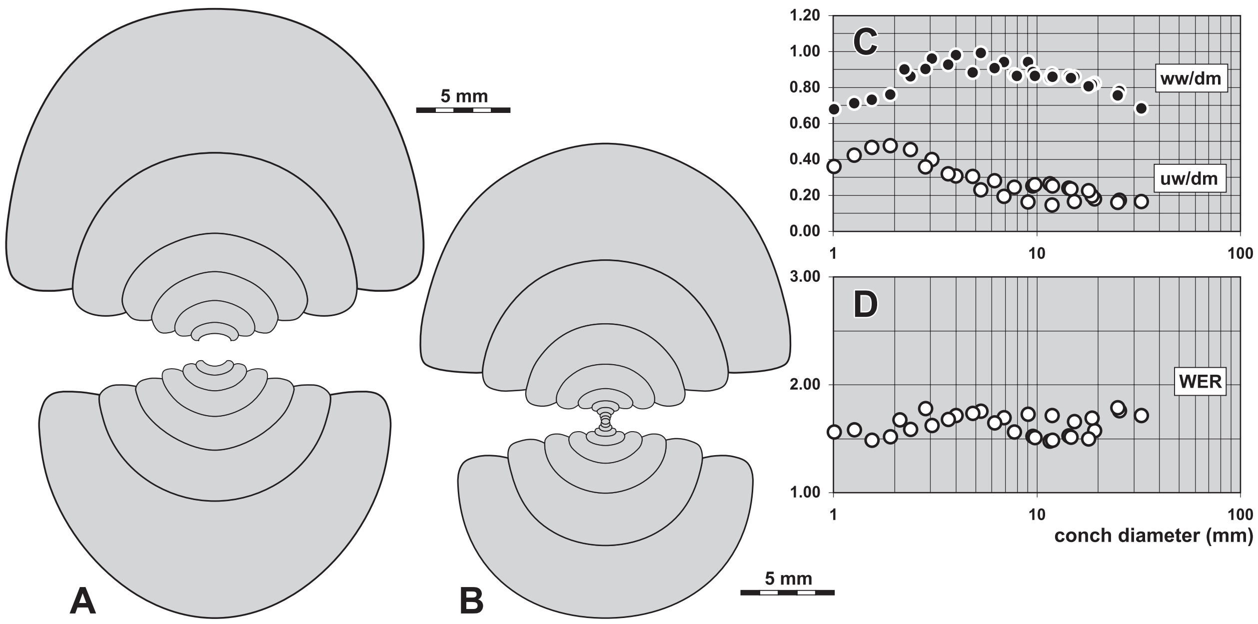


Figure 32. *Arnsbergites gracilis* Korn, 1988 from the Rhenish Mountains. **A.** Cross section of specimen MB.C.13300 from Nehden (Korn 1987 Coll.); ×2.5. **B.** Cross section of specimen MB.C.13304 from the Eulenspiegel (Korn 1983 Coll.); ×2.5. **C**, **D.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm) and whorl expansion rate (WER) of the sectioned specimens MB.C.13300, MB.C.13304, and the topotype (not figured) MB.C.13298.

of almost 16 mm. It demonstrates the conspicuous ontogenetic changes, beginning with an open umbilicate conch with crescent-shaped whorl section, being transformed into C-shaped sections in later stages. The venter is broad and continuously rounded in all stages, and the umbilical margin is narrowly rounded.

Holotype MB.C.13291.1 (30 mm conch diameter) is the largest available specimen (Fig. 30A). It is fully chambered and slightly deformed tectonically. Most of the specimen is covered by an iron hydroxide crust, and ornament traces are thus only barely visible. The specimen is thickly pachyconic (ww/dm = 0.81), a narrow umbilicus (uw/dm = 0.16), and a very low aperture (WER = 1.54). The flanks and venter are continuously rounded. Some impressions of the ornament are visible near the aperture; they show fine spiral lines.

Other slightly deformed specimens are paratypes MB.C.13284.1 (24 mm dm) and MB.C.13291.2 (20 mm dm). The first of these is thickly pachyconic (ww/dm = 0.78) and bears some shell remains. Its ornament is composed of fine and delicately granulated spiral lines, which are almost as wide as their interspaces. Constrictions are absent on the steinkern. The smaller paratype MB.C.13291.2 is globular (ww/dm = 0.90) with continuously rounded flanks and venter and a rounded umbilical margin (Fig. 30B). The specimen shows one almost linear constriction of the steinkern with a very low and wide ventral projection near the beginning of the last whorl.

Almost all specimens smaller than 16 mm dm are globular and widely umbilicate. For instance, specimen MB.C.13218.4 has, at 16 mm dm, an umbilicus of one quarter of the conch diameter. This ratio is 0.31 in specimen MB.C.13218.1 (11 mm dm) and 0.36 in specimen MB.C.13218.5 (9.5 mm dm). None of these three specimens shows constrictions of the steinkern.

A series of suture lines has been drawn to outline the ontogenetic changes and variability between various specimens. For this purpose, the five paratypes MB.C.13218.1 (10 mm dm), MB.C.13218.3 (11 mm dm), MB.C.13218.4 (15 mm dm), MB.C.13291.2 (19 mm dm), and MB.C.13291.1 (30 mm dm) are illustrated here (Figs 31C–G). Several general ontogenetic trends can be seen, (1) the heightening of the median saddle (less than 0.40 of the E lobe depth at 11 mm dm; 0.56 at 30 mm dm), (2) the transformation of a Y-shaped external lobe in juveniles into a more V-shaped in adults, (3) the loss of pouching of the lower half of the external lobe, (4) the transformation of a rounded ventrolateral saddle into a subacute. It is only the adventive lobe that has a very similar outline in the studied growth interval of the specimens, possessing a gently curved ventral and a stronger curved dorsal flank.

Discussion. *A. ferrus* is the most common species of *Arnsbergites* at Chebket el Hamra. It differs from *A. proiecturus* in having stronger sinuous flanks of the external lobe, a subacute ventrolateral saddle, and in the narrower umbilicus in the intermediate stage. *A. sphaericostriatus* has a narrower conch than *A. ferrus* and a suture line with a much narrower external lobe.

Arnsbergites gracilis has a similar suture line with wide external lobe, but with a narrower conch and a narrower umbilicus in the intermediate stage (Fig. 32). *A. robustus* has a similar conch geometry, but possesses

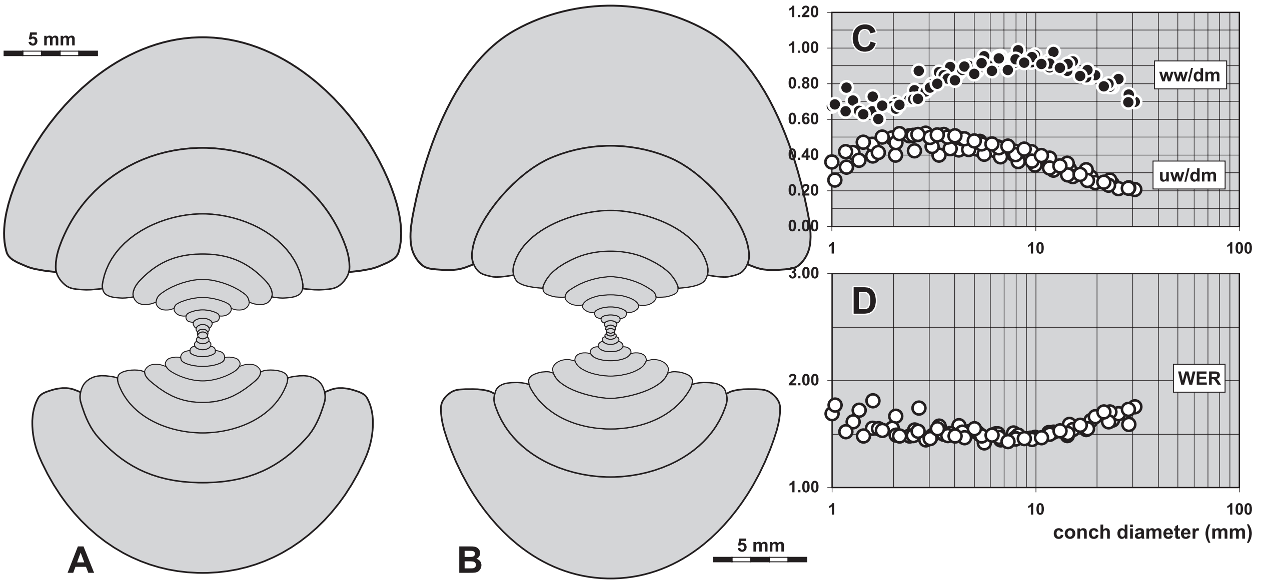


Figure 33. *Arnsbergites robustus* (Moore & Hodson, 1958) from the Rhenish Mountains. **A.** Cross section of specimen MB.C.13306 from the Biesenberg (Korn 1983 Coll.); ×2.5. **B.** Cross section of specimen MB.C.13301 from Nehden (Korn 1986 Coll.); ×2.5. **C**, **D.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm) and whorl expansion rate (WER) of the four sectioned specimens MB.C.13302, MB.C.13301, MB.C.13305, and MB.C.13306.

a wider umbilicus and a narrower external lobe. Specimens of *A. robustus* from the Rhenish Mountains (Fig. 33) show that the ontogeny of the conch parameters is very similar.

Arnsbergites proiecturus n. sp.
Figures 34–36

Derivation of name. From Latin *proiecturus* = projection, because of the course of the growth lines.

Holotype. Specimen MB.C.13219.1 (Korn & Ebbighausen 2006 Coll.); illustrated in Figure 34A.

Type locality and horizon. Chebket el Hamra-F (Jerada Basin, NE-Morocco); horizon CeH-2, most probably *Neoglyphioceras spirale* Zone (middle Brigantian, Early Carboniferous).

Material. Five limonitic steinkern specimens ranging from 9 to 19 mm in conch diameter from horizon CeH-2 at locality Chebket el Hamra-F.

Diagnosis. *Arnsbergites* with thickly pachyconic conch at 5 mm diameter (ww/dm = 0.75–0.85), globular conch at 10 mm diameter (ww/dm = 0.85–0.95), and globular conch at 25 mm diameter (ww/dm = 0.85–0.95). Umbilicus wide in early juveniles (uw/dm = 0.45–0.50 at 2–5 mm dm) and continuously becoming narrower in later stages (uw/dm = 0.30 at 20 mm dm); umbilical margin subangular, umbilical wall flattened. Ornamentation with fine and granulated spiral lines. Suture line with Y-shaped, moderately narrow external lobe (0.50 of the external lobe depth; 0.90 of the adventive lobe width), and moderate median saddle (0.45 of the external lobe depth). Flanks of the external lobe slightly sinuous, ventrolateral saddle rounded, adventive lobe with sinuous flanks.

Description. The small sectioned paratype MB.C.13219.3 (Fig. 35A) shows the serpenticonic inner whorls (ww/dm = 0.50, uw/dm = 0.46 at 2 mm dm), which are transformed into a cadyconic shape that is present from 5 to 11 mm conch diameter (ww/dm = 0.86, uw/dm = 0.36 at 11 mm dm). The aperture is low in this growth interval, with a whorl expansion rate of 1.50 (Figs 35D, E).

The largest available specimen, holotype MB.C.13219.1 (Fig. 34A) has 18.6 mm conch diameter and is globular (ww/dm = 0.92) with a moderate umbilicus (uw/dm = 0.31). It has a subangular umbilical margin and a flattened and steep umbilical wall. Almost the entire specimen represents the body chamber, but the last suture line is only barely visible, probably due to incomplete mineralization of the septum. Two steinkern constrictions, arranged in opposite position, extend with a shallow lateral sinus and a wide rounded ventral projection. Traces of growth lines show the same

Figure 34. *Arnsbergites proiecturus* n. sp. **A.** Holotype MB.C.13219.1 from locality Chebket el Hamra-F; ×2.0. **B.** Paratype MB.C.13219.2 from locality Chebket el Hamra-F; ×2.5.

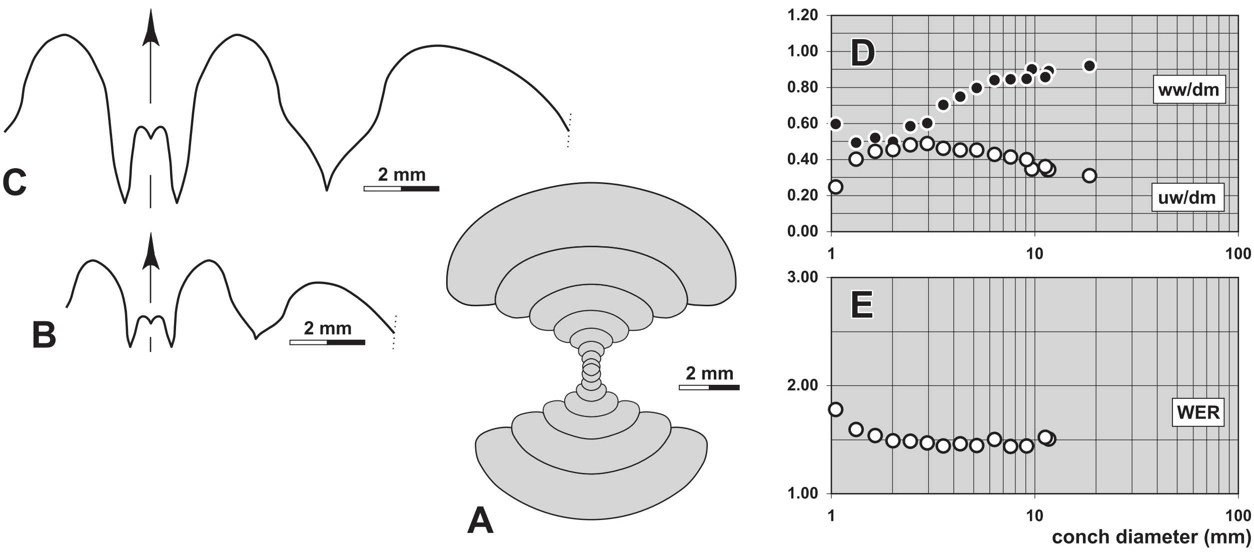


Figure 35. *Arnsbergites proiecturus* n. sp. **A.** Cross section of paratype MB.C.13219.3 from locality Chebket el Hamra-F; ×4.0. **B.** Suture line of paratype MB.C.13219.2 from locality Chebket el Hamra-F, at 11.0 mm dm, 9.9 mm ww, 4.1 mm wh; ×5.0. **C.** Suture line of holotype MB.C.13219.1 from locality Chebket el Hamra-F, at 17.6 mm dm, 15.9 mm ww, 6.5 mm wh; ×5.0. **D**, **E.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm) and whorl expansion rate (WER) of all available specimens.

course, yielding evidence that, at this diameter, a ventral sinus had not yet developed. The sparse shell remains around the umbilicus show delicate spiral lines.

Paratype MB.C.13219.2 (11.7 mm dm; Fig. 34B) has similar conch geometry with a globular form (ww/dm = 0.89) and a moderate umbilicus (uw/dm = 0.35). One visible steinkern constriction follows a course in which the rounded and wide ventral projection is the dominant element. Shell remains at the beginning of the last whorl show rather coarse growth lines, which bend strongly forward to form a broad and flattened ventral projection.

The suture line of the holotype MB.C.13219.1 (drawn at 17.5 mm dm; Fig. 35B) has a rather narrow external lobe that has a width, at half depth, of half of the lobe depth, being narrower than the narrowly rounded ventrolateral saddle. The flanks of the external lobe are straight in the lower three quarters and form

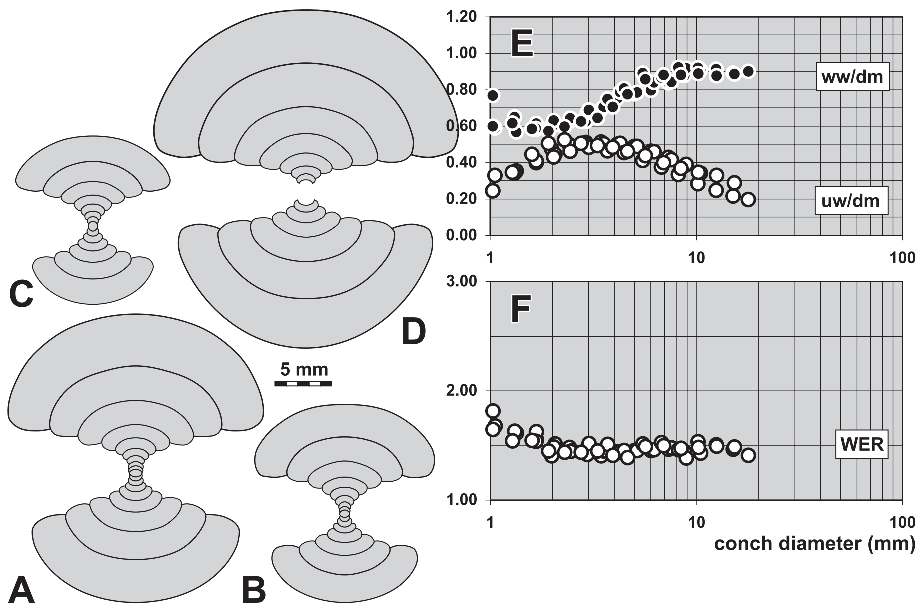


Figure 36. *Arnsbergites proiecturus* n. sp. from bed 144 of the Praia de Murração section (B) and from bed 134 of the Praia das Quebradas section (A, C, D), SW Portugal (Korn & Horn 1995 Coll.). **A.** Cross section of specimen MB.C.13311.1; ×2.5. **B.** Cross section of specimen MB.C.13312; ×2.5. **C.** Cross section of specimen MB.C.13311.2; ×2.5. **D.** Cross section of specimen MB.C.13311.3; ×2.5. **E**, **F.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm) and whorl expansion rate (WER) of the four sectioned specimens.

narrow prongs together with the flanks of the median saddle that reaches 0.46 of the E lobe depth. The adventive lobe has rather strongly curved flanks.

The suture line of the juvenile paratype MB.C.13219.2 (11 mm dm) has a Y-shaped external lobe with slightly diverging flanks in the lower half (Fig. 35C). The ventrolateral saddle is asymmetric and narrowly rounded, and the adventive lobe is wide with curved flanks.

Discussion. In conch shape and course of the constrictions, the new material from Chebket el Hamra closely resembles material from the South Portuguese Zone (Fig. 36) and the type specimen of '*Goniatites robustus* Moore & Hodson, 1958. However, the suture line of the Irish species has a subacute ventrolateral saddle with strongly converging flanks, whereas in *A. proiecturus* the ventrolateral saddle is rather broadly rounded.

A. proiecturus differs from the other Moroccan species of *Arnsbergites* in the much wider umbilicus in comparable stages. Furthermore, it differs from the others in the presence of a ventral projection of the growth lines in a rather large conch diameter of 18 mm (i.e. the absence of a ventral sinus). The narrow external lobe is another clear distinguishing character from *A. ferrus*.

***Arnsbergites rufus* n. sp.**
Figures 37–38

Derivation of name. From Latin *rufus* = red, after the colour of the specimens and the shales from which they derive.

Holotype. Specimen MB.C.13285.1 (Korn & Ebbighausen 2006 Coll.); illustrated in Figure 37A.

Type locality and horizon. Chebket el Hamra (Jerada Basin, NE-Morocco); horizon CeH-2, *Arnsbergites gracilis* or *Neoglyphioceras spirale* Zone (middle Brigantian, Early Carboniferous).

Material. Seven limonitic specimens ranging from 23 and 38 mm conch diameter from horizon CeH-2 of an unspecified locality at the Chebket el Hamra.

Diagnosis. *Arnsbergites* with thickly pachyconic conch at 20 mm diameter (ww/dm = 0.80–0.85) and thinly pachyconic conch at 25 mm diameter (ww/dm = 0.60–0.65). Umbilicus very narrow at 20–35 mm dm (uw/dm = 0.05–0.15); umbilical margin and umbilical wall rounded. Ornamentation with 150 lamellose and granulated spiral lines. Suture line with V-shaped, moderately wide external lobe (0.60 of the external lobe depth; 1.00 of the adventive lobe width), and moderate median saddle (0.50 of the external lobe depth). Flanks of the external lobe sinuous, ventrolateral saddle subacute, adventive lobe with sinuous flanks.

Description. None of the specimens shows the internal whorls, and they are not preserved in the sectioned specimen MB.C.13285.3 (Fig. 38A). The last whorl however shows the laterally slightly compressed whorl cross section, in which flanks and venter are separated by a broadly rounded ventrolateral shoulder.

Holotype MB.C.13285.1 is a well preserved haematitic specimen on which many shell remains are still attached (Fig. 37A). It has a diameter of 37.5 mm, it is thinly pachyconic (ww/dm = 0.61) and laterally compressed with a very narrow umbilicus (uw/dm = 0.11) and a low aperture (WER = 1.56). The well-preserved ornament consists of approximately 150 lamellose and faintly granulated spiral lines and growth lines, which extend with equally high lateral projections and a wide and shallow ventral sinus.

Paratype MB.C.13285.2 (32.5 mm dm; Fig. 37B) has a similar applanate shape (ww/dm = 0.64). It is slightly deformed and fully septate with 15 chambers. The steinkern bears one very shallow constriction, extending straight across flanks and venter.

The suture line of paratype MB.C.13285.2 (drawn at 28 mm dm) has a V-shaped external lobe with double-curved flanks diverging towards the narrow, slightly asymmetric and subacute ventrolateral saddle (Fig. 38B). The median saddle reaches about the half height of the external lobe, producing two narrow and symmetric prongs of the E lobe.

Discussion. *Arnsbergites rufus* differs from the other species of the genus by its slender, laterally compressed conch shape. At 25 mm conch diameter, the ww/dm ratio is only 0.60–0.65 in *A. rufus*, whereas all other species show a ratio of at least 0.75. It is thus easily separable from the other species.

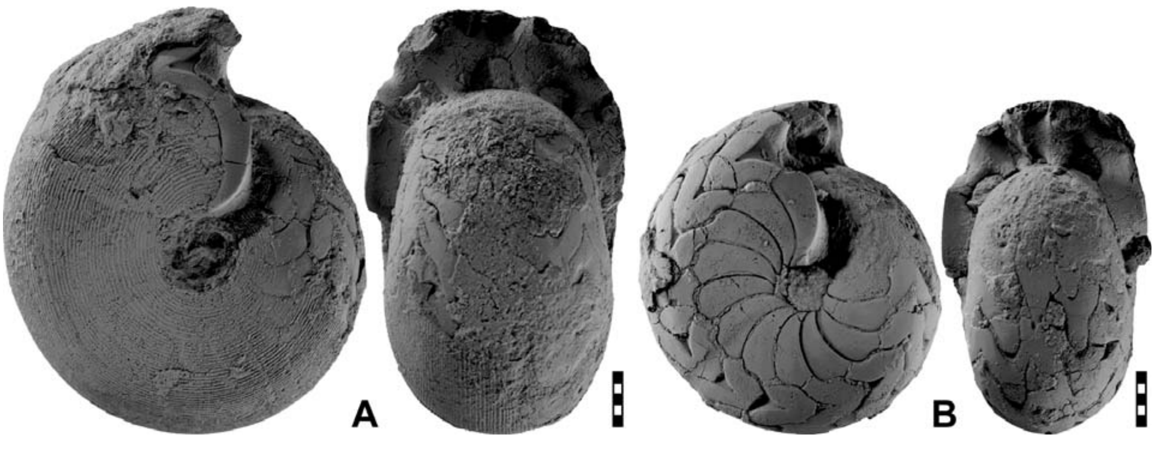


Figure 37. *Arnsbergites rufus* n. sp. **A.** Holotype MB.C.13285.1 from Chebket el Hamra; ×1.5. **B.** Paratype MB.C.13285.2 from Chebket el Hamra; ×1.5.

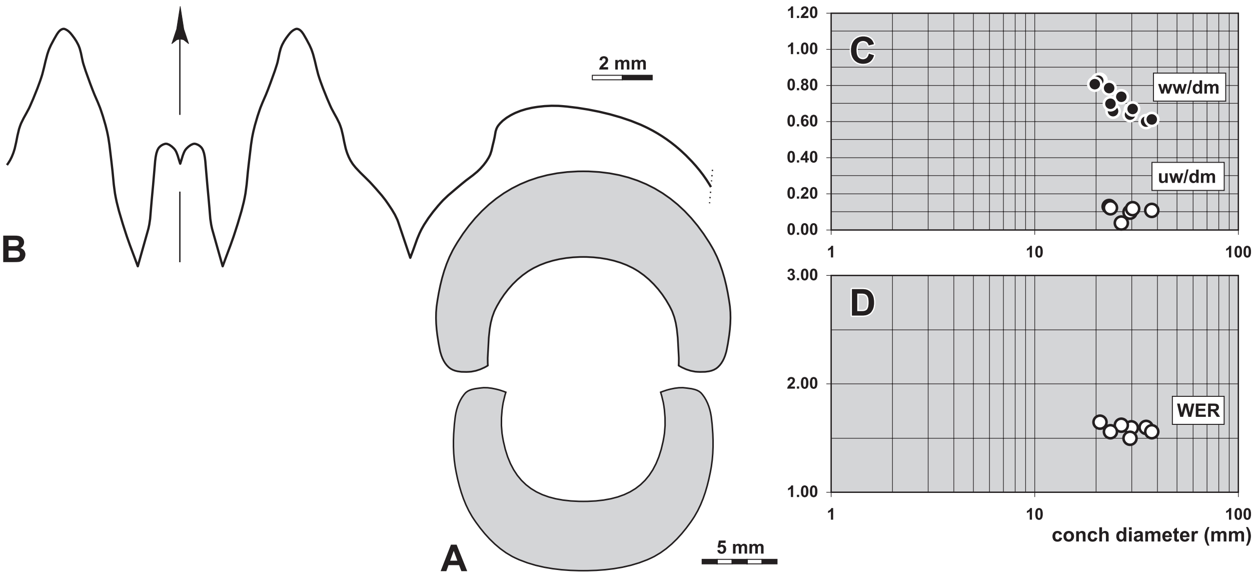


Figure 38. *Arnsbergites rufus* n. sp. **A.** Cross section of paratype MB.C.13285.3 from Chebket el Hamra; ×2.0. **B.** Suture line of paratype MB.C.13285.2 from Chebket el Hamra, at 28.2 mm dm, 18.6 mm ww, 6.5 mm wh; ×4.0. **C**, **D.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm) and whorl expansion rate (WER) of all available specimens.

Hibernicoceras Moore & Hodson, 1958

Type species. Hibernicoceras hibernicum Moore & Hodson, 1958.

Discussion. At present, eleven species of *Hibernicoceras* have been described (AMMON database; Korn & Ilg 2007). Two of these, *H. mucronatum* (Knopp, 1931) and *H. waldeckense* (Haubold, 1933) are based on crushed, poorly preserved material and are very difficult to interpret. Of the remaining species, only *H. hibernicum* Moore & Hodson, 1958, *H. tumidum* Moore & Hodson, 1958, *H. striatosphaericum* (Brüning, 1923), and *H. doliolum* Korn, 1988 have been described with respect to their conch ontogeny (Korn 1988, 1997).

The species of *Hibernicoceras* can be grouped as follows:

A – species with a prominent ventral projection of the growth lines, a ventral sinus is lacking or very shallow at 20 mm conch diameter; the external lobe has a width of 1.20–1.30 of the adventive lobe:

- *H. hibernicum* Moore & Hodson, 1958: with a thickly pachyconic conch (ww/dm = 0.80 at 20 mm dm) and coarse growth lines;
- *H. touissitense* n. sp.: with a thinly pachyconic conch (ww/dm = 0.63–0.70 at 20 mm dm) and moderately coarse growth lines;
- *H. doliolum* Korn, 1988: with a thickly pachyconic to globular conch (ww/dm = 0.85 at 20 mm dm) and fine growth lines.

B – species with a ventral sinus of the growth lines; the external lobe has a width of 1.10–1.30 of the adventive lobe:

- *H. striatosphaericum* (Brüning, 1923) [= *H. posthibernicum* Moore & Hodson, 1958]: with a spindle-shaped juvenile conch, a thinly pachyconic conch at 25 mm dm (ww/dm = 0.67), a comparatively high dorsolateral projection of the growth lines, and a Y-shaped external lobe;
- *H. tumidum* Moore & Hodson, 1958: with a globular juvenile conch, a thinly pachyconic conch at 25 mm dm (ww/dm = 0.67), a moderate dorsolateral projection of the growth lines, and a rather wide, V-shaped external lobe;
- *H. mediocris* Moore & Hodson, 1958: juvenile conch not known, with a thinly pachyconic conch at 25 mm dm (ww/dm = 0.67), a low dorsolateral projection of the growth lines, and a rather wide, V-shaped external lobe;
- *H. ramsbottomi* Moore & Hodson, 1958 [suture line not yet figured]: with a thinly pachyconic conch (ww/dm = 0.60–0.65 at 30 mm dm) and closely spaced growth lines in larger growth stages;
- *H. artilobatum* n. sp.: with a globular juvenile conch, a pachyconic conch at 25 mm dm (ww/dm = 0.70), a low dorsolateral projection of the growth lines, and a rather narrow, V-shaped external lobe.

C – species with a ventral sinus of the growth lines; the external lobe has a width of 1.40 of the adventive lobe:

- *H. carraunense* Moore & Hodson, 1958: with a thinly pachyconic conch (ww/dm = 0.65 at 30 mm dm) and widely spaced growth lines in larger growth stages, ventrolateral saddle rounded;
- *H. ultimum* Korn, 1988: with a thickly pachyconic conch (ww/dm = 0.75 at 20 mm dm) and moderately spaced growth lines in larger growth stages, ventrolateral saddle subacute;

H. alentejoense Korn, 1997: with a thinly pachyconic conch (ww/dm = 0.70 at 30 mm dm) and widely spaced growth lines in larger growth stages, ventrolateral saddle acute.

Hibernicoceras carraunense **Moore & Hodson, 1958**
Figures 39–40

1958 *Hibernicoceras carraunense* Moore & Hodson, p. 89, pl. 4, fig. 2.
1997 *Hibernicoceras carraunense*. – Korn, p. 56, textfig. 45.

Holotype. Specimen GSM ZI3845 (Moore Coll.); figured by Moore & Hodson (1958, pl. 4, fig. 2).

Type locality and horizon. Townland of Carraun, 3 km south-southwest of Kiltyclogher (Co. Leitrim, Ireland); P1c Subzone (Late Viséan).

Material. 38 limonitic steinkern specimens ranging from 6 and 33 mm in conch diameter from horizon CeH-2 at localities Chebket el Hamra-E, F, I, and T.

Diagnosis. *Hibernicoceras* with globular conch at 5 mm diameter (ww/dm = 0.85–0.95), globular conch at 10 mm diameter (ww/dm = 0.85–0.95), and thinly pachyconic conch at 30 mm diameter (ww/dm = 0.65–0.70). Umbilicus very wide in early juvenile stage (uw/dm = 0.50 at 2 mm dm) and becoming continuously narrower throughout ontogeny (uw/dm = 0.20–0.30 at 10 mm dm, uw/dm = 0.10–0.20 at 20 mm dm); umbilical margin and wall narrowly rounded. Ornamentation with fine, crenulated biconvex and rectiradiate growth-lines with rather high dorsolateral projection and lower ventrolateral projection; ventral sinus very shallow. Spiral lines in a narrow zone around the umbilicus. Suture line with Y-shaped external lobe in juveniles; in the adult stage with V-shaped, moderately wide external lobe (0.70–0.80 of the external lobe depth; 1.50 of the adventive lobe width), and moderate median saddle (almost 0.50 of the external lobe depth). Flanks of the external lobe almost straight, ventrolateral saddle narrowly rounded, adventive lobe with slightly sinuous flanks.

Description. Ontogenetic trends of the conch geometry can mainly be seen in the ww/dm ratio and in the uw/dm ratio (Fig. 40G). The conch is thickest between 4 and 12 mm diameter, with a ww/dm ratio ranging from 0.80 to 0.94. Later stages show a decrease of the relative conch width, and the largest specimens are thinly pachyconic at 33 mm dm (ww/dm = 0.69). The umbilical width index shows a continuous decrease from a value of 0.40–0.45 to 0.12–0.20 between 3 and 16 mm dm. Intraspecific variability is limited and exposed in both characters. A character rather stable during ontogeny is the apertural height; the whorl expansion rate is stable at 1.50 between 2.5 and 24 mm conch diameter, and only the adult conch shows a slight increase to 1.67 at 33 mm dm (Fig. 40H).

The two figured cross sections MB.C.13236.1 and MB.C.13236.2, both of specimens with 21 mm diameter, are very similar and differ only in minor details (Figs 40A, B). They possess the crescent-shaped juvenile whorls, which change into almost U-shaped outer whorls, which are widest at the umbilical margin. The flanks converge towards the rounded venter from the margin. The umbilical opening increases slowly in all stages represented by the specimens.

MB.C.13209.1 is the largest specimen (Fig. 39A); it is fully chambered at almost 33 mm dm and does not show any shell remains. The conch is pachyconic (ww/dm = 0.71) with a narrow umbilicus (uw/dm = 0.16). It is widest at the narrowly rounded umbilical wall; the flanks converge to the widely rounded venter. The aperture is low, causing a whorl expansion rate of 1.73. The internal mould possesses three shallow radial constrictions, which extend almost linearly across flanks and venter.

The smaller specimen MB.C.13209.2, reaching nearly 23 mm dm (Fig. 39B), is stouter (ww/dm = 0.77), but otherwise closely resembles the larger specimen. It shows few shell remains with rather widely spaced, fine and crenulated growth lines. The specimen possesses three shallow radial constrictions.

Shell remains are only occasionally preserved. Specimen MB.C.13275.1 (19 mm dm) possesses fine, closely standing growth lines, which show a dorsolateral projection that is higher than the ventrolateral projection. A very shallow sinus is visible on the venter.

The suture line shows an ontogenetic modification from the condition with Y-shaped external lobe towards a V-shaped form (Figs 40C–E). This transformation takes place at approximately 20 mm dm, where the

Figure 39. *Hibernicoceras carraunense* Moore & Hodson, 1958. **A.** Specimen MB.C.13209.1 from locality Chebket el Hamra-E; ×1.5. **B.** Specimen MB.C.13209.2 from locality Chebket el Hamra-E; ×2.0.

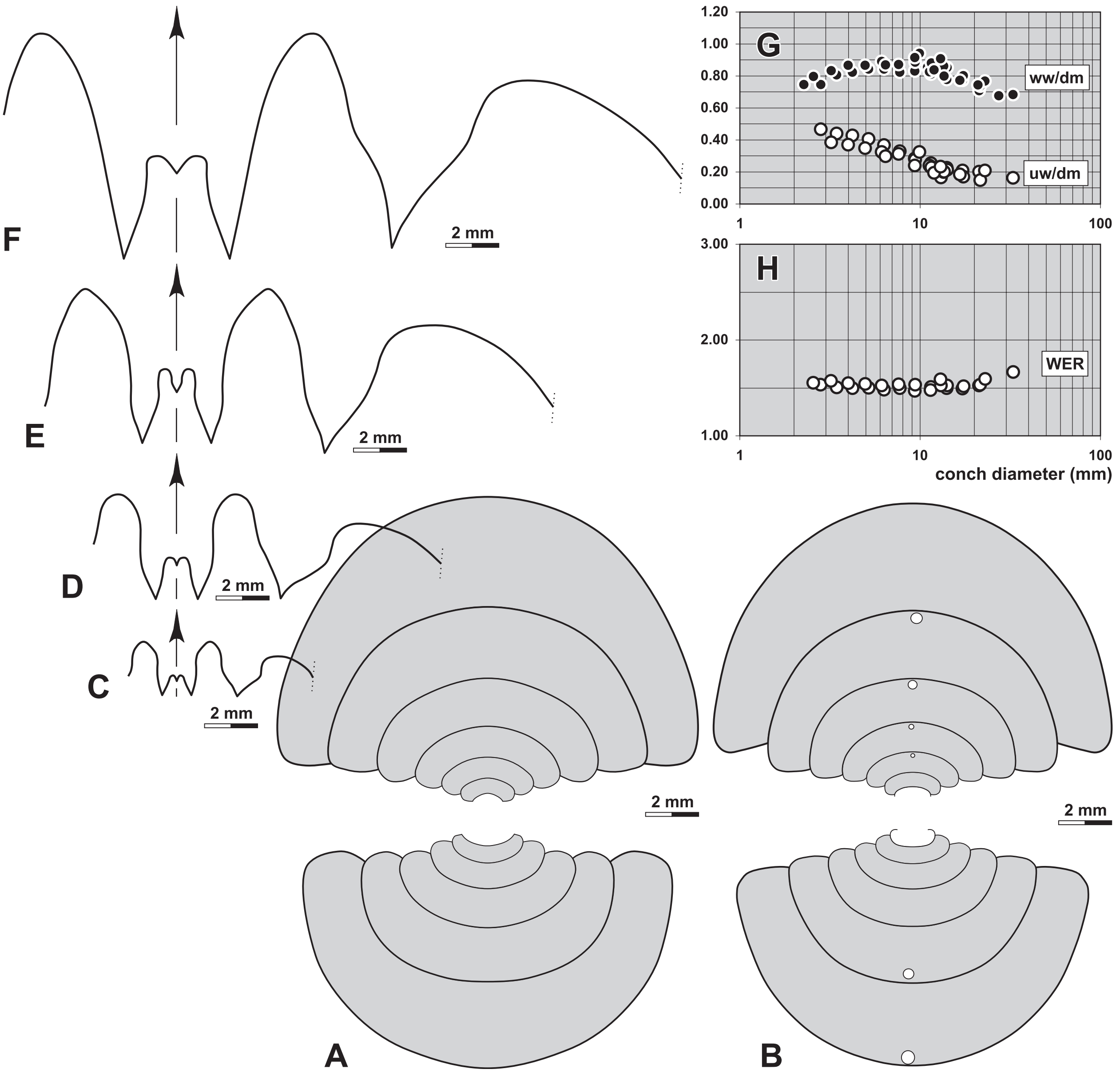


Figure 40. *Hibernicoceras carraunense* Moore & Hodson, 1958. **A.** Cross section of specimen MB.C.13236.1 from locality Chebket el Hamra-I; ×4.0. **B.** Cross section of specimen MB.C.13236.2 from locality Chebket el Hamra-I; ×4.0. **C.** Suture line of specimen MB.C.13236.3 from locality Chebket el Hamra-I, at 8.5 mm dm, 7.4 mm ww, 4.2 mm wh; ×4.0. **D.** Suture line of specimen MB.C.13236.4 from locality Chebket el Hamra-I, at 16.4 mm dm, 14.1 mm ww, 7.8 mm wh; ×4.0. **E.** Suture line of specimen MB.C.13209.2 from locality Chebket el Hamra-E, at 22.1 mm dm, 17.6 mm ww, 10.8 mm wh; ×4.0. **F.** Suture line of specimen MB.C.13209.1 from locality Chebket el Hamra-E, at 31.3 mm dm, 22.5 mm ww, 15.3 mm wh; ×4.0. **G**, **H.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm) and whorl expansion rate (WER) of all available specimens.

slightly pouched external lobe of the juvenile stage (specimens MB.C.13236.3 at 8.5 mm dm; specimen MB.C.13236.4 at 16.6 mm dm) changes into a V-shaped external lobe (such as on specimen MB.C.13209.2 at 22 mm dm).

The adult suture line (specimen MB.C.13209.1 with 31 mm dm) is characterised by a rather wide external lobe (1.40 of the adventive lobe) with almost uncurved flanks (Fig. 40F). The median saddle reaches almost half the external lobe, and the ventrolateral saddle is narrowly rounded. The V-shaped adventive lobe has moderately strongly curved flanks.

Discussion. Attribution to the Irish species is based on close resemblance of conch geometry and the suture line in specimens of 25–30 mm diameter. However, the Irish species needs to be described in greater detail, particularly with respect to its ontogenetic development to confirm this determination.

Hibernicoceras carraunense has a stouter conch than the co-occurring *H. touissitense*, a wider external lobe, and growth lines with a ventral sinus. The umbilical margin is less pronounced in *H. carraunense*. *H. artilobatum* has a lower median saddle and a V-shaped external lobe.

Hibernicoceras touissitense n. sp.
Figures 41–42

Derivation of name. After the town of Touissit, where the material was collected.

Holotype. Specimen MB.C.13292.1 (Ebbighausen & Weyer 2007 Coll.); illustrated in Figure 41A.

Type locality and horizon. Chebket el Hamra-U (Jerada Basin, NE-Morocco); horizon CeH-2, *Arnsbergites gracilis* Zone or *Neoglyphioceras spirale* Zone (middle Brigantian, Early Carboniferous).

Material. 67 limonitic steinkern specimens ranging from 7 to 28 mm in conch diameter from horizon CeH-2 at localities Chebket el Hamra-F, I, T, and an unspecified locality.

Diagnosis. *Hibernicoceras* with globular conch at 5 mm diameter (ww/dm = 0.85–0.90), thickly pachyconic conch at 10 mm diameter (ww/dm = 0.75–0.85), and thickly discoidal conch at 30 mm diameter (ww/dm = 0.50–0.60). Umbilicus very wide in early juveniles (uw/dm = 0.50 at 2 mm dm) and narrow to very narrow in all stages larger than 8 mm dm (uw/dm = 0.10–0.20); umbilical margin subangular, umbilical wall rounded. Ornamentation of rather coarse and weakly crenulated, biconvex and rectiradiate growth lines with dorsolateral projection and ventral projection of the same height; external sinus and spiral lines lacking. Suture line with V-shaped, moderately wide external lobe (0.70 of the external lobe depth; 1.30 of the adventive lobe width), and moderate median saddle (0.50 of the external lobe depth). Flanks of the external lobe slightly sinuous, ventrolateral saddle narrowly rounded, adventive lobe with sinuous flanks.

Description. The ontogeny of the species can be subdivided into three stages. The first (0.5–2 mm diameter) is characterised by a narrowing of the conch (ww/dm = 0.70) and a widening of the umbilicus (uw/dm = 0.50). The second (2–8 mm dm) likewise is characterised by a widening of the conch (ww/dm = 0.85–0.90) and the narrowing of the umbilicus (uw/dm = 0.15–0.20). In the third (above 8 mm dm), the conch becomes thinner again (ww/dm = 0.50–0.55 at 30 mm dm), and the umbilical width is stable. The aperture is low in all stages (WER = 1.50–1.60), but there is a slow increase in apertural height in the largest specimens (WER = 1.70 at 30 mm dm).

The two sectioned paratypes MB.C.13237.2 and MB.C.13237.3, both with about 15 mm diameter, display the ontogenetic development of the conch geometry from the initial to the preadult stage (Figs 42A–B). Beginning with a crescent-shaped whorl section, later whorls are U-shaped in section with a high rate of whorl overlap.

Paratype MB.C.13237.1 is with 30 mm dm the largest of the specimens. It is fully septate and shows a thickly discoidal conch (ww/dm = appr. 0.55).

Smaller specimens, such as the holotype MB.C.13292.1 (18 mm dm) have a stouter conch (ww/dm = 0.74) with a low aperture (WER = 1.53) and a subangular umbilical margin (Fig. 41A). This specimen possesses remains of the shell; the ornament consists of rather coarse growth lines, which show a dorsolateral projection, a shallow lateral sinus, and a low and wide ventral projection.

The suture line exhibits an ontogenetic development from a near parallel-sided to a V-shaped external lobe (Figs 42C–E). The typical adult suture line is shown in paratype MB.C.13237.1 (Fig. 42F) at almost 30 mm conch diameter. Smaller specimens of 10–15 mm diameter show some variability in the shape of the external lobe, which may possess either V-shaped or slightly pouched prongs (such as MB.C.13276.1; Fig. 42D).

Discussion. *Hibernicoceras touissitense* differs from the co-occurring *H. carraunense* in slightly deviating ontogenetic trajectories of the conch. *H. touissitense* is more slender in comparable growth stages and the closure of

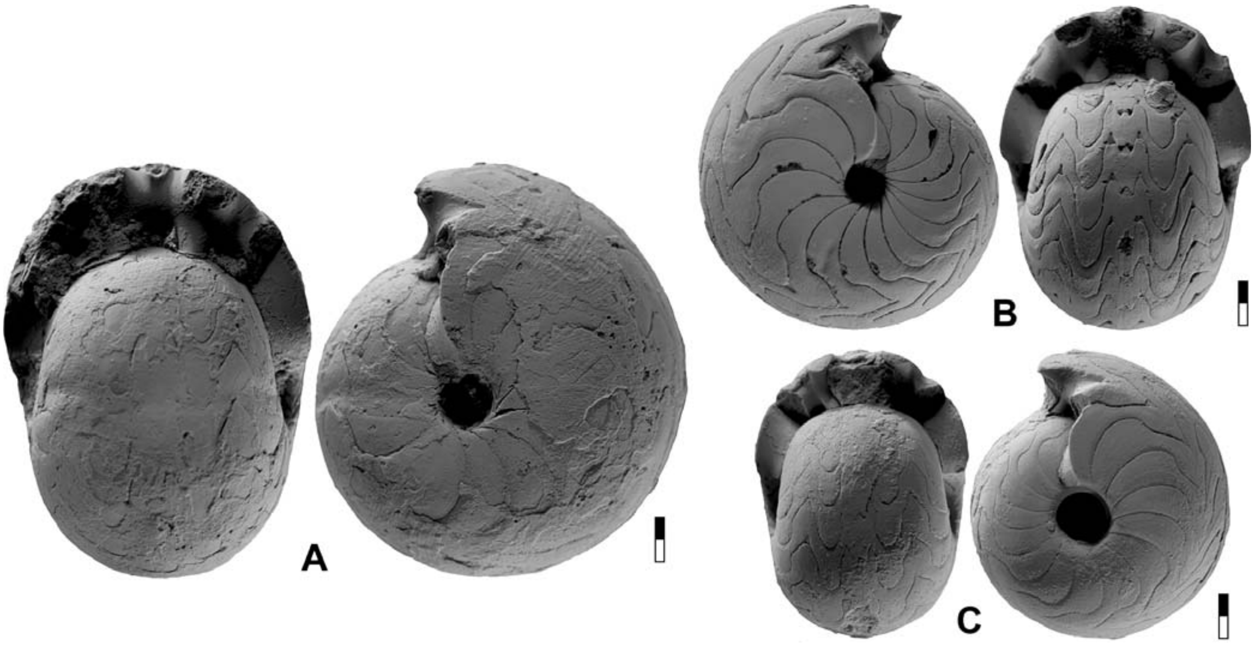


Figure 41. *Hibernicoceras touissitense* n. sp. **A.** Holotype MB.C.13292.1 from locality Chebket el Hamra-U; ×3.0. **B.** Paratype MB.C.13276.1 from locality Chebket el Hamra-T; ×3.0. **C.** Paratype MB.C.13276.2 from locality Chebket el Hamra-T; ×3.0.

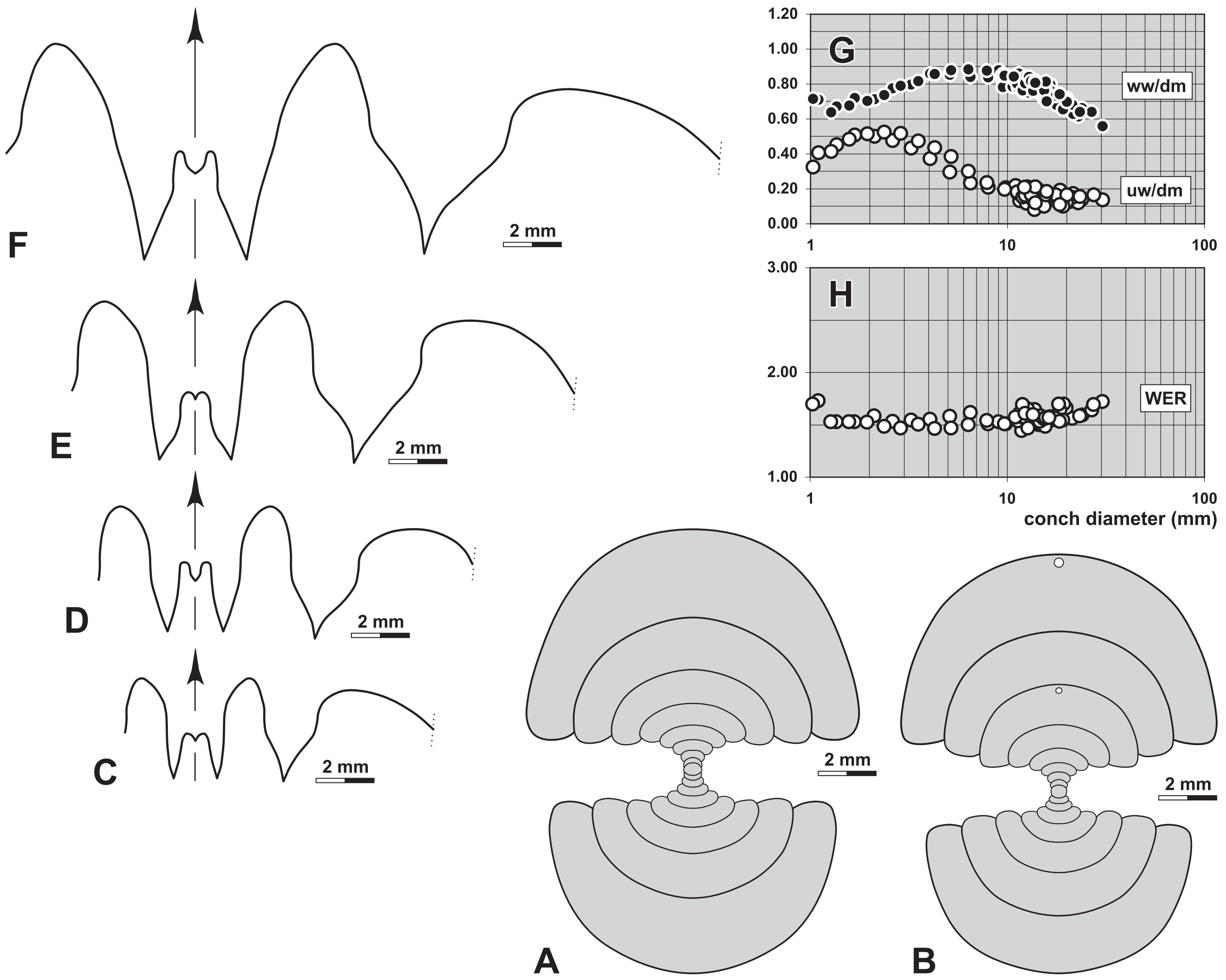


Figure 42. *Hibernicoceras touissitense* n. sp. **A.** Cross section of paratype MB.C.13237.2 from locality Chebket el Hamra-I; ×4.0. **B.** Cross section of paratype MB.C.13237.3 from locality Chebket el Hamra-I; ×4.0. **C.** Suture line of paratype MB.C.13276.2 from locality Chebket el Hamra-T, at 12.5 mm dm, 9.3 mm ww, 5.9 mm wh; ×4.0. **D.** Suture line of paratype MB.C.13276.1 from locality Chebket el Hamra-T, at 14.1 mm dm, 11.1 mm ww, 7.1 mm wh; ×4.0. **E.** Suture line of paratype MB.C.13276.3 from locality Chebket el Hamra-T, at 19.7 mm dm, 13.7 mm ww, 9.9 mm wh; ×4.0. **F.** Suture line of paratype MB.C.13237.1 from locality Chebket el Hamra-I, at 29.5 mm dm, 16.2 mm ww, 14.6 mm wh; ×4.0. **G**, **H.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm) and whorl expansion rate (WER) of all available specimens.

the umbilicus is more rapid. *H. touissitense* has a more pronounced umbilical margin that marks the position where the conch is widest.

In terms of ornament, with the ventral projection of the growth lines (and the absence of a ventral sinus), *H. touissitense* is similar to *H. hibernicum* Moore & Hodson, 1958, but has a more slender conch (ww/dm = 0.63–0.70 in *H. touissitense*, but 0.79 in *H. hibernicum* at 21 mm dm).

H. mediocris Moore & Hodson, 1958 has a similar conch shape and suture line, but possesses very fine growth lines, which form a shallow sinus on the venter.

Hibernicoceras artilobatum n. sp.

Figures 43–44

Derivation of name. From Latin *artis* = narrow, because of the narrow external lobe.

Holotype. Specimen MB.C.13286 (Korn & Ebbighausen 2006 Coll.); illustrated in Figure 43.

Type locality and horizon. Chebket el Hamra (Jerada Basin, NE-Morocco); horizon CeH-2, *Arnsbergites gracilis* Zone or *Neoglyphioceras spirale* Zone (middle Brigantian, Early Carboniferous).

Figure 43. *Hibernicoceras artilobatum* n. sp. Holotype MB.C.13286 from Chebket el Hamra; ×2.0.

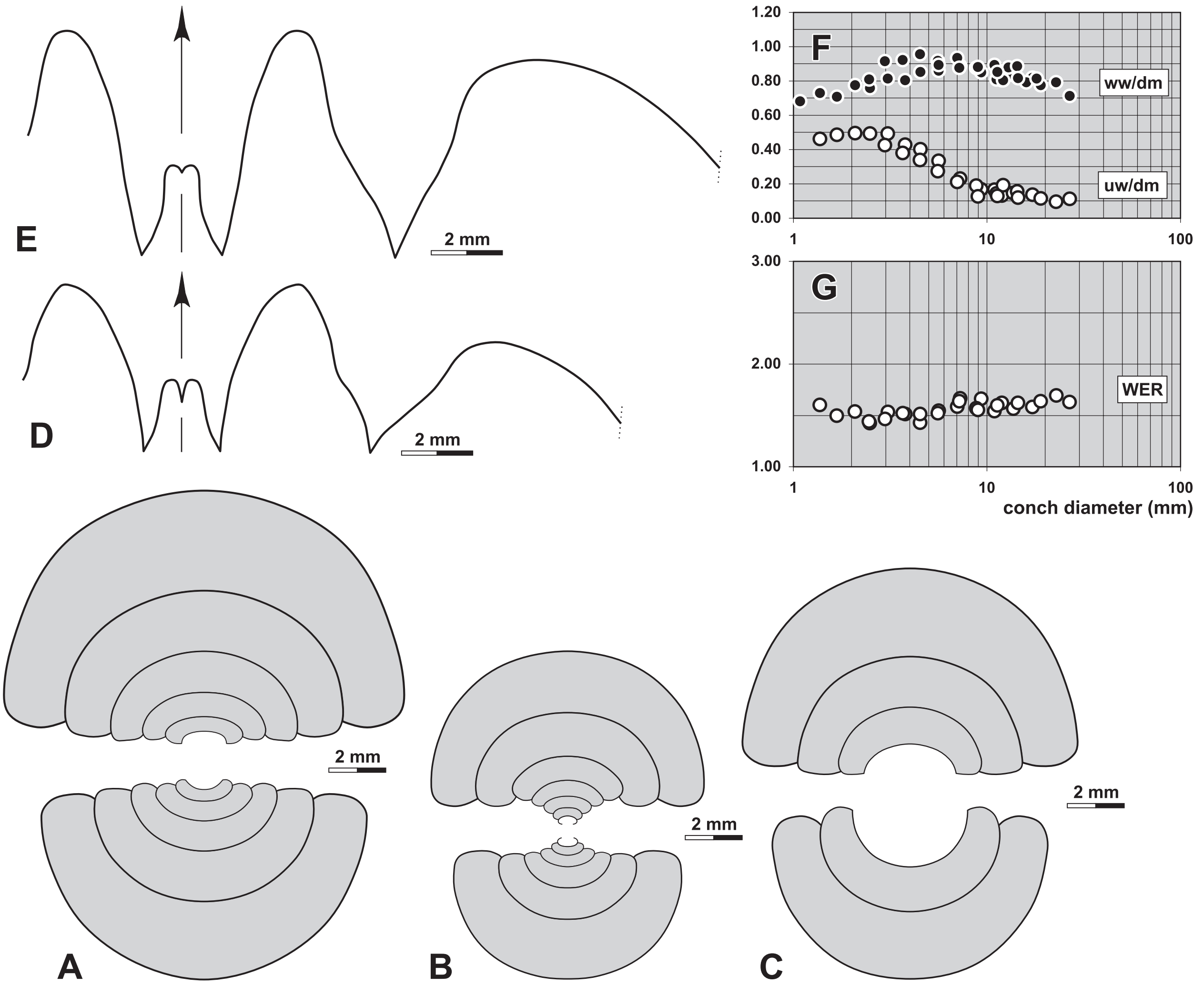


Figure 44. *Hibernicoceras artilobatum* n. sp. **A.** Cross section of paratype MB.C.13277.1 from locality Chebket el Hamra-T; ×4.0. **B.** Cross section of paratype MB.C.13277.2 from locality Chebket el Hamra-T; ×4.0. **C.** Cross section of paratype MB.C.13238.1 from locality Chebket el Hamra-I; ×4.0. **D.** Suture line of paratype MB.C.13238.2 from locality Chebket el Hamra-I, at 18.3 mm dm, 15.3 mm ww, 9.5 mm wh; ×5.0. **E.** Suture line of holotype MB.C.13286 from Chebket el Hamra, at 22.0 mm dm, 17.2 mm ww, 11.6 mm wh; ×5.0. **F, G.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm) and whorl expansion rate (WER) of all available specimens.

Material. 13 limonitic steinkern specimens varying from 10 to 27 mm in conch diameter from horizon CeH-2 at localities Chebket el Hamra-F, I, T, and an unspecified locality.

Diagnosis. *Hibernicoceras* with globular conch at 5 mm diameter (ww/dm = 0.85–0.95), thickly pachyconic to globular conch at 10 mm diameter (ww/dm = 0.80–0.90), and thickly pachyconic conch at 20 mm diameter (ww/dm = 0.75–0.80). Umbilicus very wide in early juveniles (uw/dm = 0.50 at 2 mm dm) and becoming continuously narrower throughout ontogeny (uw/dm = 0.12–0.16 at 10 mm dm, uw/dm = 0.10–0.15 at 20 mm dm); umbilical margin and wall rounded. Ornamentation with rather coarse, crenulated biconvex and rectiradiate growth-lines having rather high dorsolateral projection and lower ventrolateral projection; ventral sinus very shallow. Spiral lines in a narrow zone around the umbilicus. Suture line with V-shaped external lobe in juveniles; in the adult stage with V-shaped, narrow external lobe (0.55 of the external lobe depth; 1.10 of the adventive lobe width), and moderate median saddle (almost 0.40 of the external lobe depth). Flanks of the external lobe almost straight, ventrolateral saddle narrowly rounded, adventive lobe with slightly sinuous flanks.

Description. The species shows ontogenetic changes only in the ww/dm and the uw/dm ratios (Fig. 44F). Two phases of ontogeny can be distinguished. A first phase ranges up to about 9 mm conch diameter; this phase is characterised by a slow increase of the whorl width up 0.90–0.95 and a reduction of the uw/dm ratio from 0.50 in early juveniles to 0.10–0.20. The second phase shows a development towards a more slender conch (ww/dm = 0.70 at 27 mm dm) and an umbilicus that remains narrow (uw/dm = 0.10 at 15–27 mm dm). The aperture is low in all growth stages, with a WER very slowly increasing from 1.50 in early juveniles to 1.65–1.70 at 20–27 mm dm (Fig. 44G).

Holotype MB.C.13286 is the largest individual having a diameter of nearly 23 mm (Fig. 43). It is thickly pachyconic (ww/dm = 0.79) with a narrow umbilicus (uw/dm = 0.10) and a low aperture (WER = 1.69). Flanks, venter, and umbilical margin are broadly rounded. Some remains of the shell are visible; they show rather coarse growth lines, which extend with biconvex course and form a wide and shallow ventral sinus. The steinkern has five shallow, almost linear constrictions.

A similar conch geometry can be seen in specimen MB.C.13238.2 with 19 mm dm. It possesses shell remains that show fine and crenulated growth lines and a few spiral lines around the umbilicus.

The suture line of specimen MB.C.13286 (22 mm dm) differs from the suture lines of other species of *Hibernicoceras* (Fig. 44E). Its external lobe is V-shaped with almost straight flanks, and the median saddle reaches only 40% of the depth of the E lobe. The E lobe is only little wider (1.10) than the adventive lobe, and the ventrolateral saddle is narrowly rounded.

A V-shaped external lobe with strongly diverging flanks is seen in the smaller specimen MB.C.13238.2 (18 mm dm; Fig. 44D). The median saddle has 0.40 of the E lobe depth, and the ventrolateral saddle is asymmetric with a blunt top. The adventive lobe is V-shaped with a stronger sinuous ventral flank.

Discussion. *Hibernicoceras artilobatum* differs from the other two species of the genus found at Chebket el Hamra in having a suture line that possesses a V-shaped external lobe in the intermediate growth stage. Additionally, the external lobe is much narrower and the median saddle is lower in *H. artilobatum* (0.40 of the E lobe depth). In these two respects, the new species differs from all other representatives of *Hibernicoceras*.

Paraglyphioceras Brüning, 1923

Type species. Paraglyphioceras rotundum Brüning, 1923.

Discussion. At present, 15 possible valid species of *Paraglyphioceras* have been described (AMMON database; Korn & Ilg 2007). However, a number of these species, i.e. *P. densiplicatum* (Kumpera, 1971), *P. dorsoplanum* (Brüning, 1923), *P. elegans* (Bisat, 1928), *P. kajlovecense* (Patteisky, 1930), *P. myrtilense* (Feio, 1946), *P. pseudostriatum* (Bisat, 1924), *P. reticulatum* (Bisat, 1924), and *P. semistriatum* (Nicolaus, 1963) are based on crushed or otherwise poorly preserved material and are very difficult to interpret and determine. Of the remaining species, only *P. radiatum* Hodson & Moore, 1959, *P. rudis* (Moore & Hodson, 1958), *P. rotundum* (Brüning, 1923), and *P. castor* Korn, 1988 have been described with respect to their conch ontogeny (Korn 1988, 1990b).

The species of *Paraglyphioceras* can be grouped as follows:

A – species with a narrow external lobe (1.20 of the adventive lobe) and a weak ornament:

- *P. castor* Korn, 1988: with a low aperture (WER = 1.55 at 30 mm dm) and spiral lines around the narrow umbilicus;
- *P. bisati* (Moore, 1936): with spiral lines around the narrow umbilicus and on the venter;
- *P. guadianense* Korn, 1997: with spiral lines around the rather wide umbilicus and on the venter;
- *P. celeris* n. sp.: with a moderately high aperture (WER = 1.90–2.20 in stages larger than 10 mm dm).

B – species with a narrow external lobe (1.20 of the adventive lobe) and a coarse falcate ornament:

- *P. radiatum* Hodson & Moore, 1959.

C – species with a wide external lobe (1.40 of the adventive lobe or more):

- *P. striatum* (Sowerby, 1814): with a well-rounded ventrolateral saddle and a pouched adventive lobe;
- *P. rudis* (Moore & Hodson, 1958): with a thickly discoidal to thinly pachyconic conch at 15 mm diameter (ww/dm = 0.55–0.65), a narrowly rounded ventrolateral saddle, and a simple V-shaped adventive lobe;
- *P. rotundum* (Brüning, 1923): with a thickly pachyconic conch at 15 mm diameter (ww/dm = 0.75), a subacute ventrolateral saddle, and a simple V-shaped adventive lobe.

Paraglyphioceras rudis (Moore & Hodson, 1958)
Figures 45–46

Holotype. Specimen GSM ZI4083 (Moore Coll.); figured by Moore & Hodson (1958, pl. 9, fig. 2).

Type locality and horizon. Townland of Carraun, 3 km south-west of Kiltyclogher (Co. Leitrim, Ireland); P1c Subzone, approximately 10 m above the highest occurrence of *Arnsbergites sphaericostriatus* (middle Brigantian, Late Viséan).

Material. 102 limonitic steinkern specimens from 8 and 38 mm in conch diameter, from horizon CeH-2 at localities Chebket el Hamra-F, I, T, and an unspecified locality.

Diagnosis. *Paraglyphioceras* with thickly pachyconic to globular conch at 5 mm diameter (ww/dm = 0.80–0.90), thickly pachyconic conch at 10 mm diameter (ww/dm = 0.75–0.85), and thickly discoidal to thinly pachyconic conch at 25 mm diameter (ww/dm = 0.55–0.65). Umbilicus wide in early juveniles (uw/dm = 0.40 at 2 mm dm) and narrow to very narrow in all stages larger than 8 mm dm (uw/dm = 0.05–0.12); umbilical margin and umbilical wall rounded. Aperture moderately high, WER = 1.70–1.80 in stages larger than 10 mm dm. Ornamentation with strongly crenulated bicovex and rectiradiate growth-lines; fine spiral lines on flanks and venter. Suture line with V-shaped, moderately wide external lobe (0.70 of the external lobe depth; 1.50 of the adventive lobe width), and moderate median saddle (almost 0.50 of the external lobe depth). Flanks of the V-shaped external lobe slightly sinuous, ventrolateral saddle subacute, adventive lobe with slightly sinuous flanks.

Description. The morphometric plots show that intraspecific variability is rather limited in this species (Figs 46H, I). Ontogenetic changes can, however, clearly be seen in the three cardinal conch parameters. The short juvenile stage with a wide umbilicus (uw/dm = 0.40–0.45 at 2–3 mm dm) is replaced by a stage with thickly pachyconic to globular conch (ww/

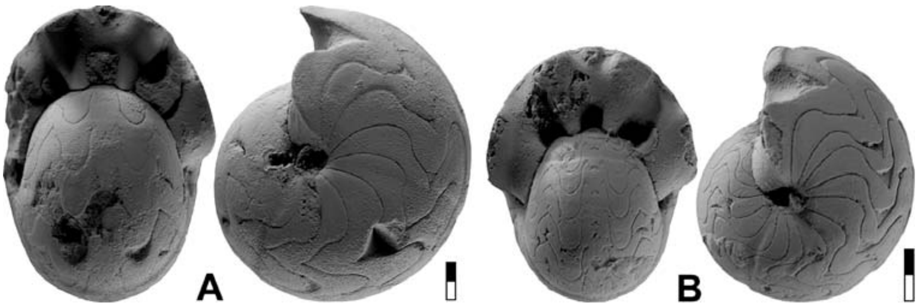


Figure 45. *Paraglyphioceras rudis* (Moore & Hodson, 1958). **A.** Specimen MB.C.13278.1 from locality Chebket el Hamra-T; ×2.5. **B.** Specimen MB.C.13278.2 from locality Chebket el Hamra-T; ×3.5.

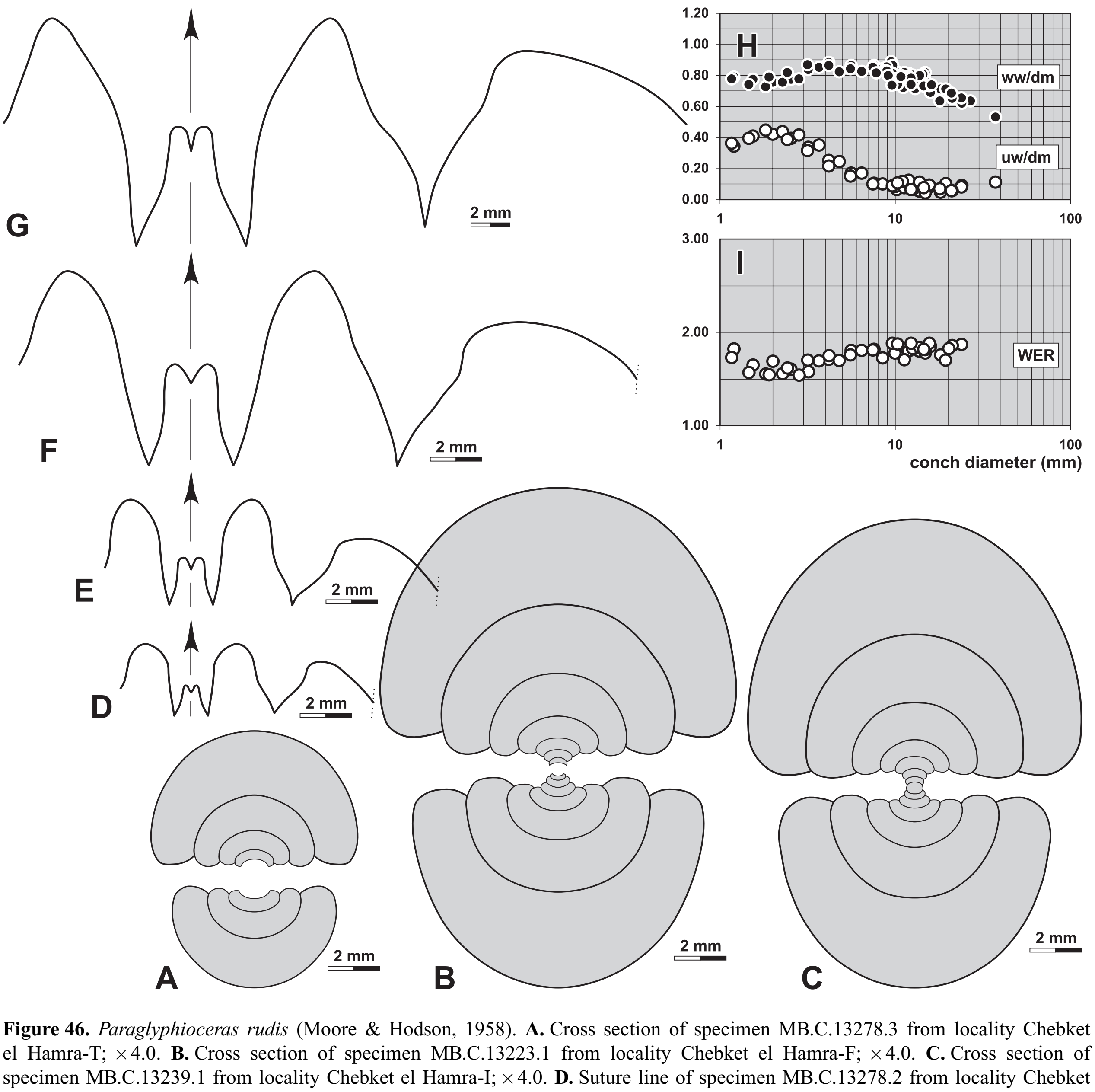


Figure 46. *Paraglyphioceras rudis* (Moore & Hodson, 1958). **A.** Cross section of specimen MB.C.13278.3 from locality Chebket el Hamra-T; ×4.0. **B.** Cross section of specimen MB.C.13223.1 from locality Chebket el Hamra-F; ×4.0. **C.** Cross section of specimen MB.C.13239.1 from locality Chebket el Hamra-I; ×4.0. **D.** Suture line of specimen MB.C.13278.2 from locality Chebket el Hamra-T, at 9.2 mm dm, 7.7 mm ww, 5.1 mm wh; ×4.0. **E.** Suture line of specimen MB.C.13278.1 from locality Chebket el Hamra-T, at 14.0 mm dm, 10.5 mm ww, 7.6 mm wh; ×4.0. **F.** Suture line of specimen MB.C.13278.4 from locality Chebket el Hamra-T, at 16.7 mm ww, 14.8 mm wh; ×4.0. **G.** Suture line of specimen MB.C.13278.5 from locality Chebket el Hamra-T, at 21.0 mm wh; ×3.0. **H**, **I.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm) and whorl expansion rate (WER) of all available specimens.

dm = 0.80–0.90) and closure of the umbilicus between 3 and 9 mm dm. Later in ontogeny, the conch becomes more slender (ww/dm = 0.60–0.65 at 25 mm dm) and the umbilicus remains very narrow (uw/dm = 0.05–0.10). The aperture is low in early juveniles (WER = 1.55–1.70 at 2–4 mm dm) and becomes slightly higher during ontogeny (WER = 1.70–1.90 between 10 and 25 mm dm).

The cross sections MB.C.13278.3, MB.C.13223.1, and MB.C.13239.1, display the characteristic conch development of the species (Figs 46A–C). The inner whorls are crescent-shaped and embrace the preceding to a small degree. From 2 mm conch diameter onward, there is a rather stable umbilical opening of approximately 1 mm, resulting in a continuously decreasing uw/dm ratio. The whorls become rapidly wider and more embracing. The conch then becomes narrowly umbilicate with broadly rounded flanks and venter, and rounded umbilical wall at 10 mm diameter.

Unfortunately all large specimens are fragmentary. The largest consists of a phragmocone measuring about 50 mm. It possesses few remains of the shell around the umbilicus; there are delicate spiral lines and fine backwardly directed growth lines.

Specimen MB.C.13278.1 is an immature individual of 15.5 mm diameter (Fig. 45A) and is thickly pachyconic (ww/dm = 0.74) with very narrow umbilicus (uw/dm = 0.09). It has broadly rounded flanks and venter and a rounded umbilical wall. The steinkern is smooth except for some very weak linear constrictions. Some ornament is preserved; it consists of very fine, almost linear growth lines. The fragmentary specimen MB.C.13278.6 contains the impression of shell ornament in the dorsal portion; at about a diameter of 20 mm fine spirals on flanks and venter, and biconvex, strongly crenulated growth lines appear.

The juvenile specimen MB.C.13278.2 is, at 9.5 mm diameter, similar in its conch geometry (Fig. 45B). It has four steinkern constrictions, which extend in a near-linear manner with a shallow ventral sinus.

The adult suture line, drawn from specimen MB.C.13278.5 (21 mm whorl height), as in most of the goniatitoid species, has a Y-shaped external lobe, which has a median saddle reaching about half height of the E lobe (Fig. 46G). The ventrolateral saddle is subacute and the adventive lobe is V-shaped with curved flanks; it is asymmetric with a slightly curved ventral flank and a stronger curved dorsal flank.

Smaller specimens, such as specimen MB.C.13278.4 (16.5 mm ww) possess a V-shaped external lobe and a narrowly rounded ventrolateral saddle (Fig. 46F). The median saddle reaches half the height of the external lobe. Juvenile specimens, such as MB.C.13278.1 (14 mm dm) and MB.C.13278.2 (9 mm dm) show a more rounded ventrolateral saddle (Figs 46D, E), but have an adventive lobe similar to the larger specimens.

Discussion. *Paraglyphioceras rudis* and *P. celeris* possess similar conchs in terms of the ww/dm and uw/dm ratios, but they differ significantly in the ontogenetic development of the apertural height. In specimens between 10 and 25 mm dm, the whorl expansion rate reaches only 1.90 in *P. rudis*, but 2.20 in *P. celeris*. The suture line shows further differences, with *P. celeris* possessing a wider external lobe. *P. rotundum* is similar in the E lobe width, but has a stouter conch and a wider umbilicus.

***Paraglyphioceras celeris* n. sp.**

Figures 47–48

Derivation of name. From Latin *celeris* = quick, because of the rapidly increasing apertural height.

Holotype. Specimen MB.C.13279.1 (Ebbighausen & Weyer 2007 Coll.); illustrated in Figure 47A.

Type locality and horizon. Chebket el Hamra-T (Jerada Basin, NE-Morocco); horizon CeH-2, *Arnsbergites gracilis* Zone or *Neoglyphioceras spirale* Zone (middle Brigantian, Late Viséan).

Material. 18 limonitic steinkern specimens between 7 and 28 mm conch diameter from horizon CeH-2 at localities Chebket el Hamra-F, I, and T.

Diagnosis. *Paraglyphioceras* with globular conch at 5 mm diameter (ww/dm = 0.85–0.90), thickly pachyconic conch at 10 mm diameter (ww/dm = 0.80–0.85), and thinly pachyconic conch at 15 mm diameter (ww/dm = 0.65–0.75). Umbilicus wide in early juveniles (uw/dm = 0.40 at 2 mm dm) and narrow to very narrow in all stages larger than 8 mm dm (uw/dm = 0.05–0.10); umbilical margin and umbilical wall rounded. Aperture moderately high, WER increases rapidly to 1.90–2.20 in stages larger than 10 mm dm. Ornamentation with crenulated biconvex and rectiradiate growth-lines having low dorsolateral projection and higher ventrolateral projection; external sinus deep; spiral lines lacking. Suture line with V-shaped, moderately wide external lobe (0.65 of the external lobe depth; 1.10 of the adventive lobe width), and with moderate median saddle (almost 0.50 of the external lobe depth). Flanks of the V-shaped and later Y-shaped external lobe slightly incurved, ventrolateral saddle subacute, adventive lobe with strongly sinuous dorsal flank.

Description. Ontogenetic changes are mainly visible in the umbilical width and the apertural height, whereas the ww/dm ratio shows only minor changes (Figs 48E, F). After the evolute juvenile stage (uw/dm = 0.40 at 2–3 mm dm) a rapid reduction of the relative umbilical width towards less than 0.10 at 9 mm dm follows. At the same time, the apertural height increases from 1.50–1.65 in juvenile stages to 1.90–2.20 in stages larger than 10 mm dm.

The two cross sections MB.C.13279.4 and MB.C.13279.5, both of specimens between about 15 and 16.5 mm diameter, are similar and show well the ontogenetic changes of the species (Figs 48A, B). The widely umbilicate juvenile stage that is replaced by a pachyconic stage with a stagnating absolute opening of the umbilicus, (and therefore a continuous lowering of the uw/dm ratio), may be seen, accompanied by an increase in height of the aperture.

The incomplete paratype MB.C.13279.6 has 22.5 mm diameter and belongs to the largest individuals. It is thinly pachyconic with a very narrow umbilicus and a high aperture (WER = 2.17). Weak constrictions are

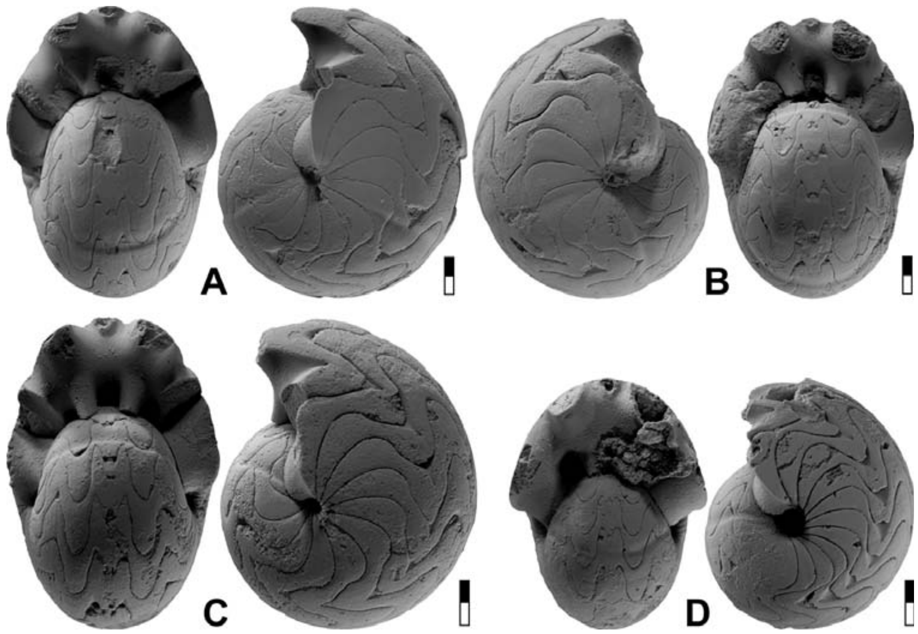
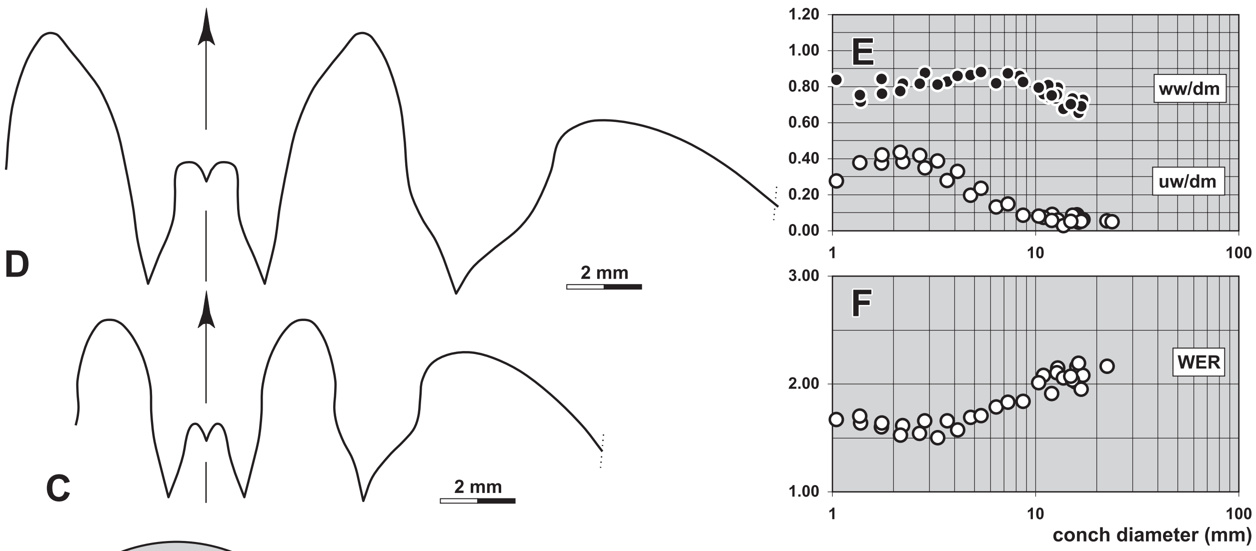


Figure 47. *Paraglyphioceras celeris* n. sp. **A.** Holotype MB.C.13279.1 from locality Chebket el Hamra-T; ×2.5. **B.** Paratype MB.C.13279.2 from locality Chebket el Hamra-T; ×2.5. **C.** Paratype MB.C.13279.3 from locality Chebket el Hamra-T; ×3.0. **D.** Paratype MB.C.13224.1 from locality Chebket el Hamra-F; ×3.0.



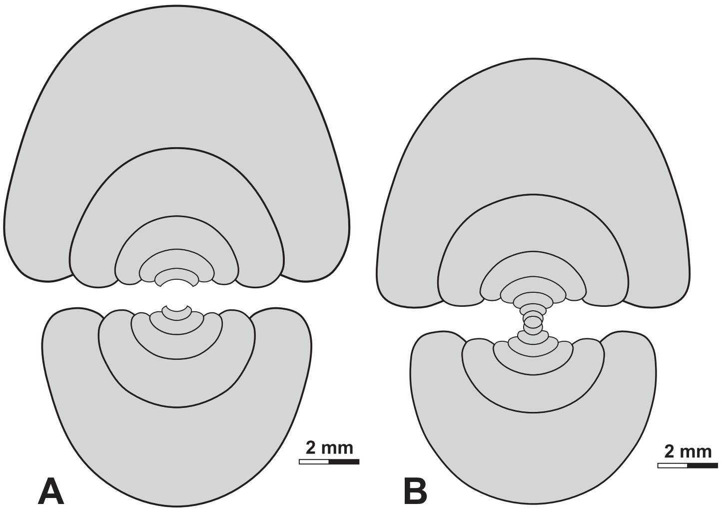


Figure 48. *Paraglyphioceras celeris* n. sp. **A.** Cross section of paratype MB.C.13279.4 from locality Chebket el Hamra-T; ×4.0. **B.** Cross section of paratype MB.C.13279.5 from locality Chebket el Hamra-T; ×4.0. **C.** Suture line of paratype MB.C.13279.2 from locality Chebket el Hamra-T, at 14.7 mm dm, 11.1 mm ww, 7.8 mm wh; ×5.0. **D.** Suture line of paratype MB.C.13279.6 from locality Chebket el Hamra-T, at 21.3 mm dm, 12.8 mm wh; ×5.0. **E, F.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm) and whorl expansion rate (WER) of all available specimens.

visible on the internal mould; these run almost straight across the flanks and then bend back to form a shallow ventral sinus.

Holotype MB.C.13279.1 shows the morphology of the intermediate growth stage (Fig. 47A). It has a conch diameter of about 15.5 mm and is thinly pachyconic (ww/dm = 0.72) with a very narrow umbilicus (uw/dm = 0.08) and a rather high aperture (WER = 2.02). Flanks and venter are broadly rounded. It is a fully septate internal mould showing weak radial constrictions standing 90–120° apart; these extend almost linearly across the flanks and venter but form a shallow ventral sinus.

Paratype MB.C.13279.2 (15.2 mm dm) is very similar in its conch ratios. It also possesses irregularly arranged steinkern constrictions, but here these are curved with a shallow lateral sinus and a more pronounced ventral sinus (Fig. 47B).

The suture line of paratype MB.C.13279.6 (drawn at 21 mm dm) shows the Y-shaped external lobe, which has almost straight flanks in the lower three quarters (Fig. 48D). A median saddle is raised up to almost half the depth of the E lobe and produces two slightly asymmetric, narrow prongs of the E lobe. The subacute and rather narrow ventrolateral saddle is asymmetric with a blunt top. The asymmetric adventive lobe has a much stronger curved dorsal flank.

Smaller stages differ significantly in the suture line. Specimen MB.C.13279.2 (14.7 mm dm) has an external lobe with stronger sinuous flanks, a lower median saddle, a very narrow and narrowly rounded ventrolateral saddle, and an almost lanceolate, pouched adventive lobe (Fig. 48C).

Discussion. For a comparison with the co-occurring *P. rudis*, see discussion under that species. *P. celeris* differs from the species *P. castor* and *P. bisati* in its wider external lobe.

Lusitanoceras Pereira de Sousa, 1923

Type species. Lusitanoceras algarviense Pereira de Sousa, 1923.

Discussion. Thirteen possibly valid species of *Lusitanoceras* are currently known (AMMON database; Korn & Ilg 2007). The genus is widely distributed from the western United States across North Africa, Iberia, Northwest and Central Europe to the South Urals, Novaya Zemlya, Northwest China, and Mongolia. Only some of the species have been described with respect to their complete morphological inventory.

The European species of *Lusitanoceras* can be grouped as follows:

A – species with falcate ornament in the adult stage:

- *L. algarviense* Pereira de Sousa, 1923: with weak spiral ornament (120–150 spiral lines at 30 mm conch diameter);
- *L. zirari* n. sp.: with coarse spiral ornament (approximately 80–90 spiral lines at 30 mm conch diameter).

B – species without falcate ornament in the adult stage:

- *L. poststriatum* (Brüning, 1923): with weak spiral ornament (approximately 120 spiral lines at 30 mm conch diameter);
- *L. granosum* (Portlock, 1843): with coarse spiral ornament (approximately 80 spiral lines).

Lusitanoceras zirari n. sp.

Figures 49–50

Derivation of name. After Yahia Zirar (Touissit), for his assistance in the field.

Holotype. Specimen MB.C.13296 (Ebbighausen & Weyer 2007 Coll.); illustrated in Figure 49C.

Type locality and horizon. Chebket el Hamra (Jerada Basin, NE-Morocco); horizon CeH-5, probably *Lusitanoceras poststriatum* Zone (late Brigantian, Early Carboniferous).

Material. 58 limonitic and phosphatic specimens ranging in diameter from 12 and 71 mm from horizon CeH-5 at localities Chebket el Hamra-K, L, O, P, and an unspecified locality.

Diagnosis. *Lusitanoceras* with thickly pachyconic to globular conch at 10 mm diameter (ww/dm = 0.80–0.90), pachyconic conch at 30 mm diameter (ww/dm = 0.65–0.80), and thinly pachyconic conch at 50 mm diameter (ww/dm = 0.60–0.65). Umbilicus very narrow in all stages larger than 10 mm dm (uw/dm = 0.08–0.18); umbilical wall rounded. Ornamentation at 6 mm dm with coarse, crenulated biconvex and prorsiradiate growth-lines; over 30 mm dm with 80–90 granulated spiral lines as well as crenulated, biconvex and rectiradiate growth lines with low dorsolateral projection and higher ventrolateral projection; external sinus deep. Weak constrictions of the shell cause a falcate ornament in the adult stage. Suture line with Y-shaped, moderately wide external lobe (0.70–0.75 of the external lobe depth, 1.00–1.20 of the adventive lobe), and moderately high median saddle (slightly above 0.50 of the external lobe depth). Flanks of the external lobe strongly sinuous, ventrolateral saddle subacute, adventive lobe V-shaped with inflexed flanks.

Description. Ontogenetic changes in conch form are well visible in the species. A juvenile thickly pachyconic and evolute stage (ww/dm = 0.80, uw/dm = 0.35–0.40 at 2 mm dm) is replaced by a globular involute stage at 5–8 mm dm (ww/dm = 0.85–1.00, uw/dm decreasing to 0.12), followed by a continuous decreasing of the ww/dm ratio to 0.60 in the adult stage. The uw/dm ratio stabilizes at uw/dm = 0.08–0.18 (Fig. 50G). The aperture is very low in all stages between 2 and 30 mm dm (WER around 1.50) and shows a slight increase in height in the adult stage (1.70–1.80; Fig. 50H).

The material from Chebket el Hamra suggests that intraspecific variability is particularly well expressed in the growth interval between 4 and 30 mm conch diameter. The sectioned specimens MB.C.13206.1 (cuboid form; Fig. 50A) and MB.C.13206.2 (non-cuboid form; Fig. 50B) demonstrate the range of variability, with cross section MB.C.13247.2 being an intermediate form (Fig. 50C).

The largest specimens are incompletely preserved and somewhat distorted. Paratype MB.C.13250.1 is such a specimen; it has a ww/dm ratio of 0.63 at

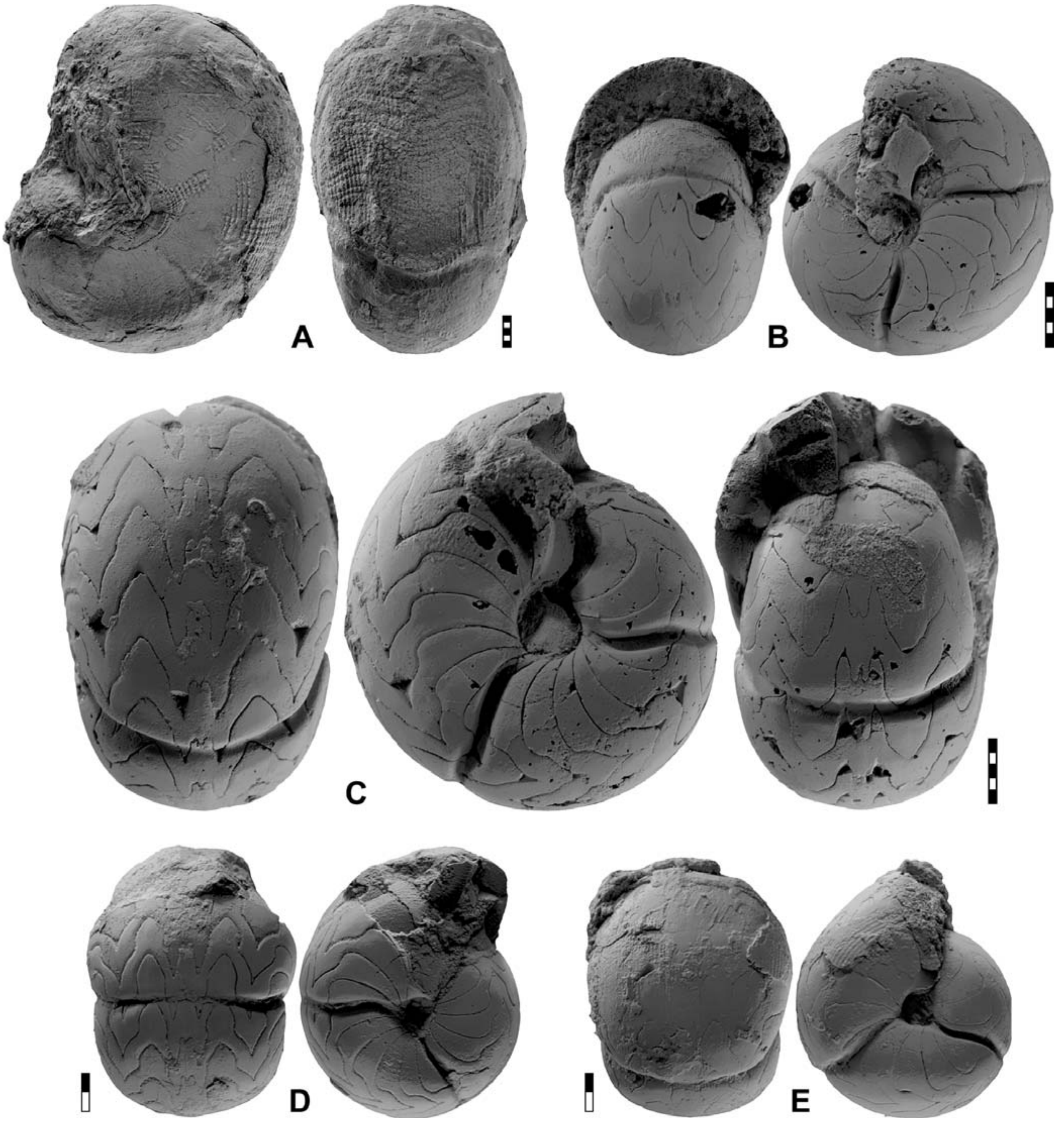


Figure 49. *Lusitanoceras zirari* n. sp. **A.** Paratype MB.C.13250.1 from locality Chebket el Hamra-L; × 1.0. **B.** Paratype MB.C.13288 from Chebket el Hamra; × 2.0. **C.** Holotype MB.C.13296 from Chebket el Hamra; × 2.0. **D.** Paratype MB.C.13247.1 from locality Chebket el Hamra-K; × 3.0. **E.** Paratype MB.C.13261.1 from locality Chebket el Hamra-P; × 3.0.

55 mm conch diameter (Fig. 49A). It possesses shell remains, which show the falcate ornament composed of rhythmic narrow-spaced constrictions, crossing the coarse and granulated spiral lines, of which approximately 90 can be counted from umbilicus to umbilicus.

Some of the smaller specimens are well preserved as limonitic internal moulds. The largest of these, holotype MB.C.13296 with 31 mm conch diameter, is fully septate with about 20 chambers (Fig. 49C). It is thinly pachyconic (ww/dm = 0.69) with a narrow umbilicus (uw/dm = 0.16) and represents the typical conch geometry of the species. The last volution of the specimen possesses three deep constrictions of the steinkern, standing in angles of 120°. They extend with a low dorsolateral projection in slight backward direction across the flank to form a very low ventrolateral projection and a very low ventral sinus. The steinkern possesses traces of approximately 100 spiral lines.

Paratype MB.C.13288 belongs to the more slender specimens (Fig. 49B); at 23.5 mm conch diameter the ww/dm ratio is 0.74 and the uw/dm ratio 0.15. It also shows three steinkern constrictions, but these are ar-

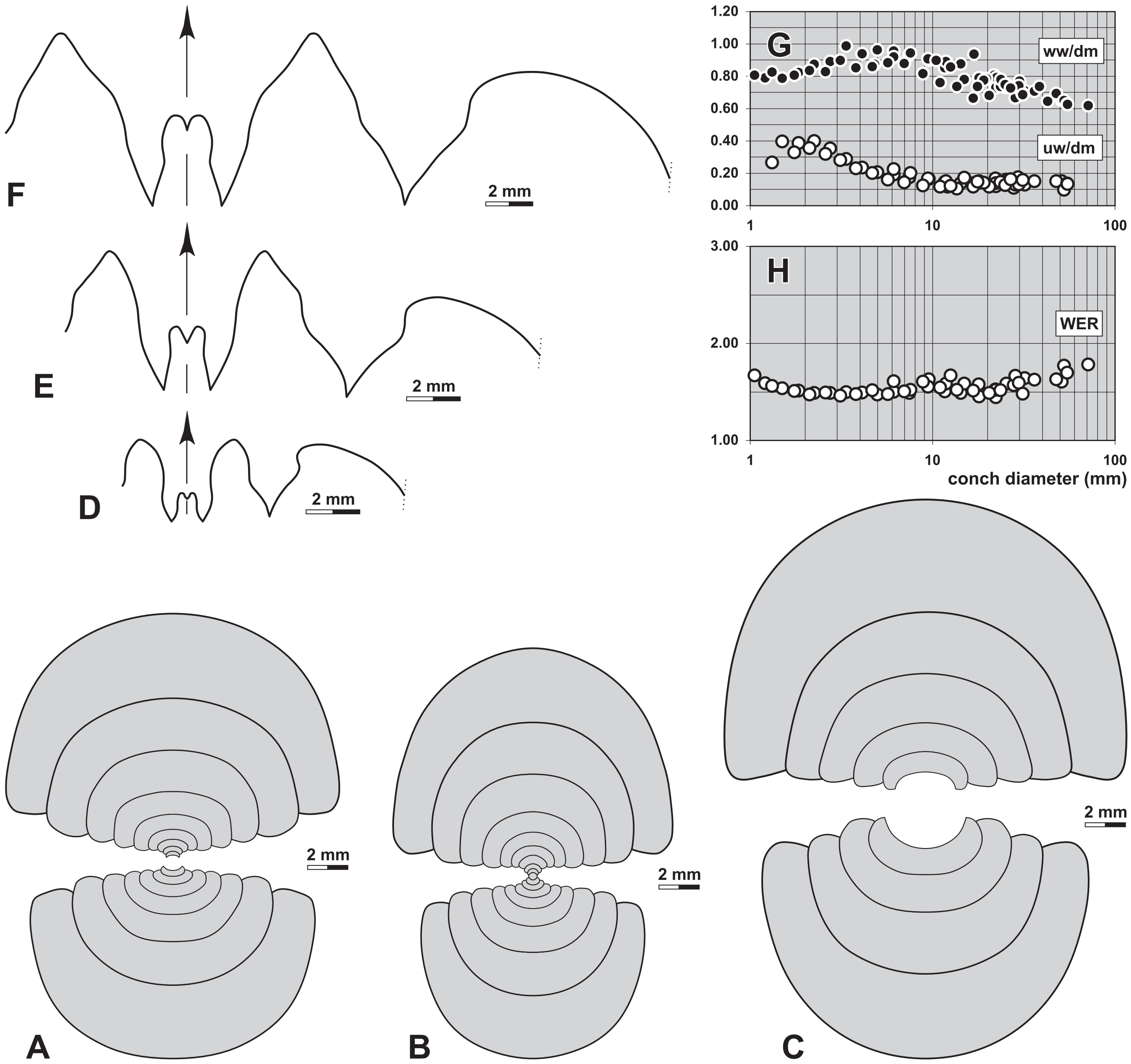


Figure 50. *Lusitanoceras zirari* n. sp. **A.** Cross section of paratype MB.C.13206.1 from locality Chebket el Hamra-D; ×3.0. **B.** Cross section of paratype MB.C.13206.2 from locality Chebket el Hamra-D; ×3.0. **C.** Cross section of paratype MB.C.13247.2 from locality Chebket el Hamra-K; ×3.0. **D.** Suture line of paratype MB.C.13261.1 from locality Chebket el Hamra-P, at 10.4 mm ww, 9.4 mm wh; ×4.0. **E.** Suture line of paratype MB.C.13288 from Chebket el Hamra, at 20.4 mm dm, 15.5 mm ww, 10.7 mm wh; ×4.0. **F.** Suture line of holotype MB.C.13296 from Chebket el Hamra, at 30.6 mm dm, 21.3 mm ww, 13.8 mm wh; ×3.5. **G, H.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm) and whorl expansion rate (WER) of all available specimens.

ranged with slightly irregular distances. They extend across flanks and venter with a low dorsolateral projection, a shallow lateral sinus and a wide and low ventral projection.

Two smaller well-preserved steinkern specimens MB.C.13247.1 and MB.C.13261.1, both with about 12 mm conch diameter, give an impression of the variable morphology at this growth stage (Figs 49D, E). Both are similar in their globular shape (ww/dm = 0.86–0.88) and their very narrow umbilicus (uw/dm = 0.12–0.14). They differ in the strength of the constrictions, which are arranged more or less at intervals of 120°. They are weaker on the midventer in specimen MB.C.13247.1. Both specimens show traces of the spiral ornament, which consists of 70–80 fine lines.

The three figured suture lines demonstrate the significant ontogenetic changes in this feature (Figs 50D–F). A Y-shaped, partly parallel-sided external lobe is present in the juvenile stage (specimen MB.C.13261.1, 10 mm dm), and the median saddle reaches one third of the E lobe depth. The pouched adventive lobe has strongly curved flanks.

An ontogenetic trend towards a widening of the sutural elements can be seen in the studied specimens. The shape of the external lobe changes strikingly, being

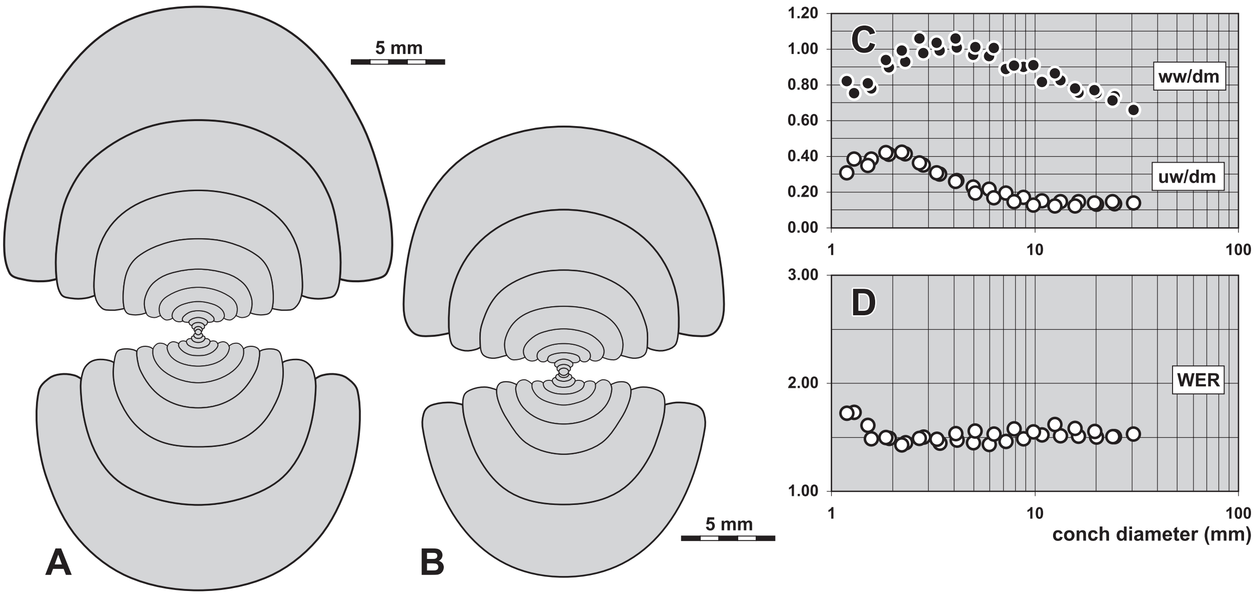


Figure 51. *Lusitanoceras poststriatum* (Brüning, 1923) from the Rhenish Mountains. **A.** Cross section of specimen MB.C.13307 (cuboid variant) from Mälers Länder (Korn 1986 Coll.); ×2.5. **B.** Cross section of specimen MB.C.13303 (non-cuboid variant) from Nehden (Korn 1986 Coll.); ×2.5. **C**, **D.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm) and whorl expansion rate (WER) of the two sectioned specimens.

moderately wide in paratype MB.C.13288 (20 mm dm; Fig. 50E) and widely Y-shaped in holotype MB.C.13296 (30 mm dm; Fig. 50F). In the latter, the flanks are strongly sinuous with a sharp bend at half height, above which the flanks diverge prominently. At this stage, the height of the median saddle is slightly more than 0.50 of the external lobe depth. The subacute ventrolateral saddle is almost symmetric in holotype MB.C.13296. While the flanks of the ventral lobe become more sinuous during ontogeny, the flanks of the adventive lobe lose their strong sinuosity of the juvenile stage. However, rather sharp bends are still visible at half the depth of the adventive lobe.

Discussion. The similar species *L. algarviense* is so far only known from crushed or otherwise incompletely preserved material (Korn 1997), but never the less it can easily be distinguished from the well preserved new material from Chebket el Hamra. The two species differ mainly in the strength of the spiral ornament, with 110 spiral lines at 10–12 mm dm in *L. algarviense* and only 70–80 in *L. zirari*. This difference is even more striking in adult specimens, with 80–100 spirals in *L. zirari* and approximately 150 in *L. algarviense*.

The new material shows that the differences with the other European species *L. poststriatum* (Brüning, 1923) are most discernible in adult specimens (lack of the falcate ornament and straight constrictions in *L. poststriatum*). Juvenile conchs, however, are very similar and may be difficult to separate. As demonstrated by Brüning (1923a) and Korn (1988), *L. poststriatum* occurs, like *L. zirari*, in cuboid and non-cuboid variants (Fig. 51). This phenomenon was analysed by Korn et al. (2004) for a number of goniatites. The number of spiral lines is higher in *L. poststriatum* (more than 100 at 12 mm dm).

More difficult is a clear separation from the still problematic Irish species *L. granosum* (Portlock, 1843), of which no additional material has been collected. The partly crushed original specimen shows fewer spiral lines and no indication of a falcate ornament.

Subfamily Sudeticeratinae Korn & Ebbighausen, 2006

Included genus.
Sudeticeras Patteisky, 1930.

Discussion. Based on similarities in the suture lines *Sudeticeras* was usually included in subfamily Sudeticeratinae along with *Anthracoceras* Frech, 1899 in the Anthracoceratidae Plummer & Scott, 1937 (see for instance Ruzhencev & Bogoslovskaya 1971, who also attributed *Beyrichoceras* to this family). This arrangement cannot be supported because of major differences in the conch shapes between these genera, with *Anthracoceras* possessing a high aperture; in addition the suture line of *Sudeticeras* shows a clear development from a goniatitid origin, but in *Anthracoceras* it is very simple with very low median saddle and small and rounded adventive lobe. Therefore, Korn & Ebbighausen (in Klug et al. 2006) erected the new family Sudeticeratidae, which will be downgraded here to the rank of subfamily and placed in the Goniatitidae.

The new material shows that the stratigraphically oldest species of *Sudeticeras* are very close to representatives of genera such as *Hibernicoceras* and *Paragly-*

phioceras, and that there appears to be an almost continuous morphocline between these genera. The conch ontogeny of *Sudeticeras* closely resembles these two genera, and the suture line also indicates close relationships. These data suggest that *Sudeticeras* derives from the Goniatitida as a side branch, in which the ventrolateral saddle became secondarily rounded as in other representatives such as *Hibernicoceras*. The *Sudeticeras* group is therefore thought to represent a subfamily within the Goniatitidae.

Sudeticeras Patteisky, 1930

Type species. Homoceratoides Hoeferi Patteisky, 1929.

Discussion. *Sudeticeras* is a genus with an almost global occurrence (except for central North America) and 27 valid species are listed in the AMMON database (Korn & Ilg 2007). Unfortunately, many of these species, including the type material, are based on insufficiently preserved material and are thus very difficult to interpret. Seventeen of the species were erected on material from Europe; few of these were described with the full inventory of conch geometry, ornament, and suture line. Therefore *Sudeticeras* can be regarded as a somewhat problematic genus.

The Western and Central European species of *Sudeticeras* can be grouped as follows:

A – species with a wide external lobe (1.50 of the adventive lobe width or more):

- *S. regina* Bisat, 1952: very slender form (ww/dm = 0.54 at 39 mm dm) with fine crenulated growth lines and without spiral lines, very low ventrolateral projection of the growth lines;
- *S. murracaoense* Korn, 1997: slender form (ww/dm = 0.60 at 25 mm dm) with fine, barely crenulated growth lines and without spiral lines, very low ventrolateral projection of the growth lines;
- *S. turneri* Moore & Hodson, 1958: slender form (ww/dm = 0.60 at 30 mm dm) with fine crenulated growth lines and without spiral lines, moderate ventrolateral projection of the growth lines;
- *S. varians* (Bisat, 1950): very slender form (ww/dm = 0.48 at 25 mm dm) with delicate growth lines but without spiral lines, moderate ventrolateral projection of the growth lines.

B – species with a rather narrow external lobe (less than 1.50 of the adventive lobe) and a moderately narrow umbilicus (uw/dm more than 0.15):

- *S. newtonense* Moore, 1950: very slender form (ww/dm = 0.55 at 38 mm dm) with fine crenulated growth lines and without spiral lines, very low ventrolateral projection of the growth lines;
- *S. adeps* Moore, 1950: stout form (ww/dm = 0.80 at 20 mm dm) with roughened growth lines and without spiral lines, very low ventrolateral projection of the growth lines.

C – species with a rather narrow external lobe (less than 1.50 of the adventive lobe), a very narrow umbilicus (uw/dm less than 0.15), and a rather prominent ventrolateral projection of the growth lines:

- *S. splendens* (Bisat, 1928): slender form (ww/dm = 0.67 at 25 mm dm) with spiral lines on venter and ventrolateral shoulder;
- *S. horoni* n. sp.: very slender form (ww/dm = 0.55–0.65 at 24 mm dm) with spiral lines on venter, ventrolateral shoulder, and around the umbilicus;
- *S. ordinatum* Moore, 1950: stout form (ww/dm = 0.75 at 25 mm dm) with spiral lines on venter, ventrolateral shoulder, and flanks;
- *S. subtilis* Moore, 1950: very slender form (ww/dm = 0.57 at 21 mm dm) with fine crenulated growth lines and without spiral lines.

D – species with a rather narrow external lobe (less than 1.50 of the adventive lobe), a very narrow umbilicus (uw/dm less than 0.12), and without or with a very low ventrolateral projection of the growth lines:

- *S. crenistriatum* (Bisat, 1928): very slender form (ww/dm = 0.58 at 24 mm dm) with fine crenulated growth lines and without spiral lines;
- *S. procerum* Moore, 1950: slender form (ww/dm = 0.62 at 21 mm dm) with fine crenulated growth lines and few spiral lines around the umbilicus;
- *S. delepinei* Moore, 1950: very slender form (ww/dm = 0.55 at 27 mm dm) with fine crenulated growth lines and without spiral lines;
- *S. laevigatum* Ruprecht, 1937: stout form (ww/dm = 0.70 at 17 mm dm) with rather coarsely crenulated growth lines and without spiral lines, without ventrolateral projection of the growth lines.

Sudeticeras murracaoense Korn, 1997
Figures 52–54

1997 *Sudeticeras murracaoense* Korn, p. 40, pl. 2, figs 6–8.

Holotype. Specimen IGML250 (Korn & Horn 1995 Coll.); figured by Korn (1997, pl. 2, fig. 6).

Material. 382 limonitic steinkern specimens varying from a conch diameter of 5 and 22 mm from horizon CeH-3 at localities Chebket el Hamra-A, B, C, and S.

Diagnosis. *Sudeticeras* with highly variable pachyconic conch at 10 mm diameter (ww/dm = 0.68–0.82) and thinly pachyconic conch at 20 mm diameter (ww/dm = 0.60–0.65). Umbilicus moderately wide in early juveniles (uw/dm = 0.30 at 2 mm dm) and then continuously closing (uw/dm = 0.05–0.10 at 20 mm dm); umbilical margin broadly rounded, umbilical wall rounded. Ornamentation with delicate, crenulated rectiradiate growth-lines, which extend almost straight across the flanks and form a shallow ventral sinus; spiral lines lacking. Suture line with moderately wide external lobe (0.70–0.80 of the external lobe depth, 1.30–1.50 of the adventive lobe), V-shaped in the juvenile stage and Y-shaped in the adult, and moderate median saddle (0.50 of the external lobe depth). Ventrolateral saddle narrowly rounded, adventive lobe V-shaped with strongly sinuous flanks.

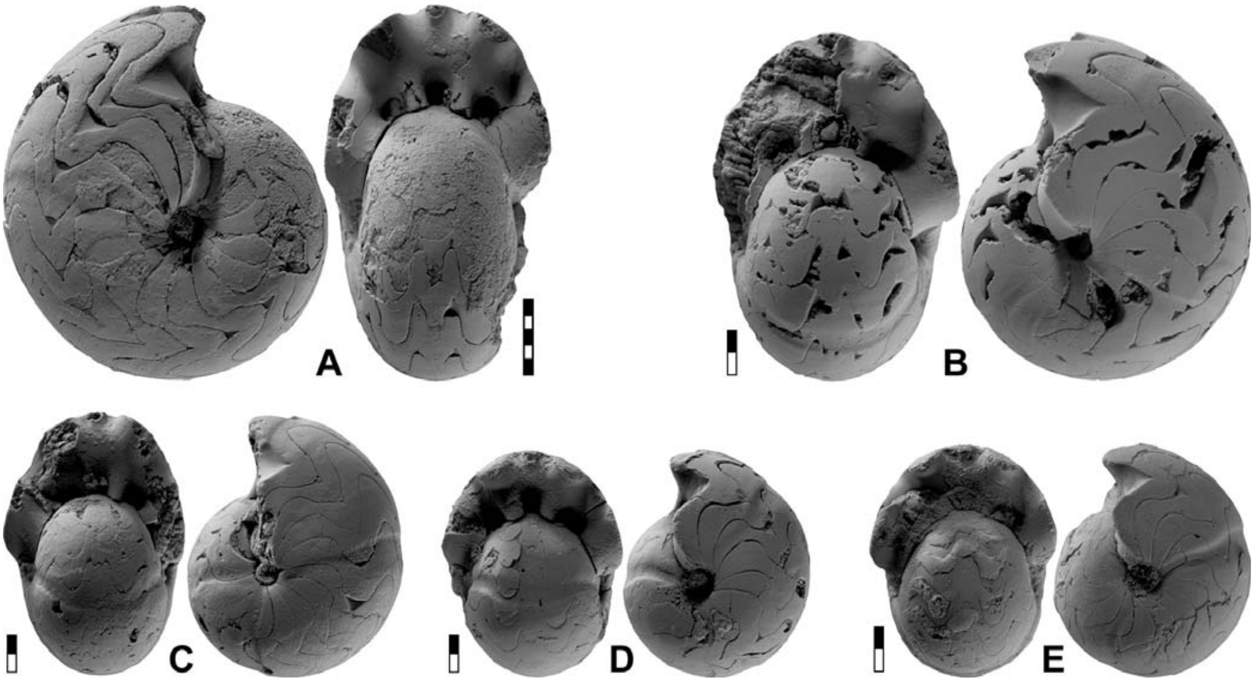


Figure 52. *Sudeticeras murracaoense* Korn, 1997. **A.** Specimen MB.C.13202.1 from locality Chebket el Hamra-A; ×2.0. **B.** Specimen MB.C.13271.1 from locality Chebket el Hamra-S; ×3.0. **C.** Specimen MB.C.13271.2 from locality Chebket el Hamra-S; ×2.5. **D.** Specimen MB.C.13202.2 from locality Chebket el Hamra-A; ×2.5. **E.** Specimen MB.C.13203.1 from locality Chebket el Hamra-B; ×3.0.

Description. The plots of the major conch parameters show two phenomena (Figs 53G, H): (1) the ontogenetic changes from the moderately umbilicate, pachyconic to globular inner whorls with low aperture (ww/dm = 0.85, uw/dm = 0.30, WER = 1.70 at 2 mm dm) to the involute, thickly discoidal large stage with moderately high aperture (ww/dm = 0.55, uw/dm = 0.10, WER = 2.00–2.10 at 25 mm dm). (2) the significant variability of the ww/dm ratio and the whorl expansion rate.

Only a few specimens have well-preserved inner whorls, and specimen MB.C.13271.3 is the best preserved of these (Fig. 53A). The cross section allows study of all inner whorls up to 14 mm dm; it displays the ontogenetic modifications beginning with an evolute initial stage and ending with the involute, pachyconic shape at 14 mm dm (ww/dm = 0.66; uw/dm = 0.07). The last half whorl shows a section that is widest at the rounded umbilical margin, from which the flanks converge toward the broadly rounded venter.

MB.C.13271.4 is one of the larger sectioned specimens in which the internal whorls are not preserved. The umbilical margin is more pronounced in this specimen and separates the converging flanks and the flattened umbilical wall.

Specimen MB.C.13202.1 belongs to the larger individuals (Fig. 52A); it is, at a diameter of nearly 25 mm, thickly discoidal (ww/dm = 0.58) with a very narrow umbilicus (uw/dm = 0.08) and a moderately high aperture (WER = 2.02). It is fully septate with 16 chambers, of which the last are shorter than the average. The steinkern has weak constrictions, which extend with a very shallow lateral sinus and a deeper ventral sinus; remains of the shell show fine and crenulated growth lines with the same course.

Smaller specimens such as MB.C.13271.1 (15 mm dm) and MB.C.13271.2 (13 mm dm) have a similar conch geometry (Figs 52B, C), but are somewhat stouter (ww/dm = 0.70). The umbilicus is very narrow in these two specimens (uw/dm = 0.07). Both show the same type of irregularly distributed constrictions on the steinkern, but no shell remains.

Juveniles such as specimen MB.C.13203.1 (10 mm dm) tend to have a thickly discoidal conch (ww/dm = 0.79) with a lower aperture (WER = 1.87). The steinkern of this specimen has two broad and shallow constrictions, which extend almost straight across flanks and venter (Fig. 52E).

The atypical suture line of the large specimen MB.C.13202.1 (drawn at 23.5 mm dm) shows a Y-shaped external lobe, whose lower part has nearly parallel flanks (Fig. 53F). A narrow median saddle, reaching the half height of the E lobe depth produces asymmetric prongs with strongly curved ventral flank. The ventrolateral saddle is strongly asymmetric and appears dorsally inclined. It is narrowly rounded at its top and continues into the deep and narrow adventive lobe.

Differences can be recognised in the suture line of the smaller specimens MB.C.13271.1 (15 mm dm) and MB.C.13203.1 (10 mm dm); these have a V-shaped external lobe with strongly diverging flanks (Figs 53D, E).

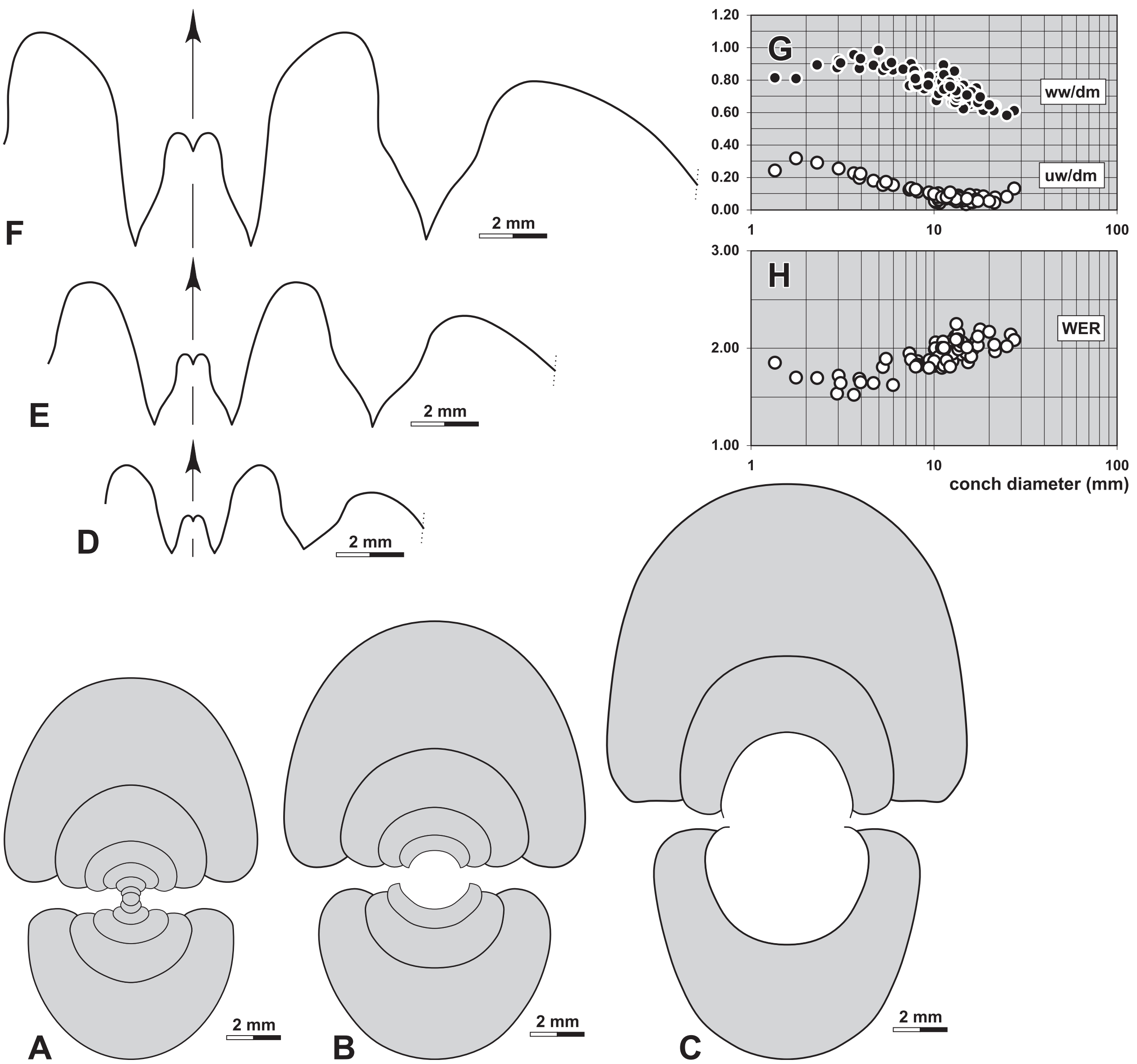


Figure 53. *Sudeticeras murracaoense* Korn, 1997. **A.** Cross section of specimen MB.C.13271.3 from locality Chebket el Hamra-S; ×4.0. **B.** Cross section of specimen MB.C.13205.1 from locality Chebket el Hamra-C; ×4.0. **C.** Cross section of specimen MB.C.13271.4 from locality Chebket el Hamra-S; ×4.0. **D.** Suture line of specimen MB.C.13203.1 from locality Chebket el Hamra-B, at 10.3 mm dm, 8.1 mm ww, 5.8 mm wh; ×5.0. **E.** Suture line of specimen MB.C.13271.1 from locality Chebket el Hamra-S, at 15.1 mm dm, 10.7 mm ww, 8.1 mm wh; ×5.0. **F.** Suture line of specimen MB.C.13202.1 from locality Chebket el Hamra-A, at 23.6 mm dm, 14.9 mm ww, 12.8 mm wh; ×5.0. **G, H.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm) and whorl expansion rate (WER) of all available specimens.

Discussion. The material from the Chebket el Hamra closely resembles the Portuguese material in the development of conch shape and suture line (for a comparison, see Fig. 54). *S. murracaoense* is one of the few species of the genus that lacks spiral ornament, and can thus be separated from a number of other *Sudeticeras* species. Furthermore, the species has a wide external lobe with diverging flanks, which separates it from many other species with subparallel flanks of the external lobe. *S. turneri* Moore & Hodson, 1958 is closely related but this species has an even wider external lobe and a higher ventrolateral projection of the growth lines.

***Sudeticeras ibnbajjahi* n. sp.**
Figures 55–56

Derivation of name. After Ibn Bajjah (Avempace) one of the most important medieval Arab scientists.

Holotype. Specimen MB.C.13241.1 (Korn & Ebbighausen 2006 Coll.); illustrated in Figure 55A.

Type locality and horizon. Chebket el Hamra-I (Jerada Basin, NE-Morocco); horizon CeH-2, most probably *Neoglyphioceras spirale* Zone (middle Brigantian, Early Carboniferous).

Material. 35 limonitic steinkern specimens ranging from 8 and 37 mm in conch diameter from horizon CeH-2 at localities Chebket el Hamra-F, I, and T.

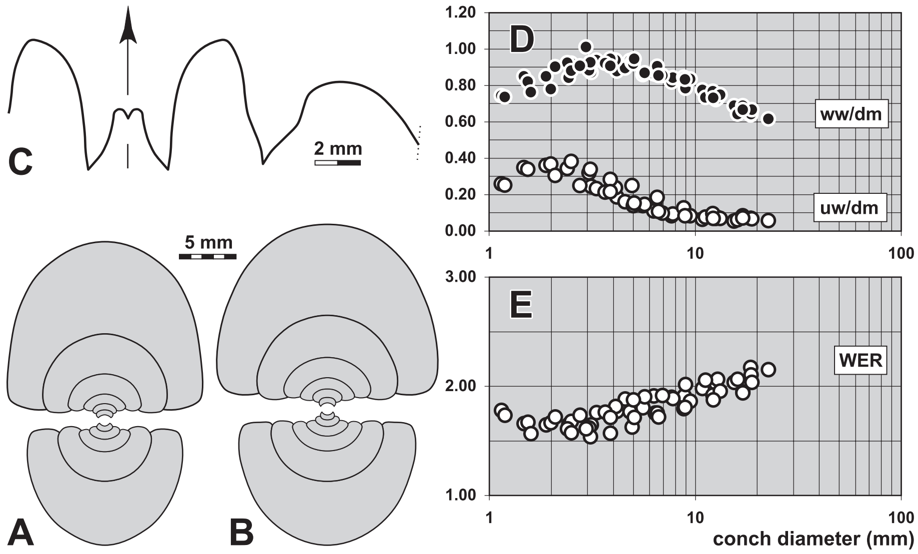


Figure 54. *Sudeticeras murracaoense* Korn, 1997 from bed 145 of the Praia das Quebradas section, SW Portugal (Korn 2000 Coll.). **A.** Cross section of specimen MB.C.13313.1; ×2.5. **B.** Cross section of specimen MB.C.13313.2; ×2.5. **C.** Suture line of specimen MB.C.13313.8, at 16.5 mm dm, 11.8 mm ww, 8.6 mm wh; x 3.0. **D**, **E.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm) and whorl expansion rate (WER) of the seven sectioned specimens MB.C.13313.1–MB.C.13313.7.

Diagnosis. *Sudeticeras* with thickly pachyconic conch at 10 mm diameter (ww/dm = 0.75–0.85) and thinly pachyconic conch at 20 mm diameter (ww/dm = 0.60–0.65). Umbilicus very narrow in specimens larger than 8 mm dm (uw/dm = 0.05–0.15), in the adult stage slightly opening; umbilical margin broadly rounded, umbilical wall rounded. Ornamentation with delicate, weakly crenulated rectiradiate growth-lines, which extend almost straight across the flanks and form a shallow external sinus; spiral lines lacking. Suture line with V-shaped, moderately wide external lobe (0.70 of the external lobe depth, 1.30 of the adventive lobe), and moderate median saddle (0.45 of the external lobe depth). Ventrolateral saddle narrowly rounded, adventive lobe V-shaped with weakly sinuous flanks.

Description. The morphometric plots demonstrate that the short early juvenile growth stage individuals possess a moderately wide umbilicus (uw/dm = 0.30–0.35 at 1.5–2 mm dm), with a rapid closure of the umbilicus (uw/dm = 0.10 at 5 mm dm), and a very narrow umbilicus in all later stages (Fig. 56H). The conch is widest at 4 mm dm (ww/dm = 1.00) and becomes continuously narrower during growth, being thickly discoidal at 37 mm dm (ww/dm = 0.56). During ontogeny, there is a continuous heightening of the aperture, visible in the increase of the whorl expansion rate from 1.70 at 2 mm dm to 2.00 at 20 mm dm (Fig. 56I).

The two cross sections show similar pictures. Paratype MB.C.13225.4 is the more complete of these; it has a maximum diameter of almost 15 mm and displays five and a half whorls (Fig. 56B). Early whorls are ventrally depressed and semilunate in cross section (ww/dm = 1.00 at 4.8 mm dm), but an increase in height of the aperture leads to the thinly pachyconic conch at 15 mm dm (ww/dm = 0.67). The umbilical margin and also the umbilical wall are rounded in all stages.

The incompletely preserved holotype MB.C.13241.1 with a conch diameter of 21 mm belongs among the largest specimens (Fig. 55A). It is thinly pachyconic (ww/dm appr. 0.67) with a rather high aperture (WER = 2.02) and is fully septate with a smooth internal mould. Two very weak constrictions are visible; they extend straight across the flanks and form a shallow ventral sinus.

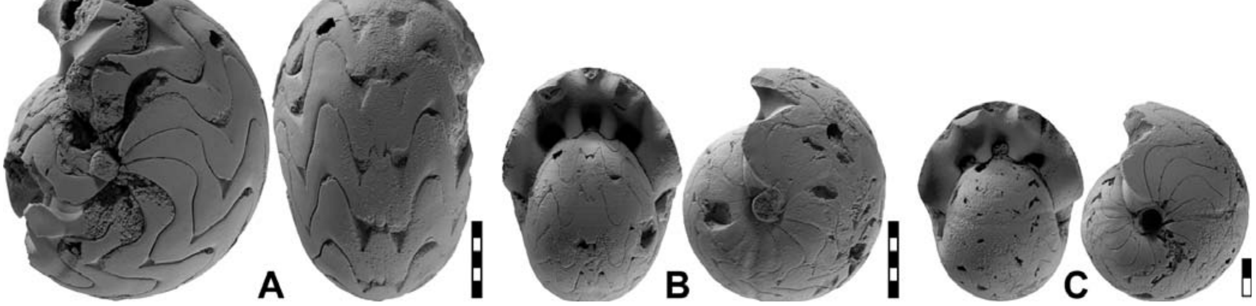


Figure 55. *Sudeticeras ibnbajjahi* n. sp. **A.** Holotype MB.C.13241.1 from locality Chebket el Hamra-I; ×2.0. **B.** Specimen MB.C.13225.1 from locality Chebket el Hamra-F; ×2.0. **C.** Specimen MB.C.13225.2 from locality Chebket el Hamra-F; ×2.5.

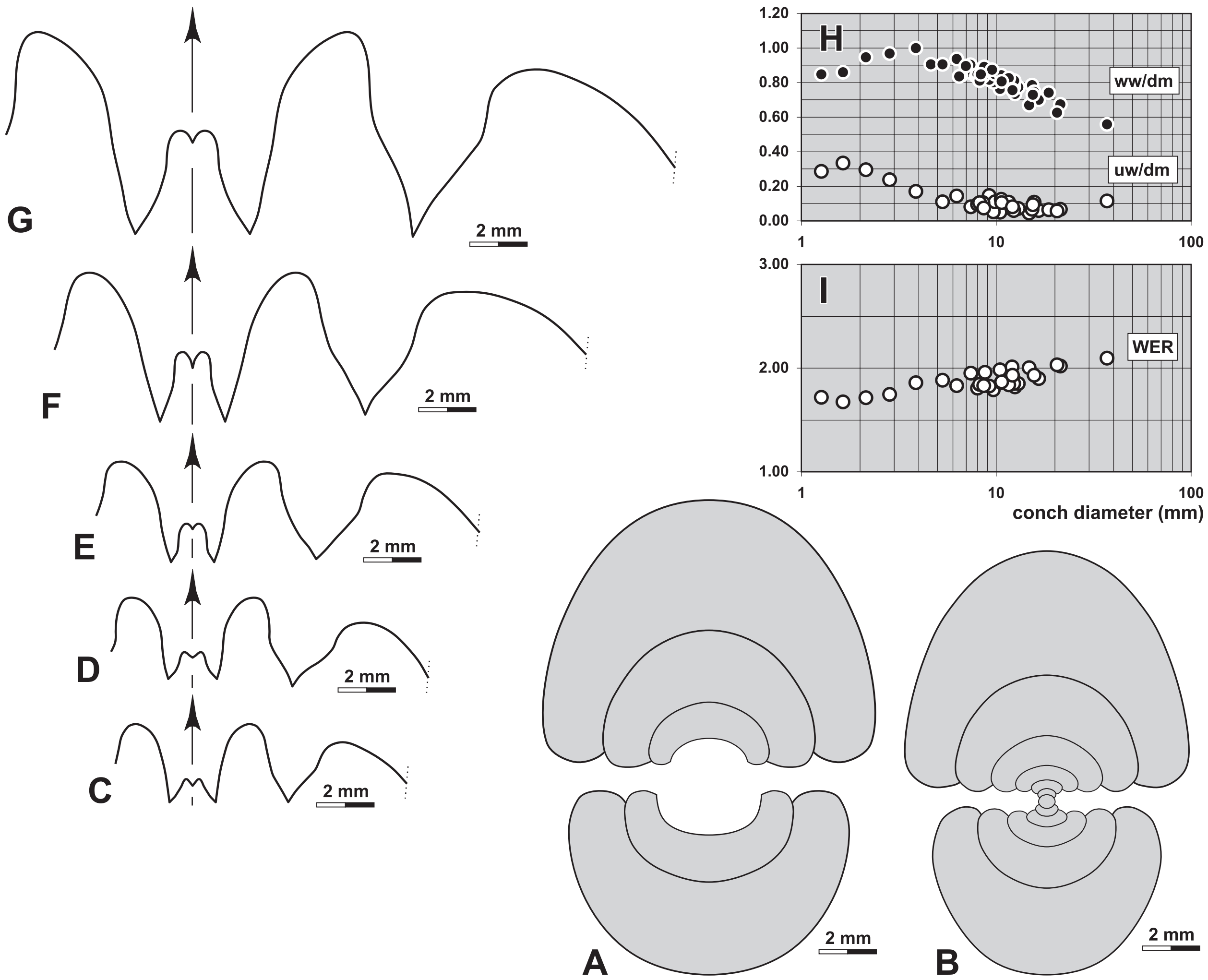


Figure 56. *Sudeticeras ibnbajjahi* n. sp. **A.** Cross section of paratype MB.C.13225.3 from locality Chebket el Hamra-F; ×4.0. **B.** Cross section of paratype MB.C.13225.4 from locality Chebket el Hamra-F; ×4.0. **C.** Suture line of paratype MB.C.13225.2 from locality Chebket el Hamra-F, at 10.3 mm dm, 8.6 mm ww, 5.8 mm wh; ×4.0. **D.** Suture line of paratype MB.C.13225.5 from locality Chebket el Hamra-F, at 11.3 mm dm, 9.3 mm ww, 6.1 mm wh; ×4.0. **E.** Suture line of paratype MB.C.13225.1 from locality Chebket el Hamra-F, at 15.1 mm dm, 11.7 mm ww, 8.6 mm wh; ×4.0. **F.** Suture line of holotype MB.C.13241.1 from locality Chebket el Hamra-I, at 20.0 mm dm, 10.3 mm wh; ×4.0. **G.** Suture line of paratype MB.C.13280.1 from locality Chebket el Hamra-T, at 13.6 mm wh; ×4.0. **H**, **I.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm) and whorl expansion rate (WER) of all available specimens.

Paratype MB.C.13225.1 shows the characteristic morphology of the immature stage (ww/dm = 0.75, uw/dm = 0.11, WER = 1.93 at 15 mm dm). The specimen possesses some minor remains of the shell, which show that the delicate, finely crenulated growth lines extend almost straight across the flanks and form a shallow ventral sinus. The steinkern has two very shallow constrictions (Fig. 55B).

Suture lines of the adult stage have a Y-shaped external lobe, of which the flanks are particularly strongly diverging in the upper quarter (paratype MB.C.13280.1 at 13 mm whorl height; Fig. 56G). The external lobe is wide (0.80 of the lobe depth at half height; 1.55 of the adventive lobe) and is subdivided by a median saddle that has the half height of the E lobe depth. The ventrolateral saddle is asymmetric and narrowly rounded, and the adventive lobe is deep with curved flanks.

The suture line of holotype MB.C.13241.1, drawn at 20 mm conch diameter, displays the V-shaped external lobe with almost linear flanks in the lower three quarters (Fig. 56F). The median saddle is raised to nearly half the height of the external lobe and generates two slightly asymmetric prongs of the external lobe. A slightly asymmetric ventrolateral saddle follows, and then a V-shaped adventive lobe with barely curved ventral and strongly sinuous dorsal flank.

The smaller specimens MB.C.13225.1 (15 mm dm) and MB.C.13225.2 (10 mm dm) principally resemble the suture line of MB.C.13241.1, but have a lower median saddle and a broader rounded ventrolateral saddle (Figs 56C, E).

Discussion. *Sudeticeras ibnbajjahi* is the species that shows most resemblance to species of other genera, such as *Hibernicoceras* and *Paraglyphioceras*. The resemblance is close particularly among juvenile conchs, but distinguishable differences can be seen in the suture line. *S. ibnbajjahi* possesses an external lobe in which the prongs are strikingly asymmetric, with the flanks of the median saddle being characteristically concave.

Sudeticeras murracaoense is very similar in conch geometry and suture line, but possesses strong steinkern constrictions in juveniles, which are only very weakly developed in *S. ibnbajjahi*. *S. murracaoense* has a higher aperture in specimens between 15 and 25 mm dm (WER = 2.00–2.20) in contrast to *S. ibnbajjahi*, in which it is below 2.00.

Sudeticeras splendens **(Bisat, 1928)**

Figures 57–60

1928 *Goniatites crenistriatus* var. *splendens* Bisat, p. 43, pl. 6A, fig. 3.
1929 *Sudeticeras stolbergi* Patteisky, p. 279, pl. 15, figs 1–2, pl. 20, figs 10a, 10b, 11, pl. 15, fig. 3, pl. 22, fig. 6, pl. 23, figs 29–30.
1931 *Glyphioceras stolbergi*. – Knopp, p. 19, pl. 3, figs 1–6.
1937 *Sudeticeras stolbergi*. – Ruprecht, p. 269, pl. 9, figs 10–15.
1950 *Sudeticeras splendens*. – Moore, p. 40, pl. 1, figs 3–5, pl. 2, fig. 6, pl. 3, figs 4–5.
1988 *Sudeticeras splendens*. – Korn, p. 43, pl. 15, fig. 7.

Holotype. Specimen NHM c33151 (Moore Coll.); figured by Bisat (1928, pl. 6A, figs 3, 3a).

Type locality and horizon. Eastby Beck near Skipton (West Yorkshire, Great Britain); P2 Zone (Late Viséan).

Material. 46 limonitic steinkern specimens ranging from conch diameter of 30 to 58 mm from horizon CeH-6 at localities Chebket el Hamra-D, L, M, O, P, and R.

Diagnosis. *Sudeticeras* with thickly discoidal conch at 10 mm diameter (ww/dm = 0.75), thickly discoidal to thinly pachyconic conch at 30 mm diameter (ww/dm = 0.55–0.65), and thickly discoidal conch at 50 mm diameter (ww/dm = 0.45–0.55). Umbilicus very narrow in stages between 10 and 30 mm dm (uw/dm = 0.08–0.12), but opening slightly in the adult stage (uw/dm = 0.15–0.20 at 50 mm dm); umbilical wall oblique, incurved in the adult stage. Ornamentation with crenulated biconvex and rectiradiate growth-lines having a low dorsolateral projection and pronounced ventrolateral projection; external sinus deep. Spiral lines around the umbilicus and on the outer flanks and venter. Suture line with V-shaped, moderately wide external lobe (0.65–0.75 of the external lobe depth, 1.30–1.40 of the adventive lobe), and moderate median saddle (0.50 of the external lobe depth). Ventrolateral saddle rounded, adventive lobe V-shaped with weakly sinuous flanks.

Description. Nearly all attempts to produce a usable cross section failed, and hence only the growth stages from conch diameters 14 to 60 mm can be studied (Figs 58C, D). Ontogenetic changes during this interval are best seen in the ww/dm ratio, which continuously decreases from 0.71 at 14 mm dm to 0.47 at 58 mm dm. The uw/dm ratio remains almost stable during this growth interval; there is only a slight increase from 0.13 to 0.17. The aperture also becomes higher, resulting in an increase of the whorl expansion rate from 1.74 to approximately 2.00.

The sectioned specimen MB.C.13248.1 shows the compressed whorl cross section (ww/dm = 0.51 at 47 mm dm) with the rounded flanks converging toward the broadly rounded venter (Fig. 58A). The umbilical margin is rounded, and the umbilical wall is obliquely oriented and, in the last two volutions, sinuously curved in the section.

Larger specimens, such as MB.C.13264.1 (55 mm dm), develop a subangular ventrolateral margin that separates the flanks from the slightly flattened venter (Fig. 57A). This specimen also shows the slight adult opening of the umbilicus (uw/dm = 0.15) and the longitudinal groove on the umbilical wall. The entire specimen represents the body chamber, which is smooth except for four shallow constrictions on the last third of the volution. These begin on the flanks at some distance from the umbilicus and show a shallow lateral sinus, a pronounced angular ventrolateral salient, and a deep ventral sinus. Remains of the shell ornament are only visible in the umbilicus, where spiral lines and growth lines of equal strength occur.

Shell remains are very rare in this material. Specimens MB.C.13264.4 (50 mm dm) and MB.C.13258.1 (46 mm dm) display traces of the ornament that are impressed on the steinkern. They show spiral lines on the

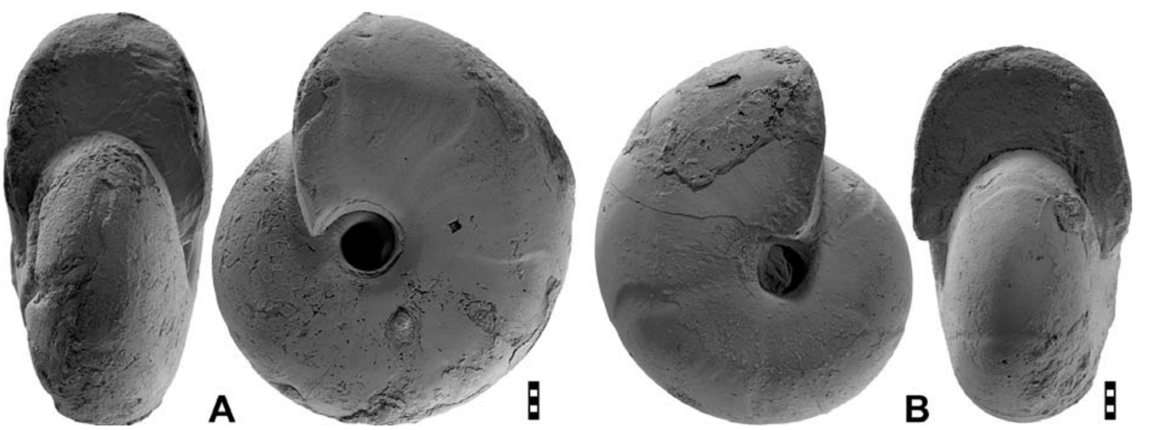


Figure 57. *Sudeticeras splendens* (Bisat, 1928). **A.** Specimen MB.C.13264.1 from locality Chebket el Hamra-P; × 1.0. **B.** Specimen MB.C.13264.2 from locality Chebket el Hamra-P; × 1.0.

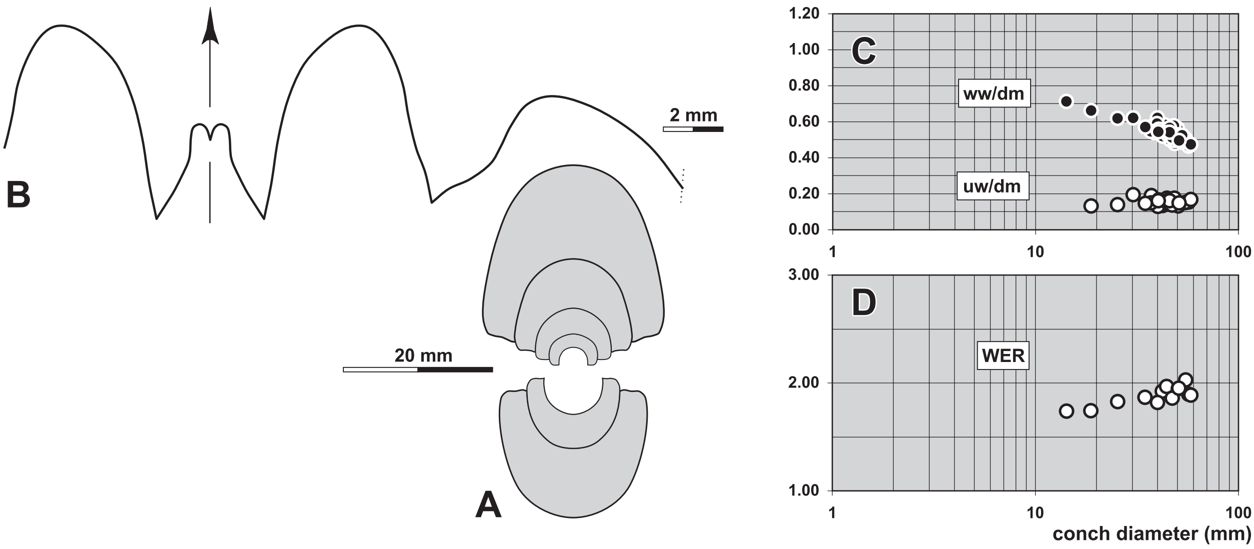


Figure 58. *Sudeticeras splendens* (Bisat, 1928). **A.** Cross section of specimen MB.C.13248.1 from locality Chebket el Hamra-K; ×1.0. **B.** Suture line of specimen MB.C.13264.3 from locality Chebket el Hamra-P, at 13 mm wh; ×4.0. **C**, **D.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm) and whorl expansion rate (WER) of all available specimens.

venter and in the area of the ventrolateral projection; these spirals become weaker on the flanks and disappear in the midflank area. Specimen MB.C.13264.4 in particular exhibits the spiral lines do not follow an exact spiral course, but are frequently dislocated.

The suture line was drawn from specimen MB.C.13264.3 at a whorl height of 13 mm (corresponding to a conch diameter of 30 mm). The rather wide external lobe renders it characteristic for *Sudeticeras*, whose incurved flanks strongly converge (Fig. 58B). The median saddle reaches exactly the half the height of the external lobe depth; its flanks are inwardly curved forming asymmetric prongs of the external lobe. The ventrolateral saddle is broadly rounded; the adventive lobe is less deep as the external lobe. It has a slightly curved ventrally and has a stronger curved dorsal flank.

Figure 59. *Sudeticeras splendens* (Bisat, 1928), specimen NHM c38123 from Hilly Clough Farm near Barnoldswick, Lancashire (Moore Coll.); ×2.0. This figure is available in colour online at museum-fossilrecord.wiley-vch.de

Discussion. Comparison of the British and Moroccan material is difficult because of different modes of preservation. The suture lines published by Moore (1950, pl. 3, figs 4, 5) are too schematic to be diagnostic (the external lobe is drawn asymmetrically in nearly all the figures); however, his figure 4 shows that the ventrolateral saddle is narrowly rounded at 33 mm conch diameter and differs from the Moroccan specimen MB.C.13264.3, in which the saddle is rounded. The suture line of the beautifully preserved specimen NHM c38123 (Figs 59, 60) from Hilly Clough Farm near Barnoldswick has a rounded ventrolateral saddle. It also has a moderately wide external lobe (0.65 of the E lobe depth; 1.30 of the adventive lobe) and a moderate median saddle (0.40 of the E lobe depth).

Sudeticeras splendens differs from most of the other species of the genus in its strong spiral ornament on the venter and ventrolateral shoulder. Only *S. ordinatum* Moore, 1950 is very similar; it is a stout form (ww/dm = 0.75 at 25 mm dm) with spiral lines on venter and ventrolateral area. However, *S. ordinatum* also has spiral ornament on the flanks. The co-occurring *S. horoni* has a narrower umbilicus, a less well developed

Figure 60. *Sudeticeras splendens* (Bisat, 1928), suture line of specimen NHM c38123 from Hilly Clough Farm near Barnoldswick, Lancashire (Moore Coll.), at 26.7 mm dm, 17.2 mm ww, 13.3 mm wh; ×3.5.

ventrolateral angularity of the conch, and weaker spiral lines.

Sudeticeras horoni n. sp.
Figures 61–63

Derivation of name. After O. Horon, one of the pioneers who investigated the geology of the Jerada Basin.

Holotype. Specimen MB.C.13212.1 (Korn & Ebbighausen 2006 Coll.); illustrated in Figure 61C.

Type locality and horizon. Chebket el Hamra-E (Jerada Basin, NE-Morocco); horizon CeH-4 (late Brigantian, Early Carboniferous).

Material. 163 sideritic specimens ranging from a conch diameter 21 to 76 mm, from horizon CeH-4 at localities Chebket el Hamra-E, J, O, P, Q, and R, of which many were collected as float material.

Diagnosis. *Sudeticeras* with thickly pachyconic conch at 10 mm diameter (ww/dm = 0.75–0.85), thickly discoidal conch at 30 mm diameter (ww/dm = 0.50–0.60), and discoidal conch at 50 mm diameter (ww/dm = 0.40–0.50). Umbilicus very narrow in all stages larger than 10 mm dm (uw/dm = 0.05–0.12), but opening slightly in the adult stage; umbilical margin broadly rounded, umbilical wall rounded. Ornamentation with strongly crenulated biconvex and rectiradiate growth-lines having a low dorsolateral projection and low ventrolateral projection; external sinus deep. Weak spiral lines mainly caused by crenulation of the growth lines; in the adult stage rather strong spirals in the ventrolateral area. Suture line with V-shaped, moderately wide external lobe (0.80 of the external lobe depth, 1.30 of the adventive lobe), and moderate median saddle (0.50 of the external lobe depth). Ventrolateral saddle broadly rounded, adventive lobe V-shaped with weakly sinuous flanks.

Description. The morphometric plots illustrate limited intraspecific variability (Figs 62F, G). A number of cross sections have been produced, but only three are suitable for a description of conch ontogeny. The best belongs to specimen MB.C.13246 (Fig. 62A), which displays the conch ontogeny between 1.4 and 51 mm dm. The conch shape has a continuous trend toward become slender after a maximum of ww/dm = 0.96 at 4.5 mm conch diameter. In the largest specimen of 76 mm dm, the ratio is at 0.42. After a widely umbilicate juvenile stage (uw/dm = 0.34 at 2.5 mm dm), the conch becomes involute with a very narrow umbilicus throughout ontogeny (uw/dm around 0.10 between 13 and 40 mm dm). Later stages show a slight increase of the ratio.

The partly crushed paratype MB.C.13260.1 (68 mm dm) displays the adult morphology (ww/dm = 0.44;

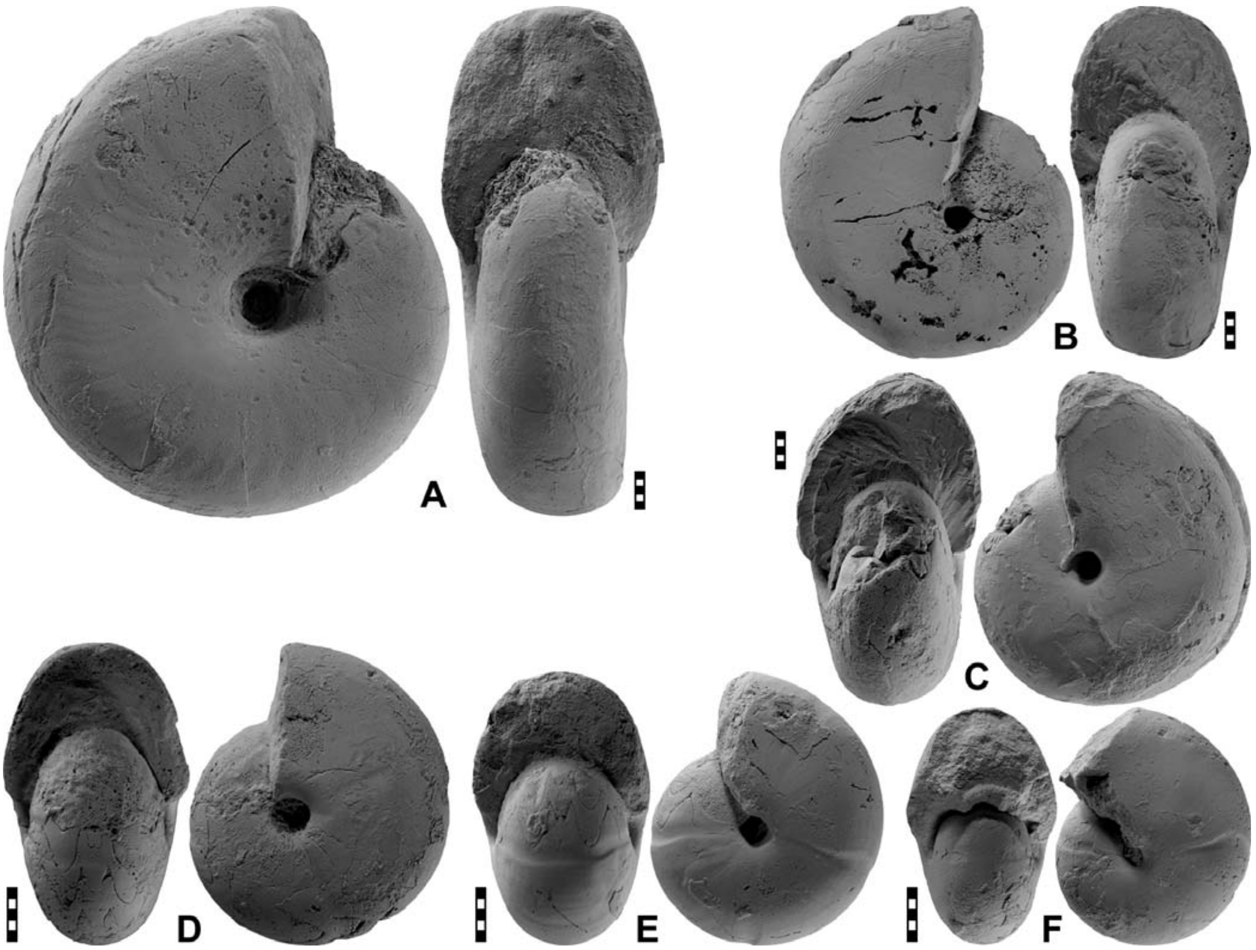


Figure 61. *Sudeticeras horoni* n. sp. **A.** Paratype MB.C.13260.1 from locality Chebket el Hamra-O; ×1.0. **B.** Paratype MB.C.13212.2 from locality Chebket el Hamra-E. **C.** Holotype MB.C.13212.1 from locality Chebket el Hamra-E; ×1.0. **D.** Paratype MB.C.13212.4 from locality Chebket el Hamra-E; ×1.5. **E.** Paratype MB.C.13212.3 from locality Chebket el Hamra-E; ×1.5. **F.** Specimen MB.C.13260.2 from locality Chebket el Hamra-O; ×1.5.

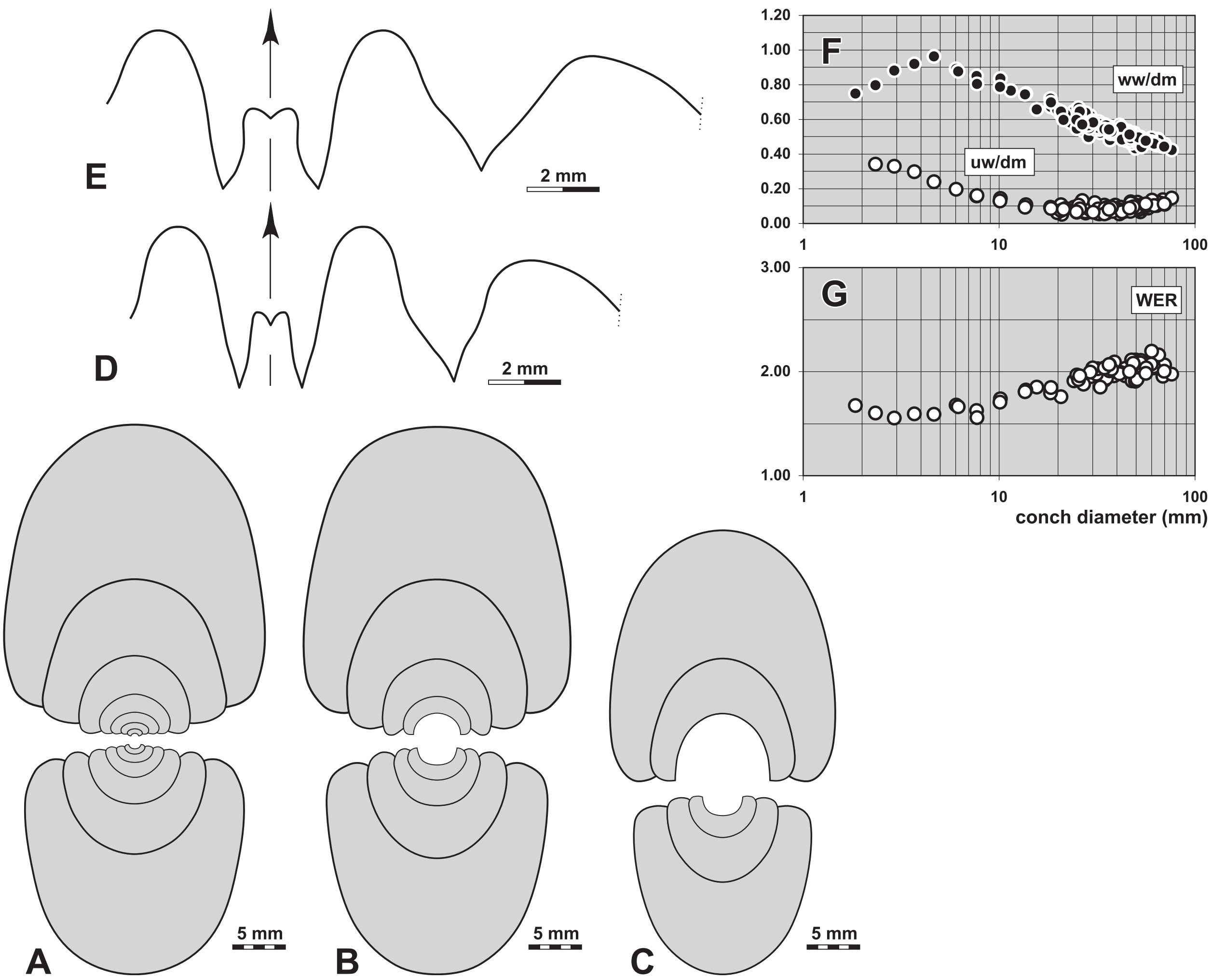


Figure 62. *Sudeticeras horoni* n. sp. **A.** Cross section of paratype MB.C.13246 from locality Chebket el Hamra-J; ×1.5. **B.** Cross section of paratype MB.C.13266.1 from locality Chebket el Hamra-Q; ×1.5. **C.** Cross section of paratype MB.C.13289.1 from Chebket el Hamra; ×1.5. **D.** Suture line of paratype MB.C.13212.3 from locality Chebket el Hamra-E, at 11.1 mm ww, 8.0 mm wh; ×5.0. **E.** Suture line of paratype MB.C.13212.4 from locality Chebket el Hamra-E, at 12.7 mm ww, 8.3 mm wh; ×5.0. **F, G.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm) and whorl expansion rate (WER) of all available specimens.

uw/dm = 0.14; WER = 1.96) in which, after about 54 mm dm, slowly converging flanks stand almost parallel, being separated from the slightly flattened venter by a subangular margin (Fig. 61A). The whorl is widest at the inner third of the flank; the umbilical margin is broadly rounded and allows the flank to continue slowly into the rounded umbilical wall. Almost the entire last whorl of the specimen belongs to the body chamber, which is smooth except for impressions of a rhythmical strengthening of the growth lines particular on the last half volution. This pattern is particularly well-developed on the outer flank.

A similar conch geometry is displayed by paratype MB.C.13212.2 with 47 mm dm (ww/dm = 0.49; uw/dm = 0.09; WER = 1.99). This specimen is remarkable for its shell remains, which show a development from strongly crenulated growth lines, which cause a fine spiral ornament at the beginning of the last volution, towards a rather strong spiral ornamentation half a volution later (Fig. 61B). This consists of sharp, irregularly arranged spirals, which are strongest on the venter and ventrolateral shoulder. These spirals differ in their strength and have the same width as their interspaces.

The smaller, somewhat distorted but otherwise rather well-preserved holotype MB.C.13212.1 (44 mm dm) still displays the stage in which flanks and venter are broadly rounded (Fig. 61C). The flanks are widest near the very narrow umbilicus (uw/dm = 0.09). The specimen displays beautifully preserved shell ornament, which is composed of slightly biconvex, strongly crenulated growth lines with a very low dorsolateral projection, a low ventrolateral projection, and a deep ventral sinus. The strong crenulation causes a delicate spiral ornament particularly in the umbilical area, which in association with the growth lines, forms a spider-web like pattern.

Shell remains are also preserved on the small paratype MB.C.13260.2 (20 mm dm). The growth lines are

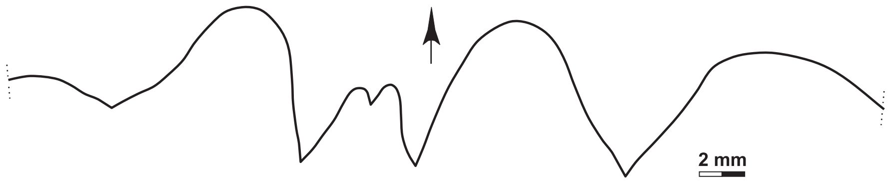


Figure 63. *Sudeticeras horoni* n. sp. Suture line of the pathologic paratype MB.C.13260.3 from locality Chebket el Hamra-O, at 19.4 mm ww, 15.5 mm wh; ×5.0.

delicate in this stage; they are crenulated and form spirals only in a narrow zone around the umbilicus (Fig. 61F). The growth lines run with equally high lateral projections and a low ventral sinus across flanks and venter. A few irregularly arranged shallow constrictions can be seen on the steinkern.

Suture lines can be studied in three specimens. The first of these, MB.C.13260.3, is a pathologic specimen in which the external lobe of the strikingly asymmetric suture line does not have a midventral position (Fig. 63). The adventive lobe is conspicuously deformed on one side, being much lower than in normal suture lines.

The suture line of specimen MB.C.13212.4 (at 12.7 mm ww, corresponding to 20 mm conch diameter) has a broad V-shaped external lobe with moderately strong diverging flanks (Fig. 62E). The median saddle is raised to half the height of the external lobe and subdivides the external lobe into slightly asymmetric prongs. The ventrolateral saddle is also asymmetric and rounded; it is followed by the V-shaped adventive lobe with slightly curved flanks. The suture line of the smaller specimen MB.C.13212.3 is similar but has a narrower external lobe (Fig. 62D).

Discussion. *Sudeticeras horoni* differs from most species of *Sudeticeras* in the strong spiral ornament, particularly on the venter and ventrolateral shoulder. Of these species, *S. ordinatum* has a stouter conch (ww/dm = 0.66 at 38 mm dm, in contrast to 0.50–0.55 in *S. horoni*).

S. splendens possesses a similar ornament but has a wider umbilicus (uw/dm = less than 0.10 between 20 and 60 mm dm in *S. horoni*, but 0.12–0.16 in *S. splendens*) and lacks steinkern constrictions in the larger growth stage. A further criterion to separate the two species is the shape of the umbilical wall, being simply rounded in *S. horoni* but sinuous in cross section in *S. splendens*.

Family **Neoglyphioceratidae** Plummer & Scott, 1937

Neoglyphioceras **Brüning, 1923**

Type species. *Goniatites spiralis* Phillips, 1841.

Discussion. *Neoglyphioceras* is a species-rich genus, of which about 25 species have been described (AMMON database; Korn & Ilg 2007). The genus is almost globally distributed, with the various species having been described from North America (4 species), Northwest and Central Europe (3 species), the South Urals and Central Asia (5 species), Novaya Zemlya (3 species), Iran (1 species), the Far East (2 species), and China (7 species).

The European species of *Neoglyphioceras* can be grouped as follows:

A – species with a slender conch (ww/dm = less than 0.60):

N. spirale (Phillips, 1841): with 55–60 spiral lines;
N. suerlandense Korn, 1988: with 30 spiral lines.

B – species with a stout conch (ww/dm = more than 0.70):

N. orculum Korn, 1988: with 40 spiral lines.

Neoglyphioceras spirale **(Phillips, 1841)**
Figures 64–65

1841 *Goniatites spiralis* Phillips, p. 121, pl. 50, fig. 233.
1937 *Goniatites spiralis*. – Ruprecht, p. 266, pl. 9, figs 8–9.
1955 *Neoglyphioceras spirale*. – Bisat, p. 15, pl. A, figs 1–9.
1958 *Neoglyphioceras spirale*. – Moore & Hodson, p. 101, pl. 8, fig. 5.
1988 *Neoglyphioceras spirale*. – Korn, p. 157, pl. 52, figs 1–7.
1992 *Neoglyphioceras spirale*. – Gischler & Korn, p. 283, textfigs 4J, 5D, 6I.
1997 *Neoglyphioceras spirale*. – Korn, p. 63, pl. 8, figs 5–6.

Neotype. Specimen NHM c1640 (Lee Coll.); figured by Bisat (1955, pl. A, fig. 1).

Type locality and horizon. Bampton (Devonshire, Great Britain); probably P1d Subzone of the British zonation (Late Viséan).

Material. 16 limonitic steinkern specimens at conch diameters ranging between 12.5 to 18 mm from horizon CeH-2 at localities Chebket el Hamra-E, F, I, and T.

Diagnosis. *Neoglyphioceras* with thickly discoidal conch at 12 mm diameter (ww/dm = 0.55–0.60) and discoidal conch at 20 mm diameter (ww/dm = 0.50). Umbilicus narrow in juveniles and very narrow in adults (uw/dm less than 0.10 at 20 mm dm). Ornamentation with 55–60 spiral lines. Strong constrictions of the internal mould. Suture line with V-shaped narrow external lobe having widely diverging flanks; ventrolateral saddle wide, parabolic; adventive lobe V-shaped.

Description. Most of the specimens are fragmentary or otherwise poorly preserved, and hence a complete description of conch and ornament details is not possible. The cross section MB.C.13226.2 does not show the innermost whorls, but permits the study of the growth interval from 3 to 17 mm diameter (Fig. 65A).

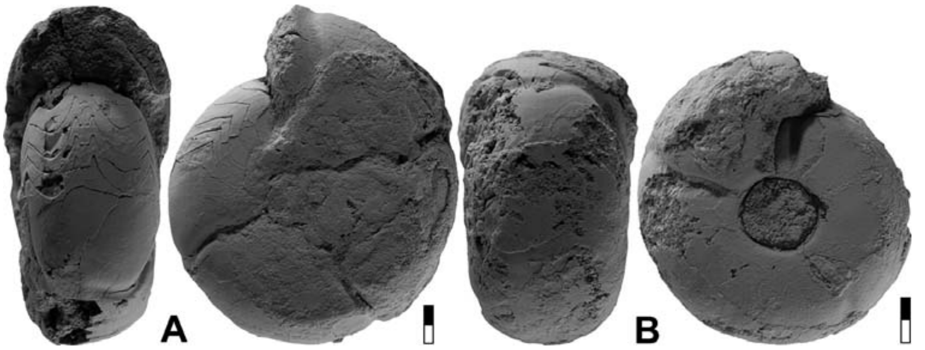


Figure 64. *Neoglyphioceras spirale* (Phillips, 1841). **A.** Specimen MB.C.13242.1 from locality Chebket el Hamra-I; ×2.5. **B.** Specimen MB.C.13226.1 from locality Chebket el Hamra-F; ×3.0.

A second not figured cross section differs in some conch parameters, with specimen MB.C.13226.2 being the wider umbilicate form (uw/dm = 0.19 at 16 mm dm) with lower aperture (WER = 1.47 at 16 mm dm).

The larger of the two figured specimens (MB.C.13242.1, 18 mm dm; Fig. 64A) is partly covered by limonite matrix that obscures the umbilicus; it is a discoidal conch (ww/dm = 0.50) with a low aperture (WER = 1.65). It has four deep constrictions on the last volution, arranged in distances slightly below 90°, and running with low dorsolateral and higher ventrolateral projection as well as a shallow ventral sinus across flanks and venter. It is estimated that 55–60 spiral lines, which are impressed on the internal mould, exist on the flanks and venter.

The smaller and better preserved specimen MB.C.13226.1 (Fig. 64B) has 12.5 mm diameter and is thickly discoidal (ww/dm = 0.58) with a narrow umbilicus (uw/dm = 0.27). It possesses three irregularly distributed constrictions on the steinkern, having a concave course on the flanks, turning forward to create a distinct ventrolateral projection, and form a shallow ventral sinus. In this specimen, spiral lines are barely visible on the internal mould; therefore their number cannot be estimated.

The suture line of specimen MB.C.13242.1 (7 mm whorl width) is remarkable because of its low amplitude, expressed in very low and wide lobes and saddles (Fig. 65B). The external lobe and the adventive lobe are almost equally wide, separated by a much wider parabolic and almost symmetric ventrolateral saddle.

Discussion. It is easy to separate *N. spirale* from the other species of *Neoglyphioceras* by its suture line with low amplitude and its very wide ventrolateral saddle. Only *N. suerlandense* Korn, 1988, is similar in this respect but this species has much fewer spiral lines (about 30) than *N. spirale* (about 55–60).

Lusitanites Ruzhencev & Bogoslovskaya, 1971

Type species. Goniatites subcircularis Miller, 1889.

Discussion. Six species of *Lusitanites* have been described (AMMON database; Korn & Ilg 2007). The genus is widely distributed from the western United States across North Africa, Iberia, Northwest and Central Europe to the South Urals and Central Asia.

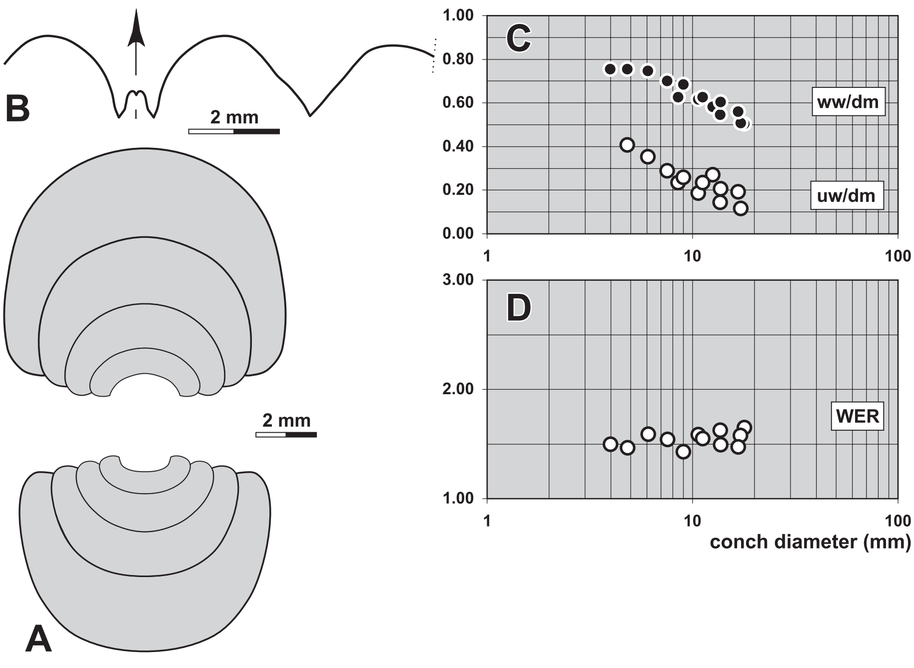


Figure 65. *Neoglyphioceras spirale* (Phillips, 1841). **A.** Cross section of specimen MB.C.13226.2 from locality Chebket el Hamra-I; ×2.5. **B.** Suture line of specimen MB.C.13242.1 from locality Chebket el Hamra-I, at 7.1 mm ww, 5.2 mm wh; ×5.0. **C, D.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm) and whorl expansion rate (WER) of all available specimens.

The species of *Lusitanites* can be grouped as follows:

A – species with a moderate umbilicus (uw/dm = more than 0.12):

L. subcircularis (Miller, 1889): with 30 spiral lines and numerous constrictions across flanks and venter;

L. clitheroensis Korn, 1988: with 35 spiral lines and a few constrictions across flanks and venter.

B – species with a very narrow umbilicus (uw/dm = less than 0.12):

L. concavus Ruzhencev & Bogoslovskaya, 1971: with 35 spiral lines and a few very short constrictions;

L. multicavus Ruzhencev & Bogoslovskaya, 1971: with 40 spiral lines and numerous short constrictions;

L. zousfanensis (Dollé, 1912): with 40 spiral lines and a few short constrictions;

L. circularis Korn, 1988: with 50 spiral lines and numerous constrictions across flanks and venter.

Lusitanites circularis Korn, 1988
Figures 66–67

1925 *Glyphioceras subcircularis subcircularis*. – Schmidt, p. 573, pl. 21, fig. 12, pl. 24, figs 1, 2.
1933 *Glyphioceras subcircularis subcircularis*. – Kobold, p. 500, pl. 22, figs 18–21.
1937 *Goniatites subcircularis subcircularis*. – Ruprecht, p. 263, pl. 9, figs 1, 2.
1988 *Lusitanites circularis* Korn, p. 162, pl. 56, figs 1–10, pl. 57, figs 1–6.

Holotype. Specimen GÖT480-70 (H. Schmidt Coll.); figured by Schmidt (1925, pl. 24, fig. 1) and Korn (1988, pl. 56, figs 1–3).

Type locality and horizon. Oelinghausen (Rhenish Mountains, Germany); probably *Lusitanoceras poststriatum* Zone (Late Viséan).

Material. Seven limonitic or phosphatic steinkern specimens ranging from 17 to 18 mm in conch diameter, from horizon CeH-5 at localities Chebket el Hamra-D, K, and P.

Diagnosis. *Lusitanites* with thickly discoidal conch at 10 mm diameter (ww/dm = 0.50–0.55) and discoidal to thinly pachyconic conch at 20 mm diameter (ww/dm = 0.40–0.45). Umbilicus very narrow in all stages larger than 10 mm dm (uw/dm = 0.08–0.15). Ornamentation of approximately 50 spiral lines. Three to five strong constrictions on the internal mould, extending in a markedly sinuous manner with flattened ventral projection. Suture line with V-shaped narrow external lobe and widely diverging flanks; ventrolateral saddle wide, parabolic; adventive lobe V-shaped.

Description. The largest of the available specimens MB.C.13262.1 (21 mm dm) has a crushed body chamber, but the phragmocone is rather well preserved (Fig. 66A). It shows five irregularly arranged strongly curved steinkern constrictions and 55–60 fine spiral lines, which are visible as traces on the steinkern.

Specimen MB.C.13208.1 is better preserved (Fig. 66B), being an almost fully septate individual of 17.5 mm dm. It is discoidal (ww/dm = 0.43) with a very narrow umbilicus (uw/dm = 0.14). The steinkern has four constrictions, arranged in distances of a little more than 90°. They are deepest on the outer flank where they form a shallow lateral sinus, and almost disappear at the transitions to the venter where they turn forward to form a rather narrow ventral projection. About 55 spiral lines, preserved as traces on the steinkern, can be counted from umbilicus to umbilicus. They are best visible in the ventrolateral area and on the venter.

Suture lines of the three better preserved specimens show, in the same growth stage, conspicuous variation (Fig. 67). The suture line of the largest specimen MB.C.13262.1 (7.2 mm ww) is remarkable because of its wide external lobe with strongly diverging, slightly sinuous flanks (Fig. 67C). The median saddle reaches slightly more than 0.30 of the E lobe depth; it produces two small asymmetric prongs with a hook-like base. On the ventrolateral shoulder a wide and parabolic ventrolateral saddle follows that continues into the rather small, V-shaped adventive lobe. This suture line is the last one of a series of six rather closely spaced septa, in which the external lobe widens markedly; most probably it represents an adult modification.

The suture lines of the two specimens MB.C.13262.2 and MB.C.13208.1 (both drawn at 16.5 mm dm) differ from the above, but resemble each other to some degree (Figs 67A–B). The external lobe is rather narrow and V-shaped in both, the ventrolateral saddle is parabolic, and the adventive lobe is small and V-shaped. Differences can be seen in the median saddle, which is much higher in specimen MB.C.13262.2.

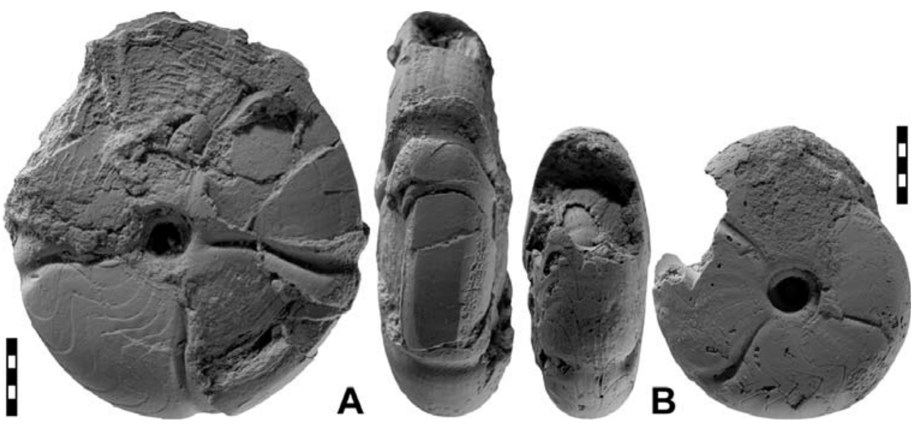


Figure 66. *Lusitanites circularis* Korn, 1988. **A.** Specimen MB.C.13262.1 from locality Chebket el Hamra-P; ×2.0. **B.** Specimen MB.C.13208.1 from locality Chebket el Hamra-D; ×2.0.

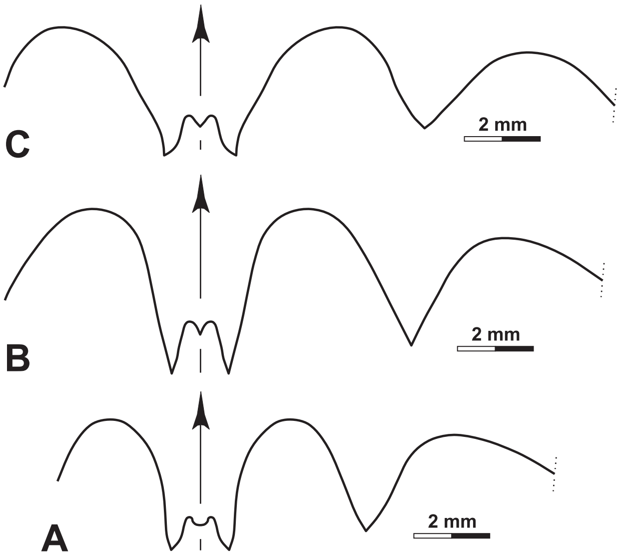


Figure 67. *Lusitanites circularis* Korn, 1988 **A.** Suture line of specimen MB.C.13208.1 from locality Chebket el Hamra-D, at 16.5 mm dm, 7.7 mm ww, 7.7 mm wh; ×5.0. **B.** Suture line of specimen MB.C.13262.2 from locality Chebket el Hamra-P, at 16.8 mm dm, 8.0 mm ww, 7.8 mm wh; ×5.0. **C.** Suture line of specimen MB.C.13262.1 from locality Chebket el Hamra-P, at 7.2 mm ww, 9.4 mm wh; ×5.0.

Discussion. The material from Chebket el Hamra is not particularly well-preserved, but can be attributed to the Rhenish species because of its very narrow umbilicus (wider than in *L. clitheroensis*) and high number of spiral lines (55–60 in contrast to 35 in *L. clitheroensis*). This high number of spiral lines allows rather clear separation from the other species of *Lusitanites*.

Family **Ferganoceratidae** Ruzhencev, 1960

***Ferganoceras* Librovitch, 1957**

Type species. Ferganoceras elegans Librovitch, 1957.

Discussion. *Ferganoceras* is a genus that is known from localities in Central Asia, the South Urals (Ruzhencev & Bogoslovskaya 1971), North Africa (Pareyn 1961; Klug et al. 2006), southern France (Delépine 1935; Korn & Feist 2007) and Arkansas (Malinky & Mapes 1982). The genus was so far not known from any North Variscan occurrences.

***Ferganoceras* sp.**
Figure 68

Material. One whorl fragment from horizon CeH-5 of locality Chebket el Hamra-P.

Description. The only known specimen MB.C.13263 of this species is a whorl fragment of an individual having a conch diameter of 20 mm (Fig. 68). It is poorly preserved but shows all characters typical for the genus *Ferganoceras*, i.e. the slightly flattened venter that is bordered by a narrow but rather deep ventrolateral furrow. The flanks are also flattened and stand almost parallel. The whorl fragment possesses a deep constriction following a biconvex course; it shows a rather wide dorsolateral projection, a shallow lateral projection on the outer flank, a high ventrolateral projection at the ventrolateral furrow, and a semicircular ventral sinus. A weak indication of fine spiral lines is visible on the flanks.

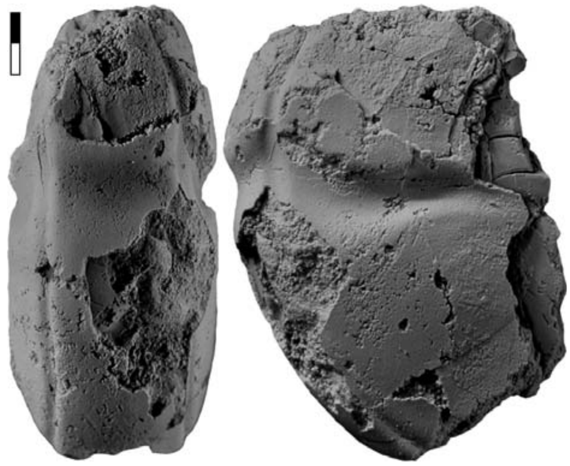


Figure 68. *Ferganoceras* sp., specimen MB.C.13263 from locality Chebket el Hamra-P; ×4.0.

Order **Prolecanitida** Hyatt, 1884
Suborder **Prolecanitina** Hyatt, 1884
Superfamily **Prolecanitoidea** Hyatt, 1884
Family **Daraelitidae** Tchernow, 1907

***Praedaraelites* Schindewolf, 1934**

Type species. Daraelites culmiensis Kobold, 1933.

Discussion. Twenty-one species of *Praedaraelites* have been described thus far (AMMON database; Korn & Ilg 2007), and fourteen of these alone from occurrences in China. Most of the species are not well characterised and some of these may be treated synonyms. The genus is widely distributed, but very rare in the western United States. It is restricted to distinct stratigraphic horizons in North Africa, Iberia, Northwest and Central Europe and more common in the South Urals and North China. Only one species is known from Central and North-western Europe.

***Praedaraelites culmiensis* (Kobold, 1933)**
Figures 69–70

1933 *Daraelites culmiensis* Kobold, p. 506, pl. 23, figs 45–48.
1952 *Epicanites bowlandensis* Moore, p. 73, pl. 7, fig. 3, textfig. 4.
1988 *Praedaraelites culmiensis*. – Korn, p. 33, pl. 1, figs 1–4.
1997 *Praedaraelites culmiensis*. – Korn, p. 36, pl. 1, fig. 11, textfig. 21.

Lectotype. The specimen figured by Kobold (1933, pl. 23, fig. 6).

Type locality and horizon. Steigertal near Lautenthal (Harz); 'IIIγ1' of Kobold (1933) = *Neoglyphioceras spirale* Zone (Late Viséan).

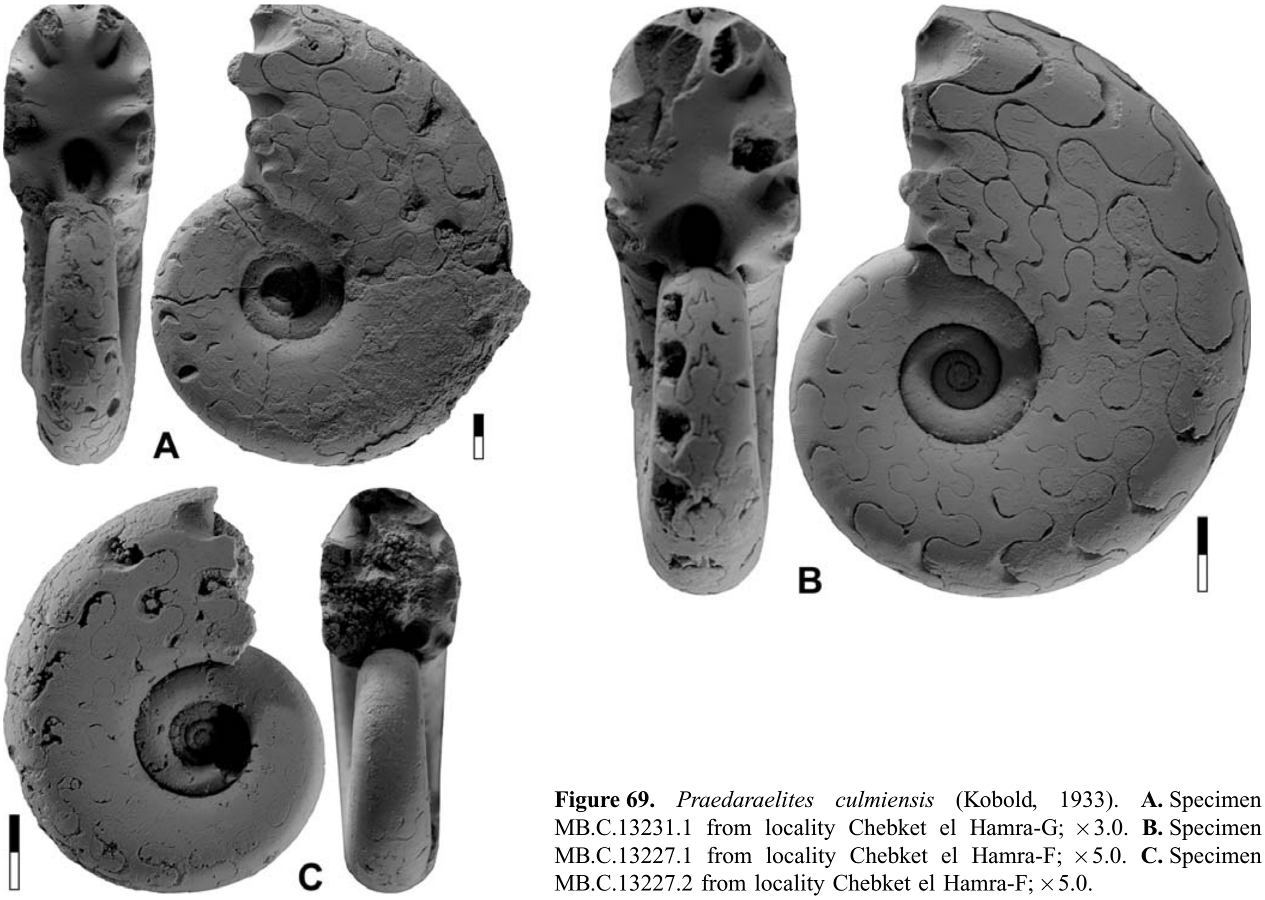


Figure 69. *Praedaraelites culmiensis* (Kobold, 1933). **A.** Specimen MB.C.13231.1 from locality Chebket el Hamra-G; ×3.0. **B.** Specimen MB.C.13227.1 from locality Chebket el Hamra-F; ×5.0. **C.** Specimen MB.C.13227.2 from locality Chebket el Hamra-F; ×5.0.

Material. 38 limonitic steinkern specimens ranging from 10 to 22 mm in conch diameter from horizon CeH-2 at localities Chebket el Hamra-E, F, G, I, and an unspecified locality.

Diagnosis. *Praedaraelites* with thinly discoidal conch (ww/dm 0.30–0.35) in all growth stages; umbilicus moderately wide in juveniles and later becoming narrow (uw/dm 0.35 at 10 mm dm, 0.25–0.30 at 20 mm dm). Whorl cross section compressed, flanks and venter rounded. Shell almost smooth with very fine growth lines. Suture line with strongly pouched external lobe, asymmetric and serrated adventive lobe, barely serrated first lateral lobe, and tongue-shaped second lateral lobe.

Description. The material exhibits only minor intraspecific variability and only little ontogenetic change. The trait that best shows the visible ontogenetic modification is the apertural height, which, in the sectioned specimen MB.C.13227.3 causes the whorl to expand from 2.25 up to 4 mm diameter, but thereafter increases to 2.70 at 21 mm dm (Fig. 70G). The whorl width/conch diameter ratio is stable around 0.40 up to 8 mm dm and then is reduced to 0.33. The cross section of the slightly embracing whorls is almost circular up to 8 mm conch diameter and becomes then laterally compressed (Fig. 70A).

The largest specimens MB.C.13295 and MB.C.13231.1 (Fig. 69A) exceed 20 mm in diameter and are thinly discoidal (ww/dm = 0.30) with a narrow umbilicus (uw/dm = 0.27). These specimens show slightly flattened flanks, which are clearly bordered against the rounded venter and the flat, oblique umbilical wall. Smaller specimens such as MB.C.13227.1 (15 mm dm) and MB.C.13227.2 (10 mm dm) are similar in general morphology but show more regularly rounded flanks (Figs 69B, C).

The suture lines of different specimens exhibit some variability, particularly compared to the degree of serration of the adventive lobe (Figs 70B–D). The external lobe has the same shape in the three specimens MB.C.13243.1, MB.C.13227.4, and MB.C.13295 (all three with 18–19 mm conch diameter) and is strongly pouched in the lower two thirds. An inflated saddle and then the asymmetric adventive lobe follow on the ventrolateral shoulder. This is serrated with only two little notches (specimen MB.C.13243.1), three notches (specimen MB.C.13227.4), or more conspicuously serrated with several denticles of different size (specimen MB.C.13295). Two further, rounded lobes are located on the flank. The first shows an incipient beginning of serration. A small lobe occupies the umbilical margin.

Discussion. *Praedaraelites culmiensis* is a widely distributed species in the northern Variscides; it is known from the Harz and Rhenish Mountains of Germany, North England, Ireland, and South-western Portugal. All occurrences are obviously time equivalents, making the species a valuable index for the Late Viséan sediments.

Clear separation from other species of the genus is problematic because of the poor descriptions of many

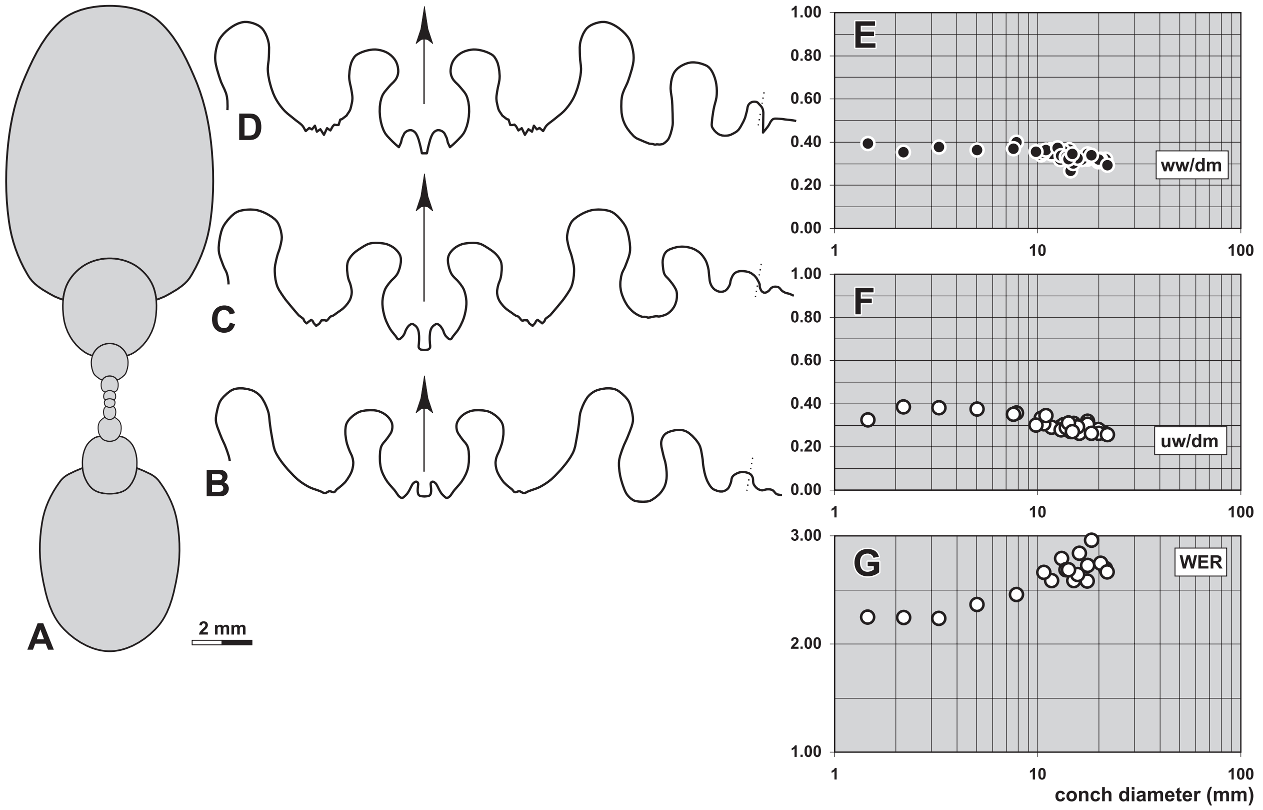


Figure 70. *Praedaraelites culmiensis* (Kobold, 1933). **A.** Cross section of specimen MB.C.13227.3 from locality Chebket el Hamra-F; ×4.0. **B.** Suture line of specimen MB.C.13243.1 from locality Chebket el Hamra-I, at 5.4 mm ww, 7.5 mm wh; ×5.0. **C.** Suture line of specimen MB.C.13227.4 from locality Chebket el Hamra-F, 6.2 mm ww, 9.0 mm wh; ×5.0. **D.** Suture line of specimen MB.C.13295 from locality Chebket el Hamra-X, at 19.0 mm dm, 6.4 mm ww, 9.1 mm wh; ×5.0. **E–G.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm) and whorl expansion rate (WER) of all available specimens.

specimens. Serration of the lobes is less well developed than in the well-known latest Viséan to earliest Serpukhovian species *P. aktubensis* Ruzhencev, 1949.

Superfamily Medlicottioidea Karpinsky, 1889
Family **Pronoritidae** Frech, 1901

Pronorites Mojsisovics, 1882

Type species. Goniatites cyclolobus Phillips, 1836.

Discussion. Eight species of *Pronorites* are listed in the AMMON database (Korn & Ilg 2007). The genus has a distribution from the western United States across North Africa, Iberia, Northwest and Central Europe to the South Urals. Some of the species were first described in Europe; they can be grouped as follows:

A – species with a moderate umbilicus:

- *P. cyclolobus* (Phillips, 1836): with the conch ratios ww/dm = 0.30, uw/dm = 0.30 at 32 mm dm and a strongly pouched first lateral lobe;
- *P. molaris* Korn, 1988: with the conch ratios ww/dm = 0.32, uw/dm = 0.25 at 35 mm dm and a lanceolate first lateral lobe;
- *P. meridionalis* Korn, 1997: with the conch ratios ww/dm = 0.26, uw/dm = 0.28 at 40 mm dm and a weakly pouched first lateral lobe.

B – species with a narrow umbilicus:

- *P. ludfordi* Bisat, 1955: with a narrow umbilicus (uw/dm appr. 0.20 at 25 mm dm) and a strongly pouched first lateral lobe and pouched and narrow additional lateral lobes;
- *P. owodenkoi* n. sp.: with the conch ratios ww/dm = 0.35, uw/dm = 0.20 at 30–40 mm dm and a weakly pouched first lateral lobe and lanceolate additional lateral lobes.

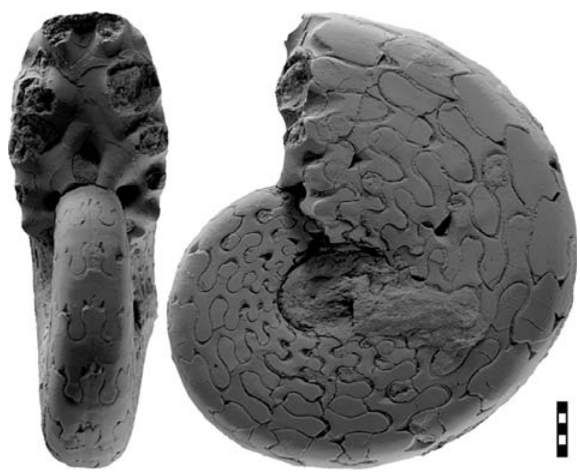


Figure 71. *Pronorites owodenkoi* n. sp., holotype MB.C.13287.1 from Chebket el Hamra; ×1.5.

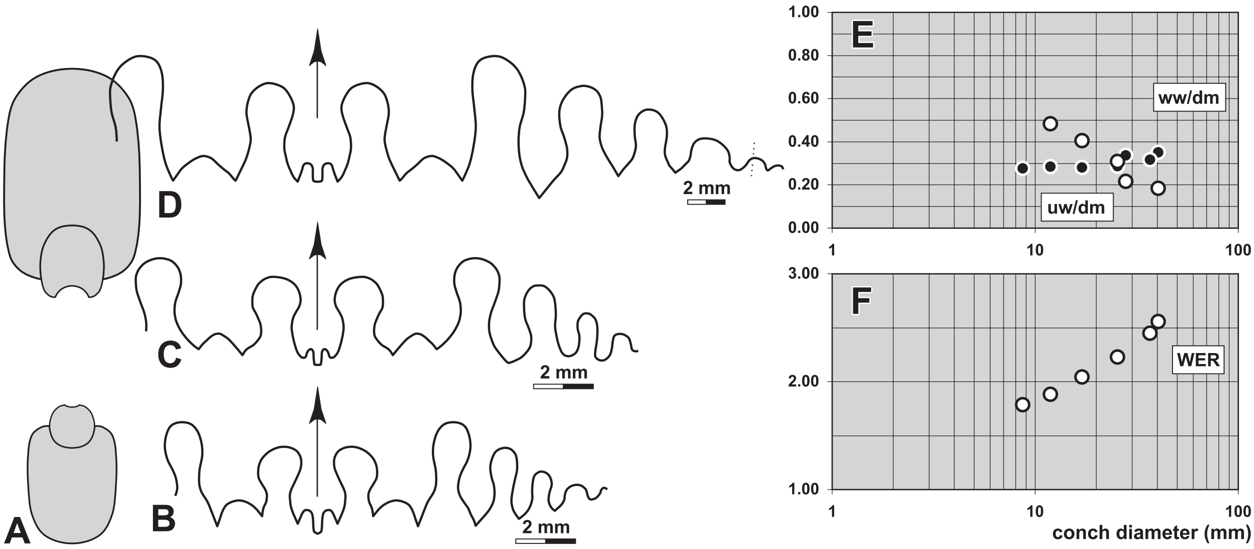


Figure 72. *Pronorites owodenkoi* n. sp. **A.** Cross section of paratype MB.C.13244.1 from locality Chebket el Hamra-I; ×2.5. **B.** Suture line of paratype MB.C.13282.1 from locality Chebket el Hamra-T, at 5.4 mm ww, 7.7 mm wh; ×4.0. **C.** Suture line of holotype MB.C.13287.1 from Chebket el Hamra, at 7.3 mm ww, 9.2 mm wh; ×4.0. **D.** Suture line of holotype MB.C.13287.1 from Chebket el Hamra, at 40.3 mm dm, 13.1 mm ww, 20.5 mm wh; × 2.5. **E, F.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm) and whorl expansion rate (WER) of all available specimens.

***Pronorites owodenkoi* n. sp.**
Figures 71–72

Derivation of name. After Boris Owodenko, the pioneer mapping geologist in the Jerada Basin.

Holotype. Specimen MB.C.13287.1 (Korn & Ebbighausen 2006 Coll.); illustrated in Figure 71.

Type locality and horizon. Chebket el Hamra (Jerada Basin, NE-Morocco); horizon CeH-2, *Arnsbergites gracilis* Zone or *Neoglyphioceras spirale* Zone (late Brigantian, Early Carboniferous).

Material. 15 limonitic steinkern specimens of 20 to 41 mm in conch diameter, from horizon CeH-2 at localities Chebket el Hamra-I, T, and an unspecified locality.

Diagnosis. *Pronorites* with thinly discoidal conch (ww/dm 0.28–0.35) in all growth stages; umbilicus wide in juveniles (ww/dm = 0.48 at 10 mm dm) and later moderately narrow (uw/dm 0.20 at 30–40 mm dm). Whorl cross section compressed, flanks flattened and venter rounded. Shell almost smooth with very fine growth lines. Suture line with strongly pouched external lobe, a weakly pouched first lateral lobe and lanceolate additional lateral lobes.

Description. The morphometric data show the ontogenetic changes typical for a *Pronorites* species (Figs 72E, F). While the whorl width ratio is almost constant at 0.30 between 10 and 40 mm conch diameter, the umbilical width ratio decreases from 0.50 to 0.20 during this growth interval. At the same time, the apertural height increases rapidly, being visible in the whorl expansion rate of 1.80 at 10 mm dm and 2.50 at 40 mm dm.

Cross section MB.C.13244.1 shows only two preserved whorls but allows insight into the ontogenetic changes between 8 and 25 mm dm (Fig. 72A). The whorl cross section is almost circular at 8.6 mm dm, but half a whorl later, at 11.9 mm dm, the flanks become somewhat compressed. The last preserved whorl shows flattened parallel flanks and a rounded venter.

Holotype MB.C.13287.1 is the largest individual at a conch diameter of 40 mm and is fully chambered (Fig. 71). It is somewhat distorted tectonically but otherwise well preserved. The end of the last whorl shows a modification of the arrangement of the flattened parallel flanks, which become subparallel and converging because of a rather rapid widening of the whorl in the umbilical area. The umbilical wall is oblique at this stage.

The suture line of the holotype MB.C.13287.1 shows, at a conch diameter of 40 mm, a strongly pouched external lobe, a weakly pouched adventive lobe and five lateral lobes. The outer three are on the flanks, the fourth on the umbilical margin, and the fifth on the umbilical wall. The first lateral lobe is narrow and pouched, the second and third are lanceolate (Fig. 72D).

Suture lines in smaller stages, such as those on the same specimen at 7.3 mm ww and paratype MB.C.13282.1 at 5.4 mm ww are generally similar but show some variability in the shapes of lobes and saddles (Figs 72B, C).

Discussion. *Pronorites owodenkoi* differs from the two British species *P. cyclolobus* and *P. ludfordi* in having lesser pouched lateral lobes, from the South Portuguese *P. meridionalis* in the narrower umbilicus, and from the Rhenish *P. molaris* in the stronger pouched first lateral lobe.

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Appendix

A. List of sampled localities at the Chebket el Hamra with their ammonoid material.

Locality CeH-A (Korn & Ebbighausen 2006 coll.), limonitic material (horizon CeH-3):

Metadimorphoceras hodsoni Moore, 1958	3	specimens (MB.C.13201.1–3)
Sudeticeras murracaoense Korn, 1997	60	specimens (MB.C.13202.1–60)

Locality CeH-B (Korn & Ebbighausen 2006 coll.), limonitic material (horizon CeH-3):

Sudeticeras murracaoense Korn, 1997	37	specimens (MB.C.13203.1–37)

Locality CeH-C (Korn & Ebbighausen 2006 coll.), limonitic material (horizon CeH-3):

Metadimorphoceras hodsoni Moore, 1958	1	specimen (MB.C.13204)
Sudeticeras murracaoense Korn, 1997	30	specimens (MB.C.13205.1–30)

Locality CeH-D (Korn & Ebbighausen 2006 coll.), limonitic material and phosphatic nodules (horizon CeH-5):

Lusitanoceras zirari n. sp.	9	specimens (MB.C.13206.1–9)
Sudeticeras splendens (Bisat, 1928)	1	specimen (MB.C.13207)
Lusitanites circularis Korn, 1988	2	specimens (MB.C.13208.1–2)

Locality CeH-E (Korn & Ebbighausen 2006 coll.), limonitic material (horizon CeH-2):

Hibernicoceras carraunense Moore & Hodson, 1958	2	specimens (MB.C.13209.1–2)
Neoglyphioceras spirale (Phillips, 1841)	1	specimen (MB.C.13210)
Praedaraelites culmiensis (Kobold, 1933)	2	specimens (MB.C.13211.1–2)

Same locality, drifted sideritic nodules (horizon CeH-4):

Sudeticeras horoni n. sp.	22	specimens (MB.C.13212.1–22)

Locality CeH-F (Korn & Ebbighausen 2006 coll.), limonitic material (horizon CeH-2):

Girtyoceras luscinia Korn, 1988	4	specimens (MB.C.13213.1–4)
Girtyoceras ibnkhaldouni n. sp.	7	specimens (MB.C.13214.1–7)
Sulcogirtyoceras sp.	3	specimens (MB.C.13215.1–3)
Metadimorphoceras anguinosum n. sp.	21	specimens (MB.C.13216.1–21)
Arnsbergites sphaericostriatus (Bisat, 1924)	1	specimen (MB.C.13217)
Arnsbergites ferrus n. sp.	22	specimens (MB.C.13218.1–22)
Arnsbergites proiecturus n. sp.	5	specimens (MB.C.13219.1–5)
Hibernicoceras carraunense Moore & Hodson, 1958	1	specimen (MB.C.13220)
Hibernicoceras touissitense n. sp.	1	specimen (MB.C.13221)
Hibernicoceras artilobatum n. sp.	1	specimen (MB.C.13222)
Paraglyphioceras rudis (Moore & Hodson, 1958)	4	specimens (MB.C.13223.1–4)
Paraglyphioceras celeris n. sp.	4	specimens (MB.C.13224.1–4)
Sudeticeras ibnbajjahi n. sp.	16	specimens (MB.C.13225.1–16)
Neoglyphioceras spirale (Phillips, 1841)	8	specimens (MB.C.13226.1–8)
Praedaraelites culmiensis (Kobold, 1933)	21	specimens (MB.C.13227.1–21)

Locality CeH-G (Korn & Ebbighausen 2006 coll.), limonitic material (horizon CeH-2):

Girtyoceras luscinia Korn, 1988	1	specimen (MB.C.13228)
Girtyoceras ibnkhaldouni n. sp.	2	specimens (MB.C.13229.1–2)
Girtyoceras sp.	1	specimen (MB.C.13230)
Praedaraelites culmiensis (Kobold, 1933)	9	specimens (MB.C.13231.1–9)

Locality CeH-H (Korn & Ebbighausen 2006 coll.), from sideritic nodules (horizon CeH-1):

Goniatites crenistria Phillips, 1836	3	specimens (MB.C.13232.1–3)

Locality CeH-I (Korn & Ebbighausen 2006 coll.), limonitic material (horizon CeH-2):

Metadimorphoceras anguinosum n. sp.	2	specimens (MB.C.13233.1–2)
Arnsbergites sphaericostriatus (Bisat, 1924)	1	specimen (MB.C.13234)
Arnsbergites ferrus n. sp.	6	specimens (MB.C.13235.1–6)
Hibernicoceras carraunense Moore & Hodson, 1958	12	specimens (MB.C.13236.1–12)
Hibernicoceras touissitense n. sp.	39	specimens (MB.C.13237.1–39)
Hibernicoceras artilobatum n. sp.	3	specimens (MB.C.13238.1–3)
Paraglyphioceras rudis (Moore & Hodson, 1958)	13	specimens (MB.C.13239.1–13)
Paraglyphioceras celeris n. sp.	4	specimens (MB.C.13240.1–4)
Sudeticeras ibnbajjahi n. sp.	4	specimens (MB.C.13241.1–4)

Neoglyphioceras spirale (Phillips, 1841) 6 specimens (MB.C.13242.1–6)
Praedaraelites culmiensis (Kobold, 1933) 5 specimens (MB.C.13243.1–5)
Pronorites owodenkoi n. sp. 5 specimens (MB.C.13244.1–5)

Locality CeH-J (Korn & Ebbighausen 2006 coll.), exposed in small gully (Liassic):
Dactylioceras sp. 2 specimens (MB.C.13245.1–2)
Same locality, drifted sideritic nodules (horizon CeH-4):
Sudeticeras horoni n. sp. 1 specimen (MB.C.13246)

Locality CeH-K (Korn & Ebbighausen 2006 coll.), limonitic material and phosphatic nodules (horizon CeH-5):
Lusitanoceras zirari n. sp. 16 specimens (MB.C.13247.1–16)
Sudeticeras splendens (Bisat, 1928) 2 specimens (MB.C.13248.1–2)
Lusitanites circularis Korn, 1988 2 specimens (MB.C.13249.1–2)

Locality CeH-L (Korn & Ebbighausen 2006 coll.), limonitic material and phosphatic nodules (horizon CeH-5):
Lusitanoceras zirari n. sp. 3 specimens (MB.C.13250.1–3)
Same locality (horizon CeH-6)
Sudeticeras splendens (Bisat, 1928) 4 specimens (MB.C.13251.1–4)

Locality CeH-M (Korn & Ebbighausen 2006 coll.), limonitic material and phosphatic nodules (horizon CeH-6):
Sudeticeras splendens (Bisat, 1928) 3 specimens (MB.C.13252.1–3)
Sudeticeras sp. 1 specimen (MB.C.13253)

Locality CeH-N (Korn & Ebbighausen 2006 coll.), from sideritic nodules (horizon CeH-1):
Goniatites crenistria Phillips, 1836 30 specimens (MB.C.13254.1–30)
Goniatites globostriatus (Schmidt, 1925) 3 specimens (MB.C.13255.1–3)
Same locality (Ebbighausen & Weyer 2007 coll.)
Goniatites crenistria Phillips, 1836 43 specimens (MB.C.13256.1–43)

Locality CeH-O (Ebbighausen & Weyer 2007 coll.), limonitic material and phosphatic nodules (horizon CeH-5):
Lusitanoceras zirari n. sp. 6 specimens (MB.C.13257.1–6)
Same locality, sideritic nodules (horizon CeH-6)
Sudeticeras splendens (Bisat, 1928) 4 specimens (MB.C.13258.1–4)
Sudeticeras sp. 3 specimens (MB.C.13259.1–3)
Same locality, drifted sideritic nodules (horizon CeH-4)
Sudeticeras horoni n. sp. 99 specimens (MB.C.13260.1–99)

Locality CeH-P (Ebbighausen & Weyer 2007 coll.), limonitic material and phosphatic nodules (horizon CeH-5):
Lusitanoceras zirari n. sp. 21 specimens (MB.C.13261.1–21)
Lusitanites circularis Korn, 1988 3 specimens (MB.C.13262.1–3)
Ferganoceras sp. 1 specimen (MB.C.13263)
Same locality, sideritic nodules (horizon CeH-6)
Sudeticeras splendens (Bisat, 1928) 31 specimens (MB.C.13264.1–31)
Same locality, drifted sideritic nodules (horizon CeH-4)
Sudeticeras horoni n. sp. 8 specimens (MB.C.13265.1–8)

Locality CeH-Q (Ebbighausen & Weyer 2007 coll.), sideritic nodules (horizon CeH-4):
Sudeticeras horoni n. sp. 22 specimens (MB.C.13266.1–22)

Locality CeH-R (Ebbighausen & Weyer 2007 coll.), drifted sideritic nodules (horizon CeH-4):
Sudeticeras horoni n. sp. 5 specimens (MB.C.13267.1–5)

Same locality (horizon CeH-6)
Sudeticeras splendens (Bisat, 1928) 1 specimen (MB.C.13268)

Locality CeH-S (Ebbighausen & Weyer 2007 coll.), limonitic material (horizon CeH-3):
Eoglyphioceras minutum n. sp. 3 specimens (MB.C.13269.1–3)
Metadimorphoceras hodsoni Moore, 1958 11 specimens (MB.C.13270.1–11)
Sudeticeras murracaoense Korn, 1997 255 specimens (MB.C.13271.1–255)

Locality CeH-T (Ebbighausen & Weyer 2007 coll.), limonitic material (horizon CeH-2):
Metadimorphoceras anguinosum n. sp. 3 specimens (MB.C.13272.1–3)
Arnsbergites sphaericostriatus (Bisat, 1924) 16 specimens (MB.C.13273.1–16)
Arnsbergites ferrus n. sp. 6 specimens (MB.C.13274.1–6)
Hibernicoceras carraunense Moore & Hodson, 1958 23 specimens (MB.C.13275.1–23)

Hibernicoceras touissitense n. sp.	24	specimens (MB.C.13276.1–24)
Hibernicoceras artilobatum n. sp.	7	specimens (MB.C.13277.1–7)
Paraglyphioceras rudis (Moore & Hodson, 1958)	81	specimens (MB.C.13278.1–81)
Paraglyphioceras celeris n. sp.	10	specimens (MB.C.13279.1–10)
Sudeticeras ibnbajjahi n. sp.	15	specimens (MB.C.13280.1–15)
Neoglyphioceras spirale (Phillips, 1841)	1	specimen (MB.C.13281)
Pronorites owodenkoi n. sp.	8	specimens (MB.C.13282.1–8)

Locality not specified (Korn & Ebbighausen 2006 purchased), limonitic material and sideritic nodules (horizon CeH-2):

Arnsbergites sphaericostriatus (Bisat, 1924)	1	specimen (MB.C.13283)
Arnsbergites ferrus n. sp.	2	specimens (MB.C.13284.1–2)
Arnsbergites rufus n. sp.	7	specimens (MB.C.13285.1–7)
Hibernicoceras artilobatum n. sp.	1	specimen (MB.C.13286)
Pronorites owodenkoi n. sp.	2	specimens (MB.C.13287.1–2)
Same locality (horizon CeH-5)		
Lusitanoceras zirari n. sp.	1	specimen (MB.C.13288)
Same locality (horizon CeH-4)		
Sudeticeras horoni n. sp.	4	specimens (MB.C.13289.1–4)

Locality not specified (Ebbighausen & Weyer 2007 purchased), limonitic material and sideritic nodules (horizon CeH-2):

Arnsbergites sphaericostriatus (Bisat, 1924)	3	specimens (MB.C.13290.1–3)
Arnsbergites ferrus n. sp.	2	specimens (MB.C.13291.1–2)
Hibernicoceras touissitense n. sp.	3	specimens (MB.C.13292.1–3)
Hibernicoceras artilobatum n. sp.	1	specimen (MB.C.13293)
Paraglyphioceras rudis (Moore & Hodson, 1958)	4	specimens (MB.C.13294.1–4)
Praedaraelites culmiensis (Kobold, 1933)	1	specimen (MB.C.13295)
Same locality (horizon CeH-5)		
Lusitanoceras zirari n. sp.	1	specimen (MB.C.13296)

B. Conch dimensions and ratios of ammonoids from the Chebket el Hamra.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZW
Eoglyphioceras minutum n. sp.										
MB.C.13269.1	11.90	7.30	6.10	1.00	3.60	0.62	1.20	0.08	2.04	0.42
MB.C.13269.3	8.60	5.40	4.40	0.80	2.30	0.63	1.24	0.10	1.88	0.50
MB.C.13269.2	10.63	6.63	5.70	0.97	2.86	0.62	1.16	0.09	1.87	0.50
	7.76	5.26	3.96	0.99	1.98	0.68	1.33	0.13	1.80	0.50
	5.78	4.28	2.82	1.01	1.42	0.74	1.52	0.17	1.75	0.50
	4.37	3.51	1.96	0.98	1.00	0.80	1.80	0.22	1.68	0.49
	3.37	2.75	1.43	0.89	0.77	0.82	1.93	0.26	1.68	0.46
	2.60	2.08	1.05	0.77	0.57	0.80	1.98	0.29	1.65	0.45
	2.03	1.60	0.78	0.62	0.45	0.79	2.05	0.31	1.65	0.42
	1.58	1.26	0.62	0.45	0.37	0.80	2.01	0.29	1.72	0.40
	1.20	1.01	0.50	0.30	0.29	0.84	2.04	0.25	1.75	0.41
	0.91	0.95	0.41	0.09	0.27	1.04	2.31	0.09	2.01	0.35
Girtyoceras luscinia Korn, 1988										
MB.C.13213.1	20.30	7.20	10.50	3.20	–	0.35	0.68	0.16	–	–
MB.C.13228	18.80	6.90	9.00	3.90	5.20	0.37	0.76	0.21	1.93	0.42
MB.C.13213.2	15.50	6.60	7.30	3.20	4.30	0.43	0.91	0.21	1.91	0.41
MB.C.13213.3	8.70	4.80	3.60	2.70	2.00	0.56	1.34	0.31	1.70	0.44
MB.C.13213.4	13.50	6.00	6.01	3.22	3.46	0.44	1.00	0.24	1.81	0.42
	10.04	5.25	4.27	2.85	2.44	0.52	1.23	0.28	1.74	0.43
	7.60	4.63	2.92	2.41	1.61	0.61	1.59	0.32	1.61	0.45
	5.99	3.83	2.27	1.99	1.24	0.64	1.69	0.33	1.59	0.45
	4.75	3.20	1.74	1.66	0.96	0.67	1.84	0.35	1.57	0.45
	3.79	2.54	1.35	1.42	0.81	0.67	1.88	0.37	1.62	0.40
	2.98	1.97	1.02	1.18	0.64	0.66	1.94	0.40	1.62	0.37
	2.34	1.58	0.78	0.96	0.50	0.68	2.03	0.41	1.62	0.36

B. (continued)

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZW
	1.84	1.31	0.60	0.75	0.39	0.71	2.17	0.41	1.60	0.36
	1.46	0.98	0.49	0.57	0.32	0.67	2.00	0.39	1.64	0.35
	1.14	0.80	0.40	0.40	0.27	0.71	2.02	0.35	1.70	0.34
	0.87	0.68	0.34	0.21	0.24	0.79	2.01	0.24	1.89	0.30
Girtyoceras ibnkhaldouni n. sp.										
MB.C.13214.1	14.80	6.60	8.00	2.30	–	0.45	0.83	0.15	–	–
MB.C.13214.5	11.70	5.80	5.90	2.30	3.60	0.49	0.98	0.20	2.06	0.40
MB.C.13229.1	11.40	5.50	5.60	2.20	3.60	0.48	0.99	0.19	2.15	0.35
MB.C.13214.3	17.63	7.39	9.47	2.36	6.03	0.42	0.78	0.13	2.31	0.36
	11.60	5.98	5.80	2.32	3.49	0.52	1.03	0.20	2.05	0.40
	8.11	4.82	3.48	2.32	2.04	0.59	1.38	0.29	1.79	0.41
MB.C.13214.4	11.13	5.28	5.31	2.42	3.35	0.47	0.99	0.22	2.05	0.37
	7.78	4.35	3.40	2.18	2.09	0.56	1.28	0.28	1.87	0.39
	5.69	3.61	2.20	1.98	1.30	0.63	1.64	0.35	1.68	0.41
	4.39	2.91	1.51	1.71	0.96	0.66	1.92	0.39	1.64	0.37
	3.43	2.33	1.16	1.43	0.75	0.68	2.00	0.42	1.63	0.36
	2.69	1.76	0.84	1.19	0.56	0.65	2.09	0.44	1.60	0.33
	2.12	1.38	0.65	0.97	0.44	0.65	2.12	0.46	1.60	0.32
	1.68	1.04	0.50	0.78	0.35	0.62	2.10	0.47	1.59	0.30
	1.33	0.87	0.40	0.61	0.27	0.65	2.17	0.45	1.56	0.34
	1.07	0.70	0.33	0.45	0.23	0.66	2.15	0.42	1.63	0.29
	0.84	0.65	0.30	0.22	0.22	0.78	2.19	0.26	1.87	0.24
	0.61	0.66	0.32	0.04	0.14	1.08	2.08	0.06	1.70	0.55
Sulcogirtyoceras sp.										
MB.C.13215.2	12.90	6.20	5.00	4.30	3.00	0.48	1.24	0.33	1.71	0.40
Metadimorphoceras anguinosum n. sp.										
MB.C.13233.1	18.90	8.60	11.60	0.20	7.30	0.45	0.74	0.01	2.65	0.37
MB.C.13216.1	11.30	7.80	6.60	0.40	4.10	0.69	1.17	0.04	2.45	0.38
MB.C.13216.2	8.80	5.20	5.00	0.20	3.10	0.59	1.05	0.02	2.37	0.38
MB.C.13272.1	12.16	6.77	7.29	0.20	4.39	0.56	0.93	0.02	2.45	0.40
	7.77	4.97	4.68	0.21	2.77	0.64	1.06	0.03	2.41	0.41
	5.00	3.41	2.89	0.28	1.70	0.68	1.18	0.05	2.30	0.41
	3.30	2.40	1.84	0.19	1.04	0.73	1.30	0.06	2.14	0.43
	2.26	1.79	1.27	0.13	0.62	0.79	1.41	0.06	1.90	0.51
	1.64	1.35	0.85	0.17	0.38	0.82	1.58	0.11	1.71	0.55
	1.25	1.06	0.61	0.19	0.28	0.85	1.74	0.15	1.67	0.54
	0.97	0.80	0.45	0.19	0.25	0.83	1.79	0.20	1.79	0.45
	0.73	0.56	0.33	0.14	0.18	0.77	1.68	0.19	1.80	0.44
Metadimorphoceras hodsoni Moore, 1958										
MB.C.13201.1	12.70	7.00	7.50	0.20	4.60	0.55	0.94	0.02	2.45	0.39
MB.C.13270.1	12.60	6.70	7.60	0.20	4.60	0.53	0.88	0.01	2.46	0.40
MB.C.13270.2	11.93	6.55	6.82	0.53	4.37	0.55	0.96	0.04	2.49	0.36
	7.56	4.77	4.58	0.09	2.73	0.63	1.04	0.01	2.46	0.40
	4.82	3.22	2.89	0.08	1.66	0.67	1.12	0.02	2.33	0.42
	3.16	2.25	1.86	–	1.06	0.71	1.21	–	2.26	0.43
MB.C.13270.3	9.02	5.55	5.46	0.14	3.36	0.61	1.02	0.01	2.54	0.38
	5.66	3.92	3.43	0.04	2.06	0.69	1.14	0.01	2.48	0.40
	3.59	2.57	2.19	0.04	1.19	0.71	1.17	0.01	2.24	0.46
	2.40	1.77	1.37	–	0.76	0.74	1.30	–	2.13	0.45
Goniatites crenistria Phillips, 1836										
MB.C.13256.3	120.10	58.20	59.30	18.60	–	0.48	0.98	0.16	–	–
MB.C.13256.2	93.30	45.10	46.20	14.70	25.80	0.48	0.98	0.16	1.91	0.44

B. (continued)

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZW
MB.C.13254.1	86.50	46.70	44.40	12.70	22.40	0.54	1.05	0.15	1.82	0.50
MB.C.13254.2	68.20	40.20	35.80	8.20	16.90	0.59	1.12	0.12	1.77	0.53
MB.C.13254.3	64.10	38.10	30.50	9.70	16.20	0.59	1.25	0.15	1.79	0.47
MB.C.13254.4	79.84	45.37	41.41	9.15	20.60	0.57	1.10	0.11	1.82	0.50
	59.25	36.33	29.29	7.41	14.36	0.61	1.24	0.13	1.74	0.51
	44.88	30.85	22.54	–	9.52	0.69	1.37	–	1.61	0.58
MB.C.13256.1	59.00	34.70	29.18	8.28	14.22	0.59	1.19	0.14	1.74	0.51
	44.78	28.77	21.54	6.41	10.16	0.64	1.34	0.14	1.67	0.53
	34.63	24.43	16.83	4.34	7.03	0.71	1.45	0.13	1.57	0.58
	27.59	20.09	13.45	3.17	4.85	0.73	1.49	0.11	1.47	0.64
	22.75	17.66	10.97	2.29	4.19	0.78	1.61	0.10	1.50	0.62
	18.55	13.73	9.48	–	3.37	0.74	1.45	–	1.49	0.64
Goniatites globostriatus (Schmidt, 1925)										
MB.C.13255.1	98.00	52.00	44.80	13.70	18.80	0.53	1.16	0.14	1.53	0.58
MB.C.13255.3	63.40	41.10	32.40	7.50	–	0.65	1.27	0.12	–	–
Arnsbergites sphaericostriatus (Bisat, 1924)										
MB.C.13290.1	37.40	26.70	17.20	5.30	7.20	0.71	1.55	0.14	1.53	0.58
MB.C.13283	32.60	23.00	15.40	4.40	6.50	0.70	1.49	0.13	1.56	0.58
MB.C.13290.2	24.80	19.10	13.20	2.60	–	0.77	1.45	0.10	–	–
MB.C.13234	9.90	9.40	4.10	2.40	2.10	0.95	2.33	0.24	1.60	0.49
MB.C.13234	10.06	9.25	4.40	2.31	1.96	0.92	2.11	0.23	1.54	0.55
	8.10	7.41	3.36	2.16	1.51	0.92	2.21	0.27	1.51	0.55
	6.58	6.11	2.59	2.14	1.23	0.93	2.36	0.33	1.51	0.52
	5.36	4.87	1.86	2.02	0.97	0.91	2.62	0.38	1.49	0.48
	4.39	3.99	1.48	1.78	0.82	0.91	2.70	0.41	1.51	0.45
	3.57	3.14	1.13	1.56	0.66	0.88	2.78	0.44	1.50	0.42
	2.91	2.50	0.88	1.35	0.53	0.86	2.85	0.46	1.49	0.40
	2.39	1.91	0.69	1.14	0.44	0.80	2.78	0.48	1.51	0.35
	1.94	1.45	0.56	0.91	0.36	0.75	2.58	0.47	1.50	0.37
	1.59	1.19	0.47	0.71	0.28	0.75	2.52	0.45	1.48	0.40
	1.30	0.91	0.41	0.52	0.26	0.70	2.24	0.40	1.56	0.36
	1.04	0.75	0.38	0.38	0.24	0.72	1.97	0.37	1.68	0.37
	0.80	0.62	0.28	–	0.18	0.77	2.21	–	1.68	0.34
Arnsbergites ferrus n. sp.										
MB.C.13291.1	30.80	24.80	14.80	4.80	6.00	0.81	1.67	0.16	1.54	0.60
MB.C.13218.4	16.30	14.20	7.20	4.00	3.40	0.87	1.97	0.25	1.59	0.53
MB.C.13218.1	11.10	10.40	4.40	3.40	2.20	0.94	2.35	0.31	1.56	0.50
MB.C.13274.1	15.76	15.40	7.15	2.98	2.74	0.98	2.15	0.19	1.46	0.62
	13.03	12.17	5.64	2.83	2.46	0.93	2.16	0.22	1.52	0.56
	10.56	10.15	4.56	2.57	2.08	0.96	2.23	0.24	1.55	0.54
	8.48	8.12	3.43	2.34	1.56	0.96	2.36	0.28	1.50	0.55
	6.93	6.63	2.71	2.23	1.26	0.96	2.45	0.32	1.49	0.53
	5.67	5.05	1.99	2.14	1.07	0.89	2.54	0.38	1.52	0.46
	4.60	4.24	1.54	1.85	0.79	0.92	2.76	0.40	1.46	0.48
	3.81	3.20	1.21	1.58	0.66	0.84	2.65	0.42	1.47	0.45
	3.14	2.70	1.02	1.32	0.60	0.86	2.66	0.42	1.53	0.41
	2.54	2.04	0.81	1.08	0.50	0.80	2.54	0.42	1.55	0.38
	2.04	1.54	0.66	0.85	0.42	0.76	2.34	0.42	1.58	0.36
	1.62	1.18	0.53	0.64	0.33	0.73	2.24	0.39	1.58	0.37
	1.29	1.00	0.46	0.41	0.30	0.78	2.18	0.32	1.68	0.36
	0.99	0.75	0.42	0.24	0.27	0.76	1.78	0.24	1.86	0.37
	0.73	0.73	0.33	0.12	0.19	1.00	2.17	0.17	1.83	0.43
MB.C.13218.2	12.63	11.15	4.87	3.89	2.23	0.88	2.29	0.31	1.48	0.54
	10.39	9.36	3.87	3.48	1.80	0.90	2.42	0.33	1.46	0.53

B. (continued)

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZW
	8.59	7.92	3.05	3.20	1.65	0.92	2.60	0.37	1.53	0.46
	6.95	6.13	2.34	2.86	1.18	0.88	2.62	0.41	1.45	0.50
	5.77	5.17	1.74	2.58	1.04	0.90	2.97	0.45	1.49	0.40
	4.73	4.32	1.45	2.14	0.82	0.91	2.98	0.45	1.46	0.43
	3.91	3.31	1.14	1.83	0.74	0.85	2.91	0.47	1.52	0.35
	3.16	2.37	0.94	1.46	0.62	0.75	2.53	0.46	1.54	0.34
	2.55	1.86	0.77	1.04	0.48	0.73	2.42	0.41	1.52	0.37
	2.07	1.42	0.74	0.73	0.47	0.69	1.93	0.36	1.67	0.37
	1.60	1.19	0.60	0.54	0.37	0.75	2.00	0.34	1.70	0.37
	1.23	0.84	0.47	0.38	0.32	0.69	1.80	0.31	1.81	0.32
Arnsbergites proiecturus n. sp.										
MB.C.13219.1	18.60	17.10	6.90	5.80	–	0.92	2.48	0.31	–	–
MB.C.13219.2	11.70	10.40	5.30	4.00	2.20	0.89	1.96	0.35	1.51	0.59
MB.C.13219.3	11.25	9.66	4.10	4.07	2.13	0.86	2.35	0.36	1.52	0.48
	9.12	7.74	3.08	3.65	1.53	0.85	2.51	0.40	1.44	0.51
	7.59	6.42	2.38	3.14	1.26	0.85	2.69	0.41	1.44	0.47
	6.33	5.32	2.07	2.72	1.16	0.84	2.57	0.43	1.50	0.44
	5.17	4.13	1.54	2.35	0.87	0.80	2.68	0.45	1.45	0.43
	4.30	3.22	1.28	1.94	0.74	0.75	2.51	0.45	1.46	0.42
	3.55	2.50	1.07	1.65	0.59	0.70	2.33	0.46	1.44	0.45
	2.96	1.79	0.83	1.45	0.52	0.60	2.15	0.49	1.47	0.38
	2.44	1.43	0.68	1.18	0.44	0.58	2.09	0.48	1.49	0.36
	2.00	1.00	0.58	0.91	0.36	0.50	1.72	0.46	1.49	0.38
	1.64	0.86	0.51	0.73	0.32	0.52	1.69	0.45	1.54	0.37
	1.32	0.66	0.40	0.53	0.28	0.49	1.63	0.40	1.60	0.31
	1.05	0.63	0.39	0.26	0.26	0.60	1.60	0.25	1.78	0.33
	0.79	0.62	0.40	0.06	0.22	0.79	1.55	0.08	1.90	0.46
Arnsbergites rufus n. sp.										
MB.C.13285.1	37.60	23.00	18.60	4.10	7.50	0.61	1.24	0.11	1.56	0.60
MB.C.13285.2	29.40	18.80	14.60	2.90	5.40	0.64	1.29	0.10	1.50	0.63
MB.C.13285.4	23.60	16.50	12.10	2.90	4.70	0.70	1.36	0.12	1.56	0.61
MB.C.13285.3	26.65	19.67	13.39	1.05	5.71	0.74	1.47	0.04	1.62	0.57
	20.94	17.34	12.21	–	4.63	0.83	1.42	–	1.65	0.62
Hibernicoceras carraunense Moore & Hodson, 1958										
MB.C.13209.1	32.80	22.50	15.30	5.40	7.40	0.69	1.47	0.16	1.67	0.52
MB.C.13209.2	22.90	17.60	9.80	4.80	4.80	0.77	1.79	0.21	1.60	0.51
MB.C.13236.3	8.80	7.50	4.10	2.20	1.80	0.85	1.82	0.25	1.56	0.57
MB.C.13236.1	21.53	15.86	10.13	3.23	4.15	0.74	1.57	0.15	1.53	0.59
	17.38	13.93	8.17	2.99	3.27	0.80	1.70	0.17	1.52	0.60
	14.12	12.03	6.21	3.02	2.69	0.85	1.94	0.21	1.53	0.57
	11.43	9.51	4.89	2.64	2.03	0.83	1.95	0.23	1.48	0.58
	9.39	8.32	3.90	2.61	1.81	0.89	2.14	0.28	1.53	0.54
	7.59	6.63	2.89	2.37	1.47	0.87	2.30	0.31	1.54	0.49
	6.12	5.46	2.33	1.99	1.16	0.89	2.34	0.32	1.52	0.50
	4.96	4.30	1.80	1.73	0.97	0.87	2.39	0.35	1.54	0.46
	3.99	3.47	1.42	1.48	0.79	0.87	2.44	0.37	1.55	0.45
	3.20	2.67	1.09	1.24	0.65	0.83	2.45	0.39	1.57	0.40
	2.55	2.04	0.88	–	0.51	0.80	2.32	–	1.56	0.42
MB.C.13236.2	21.18	15.01	9.38	4.31	4.04	0.71	1.60	0.20	1.53	0.57
	17.14	13.26	7.49	3.58	3.11	0.77	1.77	0.21	1.49	0.58
	14.03	10.91	6.07	3.18	2.56	0.78	1.80	0.23	1.50	0.58
	11.47	9.32	4.78	2.94	2.14	0.81	1.95	0.26	1.51	0.55
	9.33	7.76	3.75	2.66	1.64	0.83	2.07	0.28	1.47	0.56
	7.70	6.35	2.93	2.54	1.41	0.82	2.17	0.33	1.50	0.52

B. (continued)

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZW
	6.29	5.30	2.23	2.32	1.12	0.84	2.37	0.37	1.48	0.50
	5.17	4.36	1.74	2.10	0.95	0.84	2.51	0.41	1.50	0.45
	4.22	3.47	1.33	1.80	0.77	0.82	2.61	0.43	1.50	0.42
	3.45	2.78	1.08	1.52	0.64	0.81	2.58	0.44	1.50	0.41
	2.81	2.10	0.85	1.31	0.54	0.75	2.48	0.47	1.54	0.36
Hibernicoceras touissitense n. sp.										
MB.C.13237.1	30.40	17.00	15.10	4.20	7.30	0.56	1.13	0.14	1.72	0.52
MB.C.13292.1	18.40	13.70	9.80	2.10	3.50	0.74	1.39	0.11	1.53	0.64
MB.C.13276.1	14.60	11.30	6.90	1.80	2.80	0.77	1.65	0.12	1.53	0.59
MB.C.13276.2	12.70	9.60	5.30	2.40	2.20	0.75	1.80	0.19	1.47	0.58
MB.C.13237.2	15.32	11.48	7.27	2.13	3.05	0.75	1.58	0.14	1.56	0.58
	12.28	9.89	5.93	2.01	2.60	0.81	1.67	0.16	1.61	0.56
	9.67	8.22	4.34	1.90	1.80	0.85	1.89	0.20	1.51	0.59
	7.88	6.92	3.43	1.85	1.54	0.88	2.01	0.24	1.54	0.55
	6.34	5.60	2.59	1.91	1.17	0.88	2.16	0.30	1.50	0.55
	5.18	4.55	1.85	1.99	0.91	0.88	2.46	0.39	1.47	0.51
	4.27	3.66	1.34	1.87	0.74	0.86	2.74	0.44	1.47	0.44
	3.53	2.88	1.07	1.67	0.65	0.82	2.70	0.47	1.51	0.39
	2.87	2.27	0.78	1.49	0.50	0.79	2.90	0.52	1.47	0.36
	2.37	1.75	0.60	1.24	0.43	0.74	2.90	0.53	1.49	0.29
	1.94	1.37	0.52	1.00	0.37	0.70	2.62	0.51	1.53	0.29
	1.57	1.07	0.42	0.76	0.30	0.68	2.54	0.48	1.53	0.28
	1.27	0.81	0.39	0.53	0.24	0.64	2.06	0.41	1.53	0.38
	1.03	0.74	0.35	0.34	0.24	0.71	2.08	0.33	1.70	0.32
	0.79	0.63	0.34	0.16	0.18	0.80	1.86	0.20	1.70	0.46
MB.C.13237.3	14.46	10.89	6.55	2.78	2.66	0.75	1.66	0.19	1.50	0.59
	11.80	9.14	5.13	2.35	1.99	0.78	1.78	0.20	1.45	0.61
	9.80	7.90	4.31	2.04	1.83	0.81	1.83	0.21	1.51	0.58
	7.97	6.69	3.45	1.67	1.49	0.84	1.94	0.21	1.51	0.57
	6.49	5.46	2.85	1.51	1.39	0.84	1.91	0.23	1.62	0.51
	5.10	4.35	2.13	1.51	1.05	0.85	2.05	0.30	1.58	0.51
	4.05	3.49	1.47	1.52	0.80	0.86	2.38	0.37	1.56	0.45
	3.25	2.59	1.07	1.41	0.64	0.80	2.42	0.43	1.55	0.41
	2.61	2.03	0.77	1.25	0.50	0.77	2.62	0.48	1.53	0.35
	2.11	1.51	0.59	1.06	0.43	0.71	2.54	0.50	1.58	0.27
	1.68	1.21	0.46	0.85	0.32	0.72	2.62	0.51	1.53	0.30
	1.36	0.91	0.36	0.61	0.26	0.67	2.50	0.45	1.53	0.29
	1.10	0.78	0.38	0.45	0.26	0.71	2.06	0.41	1.73	0.30
	0.83	0.67	0.27	0.27	0.20	0.81	2.47	0.33	1.72	0.28
Hibernicoceras artilobatum n. sp.										
MB.C.13286	22.80	18.00	10.70	2.20	5.30	0.79	1.69	0.10	1.69	0.51
MB.C.13238.2	18.90	14.70	9.40	2.20	4.10	0.78	1.57	0.12	1.64	0.56
MB.C.13238.1	14.40	11.80	7.00	1.80	3.10	0.82	1.69	0.12	1.62	0.55
MB.C.13277.1	17.18	14.06	8.32	2.34	3.52	0.82	1.69	0.14	1.58	0.58
	13.67	11.43	6.52	2.01	2.75	0.84	1.75	0.15	1.57	0.58
	10.92	9.76	5.13	1.82	2.13	0.89	1.90	0.17	1.54	0.58
	8.79	7.70	3.96	1.68	1.77	0.88	1.94	0.19	1.57	0.55
	7.02	6.55	3.14	1.50	1.45	0.93	2.08	0.21	1.59	0.54
	5.57	5.12	2.38	1.53	1.06	0.92	2.15	0.28	1.52	0.55
	4.51	4.32	1.66	1.54	0.85	0.96	2.60	0.34	1.51	0.49
	3.67	3.38	1.32	1.40	0.69	0.92	2.57	0.38	1.52	0.47
	2.97	2.72	0.95	1.27	0.52	0.91	2.86	0.43	1.46	0.46
MB.C.13277.2	11.92	9.58	5.85	1.57	2.56	0.80	1.64	0.13	1.62	0.56
	9.35	7.95	4.50	1.58	2.10	0.85	1.77	0.17	1.66	0.53

B. (continued)

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZW
	7.26	6.45	3.28	1.68	1.63	0.89	1.96	0.23	1.67	0.50
	5.62	4.83	2.30	1.88	1.10	0.86	2.10	0.33	1.55	0.52
	4.52	3.85	1.45	1.82	0.74	0.85	2.66	0.40	1.43	0.49
	3.78	3.04	1.25	1.62	0.71	0.80	2.43	0.43	1.51	0.44
	3.07	2.50	0.91	1.52	0.59	0.81	2.75	0.49	1.53	0.35
	2.48	1.88	0.65	1.23	0.40	0.76	2.92	0.49	1.43	0.37
	2.08	1.61	0.61	1.03	0.40	0.78	2.64	0.50	1.54	0.34
	1.68	1.19	0.44	0.82	0.31	0.71	2.73	0.49	1.50	0.30
	1.37	1.00	0.43	0.63	0.29	0.73	2.36	0.46	1.60	0.32
Paraglyphioceras rudis (Moore & Hodson, 1958)										
MB.C.13278.1	15.60	11.50	7.50	1.50	4.20	0.70	1.53	0.09	1.88	0.44
MB.C.13278.3	10.00	8.00	5.20	0.80	2.50	0.80	1.55	0.08	1.78	0.52
MB.C.13278.2	9.60	7.80	5.10	0.90	2.60	0.80	1.55	0.09	1.88	0.48
MB.C.13239.1	18.15	12.94	9.91	0.86	4.46	0.71	1.31	0.05	1.76	0.55
	13.69	10.54	7.38	0.76	3.49	0.77	1.43	0.06	1.80	0.53
	10.20	8.41	5.56	0.67	2.65	0.82	1.51	0.07	1.82	0.52
	7.56	6.54	3.97	0.80	1.95	0.86	1.64	0.11	1.82	0.51
	5.60	4.84	2.78	0.96	1.43	0.86	1.74	0.17	1.81	0.49
	4.17	3.69	1.86	1.05	0.98	0.88	1.98	0.25	1.71	0.47
	3.19	2.67	1.26	1.07	0.65	0.84	2.12	0.34	1.58	0.48
	2.54	1.97	0.86	1.00	0.54	0.78	2.30	0.40	1.61	0.37
	2.00	1.51	0.68	0.84	0.46	0.76	2.23	0.42	1.69	0.32
	1.54	1.20	0.48	0.63	0.34	0.78	2.50	0.41	1.65	0.29
	1.20	0.95	0.42	0.41	0.31	0.79	2.25	0.35	1.82	0.26
	0.88	0.81	0.35	0.21	0.21	0.92	2.28	0.23	1.73	0.41
MB.C.13223.1	19.38	13.81	9.67	2.02	4.52	0.71	1.43	0.10	1.70	0.53
	14.86	11.29	7.69	1.37	3.72	0.76	1.47	0.09	1.78	0.52
	11.14	9.06	5.80	0.91	2.68	0.81	1.56	0.08	1.73	0.54
	8.46	7.13	4.43	0.85	2.02	0.84	1.61	0.10	1.73	0.54
	6.44	5.32	3.19	1.10	1.65	0.83	1.67	0.17	1.81	0.48
	4.79	3.95	2.15	1.18	1.12	0.82	1.84	0.25	1.70	0.48
	3.67	3.13	1.46	1.29	0.85	0.85	2.14	0.35	1.70	0.42
	2.82	2.20	0.92	1.18	0.55	0.78	2.39	0.42	1.54	0.40
	2.27	1.72	0.73	1.00	0.45	0.76	2.37	0.44	1.56	0.38
	1.82	1.33	0.55	0.81	0.36	0.73	2.40	0.45	1.55	0.35
	1.46	1.08	0.45	0.58	0.29	0.74	2.39	0.39	1.57	0.35
	1.17	0.91	0.43	0.43	0.28	0.78	2.11	0.36	1.73	0.35
	0.89	0.70	0.31	0.33	0.21	0.79	2.25	0.37	1.73	0.32
Paraglyphioceras celeris n. sp.										
MB.C.13279.6	22.50	–	–	1.20	7.20	–	–	0.06	2.17	–
MB.C.13279.1	15.70	11.30	9.20	1.30	4.70	0.72	1.23	0.08	2.02	0.49
MB.C.13279.2	15.20	11.20	8.70	1.30	4.60	0.74	1.29	0.09	2.04	0.48
MB.C.13279.3	13.70	9.30	7.70	0.40	4.10	0.68	1.21	0.03	2.05	0.46
MB.C.13224.1	11.00	8.30	6.40	0.80	3.40	0.76	1.30	0.08	2.08	0.48
MB.C.13279.4	16.74	11.56	9.22	0.89	4.76	0.69	1.25	0.05	1.95	0.48
	11.98	9.02	6.64	0.69	3.32	0.75	1.36	0.06	1.91	0.50
	8.66	7.17	4.66	0.75	2.28	0.83	1.54	0.09	1.84	0.51
	6.39	5.23	3.25	0.85	1.61	0.82	1.61	0.13	1.79	0.50
	4.78	4.13	2.28	0.94	1.11	0.86	1.81	0.20	1.69	0.52
	3.67	3.04	1.55	1.03	0.82	0.83	1.96	0.28	1.66	0.47
	2.85	2.50	1.09	0.99	0.64	0.88	2.29	0.35	1.66	0.42
	2.22	1.81	0.77	0.85	0.47	0.82	2.36	0.38	1.61	0.39
	1.74	1.47	0.60	0.66	0.37	0.84	2.44	0.38	1.60	0.39
MB.C.13279.5	14.89	10.47	8.32	0.79	4.55	0.70	1.26	0.05	2.07	0.45
	10.34	8.23	5.77	0.85	3.05	0.80	1.43	0.08	2.01	0.47

B. (continued)

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZW
	7.29	6.37	3.73	1.09	1.90	0.87	1.71	0.15	1.83	0.49
	5.39	4.75	2.47	1.28	1.26	0.88	1.92	0.24	1.70	0.49
	4.13	3.54	1.64	1.36	0.84	0.86	2.16	0.33	1.57	0.49
	3.29	2.67	1.13	1.28	0.61	0.81	2.37	0.39	1.50	0.46
	2.68	2.19	0.89	1.13	0.52	0.82	2.47	0.42	1.54	0.41
	2.16	1.67	0.67	0.94	0.41	0.78	2.50	0.44	1.53	0.39
	1.75	1.33	0.55	0.74	0.38	0.76	2.44	0.42	1.64	0.30
	1.37	1.03	0.47	0.52	0.32	0.75	2.21	0.38	1.70	0.32
	1.05	0.88	0.38	0.29	0.24	0.84	2.29	0.28	1.67	0.38
	0.81	0.64	0.37	0.06	0.23	0.78	1.70	0.07	1.93	0.39
Paraglyphioceras celeris n. sp.										
MB.C.13279.6	22.50	–	–	1.20	7.20	–	–	0.06	2.17	–
MB.C.13279.1	15.70	11.30	9.20	1.30	4.70	0.72	1.23	0.08	2.02	0.49
MB.C.13279.2	15.20	11.20	8.70	1.30	4.60	0.74	1.29	0.09	2.04	0.48
MB.C.13279.3	13.70	9.30	7.70	0.40	4.10	0.68	1.21	0.03	2.05	0.46
MB.C.13224.1	11.00	8.30	6.40	0.80	3.40	0.76	1.30	0.08	2.08	0.48
MB.C.13279.4	16.74	11.56	9.22	0.89	4.76	0.69	1.25	0.05	1.95	0.48
	11.98	9.02	6.64	0.69	3.32	0.75	1.36	0.06	1.91	0.50
	8.66	7.17	4.66	0.75	2.28	0.83	1.54	0.09	1.84	0.51
	6.39	5.23	3.25	0.85	1.61	0.82	1.61	0.13	1.79	0.50
	4.78	4.13	2.28	0.94	1.11	0.86	1.81	0.20	1.69	0.52
	3.67	3.04	1.55	1.03	0.82	0.83	1.96	0.28	1.66	0.47
	2.85	2.50	1.09	0.99	0.64	0.88	2.29	0.35	1.66	0.42
	2.22	1.81	0.77	0.85	0.47	0.82	2.36	0.38	1.61	0.39
	1.74	1.47	0.60	0.66	0.37	0.84	2.44	0.38	1.60	0.39
MB.C.13279.5	14.89	10.47	8.32	0.79	4.55	0.70	1.26	0.05	2.07	0.45
	10.34	8.23	5.77	0.85	3.05	0.80	1.43	0.08	2.01	0.47
	7.29	6.37	3.73	1.09	1.90	0.87	1.71	0.15	1.83	0.49
	5.39	4.75	2.47	1.28	1.26	0.88	1.92	0.24	1.70	0.49
	4.13	3.54	1.64	1.36	0.84	0.86	2.16	0.33	1.57	0.49
	3.29	2.67	1.13	1.28	0.61	0.81	2.37	0.39	1.50	0.46
	2.68	2.19	0.89	1.13	0.52	0.82	2.47	0.42	1.54	0.41
	2.16	1.67	0.67	0.94	0.41	0.78	2.50	0.44	1.53	0.39
	1.75	1.33	0.55	0.74	0.38	0.76	2.44	0.42	1.64	0.30
	1.37	1.03	0.47	0.52	0.32	0.75	2.21	0.38	1.70	0.32
	1.05	0.88	0.38	0.29	0.24	0.84	2.29	0.28	1.67	0.38
	0.81	0.64	0.37	0.06	0.23	0.78	1.70	0.07	1.93	0.39
Lusitanoceras zirari n. sp.										
MB.C.13250.1	54.70	34.40	27.60	7.50	12.70	0.63	1.25	0.14	1.70	0.54
MB.C.13296	31.20	21.40	14.90	5.00	5.90	0.69	1.44	0.16	1.52	0.61
MB.C.13288	23.50	17.30	10.10	3.50	4.40	0.74	1.71	0.15	1.52	0.56
MB.C.13261.1	12.60	10.80	6.90	1.60	2.90	0.86	1.58	0.12	1.67	0.58
MB.C.13247.2	27.78	19.97	13.92	3.10	5.60	0.72	1.43	0.11	1.57	0.60
	22.18	16.22	10.76	3.10	4.21	0.73	1.51	0.14	1.52	0.61
	17.97	14.20	8.32	2.73	3.06	0.79	1.71	0.15	1.45	0.63
	14.91	11.66	6.92	2.60	3.07	0.78	1.68	0.17	1.59	0.56
	11.85	10.57	5.39	1.81	2.44	0.89	1.96	0.15	1.59	0.55
	9.40	8.54	4.64	1.59	1.87	0.91	1.84	0.17	1.56	0.60
	7.54	7.12	3.17	1.54	1.43	0.94	2.25	0.20	1.52	0.55
	6.11	5.63	2.84	1.39	1.30	0.92	1.99	0.23	1.61	0.54
MB.C.13206.1	22.11	16.56	9.97	3.72	4.21	0.75	1.66	0.17	1.53	0.58
	17.90	14.15	8.43	2.60	3.65	0.79	1.68	0.15	1.58	0.57
	14.25	12.51	6.87	1.98	2.58	0.88	1.82	0.14	1.49	0.62
	11.67	9.95	5.40	1.71	2.16	0.85	1.84	0.15	1.51	0.60

B. (continued)

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZW
	9.51	8.56	4.57	1.59	2.06	0.90	1.87	0.17	1.63	0.55
	7.45	6.94	3.36	1.31	1.35	0.93	2.07	0.18	1.49	0.60
	6.10	5.84	2.79	1.17	1.12	0.96	2.09	0.19	1.50	0.60
	4.98	4.80	2.14	1.03	0.88	0.96	2.24	0.21	1.47	0.59
	4.10	3.85	1.80	0.96	0.75	0.94	2.13	0.23	1.50	0.59
	3.35	3.31	1.33	0.97	0.61	0.99	2.49	0.29	1.50	0.54
	2.74	2.44	1.05	0.97	0.49	0.89	2.33	0.35	1.49	0.53
	2.25	1.96	0.72	0.90	0.41	0.87	2.72	0.40	1.49	0.44
	1.84	1.52	0.63	0.71	0.35	0.82	2.41	0.39	1.52	0.45
	1.49	1.18	0.50	0.59	0.29	0.79	2.36	0.40	1.54	0.42
	1.21	0.95	0.40	–	0.25	0.79	2.37	–	1.59	0.38
MB.C.13206.2	20.39	13.89	10.21	2.42	3.69	0.68	1.36	0.12	1.49	0.64
	16.70	11.11	7.76	1.96	3.13	0.67	1.43	0.12	1.51	0.60
	13.57	10.01	6.98	1.44	2.57	0.74	1.44	0.11	1.52	0.63
	11.00	8.37	5.15	1.29	2.15	0.76	1.62	0.12	1.55	0.58
	8.85	7.23	4.55	1.11	1.87	0.82	1.59	0.13	1.61	0.59
	6.98	6.13	3.19	1.01	1.29	0.88	1.93	0.15	1.51	0.59
	5.69	5.03	2.78	0.92	1.01	0.88	1.81	0.16	1.48	0.64
	4.68	4.03	1.99	0.94	0.88	0.86	2.02	0.20	1.52	0.56
	3.80	3.24	1.74	0.88	0.68	0.85	1.86	0.23	1.48	0.61
	3.12	2.81	1.17	0.88	0.54	0.90	2.39	0.28	1.46	0.54
	2.58	2.14	1.07	0.83	0.47	0.83	2.01	0.32	1.49	0.56
	2.11	1.77	0.69	0.76	0.37	0.84	2.56	0.36	1.47	0.46
	1.74	1.41	0.67	0.57	0.32	0.81	2.10	0.33	1.51	0.52
	1.32	1.09	0.50	0.35	0.26	0.83	2.18	0.27	1.56	0.47
	1.05	0.85	0.47	0.22	0.24	0.81	1.83	0.21	1.67	0.49
Sudeticeras murracaoense Korn, 1997										
MB.C.13202.1	24.90	14.60	13.10	2.00	7.40	0.58	1.11	0.08	2.02	0.43
MB.C.13271.1	15.10	10.70	8.60	1.00	4.40	0.71	1.24	0.07	2.01	0.48
MB.C.13271.2	13.30	9.20	7.70	0.90	4.20	0.70	1.20	0.07	2.12	0.46
MB.C.13202.2	12.30	9.30	6.20	1.30	3.20	0.76	1.50	0.11	1.81	0.49
MB.C.13203.1	10.30	8.10	5.80	0.50	2.80	0.79	1.39	0.05	1.87	0.53
MB.C.13205.1	16.27	11.19	9.14	0.80	4.73	0.69	1.22	0.05	1.99	0.48
	11.53	8.60	6.33	0.82	3.40	0.75	1.36	0.07	2.01	0.46
	8.14	6.98	4.39	0.92	2.18	0.86	1.59	0.11	1.87	0.50
	5.96	5.14	2.83	0.92	1.28	0.86	1.82	0.15	1.62	0.55
	4.67	4.17	2.21	0.85	1.03	0.89	1.88	0.18	1.64	0.54
	3.65	3.49	1.61	0.82	0.69	0.96	2.16	0.23	1.52	0.57
MB.C.13271.3	14.16	9.40	7.58	0.99	3.98	0.66	1.24	0.07	1.93	0.47
	10.18	7.63	5.59	0.77	2.86	0.75	1.36	0.08	1.93	0.49
	7.32	5.61	3.82	0.93	2.08	0.77	1.47	0.13	1.95	0.46
	5.25	4.52	2.58	0.81	1.34	0.86	1.75	0.15	1.81	0.48
	3.90	3.41	1.86	0.77	0.90	0.87	1.83	0.20	1.69	0.52
	3.01	2.77	1.27	0.77	0.71	0.92	2.18	0.26	1.72	0.44
	2.29	2.05	0.97	0.67	0.53	0.89	2.12	0.29	1.69	0.45
	1.76	1.43	0.66	0.56	0.41	0.81	2.18	0.32	1.70	0.37
	1.35	1.10	0.55	0.33	0.36	0.82	2.01	0.24	1.85	0.35
	0.99	0.77	0.47	0.16	0.27	0.77	1.61	0.16	1.90	0.43
	0.72	0.72	0.36	0.03	0.23	1.00	2.01	0.04	2.15	0.36
MB.C.13271.4	21.36	13.37	11.82	0.99	6.39	0.63	1.13	0.05	2.04	0.46
	14.97	9.88	8.55	0.55	4.26	0.66	1.16	0.04	1.95	0.50
	10.71	7.92	5.87	0.47	2.82	0.74	1.35	0.04	1.84	0.52
Sudeticeras ibnbajjahi n. sp.										
MB.C.13241.1	21.40	14.40	11.10	1.50	6.30	0.67	1.30	0.07	2.02	0.43
MB.C.13225.1	15.60	11.70	8.20	1.70	4.40	0.75	1.43	0.11	1.93	0.46

B. (continued)

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZW
MB.C.13225.5	11.60	9.60	5.50	1.30	3.10	0.83	1.76	0.11	1.84	0.44
MB.C.13225.2	10.70	8.60	5.50	1.10	2.90	0.81	1.57	0.11	1.87	0.48
MB.C.13225.3	16.55	11.60	9.14	1.00	4.54	0.70	1.27	0.06	1.90	0.50
	12.01	9.78	6.41	0.83	3.24	0.81	1.52	0.07	1.87	0.50
	8.77	7.39	4.77	0.82	2.51	0.84	1.55	0.09	1.96	0.47
	6.27	5.88	3.18	0.91	1.64	0.94	1.85	0.15	1.83	0.49
MB.C.13225.4	14.78	9.91	8.24	0.68	4.34	0.67	1.20	0.05	2.00	0.47
	10.44	7.97	5.85	0.54	3.03	0.76	1.36	0.05	1.98	0.48
	7.42	6.37	4.05	0.61	2.11	0.86	1.57	0.08	1.95	0.48
	5.31	4.81	2.76	0.59	1.44	0.91	1.75	0.11	1.88	0.48
	3.87	3.87	1.96	0.67	1.03	1.00	1.98	0.17	1.86	0.47
	2.84	2.75	1.25	0.68	0.69	0.97	2.20	0.24	1.75	0.45
	2.15	2.03	0.91	0.64	0.51	0.95	2.23	0.30	1.72	0.44
	1.64	1.41	0.60	0.55	0.37	0.86	2.35	0.34	1.67	0.38
	1.27	1.08	0.49	0.36	0.30	0.85	2.20	0.29	1.72	0.38
	0.97	0.79	0.42	0.23	0.27	0.81	1.89	0.23	1.93	0.35
Sudeticeras splendens (Bisat, 1928)										
MB.C.13264.1	54.70	27.70	26.20	8.30	15.40	0.51	1.02	0.15	1.94	0.43
MB.C.13264.4	50.40	26.60	25.70	6.70	14.30	0.53	1.03	0.13	1.95	0.44
MB.C.13264.2	50.10	28.20	25.30	6.60	13.50	0.56	1.11	0.13	1.88	0.47
MB.C.13264.5	45.60	25.80	22.60	7.70	12.30	0.57	1.14	0.17	1.87	0.46
MB.C.13264.6	30.30	18.90	13.80	5.90	8.00	0.62	1.37	0.20	1.85	0.42
MB.C.13248.1	47.21	24.27	23.66	6.44	12.57	0.51	1.03	0.14	1.86	0.47
	34.64	19.80	17.11	5.08	9.28	0.57	1.16	0.15	1.87	0.46
	25.36	15.72	12.45	3.52	6.60	0.62	1.26	0.14	1.83	0.47
	18.76	12.44	9.39	2.50	4.54	0.66	1.33	0.13	1.74	0.52
	14.22	10.14	6.88	–	3.43	0.71	1.48	–	1.74	0.50
Sudeticeras horoni n. sp.										
MB.C.13260.1	68.50	30.40	33.20	9.40	19.50	0.44	0.91	0.14	1.96	0.41
MB.C.13260.3	47.70	24.70	23.20	5.40	13.20	0.52	1.06	0.11	1.91	0.43
MB.C.13212.2	47.10	23.20	24.80	4.30	13.80	0.49	0.93	0.09	1.99	0.45
MB.C.13212.1	44.60	24.30	24.60	3.80	12.70	0.54	0.99	0.09	1.95	0.48
MB.C.13289.1	41.10	20.90	23.20	2.30	11.90	0.51	0.90	0.06	1.98	0.49
MB.C.13212.4	27.00	16.00	13.80	3.00	7.30	0.59	1.16	0.11	1.88	0.47
MB.C.13212.3	24.10	15.60	13.00	2.20	6.70	0.65	1.20	0.09	1.91	0.48
MB.C.13246	50.86	24.14	26.14	4.81	14.31	0.47	0.92	0.09	1.94	0.45
	36.55	20.27	19.91	3.32	11.14	0.55	1.02	0.09	2.07	0.44
	25.42	16.99	13.32	2.68	7.08	0.67	1.28	0.11	1.92	0.47
	18.33	13.19	9.42	1.74	4.65	0.72	1.40	0.10	1.80	0.51
	13.68	10.27	7.17	1.48	3.56	0.75	1.43	0.11	1.83	0.50
	10.13	8.48	5.03	1.45	2.45	0.84	1.69	0.14	1.74	0.51
	7.68	6.53	3.65	1.22	1.66	0.85	1.79	0.16	1.63	0.55
	6.03	5.37	2.82	1.19	1.38	0.89	1.91	0.20	1.68	0.51
	4.65	4.49	2.01	1.12	0.96	0.96	2.23	0.24	1.59	0.52
	3.69	3.40	1.52	1.10	0.77	0.92	2.24	0.30	1.59	0.49
	2.92	2.57	1.07	0.96	0.58	0.88	2.40	0.33	1.56	0.46
	2.34	1.87	0.89	0.80	0.49	0.80	2.10	0.34	1.60	0.45
MB.C.13266.1	50.65	24.70	26.47	4.62	14.12	0.49	0.93	0.09	1.92	0.47
	36.53	20.45	19.56	3.17	10.75	0.56	1.05	0.09	2.01	0.45
	25.78	16.65	13.79	2.18	7.36	0.65	1.21	0.08	1.96	0.47
	18.42	12.89	9.81	1.58	4.87	0.70	1.31	0.09	1.85	0.50
	13.55	10.08	7.03	1.27	3.47	0.74	1.43	0.09	1.81	0.51
	10.08	7.95	5.25	1.32	2.36	0.79	1.51	0.13	1.71	0.55
	7.72	6.22	3.52	1.24	1.53	0.81	1.77	0.16	1.56	0.56

B. (continued)

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZW
Neoglyphioceras spirale (Phillips, 1841)										
MB.C.13242.1	17.90	9.00	7.90	–	4.00	0.50	1.15	–	1.65	0.50
MB.C.13226.1	12.60	7.30	5.30	3.40	–	0.58	1.38	0.27	–	–
MB.C.13226.3	17.13	8.70	8.40	1.98	3.50	0.51	1.04	0.12	1.58	0.58
	13.63	7.44	6.76	1.98	2.95	0.55	1.10	0.15	1.63	0.56
	10.69	6.58	4.90	2.00	2.20	0.62	1.34	0.19	1.58	0.55
MB.C.13226.2	16.64	9.31	7.52	3.19	2.94	0.56	1.24	0.19	1.47	0.61
	13.71	8.30	5.94	2.83	2.49	0.61	1.40	0.21	1.49	0.58
	11.22	7.02	4.95	2.63	2.21	0.63	1.42	0.23	1.55	0.55
	9.01	6.18	3.65	2.34	1.47	0.69	1.69	0.26	1.43	0.60
	7.54	5.28	3.03	2.18	1.47	0.70	1.74	0.29	1.54	0.52
	6.08	4.54	2.33	2.14	1.26	0.75	1.94	0.35	1.59	0.46
	4.82	3.64	1.60	1.97	0.84	0.75	2.28	0.41	1.47	0.48
	3.98	3.01	1.26	–	0.73	0.76	2.40	–	1.50	0.42
Lusitanites circularis Korn, 1988										
MB.C.13249.1	17.90	8.70	–	–	–	0.48	–	–	–	–
MB.C.13208.1	17.20	7.40	8.00	2.50	–	0.43	0.92	0.14		–
MB.C.13249.2	17.10	8.20	8.00	2.10	3.60	0.48	1.03	0.13	1.60	0.55
MB.C.13262.2	17.10	7.90	7.60	2.10	–	0.46	1.03	0.12	–	–
Praedaraelites culmiensis (Kobold, 1933)										
MB.C.13295	22.00	6.50	10.20	5.70	8.50	0.29	0.63	0.26	2.67	0.16
MB.C.13231.1	20.40	6.40	9.20	5.60	8.10	0.31	0.69	0.27	2.75	0.12
MB.C.13243.1	17.60	5.80	7.50	5.30	6.60	0.33	0.77	0.30	2.58	0.12
MB.C.13227.1	15.70	5.10	6.80	4.60	6.10	0.33	0.75	0.29	2.64	0.11
MB.C.13227.2	10.70	3.80	4.90	3.30	4.20	0.35	0.76	0.31	2.66	0.16
MB.C.13227.3	21.59	6.93	9.83	5.63	8.45	0.32	0.70	0.26	2.70	0.14
	13.14	4.67	6.13	3.87	5.27	0.36	0.76	0.29	2.79	0.14
	7.87	3.14	3.14	2.82	2.85	0.40	1.00	0.36	2.46	0.09
	5.02	1.82	1.91	1.88	1.76	0.36	0.95	0.38	2.36	0.08
	3.26	1.23	1.22	1.24	1.08	0.38	1.01	0.38	2.24	0.11
	2.18	0.77	0.80	0.84	0.73	0.35	0.97	0.38	2.25	0.09
	1.46	0.57	0.54	0.47	0.49	0.39	1.06	0.32	2.25	0.11
	0.97	0.41	0.44	0.22	0.41	0.42	0.93	0.22	2.95	0.08
Pronorites owodenkoi n. sp.										
MB.C.13287.1	40.30	14.10	20.30	7.40	15.10	0.35	0.70	0.18	2.56	0.25
MB.C.13287.2	36.80	11.70	17.60	–	13.30	0.32	0.66	–	2.45	0.25
MB.C.13244.1	25.42	7.29	11.27	7.86	8.40	0.29	0.65	0.31	2.23	0.25
	17.02	4.77	6.29	6.90	5.12	0.28	0.76	0.41	2.04	0.19
	11.90	3.40	3.84	5.77	3.23	0.29	0.89	0.48	1.88	0.16
	8.67	2.41	2.30	–	2.18	0.28	1.05	–	1.79	0.05