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Late Viséan (Mississippian) ammonoids (Cephalopoda) from the Central Moroccan Meseta

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Abstract. Late Viséan (Mississippian) ammonoids (Cephalopoda) from the Central Moroccan Meseta are described monographically for the first time. Several localities have yielded low-diversity assemblages, consisting mainly of species already known from southern Portugal, Ireland, northern England and the Rhenish Mountains. This clearly places the Moroccan Meseta within the Rhenohercynian-Subvariscan Province. The assemblages from the Moroccan Meseta are confined to a narrow stratigraphic interval, likely representing the *Goniatites crenistria* Zone, *Goniatites sphaericus* Zone, *Goniatites spirifer* Zone and *Arnsbergites gracilis* Zone. The new species *Goniatites amarensis* sp. nov. is described.

Keywords. Early Carboniferous, Moroccan Meseta, Ammonoida, palaeogeography.

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Introduction

Late Viséan ammonoids from the central Moroccan Meseta have been rarely described so far, and knowledge remains incomplete. Termier (1936: 1208) named several species from various localities, such as Afroug and Sidi Lamine, but illustrated only a single specimen of *Goniatites sphaericus* (Sowerby, 1814) from Afroug. Delépine (1941) mentioned Late Viséan ammonoids from Afroug, Sidi-Lamine, Tichdadine, Sidi Mohammed Abdallah, Gueltet-el-Fila and Ifri-Guertila. These include the genera *Beyrichoceratoides* Bisat, 1924, *Goniatites* de Haan, 1825, *Metadimorphoceras* Moore, 1958 and possibly *Pachylyroceras* Ruzhencev & Bogoslovskaya, 1971.

Higher diversity assemblages are known from the Jerada Basin. Korn & Ebbighausen (2008) described 27 species from 15 genera across four assemblages, highlighting the close resemblance to ammonoid successions previously documented in the Rhenish Mountains (Korn 1988, 1996), north-western Ireland (Moore & Hodson 1958) and the South Portuguese Zone (Korn 1997; Korn & Horn 1997). At the same time, significant differences were noted in comparison to time-equivalent assemblages from the Anti-Atlas (Korn *et al.* 1999, 2007; Klug *et al.* 2006). Korn *et al.* (2012) further analysed the palaeogeographic patterns of the Late Viséan and demonstrated that, despite its geographical position

between the Cantabrian Mountains and the Anti-Atlas, the Jerada Basin belongs palaeogeographically to the Subvariscan Province.

In this study, we describe some Late Viséan ammonoids to enhance understanding of their distribution in North Africa. Almost all of the cross sections shown here were prepared by the late Volker Ebbighausen, with the final one completed just two days before his tragic and untimely death on 3rd June 2011. The exceptional precision of these sections reflects Volker's deep insight into ammonoid conch geometry and his remarkable technical skill in creating these sections. His ability enabled him to conduct precise analyses of conch ontogeny and make significant contributions to our knowledge of Palaeozoic ammonoids. This paper is, therefore, part of Volker's enduring legacy.

Material and methods

The material described here consists of more than 300 specimens and comes from the following sites in the Moroccan Meseta (Fig. 1).

Sidi Lamine

This site is located on the gently sloping south-eastern side of a low hill, topped by the ruins of an old military post, 1.25 km ESE of Sidi Lamine and 35 km west of Khenifra (32.91425° N, 6.04700° W). The section was sampled by the authors in 2007, 2009, 2010 and (together with Lucyna Leda) in 2011.

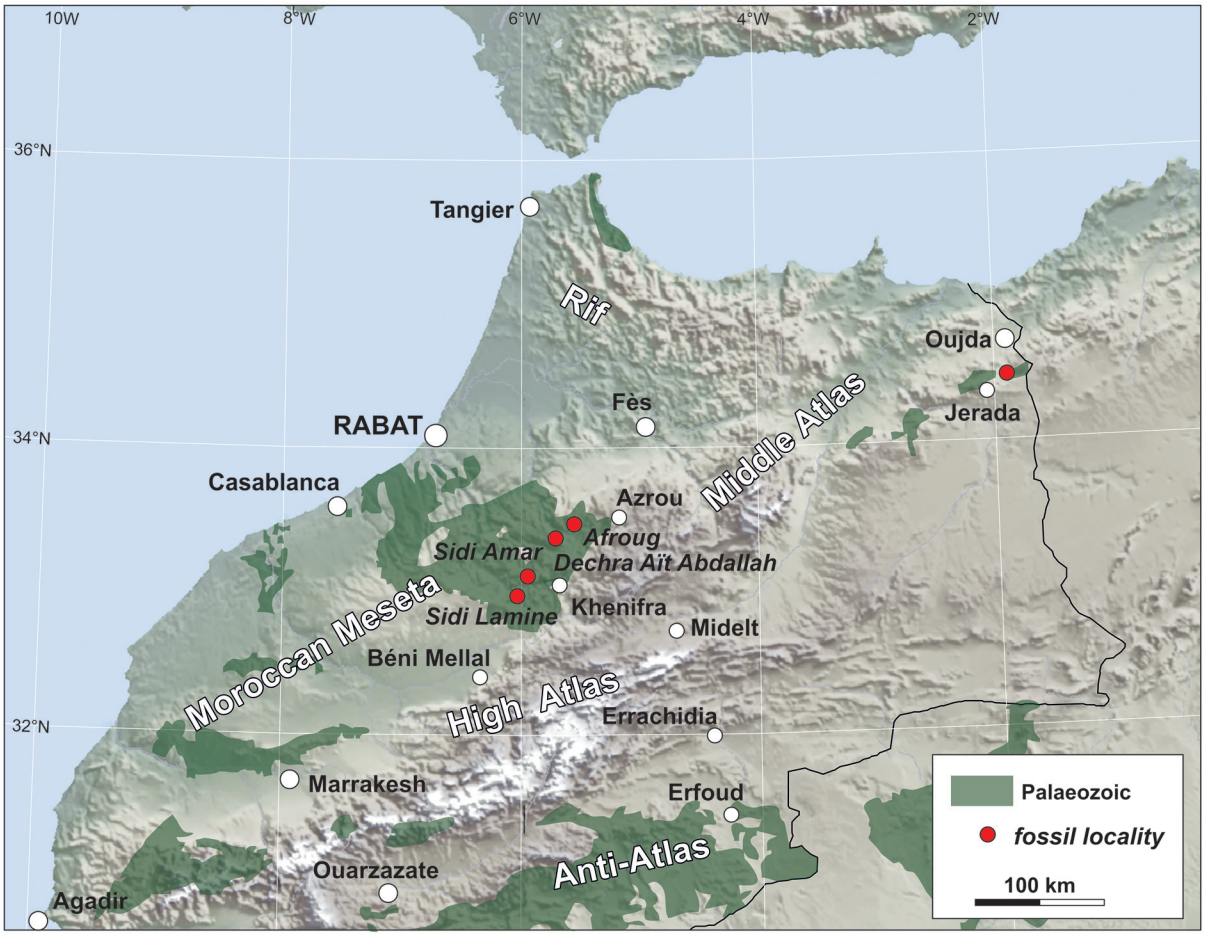

Fig. 1. Topographic map of northern Morocco showing the positions of the fossil localities described here. Basic map from https://de.m.wikipedia.org/wiki/Datei:Morocco_Topography.png; modified.

The exposed section on this slope is approximately 50 metres thick (Fig. 2), starting with a volcanite horizon and primarily consisting of grey shales. These shales frequently contain calcareous and silty horizons, and in the lower part, there are two calciturbidite layers, 2 and 5 cm thick. Five samples yielded macrofossils:

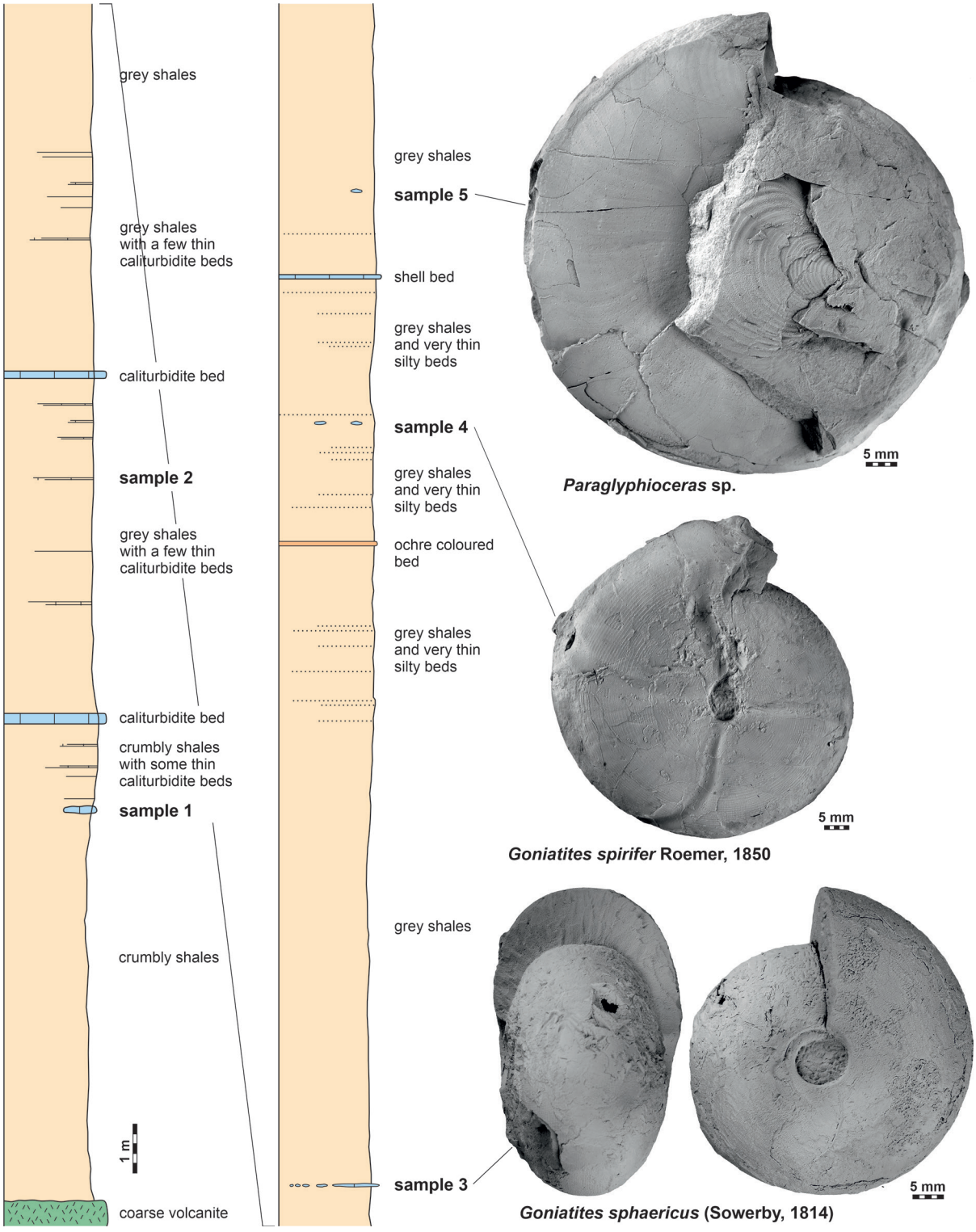

Fig. 2. The Sidi Lamine section with illustrations of some representative ammonoid specimens.

Sample 1 (8.00 m above volcanite): limestone nodule with undeterminable ammonoids.

Sample 2 (14.50 m): calcareous shales containing specimens of the bivalve *Posidonia* Bronn, 1828.

Sample 3 (25.50 m): a lenticular bed with a mass accumulation of ammonoid conchs. The horizon has provided the majority of the specimens described here. This layer is up to 7 cm thick and extends laterally for a few metres. It is densely packed with shell debris, ammonoid conchs, orthoconic nautiloids and bivalves, all deposited chaotically, giving the impression of a tempestite (Fig. 3). The limestone body tapers laterally, where it is represented by smaller nodules containing ammonoids.

Goniatites sphaericus (Sowerby, 1814) – 203 specimens
Girtyoceras ibergense Korn, 1992 – 2 specimens
Nomismoceras sp. – numerous specimens visible in polished rock samples

Sample 4 (41.00 m): small carbonate nodules in an increasingly silty sequence of shales; the nodules contain partly crushed specimens.

Goniatites spirifer Roemer, 1850 – 5 specimens

Sample 5 (about 45.00 m): small carbonate nodules with crushed specimens.

Paraglyphioceras sp. – 2 specimens

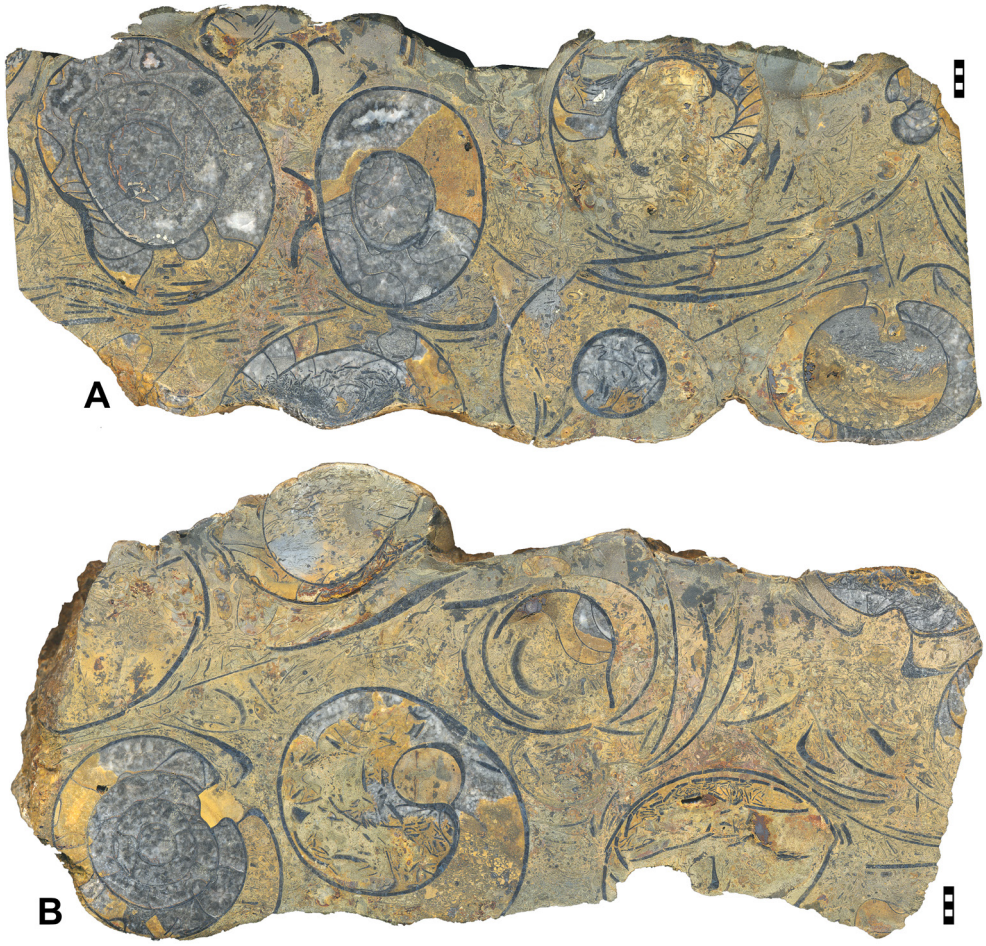

Fig. 3. Polished surfaces of sample 3 from the Sidi Lamine section; Korn & Ebbighausen 2010 Coll. **A**. Specimen MB.C.32211.1. **B**. Specimen MB.C.32211.2. Scale bar units = 1 mm.

Sidi Amar

The fossil site is situated on the southern side of the Tabaïnout mountain ridge, 250 m northwest of the school in Sidi Amar and 16 km west of Khenifra (32.95060° N, 5.83990° W). The locality is renowned for the reef complex that lies beneath the ammonoid-bearing beds (Chanton-Güvenc & Morin 1973; Aretz & Herbig 2010; Somerville *et al.* 2012; Said *et al.* 2013). Two ammonoid assemblages were recorded at this site (Korn and Ebbighausen 2011 Coll.):

Sample 1: coquinas in the topmost part of the carbonate complex:
Goniatites amarensis sp. nov. – 4 specimens
gen. et sp. indet – 1 specimen

Sample 2: Marly shales from the washed surface directly south of the limestone ridge with float material:
Hibernicoceras hibernicus Moore & Hodson, 1958 – 24 specimens
Hibernicoceras mediocre Moore & Hodson, 1958 – 18 specimens
Arnsbergites sp. – 1 specimen
Pronorites sp. – 1 specimen

Dechra Aït Abdallah

Surface material comes from several sites on both sides of the Mrirt-Azrou road, 2 km WNW of Dechra Aït Abdallah, 10.5 km NNW of Mrirt and 33 km NNE of Khenifra (33.24000° N, 5.63700° W). Ammonoids come from three samples (Korn & Ebbighausen 2009 Coll.) and a collection by H. and G. Termier from 1949.
Goniatites sphaericus (Sowerby, 1814) – 30 specimens

Afroug

Northern slope of Afroug mountain, 24 km NNE of Mrirt and 55 km south of Meknès, 33.38240° N, 5.52900° W; float material (Korn & Ebbighausen 2010 Coll.).
Goniatites sphaericus (Sowerby, 1814) – 1 specimen

Jerada

The site is located west of the Oujda–Berguent road, 4 km south of the junction with the road leading to Jerada (34.29650° N, 2.05340° W). Float material was collected 300 m south of the massive limestone ridge (Korn & Ebbighausen 2006 Coll.).
Goniatites spirifer Roemer, 1850 – 13 specimens

The descriptive methods used within this paper are based on those in the key for the description of Palaeozoic ammonoid species published by Korn (2010) and Klug *et al.* (2015), which includes an explanation of the methods (Fig. 4).

Abbreviations

ah = apertural height
dm = conch diameter
IZR = imprint zone rate
uw = umbilical width
WER = whorl expansion rate
wh = whorl height
ww = whorl width

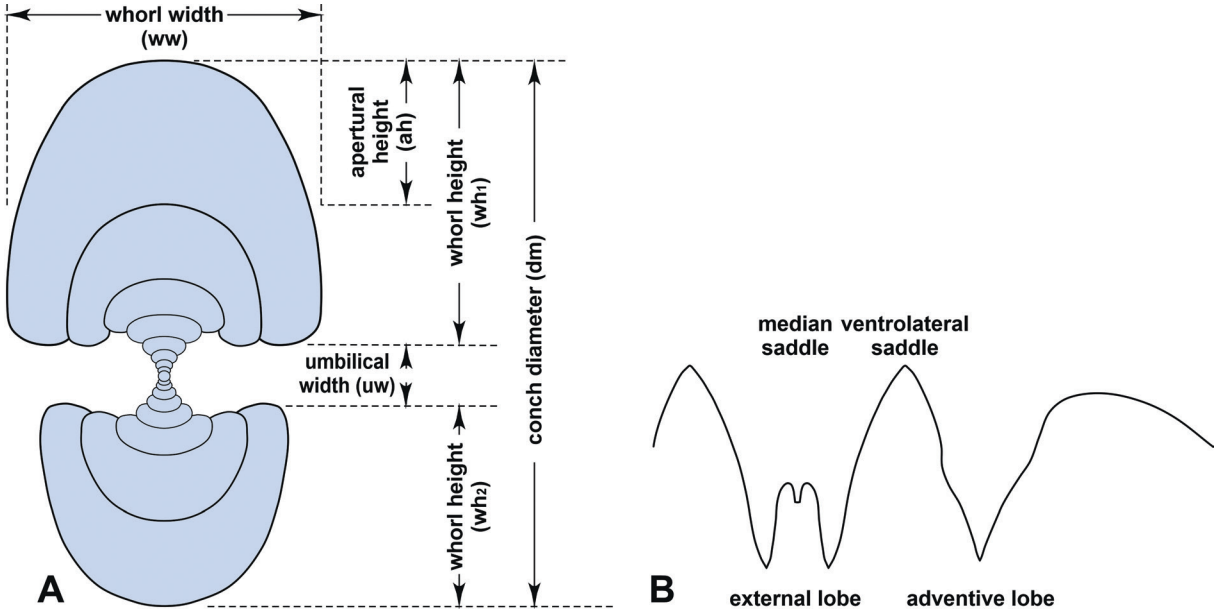

Fig. 4. Morphological terminology used in the ammonoid descriptions. **A**. Conch morphology. **B**. Suture line.

Repositories

GPIC = Technische Universität Clauthal (material on permanent loan to the Geowissenschaftiches Zentrum, Göttingen)
GSM = Geological Survey Museum, Keyworth, Nottingham
MB.C. = collection of fossil cephalopods in the Museum für Naturkunde, Berlin
NHM = British Museum (Natural History), London
SMF.Mbg. = former collection of the Marburg University, now in the Senckenberg Museum, Frankfurt am Main

Results

Class Cephalopoda Cuvier, 1797
Order Goniatitida Hyatt, 1884
Superfamily Goniatitoidea de Haan, 1825
Family Goniatitidae de Haan, 1825
Subfamily Goniatitinae de Haan, 1825

Genus ***Goniatites*** de Haan, 1825

Type species

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

Goniatites crenistria Phillips, 1836

Goniatites crenistria Phillips, 1836: 234, pl. 19 figs 7–9.
Goniatites crenistria dinckleyense Bisat, 1928: 132, pl. 6a fig. 1.

Glyphioceras crenistria – Schmidt 1925: 565, pl. 21 fig. 3.

Goniatites crenistria – Nicolaus 1963: 96, text-figs 30a, 32. — Korn 1988: 83, pl. 17 figs 1–4, pl. 18 figs 1–11, text-figs 30–34 (for more synonymy). — Korn & Ebbighausen 2008: 97, text-figs 16–21. — Nikolaeva 2008: 51, pl. 7 figs 1–4, pl. 8 figs 1–2, 4, pl. 9 figs 1–4, 6, text-figs 1.1–4, 34.

non *Goniatites crenistria* – Delépine 1941: 66, pl. 4 figs 2–3. — Nikolaeva 2008: pl. 9 figs 5, 7, pl. 17 fig. 6.

Diagnosis (from Korn & Ebbighausen 2008, emended)

Species of *Goniatites* reaching a conch diameter of 70 mm. Conch globular at 10 mm diameter (ww/dm ~ 0.90–1.00), pachyconic at 30 mm diameter (ww/dm ~ 0.65–0.75) and thickly discoidal to thinly pachyconic 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), slightly opening in the adult stage; umbilical wall rounded. Coiling rate in the adult stage moderately high (WER ~ 1.75–1.90). Ornamentation with crenulated biconvex and rectiradiate growth lines with low dorsolateral projection and higher ventrolateral projection; external sinus deep. Without spiral lines. Suture line with a V-shaped, moderately narrow external lobe (0.50 of the external lobe depth, 0.90–1.00 of the adventive lobe width) and a moderately high median saddle (0.40 of the external lobe depth). Flanks of the external lobe almost straight, ventrolateral saddle acute, adventive lobe V-shaped with almost straight flanks.

Type material

Lectotype

UNITED KINGDOM – **Lancashire** • 'Bolland'; 'Mountain Limestone' (Late Viséan); Gilbertson Coll.; NHM c282; illustrated by Phillips (1836: pl. 19 figs 7–9), Korn & Ebbighausen (2008: text-fig. 16) and Nikolaeva (2008: pl. 9 fig. 1).

Remarks

The specimens from the Jerada Basin assigned to *Goniatites crenistria* by Korn & Ebbighausen (2008) do not belong to this species, based on the knowledge of the ontogeny of specimens from Sidi Amar. Therefore, a confirmed record of *G. crenistria* from North Africa does not exist. For comparison with the new species *Goniatites amarensis* sp. nov., an emended diagnosis of *G. crenistria* is presented here.

Goniatites amarensis sp. nov.

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Figs 5–6; Tables 1–2, A1

Goniatites crenistria – Korn & Ebbighausen 2008: 97, text-figs 16–21.

Diagnosis

Species of *Goniatites* reaching a conch diameter of 120 mm. Conch globular at 10 mm diameter (ww/dm ~ 1.00), thickly pachyconic at 30 mm diameter (ww/dm ~ 0.80) and thinly pachyconic at 50 mm diameter (ww/dm ~ 0.65). Umbilicus slightly opened in all stages (uw/dm ~ 0.20 between 5 and 20 mm dm), in the adult stage slightly narrower; umbilical wall rounded. Coiling rate low, increasing in the adult stage (WER = 1.75–1.90 between 50 to 100 mm dm). Ornamentation with crenulated, weakly biconvex and rectiradiate growth lines with low dorsolateral and ventrolateral projections; external sinus deep. Without spiral lines. Suture line with a V-shaped, moderately narrow external lobe (~ 0.60 of the external lobe depth, 1.40 of the adventive lobe width), and a moderate median saddle (~ 0.40 of the external lobe depth). Flanks of the external lobe almost straight, ventrolateral saddle subacute, adventive lobe V-shaped with weakly sinuous flanks.

Etymology

Named after the type locality Sidi Amar.

Type material

Holotype

MOROCCO – **Central Meseta** • Sidi Amar, southern side of the Tabaïnout mountain ridge; coquina at the top of the Tabaïnout limestone (Late Viséan); 2011; Korn and Ebbighausen leg.; MB.C.32215.1; illustrated in Fig. 5A.

Paratypes

MOROCCO – **Central Meseta** • 3 specs; same data as for the holotype; MB.C.32215.2 to MB.C.32215.4.

Description

Holotype MB.C.32215.1 is a fully chambered conch with a diameter of 54 mm (Fig. 5A), giving a total size, including the body chamber, of approximately 95 mm. The conch is thinly pachyconic and involute (ww/dm = 0.65; uw/dm = 0.14); the flanks and venter form a broad convex arch and the umbilical margin is uniformly rounded. The coiling rate is moderately high (WER = 1.86). Shell remains are not preserved.

The suture line shows a V-shaped external lobe with nearly straight flanks; the median saddle has a height of 0.40 of the external lobe depth. The external lobe is notably wide, with an external lobe/

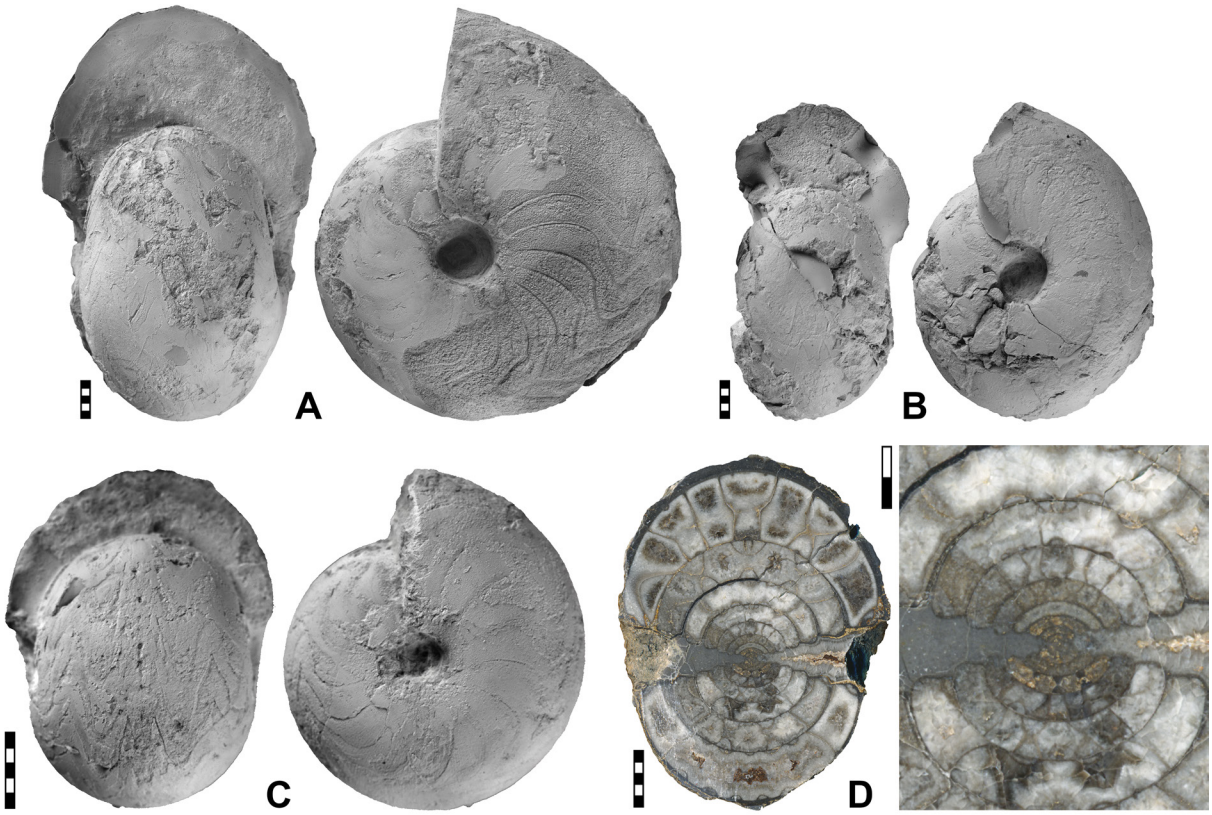

Fig. 5. *Goniatites amarensis* sp. nov. from the lower horizon of Sidi Amar (Central Moroccan Meseta), all Korn and Ebbighausen 2011 Coll. **A**. Holotype MB.C.32215.1. **B**. Paratype MB.C.32215.2. **C**. Paratype MB.C.32215.3. **D.** Paratype MB.C.32215.4; polished section. Scale bar units = 1 mm.

Table 1. Conch dimensions and ratios of specimens of *Goniatites amarensis* sp. nov. from Sidi Amar. Repeated specimen codes represent two measurements at different positions of the same specimen.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
MB.C.32215.1	54.3	34.2	27.0	7.4	14.5	0.63	1.27	0.14	1.86	0.46
MB.C.32215.1	39.8	26.2	19.0	4.8	–	0.66	1.38	0.12	–	–
MB.C.32215.2	40.9	–	17.8	6.8	9.7	–	–	0.17	1.72	0.46
MB.C.32215.3	22.5	17.8	9.7	2.9	4.6	0.79	1.84	0.13	1.58	0.53
MB.C.32215.3	17.9	15.0	7.5	–	–	0.84	2.00	–	–	–

adventive lobe ratio of approximately 1.40. The subacute ventrolateral saddle and the adventive lobe have the same width. The adventive lobe is nearly symmetrical and has weakly sinuous flanks (Fig. 6B).

Paratype MB.C.32215.3 has a conch diameter of 22.5 mm and is preserved without shell remains (Fig. 5C). The conch is thickly pachyconic and involute (ww/dm = 0.79; uw/dm = 0.13); the flanks and the venter form a very broad convex arch and the umbilical margin is uniformly rounded. The phragmocone has about 20 chambers in the last preserved volution.

Paratype MB.C.32215.4 was sectioned, allowing the study of conch ontogeny from the initial stage up to a diameter of 29 mm (Figs 5D, 6A, Table A1). At this diameter, nine and a half volutions are already present. The ontogenetic changes in conch geometry are relatively simple, consisting mainly of the reduction in whorl width relative to both the conch diameter and the whorl height. As a result, the two conch parameters ww/dm and ww/wh appear as nearly monophasic trajectories (Fig. 6C–D). The ratio of umbilical width to conch diameter remains stable throughout ontogeny (Fig. 6C), which is also evident in the cross-sectional illustration of the continuous opening of the umbilicus. The coiling rate changes only slightly, maintaining a value of about 1.50 between 2 and 23 mm conch diameter (Fig. 6E). It appears to increase slightly in the last half evolution, reaching a value of 1.59.

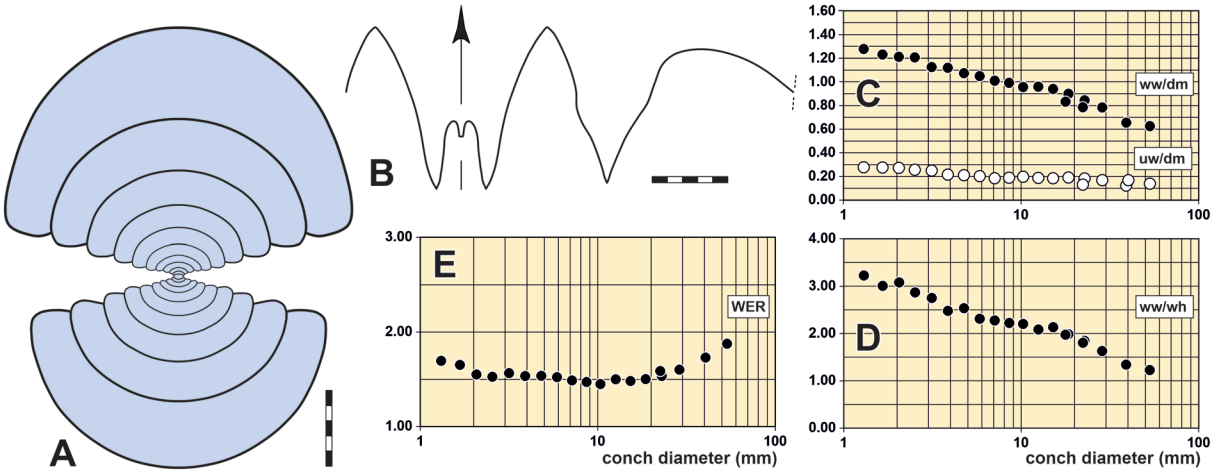

Fig. 6. *Goniatites amarensis* sp. nov. from the lower horizon of Sidi Amar (Central Moroccan Meseta), all Korn and Ebbighausen 2011 Coll. **A**. Paratype MB.C.32215.4; cross section. **B**. Holotype MB.C.32215.1; suture line at ww = 25.8 mm, wh = 19.6 mm. **C–E**. Ontogenetic trajectories of the cardinal conch parameters. Scale bar units = 1 mm.

Table 2. Conch ontogeny of *Goniatites amarensis* sp. nov. from Sidi Amar.

dm	conch shape	whorl cross section shape	whorl expansion
2 mm	spindle-shaped; subinvolute (ww/dm ~ 1.25; uw/dm ~ 0.25)	extremely depressed; very strongly embracing (ww/wh 3.00; IZR ~ 0.50)	low (WER = 1.55)
8 mm	thickly globular; subinvolute (ww/dm ~ 1.00; uw/dm ~ 0.20)	strongly depressed; extremely embracing (ww/wh ~ 2.25; IZR ~ 0.60)	very low (WER ~ 1.48)
20 mm	thinly globular; subinvolute (ww/dm ~ 0.88; uw/dm ~ 0.20)	moderately depressed; extremely embracing (ww/wh ~ 1.80; IZR ~ 0.60)	low (WER ~ 1.50)
50 mm	thinly pachyconic; involute (ww/dm ~ 0.65; uw/dm ~ 0.14)	weakly depressed; very strongly embracing (ww/wh ~ 1.30; IZR ~ 0.50)	moderately high (WER ~ 1.85)

Remarks

The specimens from Sidi Amar closely resemble those from the Jerada Basin in eastern Morocco in terms of conch morphology, and are therefore considered conspecific. The Jerada specimens were previously attributed to *G. crenistria* by Korn & Ebbighausen (2008). However, they reach a much larger conch size of up to 120 mm in diameter compared to *G. crenistria* from the Rhenish Mountains, which only attain about 70 mm in diameter. Another difference between *G. crenistria* and *G. amarensis* is observed in their conch ontogeny, now better understood from the material from Sidi Amar. *Goniatites amarensis* shows a stairway-like opening of the umbilicus, with the uw/dm ratio remaining nearly constant throughout ontogeny. In contrast, *G. crenistria* performs a near-closure of the umbilicus during the growth interval between 5 and 15 mm in conch diameter. Additionally, the rapid increase in the coiling rate in late ontogeny distinguishes *G. amarensis* from *G. crenistria*. In *G. amarensis*, the coiling rate rises from 1.50 to 1.85 between 20 and 55 mm in conch diameter, while in *G. crenistria*, it increases from around 1.60 to 1.70 over the same ontogenetic interval.

Goniatites sphaericus (Sowerby, 1814)
Figs 7–11; Tables 3–5, A2

Conchyliolithus Nautilites (*sphæricus*) Martin, 1809: pl. 7 figs 3–5.
Ammonites sphaericus Sowerby, 1814: 116, pl. 53 fig. 2.
Glyphioceras crenistria var. *globoides* Schmidt, 1925: 566, pl. 21 fig. 1.

Goniatites crenistria – Delépine 1941: 66, pl. 4 figs 2–3.
Goniatites sphaericus – Stubblefield 1951: 120, pl. 7 fig. 1. — Korn 1988: 81, text-figs 28, 29c; 2017: 342, text-figs 5–12 (for more synonymy). — Nikolaeva 2008: 7, pl. 8 fig. 5, text-fig. 1.8–10.
Goniatites fimbriatus – Korn 1988: 89, pl. 20 figs 1–7, pl. 21 figs 1–6, pl. 22 figs 1–4, text-figs 35–36, 37a–c, 38a–b; 1990: 32, pl. 8 figs 1–12, pl. 9 figs 1–11, pl. 10 figs 1–5, text-fig. 11a–d. — Nikolaeva 2008: pl. 14 figs 3, 5, pl. 15 figs 1–2, text-fig. 1.11.

Diagnosis (from Korn 2017, emended)

Species of *Goniatites* reaching a conch diameter of 120 mm. Conch globular at 10 mm diameter (ww/dm = 0.90–1.10), thickly pachyconic at 30 mm diameter (ww/dm = 0.75–0.85) and thinly pachyconic at 50 mm diameter (ww/dm = 0.65–0.70). Umbilicus very narrow at 10 mm dm (uw/dm = 0.05–0.15), in the adult stage slightly opening; umbilical wall rounded. Coiling rate in the adult stage low (WER ~ 1.50). Ornamentation with crenulated rursiradiate and biconvex growth lines with moderate dorsolateral projection and lower ventrolateral projection; external sinus shallow. Delicate spiral lines around the umbilicus caused by crenulation of growth lines. Suture line with a V-shaped, moderately narrow external lobe (0.60 of the external lobe depth, 1.10–1.20 of the adventive lobe width) and a moderately

high median saddle (0.35–0.40 of the external lobe depth); E lobe Y-shaped in very large stages. Flanks of the external lobe weakly sinuous, ventrolateral saddle acute, adventive lobe V-shaped with weakly convex flanks.

Type material

Holotype

UNITED KINGDOM – **Derbyshire** • Derbyshire, without more precise locality information; 'greyish black swinestone' (Late Viséan); Martin Coll.; NHM 43871; illustrated by Stubblefield (1951: pl. 7 fig. 1) and Korn (1988: text-fig. 28; 2017: text-fig. 5a).

Material examined

MOROCCO – **Central Meseta** • 98 specs; Sidi Lamine; sample 3, *Goniatites sphaericus* Zone (Late Viséan); 2007; Korn and Ebbighausen leg.; MB.C.32204.1 to MB.C.32204.98 • 28 specs; same data as for preceding; 2009; Korn and Ebbighausen leg.; MB.C.32205.1 to MB.C.32205.28 • 23 specs; Sidi Lamine; sample 3, *Goniatites sphaericus* Zone (Late Viséan); 2010; Korn and Ebbighausen leg.; MB.C.32206.1 to MB.C.32206.23 • 17 specs; same data as for preceding; 2011; Korn and Ebbighausen leg.; MB.C.32207.1 to MB.C.32207.17 • 7 specs; Dechra Aït Abdallah; sample 1, *Goniatites sphaericus* Zone (Late Viséan); 2009; Korn and Ebbighausen leg.; MB.C.32212.1 to MB.C.32212.7 • 8 specs; same

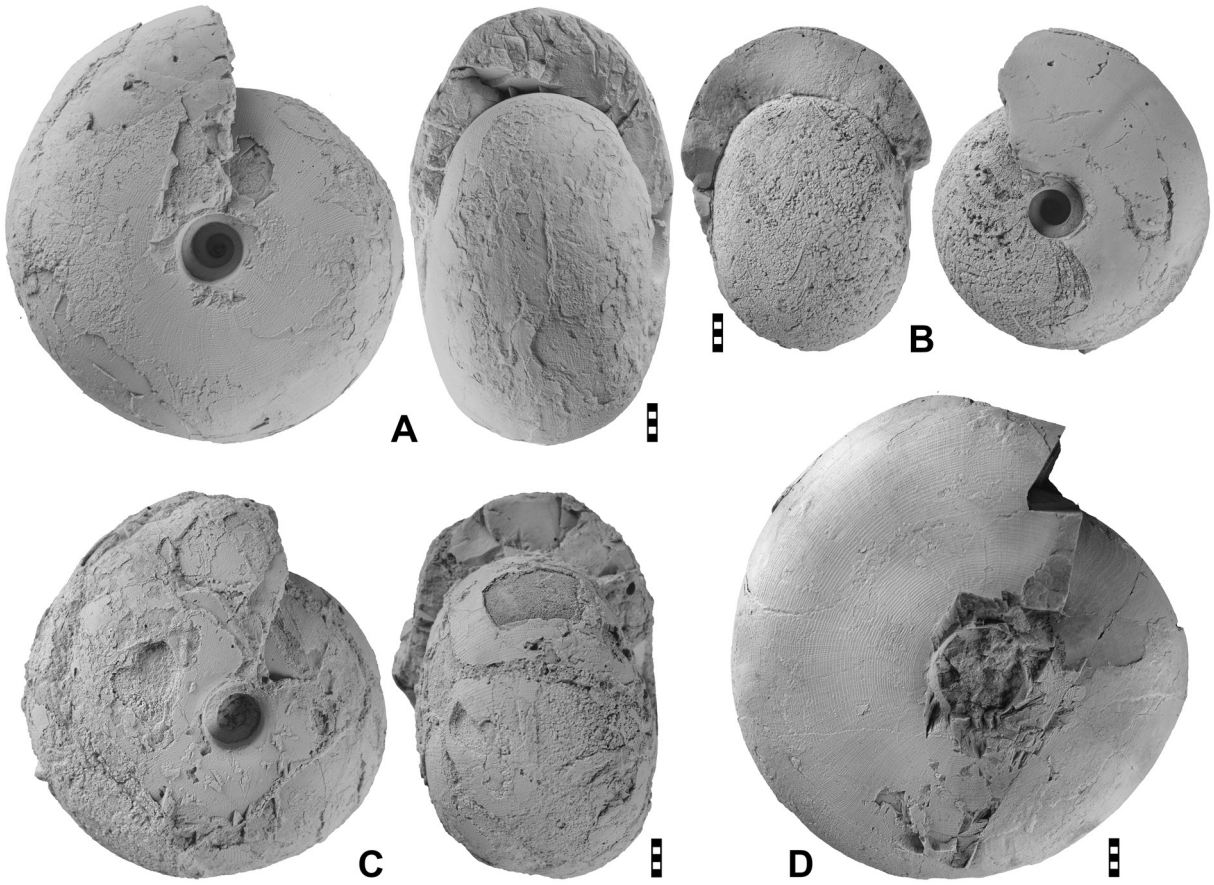

Fig. 7. *Goniatites sphaericus* (Sowerby, 1814), variant 1 (median variant) from sample 3 of Sidi Lamine (Central Moroccan Meseta), all Korn and Ebbighausen 2007–2010 Coll. **A**. Specimen MB.C.32205.1. **B**. Specimen MB.C.32206.1. **C**. Specimen MB.C.32206.2. **D**. Specimen MB.C.32204.1. Scale bar units = 1 mm.

data as for preceding; sample 2; 2009; Korn and Ebbighausen leg.; MB.C.32213.1 to MB.C.32213.8 • 9 specs; same data as for preceding; sample 3; 2009; Korn and Ebbighausen leg.; MB.C.32214.1 to MB.C.32214.9 • 6 specs; same data as for preceding; float material; 1949; H. and G. Termier leg.; MB.C.32215.1 to MB.C.32215.6 • 1 spec.; Afroug; float material, *Goniatites sphaericus* Zone (Late Viséan); 2009; Korn and Ebbighausen leg.; MB.C.32221.

Description

A detailed description of specimens from various regions, including an analysis of intraspecific variation, has been provided by Korn (2017). Therefore, only certain aspects of variation within the sample from Sidi Lamine are highlighted here. *Goniatites sphaericus* occurs in at least three variants at Sidi Lamine, which differ in the ratio of whorl width to conch diameter in the ontogenetic interval above 20 mm conch diameter:

Variant 1 is represented by specimens MB.C.32205.1 (Fig. 7A), MB.C.32206.1 (Fig. 7B), MB.C.32206.2 (Fig. 7C), MB.C.32204.1 (Fig. 7D) and the cross sections of specimens MB.C.32206.5 and MB.C.32206.6 (Fig. 11A–B). This variant can be considered as the intermediate, standard form. It shows a thickly pachyconic conch (ww/dm ~ 0.75) at a diameter of 40 mm. However, this does not imply that the inner whorls share the same geometry and ontogeny, as seen in the two cross sections. For instance, specimen MB.C.32206.5 has a low coiling rate at 3 mm diameter (WER ~ 1.60), while specimen MB.C.32206.6 has a significantly higher coiling rate (WER ~ 1.85). Other differences include MB.C.32206.5 having a more broadly rounded venter, while MB.C.32206.6 possesses an incurved umbilical wall. It seems impossible to assign adult specimens such as MB.C.32205.1 and MB.C.32207.4 to either of these sub-variants without sectioning the conch.

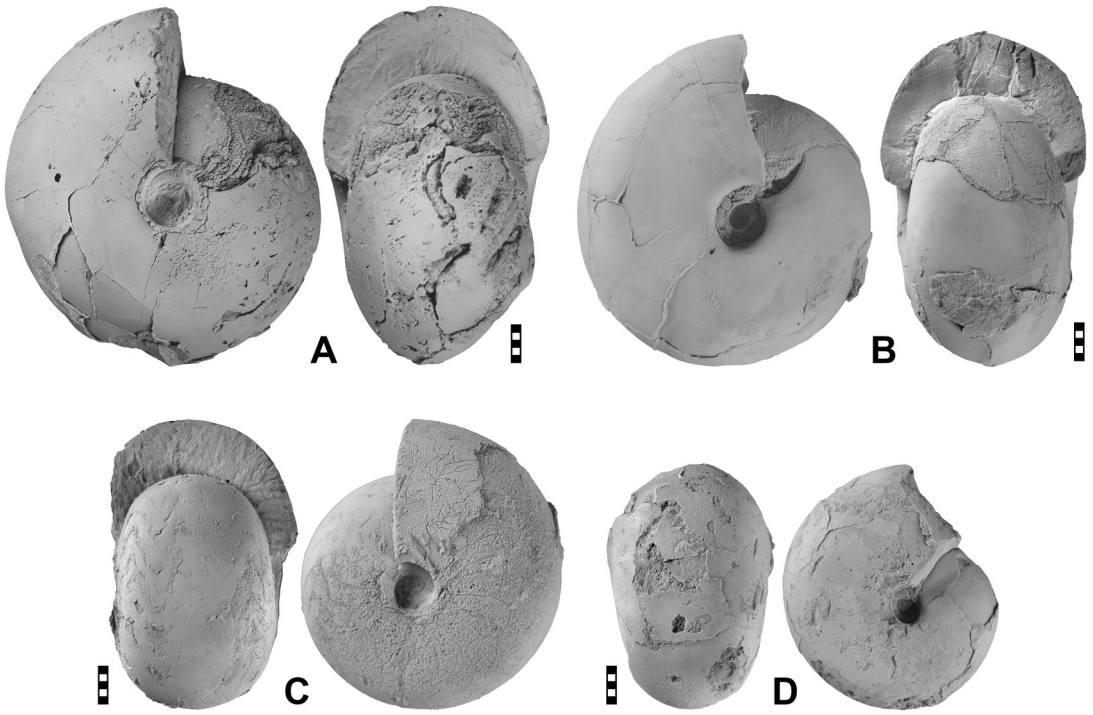

Fig. 8. *Goniatites sphaericus* (Sowerby, 1814), variant 2 (slender variant) from sample 3 of Sidi Lamine (Central Moroccan Meseta), all Korn and Ebbighausen 2009–2011 Coll. **A**. Specimen MB.C.32207.1. **B**. Specimen MB.C.32205.2. **C**. Specimen MB.C.32206.3. **D**. Specimen MB.C.32206.4. Scale bar units = 1 mm.

Table 3. Conch dimensions and ratios of selected specimens of *Goniatites sphaericus* (Sowerby, 1814) from sample 3 of Sidi Lamine.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
MB.C.32207.2	68.8	46.0	32.3	13.1	–	0.67	1.42	0.19	–	–
MB.C.32205.1	58.2	35.0	27.6	8.9	11.1	0.60	1.27	0.15	1.53	0.60
MB.C.32207.4	50.6	32.0	23.5	8.8	9.4	0.63	1.36	0.17	1.51	0.60
MB.C.32206.2	50.3	33.6	25.7	7.6	9.9	0.67	1.31	0.15	1.55	0.61
MB.C.32207.1	47.6	30.1	21.6	7.4	9.1	0.63	1.39	0.16	1.53	0.58
MB.C.32205.2	43.8	27.2	20.4	7.6	8.5	0.62	1.33	0.17	1.54	0.58
MB.C.32206.1	42.6	33.3	20.1	7.9	8.7	0.78	1.66	0.19	1.58	0.57
MB.C.32206.3	38.5	27.4	18.8	6.0	7.2	0.71	1.46	0.16	1.51	0.62
MB.C.32207.3	36.1	28.4	17.0	5.8	6.6	0.79	1.67	0.16	1.50	0.61
MB.C.32204.2	34.8	26.5	16.0	7.2	–	0.76	1.66	0.21	–	–
MB.C.32206.4	33.3	22.2	16.4	4.7	–	0.67	1.35	0.14	–	–

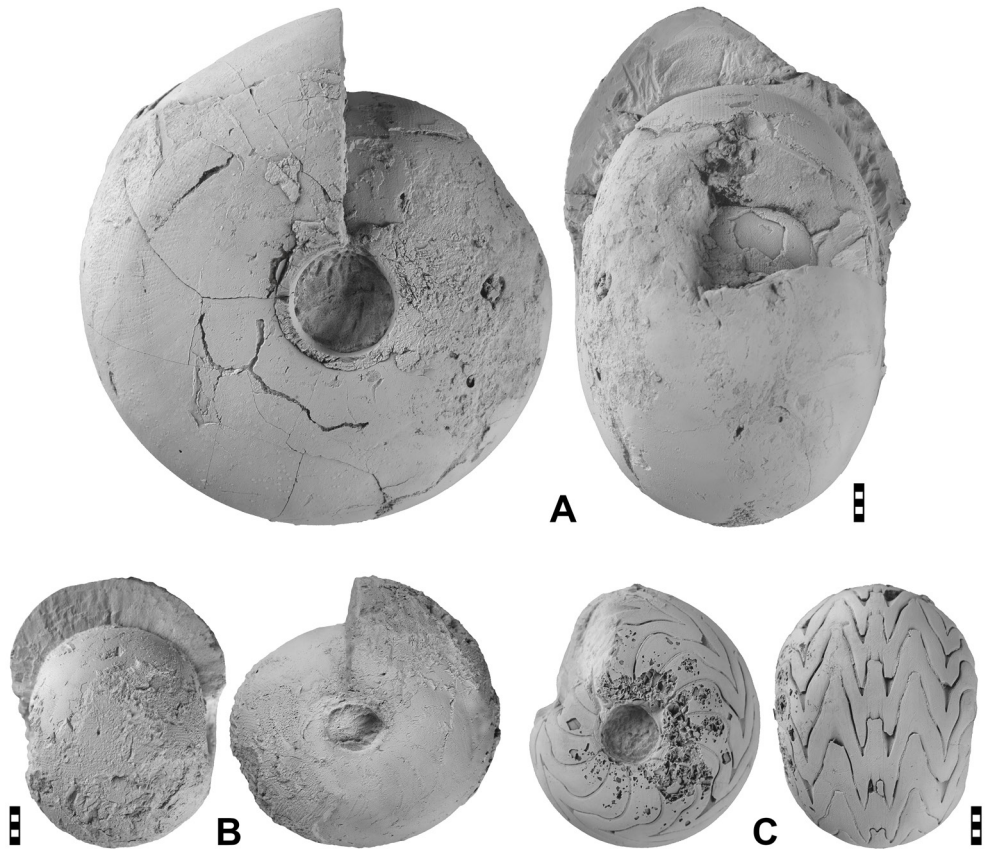

Fig. 9. *Goniatites sphaericus* (Sowerby, 1814), variant 3 (stout variant) from sample 3 of Sidi Lamine (Central Moroccan Meseta), all Korn and Ebbighausen 2007–2011 Coll. **A**. Specimen MB.C.32207.2. **B**. Specimen MB.C.32207.3. **C**. Specimen MB.C.32204.2. Scale bar units = 1 mm.

Variant 2 is represented by specimens MB.C.32207.1 (Fig. 8A), MB.C.32205.2 (Fig. 8B), MB.C.32206.3 (Fig. 8C) and MB.C.32206.4 (Fig. 8D). This variant is characterised by the most slender conch; at a conch diameter of 38 mm, specimen MB.C.32207.1 has a ww/dm value of just 0.67.

Variant 3 is represented by specimens MB.C.32207.2 (Fig. 9A), MB.C.32207.3 (Fig. 9B) and MB.C.32204.2 (Fig. 9C) and the cross sections of specimen MB.C.32206.7 (Fig. 11C). This variant is distinguished by a stout conch; for example, at 36 mm diameter, specimen MB.C.32207.3 has a ww/dm value of 0.79, and at 22 mm conch diameter, specimen Sil3 is nearly spherical (ww/dm = 0.94).

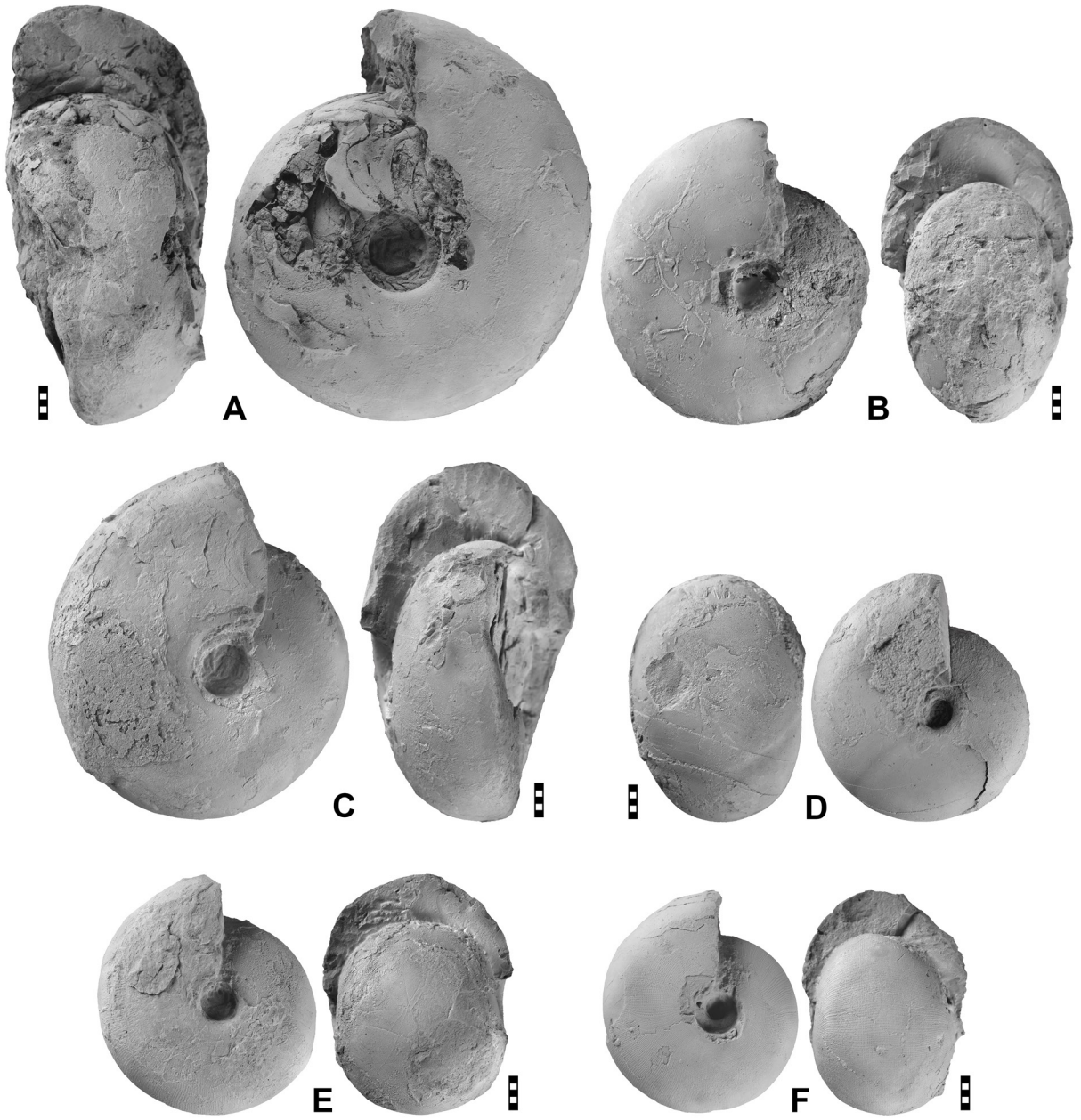

Fig. 10. *Goniatites sphaericus* (Sowerby, 1814) from Dechra Aït Abdallah (Central Moroccan Meseta), Korn and Ebbighausen 2009 Coll. (A–C, E–F), H. and G. Termier 1949 Coll. (D). **A**. Specimen MB.C.32212.1. **B**. Specimen MB.C.32214.1. **C.** Specimen MB.C.32213.1. **D**. Specimen MB.C.32215.1. **E**. Specimen MB.C.32214.2. **F**. Specimen MB.C.32213.2. Scale bar units = 1 mm.

Table 4. Conch dimensions and ratios of selected specimens of *Goniatites sphaericus* (Sowerby, 1814) from Dechra Aït Abdallah.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
MB.C.32213.1	52.7	34.0	25.3	8.4	11.4	0.65	1.34	0.16	1.63	0.55
MB.C.32214.1	45.8	28.4	21.5	6.4	9.6	0.62	1.32	0.14	1.60	0.55
MB.C.32215.1	36.9	25.8	17.7	4.7	7.3	0.70	1.46	0.13	1.55	0.59
MB.C.32214.2	36.0	28.4	16.6	5.2	7.0	0.79	1.71	0.14	1.54	0.58
MB.C.32213.2	32.6	24.5	16.5	4.6	6.3	0.75	1.48	0.14	1.54	0.62

The three variants can also be recognised in the material from Dechra Aït Abdallah (Fig. 10). At this locality, the first variant, which occupies the middle of the morphological spectrum, is the most commonly represented.

Nearly all specimens display a very similar ornamentation, characterised by strongly crenulated growth lines. These growth lines exhibit a low dorsolateral projection, are weakly curved backwards on the flank, and form a broad, shallow ventral sinus. The pronounced crenulation gives rise to clearly visible

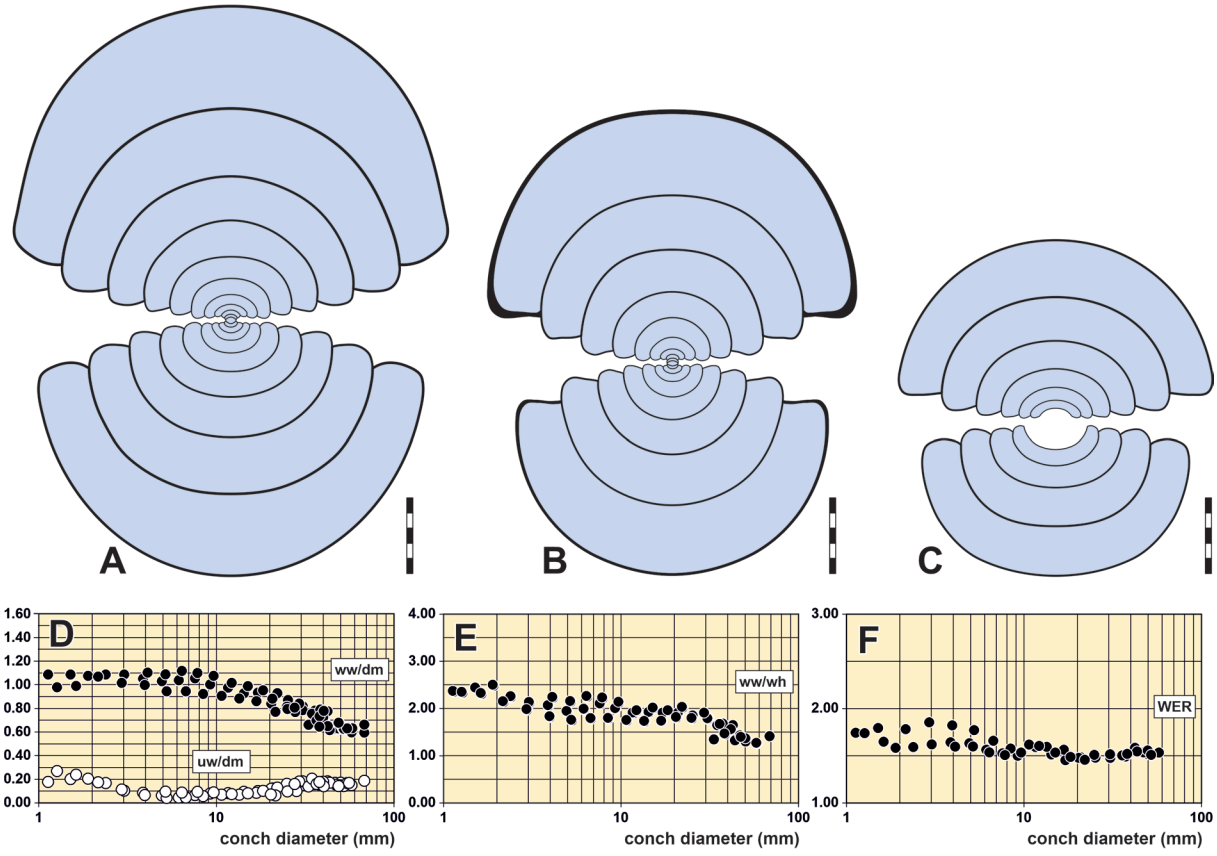

Fig. 11. *Goniatites sphaericus* (Sowerby, 1814) from sample 3 of Sidi Lamine (Central Moroccan Meseta), all Korn and Ebbighausen 2010 Coll. **A**. Cross section of specimen MB.C.32206.5. **B**. Cross section of specimen MB.C.32206.6. **C**. Cross section of specimen MB.C.32206.7. **D–F**. Ontogenetic trajectories of the cardinal conch parameters. Scale bar units = 1 mm.

Table 5. Conch ontogeny of *Goniatites sphaericus* (Sowerby, 1814) from Sidi Lamine.

dm	conch shape	whorl cross section shape	whorl expansion
2 mm	spindle-shaped; subinvolute (ww/dm ~ 1.10; uw/dm ~ 0.20)	strongly depressed; very strongly embracing (ww/wh ~ 2.30; IZR ~ 0.55)	low to mod. high (WER = 1.60–1.80)
8 mm	thickly globular to spindle-shaped; involute (ww/dm = 0.95– 1.10; uw/dm = 0.05)	moderately to strongly depressed; extremely embracing (ww/wh = 1.80–2.20; IZR ~ 0.60)	low (WER = 1.50–1.60)
20 mm	thickly pachyconic to thinly globular; involute (ww/dm = 0.80–0.95; uw/dm ~ 0.10)	moderately depressed; extremely embracing (ww/wh ~ 1.90; IZR ~ 0.60)	low (WER ~ 1.50)
40 mm	pachyconic; involute (ww/dm = 0.65–0.80; uw/dm ~ 0.15)	moderately depressed; extremely embracing (ww/wh ~ 1.55; IZR ~ 0.60)	low (WER ~ 1.50)

spiral lines, particularly noticeable in specimen MB.C.32204.1 (Fig. 7D), where continuous fine spiral lines have developed. These spiral lines are significantly narrower than the spaces separating them.

Remarks

The nomenclatorial history of the species and the type specimen was outlined in detail by Stubblefield (1951).

The material from Sidi Lamine exhibits very similar patterns of morphological variation to those recognised in the Rhenish Mountains (Korn 1988, 1990, 2017). This variation primarily concerns the ww/dm ratio, which is particularly pronounced in the inner whorls, though adult conchs also vary in this respect. Another aspect of variation is the coiling rate, although this is mainly evident during the juvenile stage between 2 and 7 mm conch diameter. Above 10 mm conch diameter, the whorl expansion rate stabilises at around 1.50 in all specimens. This relatively low coiling rate serves as the most reliable criterion for distinguishing *G. sphaericus* from *C. crenistria*, which has a whorl expansion rate of 1.70 or higher in the adult stage.

Goniatites spirifer Roemer, 1850
Figs 12–13; Tables 6–7, A3

Goniatites spirifer Roemer, 1850: 51, pl. 8 fig. 16.

Goniatites striatus – Delépine 1941: 67, pl. 5 figs 1–2.
Glyphioceras striatum spirifer – Kobold 1933: 489, pl. 22 figs 5–6.
Goniatites spirifer – Korn 1988: 93, pl. 23 figs 3–4, pl. 59 figs 5–6; 1990: 33, pl. 11 figs 1–10, pl. 12 figs 9–11, text-fig. 12a–b; 1997: 50, pl. 4 figs 10–11. — Gischler & Korn 1992: 282, text-figs 4g, 6c–d, 7a.

non *Goniatites striatus spirifer* – Nicolaus 1963: 107, pl. 1 fig. 6, pl. 2 figs 2–4, pl. 4 figs 8–11, pl. 5 figs 8–10.

Diagnosis

Species of *Goniatites* reaching a conch diameter of 80 mm. Conch thickly globular at 10 mm diameter (ww/dm ~ 1.00), thickly pachyconic at 30 mm diameter (ww/dm ~ 0.80) and thinly pachyconic at 50 mm diameter (ww/dm ~ 0.70). Umbilicus very narrow at 10 mm dm (uw/dm ~ 0.05), in the adult stage slightly opening; umbilical wall rounded. Coiling rate in the adult stage low (WER ~ 1.50). Ornamentation with spiral lines that are coarser than the growth lines, which are rursiradiate and biconvex with moderate dorsolateral projection and lower ventrolateral projection; external sinus shallow. Suture line with a Y-shaped, moderately narrow external lobe (0.60 of the external lobe depth, 1.20 of the adventive lobe

width) and a moderately high median saddle (0.45 of the external lobe depth). Flanks of the external lobe weakly sinuous, ventrolateral saddle acute, adventive lobe V-shaped with convex flanks.

Type material

Holotype

GERMANY – **Harz Mountains** • Lautenthal, without more precise information; "Posidonomyenschiefer" (Late Viséan); Roemer Coll.; GPIC Nr. 389; illustrated by Roemer (1850: pl. 6 fig. 16) and Gischler & Korn (1992: text-fig. 7a).

Material examined

GERMANY – **Harz Mountains** • 2 specs; Winterberg quarry near Bad Grund; dyke fillings of the *Goniatites spirifer* Zone (Late Viséan); 2015; Knappe leg.; MB.C.32222.1, MB.C.32222.2.

MOROCCO – **Central Meseta** • 5 specs; Sidi Lamine, sample 4; *Goniatites spirifer* Zone (Late Viséan); 2007; Korn and Ebbighausen leg.; MB.C.32208.1 to MB.C.32208.5. – **Jerada Basin** • 13 specs; Oujda-Berguent road, 4 km south of the junction with the road to Jerada; *Goniatites spirifer* Zone (Late Viséan); 2007; Korn and Ebbighausen leg.; MB.C.32220.1 to MB.C.32220.13.

Description

Specimen MB.C.32208.1 (Fig. 12A) is an incomplete, partly crushed conch about 70 mm in diameter, with a fairly well-preserved shell ornament. The ornamentation consists of spiral lines, with around 90 visible between the centre of the venter and the umbilical margin. The spiral lines are typically evenly spaced and slightly narrower than the gaps between them. Very fine granulation appears at the intersections with the much finer biconvex growth lines.

Specimen MB.C.32208.2 (Fig. 12B) is an incomplete, deformed internal mould with a diameter of about 65 mm. The shell ornament is partially preserved, though some of it has been imprinted onto the internal mould. Four constrictions of the internal mould are clearly visible at 90-degree intervals. These constrictions run in a concave arc across the flanks and tend to form a ventral projection.

Specimen MB.C.32220.1 (Fig. 12C) is an internal mould of a specimen with a conch diameter of 47 mm. It is thinly pachyconic and involute (ww/dm = 0.69; uw/dm = 0.12), with a very low coiling rate (WER = 1.46). The whorl profile shows a broad venter and nearly subparallel flanks, with a rounded umbilical margin. The body chamber spans at least one complete volution and displays three constrictions, each with a low, wide dorsolateral projection that extends almost straight across the outer flank and venter. The shell ornament is impressed on the internal mould, consisting of fine spiral lines that are nearly as wide as the spaces between them.

The cross sections of the comparative specimens MB.C.32222.1 (Fig. 13A) and MB.C.32222.2 (Fig. 13B) from Bad Grund in the Harz Mountains provide valuable insights into the ontogenetic development of conch geometry, which is not possible for the Moroccan specimens. Both specimens display almost identical conch geometry and ontogeny, reflected in parallel ontogenetic trajectories (Fig. 13C–E). The whorl profile is C-shaped in all stages beyond 2 mm conch diameter, but the ww/dm ratio decreases steadily from 1.20 to 0.80 as the conch diameter increases from 2 to 48 mm. Simultaneously, the ww/wh ratio drops from 2.60 to 1.60.

The ontogenetic trajectory of the coiling rate exhibits noticeable oscillation. An early ontogenetic stage with a low coiling rate (WER = 1.60) up to 2 mm shell diameter is followed by an accelerated coiling rate, reaching about 1.90 between 5 and 7 mm diameter, before decreasing again to approximately 1.50 between 30 and 50 mm diameter.

Table 6. Conch dimensions and ratios of a selected specimen of *Goniatites spirifer* Roemer, 1850 from the Oujda-Berguent road.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
MB.C.32220.1	46.7	32.2	22.6	5.8	8.1	0.69	1.42	0.12	1.46	0.64

Remarks

Specimens of *Goniatites spirifer* from Sidi Lamine were previously illustrated by Delépine (1941: pl. 5 figs 1–2) under the name "*Goniatites striatus*". These show a preservation state very similar to the newly collected material.

Goniatites spirifer is a common species in the Rhenish Mountains (Korn 1988, 1990), though reports of well-preserved three-dimensional specimens are rare. As a result, the species has occasionally been misinterpreted, as in the case of Nicolaus (1963), who incorrectly attributed stratigraphically older forms to *G. spirifer*.

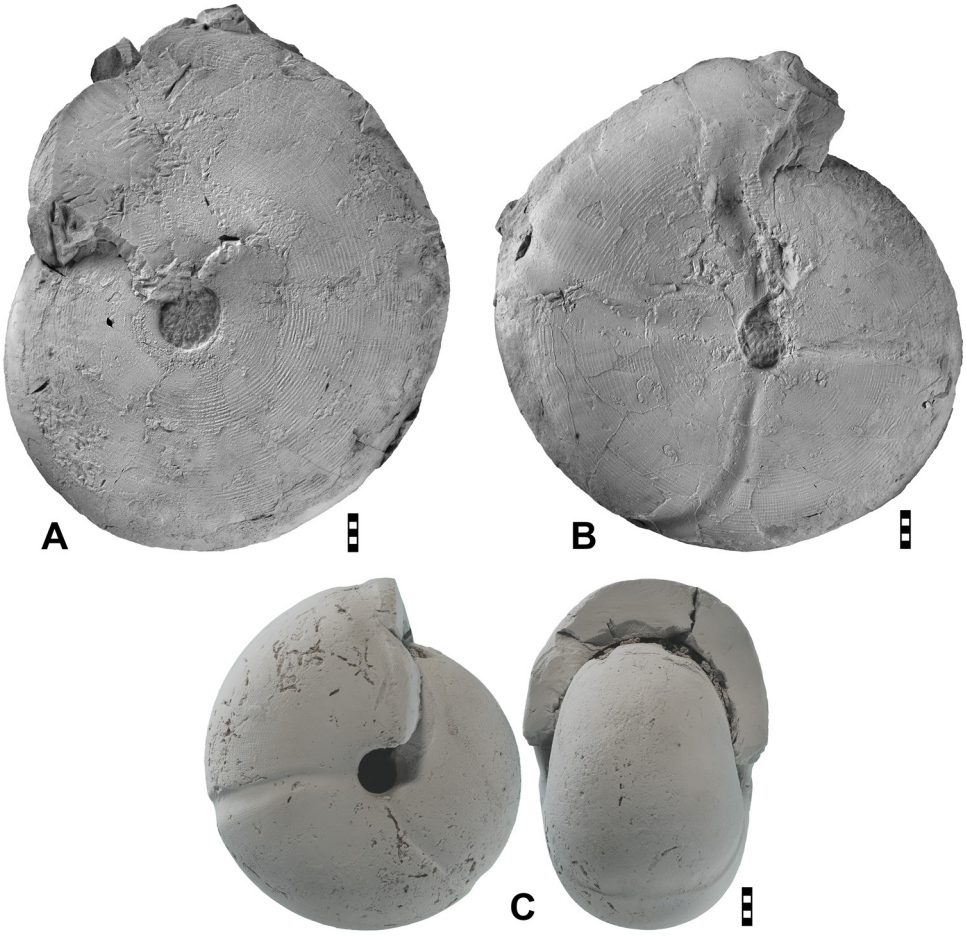

Fig. 12. *Goniatites spirifer* Roemer, 1850. **A**. Specimen MB.C.32208.1 (Korn and Ebbighausen 2007 Coll.) from sample 4 of Sidi Lamine (Central Moroccan Meseta). **B**. Specimen MB.C.32208.2 (Korn and Ebbighausen 2007 Coll.) from sample 4 of Sidi Lamine (Central Moroccan Meseta). **C**. Specimen MB.C.32220.1 (Korn and Ebbighausen 2006 Coll.) from 4 km south of the road crossing of the Oujda–Berguent road with the road to Jerada. Scale bar units = 1 mm.

Table 7. Conch ontogeny of *Goniatites spirifer* Roemer, 1850 from the Winterberg near Bad Grund (Harz Mountains, Germany).

dm	conch shape	whorl cross section shape	whorl expansion
2 mm	spindle-shaped; subinvolute (ww/dm ~ 1.20; uw/dm ~ 0.20)	strongly depressed; very strongly embracing (ww/wh ~ 2.60; IZR ~ 0.55)	low (WER ~ 1.60)
8 mm	thickly globular; involute (ww/dm ~ 0.95; uw/dm = 0.05)	moderately depressed; extremely embracing (ww/wh ~ 1.90; IZR ~ 0.55)	moderately high (WER ~ 1.85)
20 mm	thinly globular; involute (ww/dm ~ 0.90; uw/dm ~ 0.05)	moderately depressed; extremely embracing (ww/wh ~ 1.65; IZR ~ 0.55)	low (WER ~ 1.65)
40 mm	pachyconic; involute (ww/dm ~ 0.80; uw/dm ~ 0.12)	moderately depressed; extremely embracing (ww/wh ~ 1.60; IZR ~ 0.60)	very low (WER ~ 1.50)

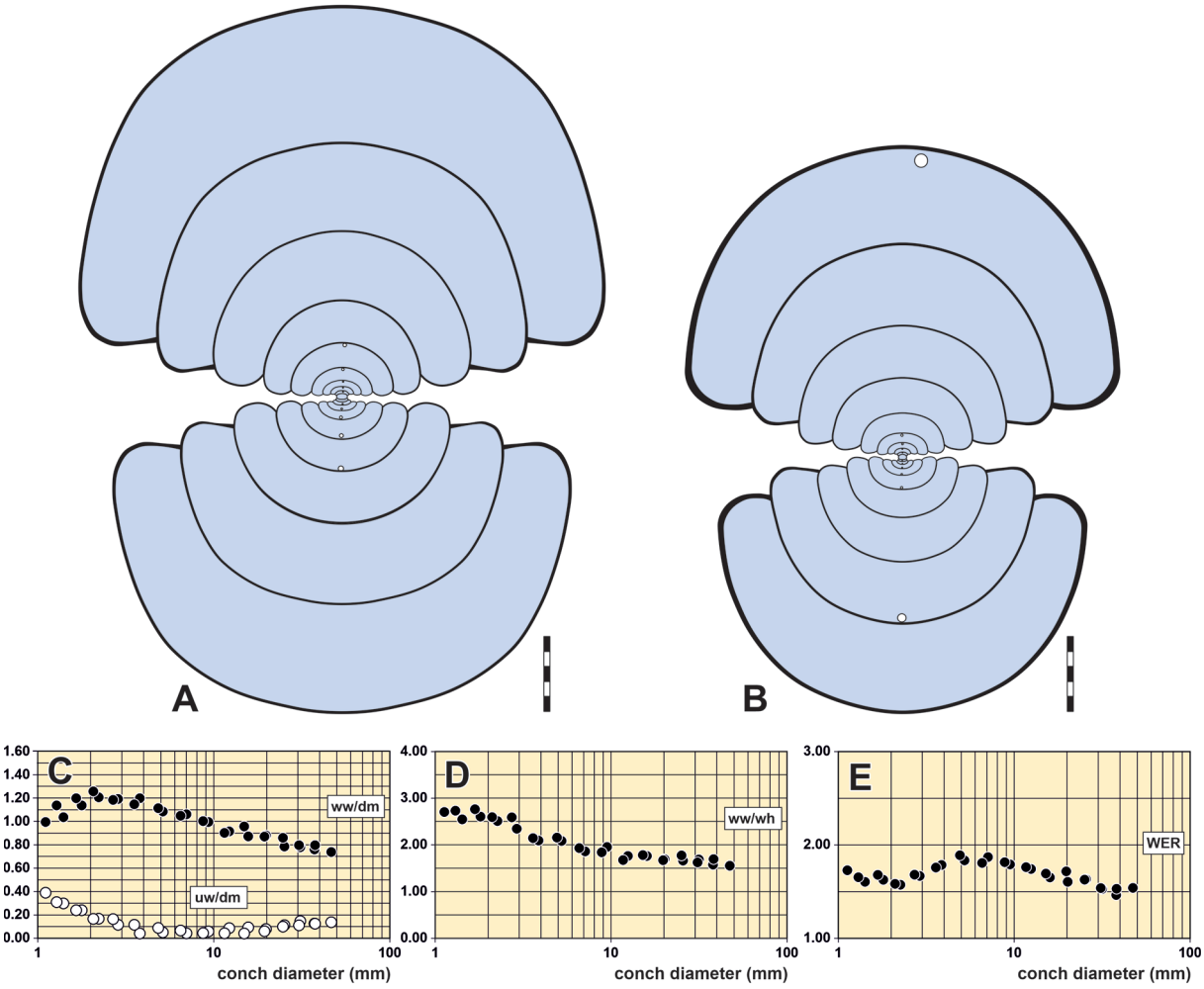

Fig. 13. *Goniatites spirifer* Roemer, 1850 from the Winterberg limestone quarry (Harz Mountains, Germany), both Knappe 2015 Coll. **A**. Cross section of specimen MB.C.32222.1. **B**. Cross section of specimen MB.C.32222.2. **C–E**. Ontogenetic trajectories of the cardinal conch parameters. Scale bar units = 1 mm.

Subfamily Arnsbergitinae Korn & Ebbighausen, 2008

Genus ***Arnsbergites*** Korn, 1988

Type species

Goniatites falcatus Roemer, 1850; by original designation.

Arnsbergites sp.
Fig. 14; Tables 8, A4

Material examined

MOROCCO – **Central Meseta** • 1 spec.; Sidi Amar, southern side of the Tabaïnout mountain ridge; Late Viséan; 2011; Korn and Ebbighausen leg.; MB.C.32216.

Description

The sectioned specimen MB.C.32216 is rather poorly preserved but shows delicate spiral lines across the flanks and venter. It provides insight into conch ontogeny from the initial stage up to a conch diameter of 17.6 mm (Fig. 14A). The specimen passes through two stages of conch ontogeny, with the transition occurring at approximately 2–2.5 mm in diameter. During the first stage, the whorl profile is kidney-shaped and strongly depressed, while in the second stage, it becomes C-shaped with a very high overlap rate. Notably, the umbilicus gradually closes from a conch diameter of around 5 mm, with the uw/dm ratio reaching just 0.08 at a diameter of 17.6 mm (Fig. 14B).

Remarks

The cross section of specimen MB.C.32216 cannot be attributed to any of the species of *Arnsbergites* from the Chebket el Hamra site (Jerada region, north-eastern Morocco). In contrast to MB.C.32216, all specimens from that locality display an umbilicus that continues to open, albeit slowly, during later stages of ontogeny (Korn & Ebbighausen 2008). This characteristic is also seen in material from other regions, such as southern Portugal (Korn 1997), Ireland (Moore & Hodson 1958) and the Rhenish Mountains (Korn 1990).

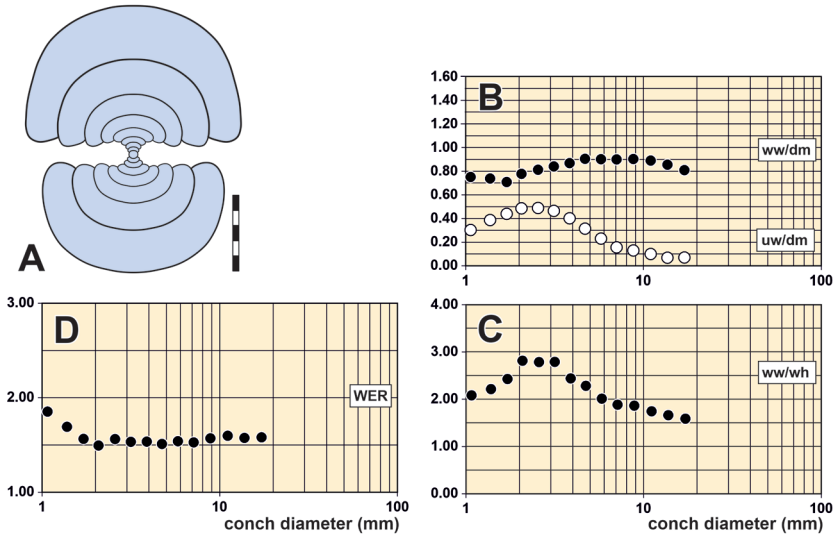

Fig. 14. *Arnsbergites* sp. from Sidi Amar (Central Moroccan Meseta), specimen MB.C.32216 (Korn and Ebbighausen 2011 Coll.). **A**. Cross section. **B–D**. Ontogenetic trajectories of the cardinal conch parameters. Scale bar units = 1 mm.

Table 8. Conch ontogeny of *Arnsbergites* sp. from Sidi Amar (Moroccan Meseta).

dm	conch shape	whorl cross section shape	whorl expansion
2 mm	thickly pachyconic; evolute (ww/dm ~ 0.75; uw/dm ~ 0.50)	very strongly depressed; widely embracing (ww/wh ~ 2.80; IZR ~ 0.35)	low (WER ~ 1.50)
8 mm	thinly globular; subinvolute (ww/dm ~ 0.90; uw/dm = 0.15)	moderately depressed; extremely embracing (ww/wh ~ 1.90; IZR ~ 0.60)	low (WER ~ 1.50)
17 mm	thickly pachyconic; involute (ww/dm ~ 0.80; uw/dm = 0.08)	moderately depressed; extremely embracing (ww/wh ~ 1.60; IZR ~ 0.60)	low (WER ~ 1.55)

Genus ***Hibernicoceras*** Moore & Hodson, 1958

Type species

Hibernicoceras hibernicus Moore & Hodson, 1958; by original designation.

Hibernicoceras hibernicus Moore & Hodson, 1958
Figs 15–17; Tables 9–10, A5

Hibernicoceras hibernicus Moore & Hodson, 1958: 87, pl. 3 figs 1–2, text-fig. 1.

Hibernicoceras hibernicus – Kumpera & Lang 1975: pl. 3 fig. 6, pl. 4 fig. 2.
Hibernicoceras hibernicum – Korn 1997: 54, pl. 6 figs 3–5, text-fig. 44.

non *Hibernicoceras hibernicum* – Liang & Wang 1991: 98, pl. 24 figs 15–16, text-fig. 69.

Diagnosis

Species of *Hibernicoceras* with a thickly pachyconic conch at 5 mm diameter (ww/dm ~ 0.80), a thickly pachyconic conch at 10 mm diameter (ww/dm ~ 0.80) and a thickly pachyconic conch at 30 mm diameter (ww/dm ~ 0.75). Umbilicus very wide in early juvenile stage (uw/dm ~ 0.50 at 2 mm dm) and becoming continuously narrower throughout ontogeny (uw/dm ~ 0.20–0.28 at 10 mm dm, uw/dm ~ 0.20 at 30 mm dm); umbilical wall sigmoidal in section with shallow spiral groove. Ornamentation at 20 mm conch diameter with wide-standing, rectiradiate growth-lines with low lateral projections. Spiral lines in a moderately wide zone on the inner flank; growth lines crenulated on the flank but almost smooth on the venter. Suture line with a weakly Y-shaped, moderately wide external lobe in the adult stage (0.60–0.70 of the external lobe depth; 1.45 of the adventive lobe width), and moderate median saddle (almost 0.45 of the external lobe depth). Ventrolateral saddle narrowly rounded, adventive lobe with slightly sinuous flanks.

Type material

Holotype

IRELAND – **County Leitrim** • Townland of Carraun, north-east slope of Dough Mountain, two miles south-west of Kiltyclogher; beds a few feet above the highest beds with *G. sphaericostriatus* (Late Viséan); Moore and Hodson Coll.; GSM ZI3025; illustrated by Moore & Hodson (1958: pl. 3 figs 1–2), re-illustrated here in Fig. 15A.

Material examined

MOROCCO – **Central Meseta** • 24 specs; Sidi Amar, southern side of the Tabaïnout mountain ridge; Late Viséan; 2011; Korn and Ebbighausen leg.; MB.C.32217.1 to MB.C.32217.24.

Description

Specimen MB.C.32217.1 is the largest of the available specimens, with a conch diameter of 42 mm (Fig. 15B). The specimen is fully chambered and has undergone two phases of corrosion. The first phase occurred during embedding, which resulted in the destruction of the body chamber and the erosion of much of the shell surface. After this, the specimen acted as a 'benthic island', serving as a substrate for crinoids to attach. The second phase of erosion and corrosion occurred more recently, during the weathering of the surrounding shales. Consequently, only small fragments of the shell ornamentation have been preserved. The specimen is thinly pachyconic and involute (ww/dm = 0.70; uw/dm = 0.12); the preserved shell fragments exhibit fine spiral lines on the inner flank and widely spaced, apparently uncrenulated growth lines on the venter.

Specimen MB.C.32217.2 is a somewhat corroded, fully septate conch with a diameter of 23 mm (Fig. 15C). It is thickly pachyconic and subinvolute (ww/dm = 0.82; uw/dm = 0.23) with a moderately depressed whorl profile (ww/wh = 1.84) and a low coiling rate (WER = 1.54). Although much of the shell surface has eroded, some details are well preserved in the dorsal whorl area. The specimen possesses very coarse growth lines that curve backwards from the umbilicus, along with around ten spiral lines on the inner flank, which are much finer than the growth lines.

The six sectioned specimens (MB.C.32217.4–MB.C.32217.9) show remarkable similarity in both conch geometry and ontogeny (Figs 16, 17A–F), resulting in minimal variation in the conch parameter diagrams (Fig. 17G–I). All specimens display a continuous transition from the early juvenile stage, characterised by a kidney-shaped whorl profile, to the middle ontogenetic stage, where the whorl profile becomes

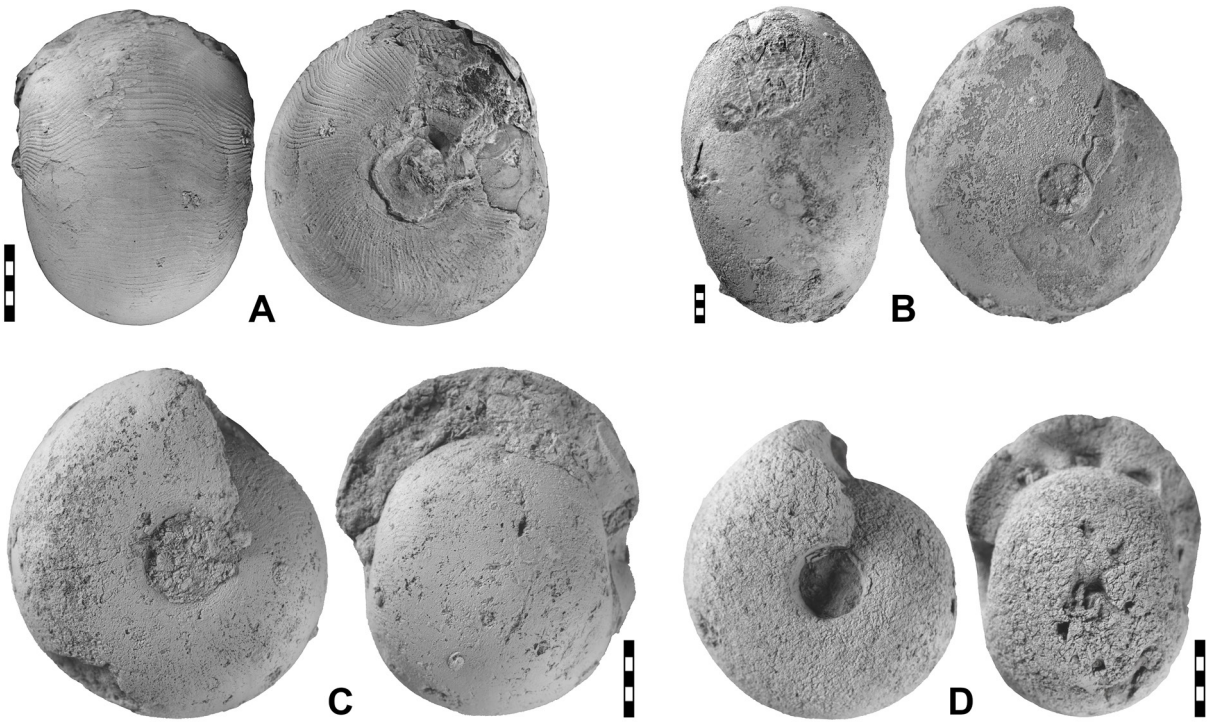

Fig. 15. *Hibernicoceras hibernicus* Moore & Hodson, 1958. **A**. Holotype GSM ZI3025 (Moore and Hodson Coll.) from the Townland of Carraun (Ireland). **B**. Specimen MB.C.32217.1 (Korn and Ebbighausen 2011 Coll.) from the upper horizon of Sidi Amar (Central Moroccan Meseta). **C**. Specimen MB.C.32217.2 (Korn and Ebbighausen 2011 Coll.) from the upper horizon of Sidi Amar. **D**. Specimen MB.C.32217.3 (Korn and Ebbighausen 2011 Coll.) from the upper horizon of Sidi Amar. Scale bar units = 1 mm.

Table 9. Conch dimensions and ratios of selected specimens of *Hibernicoceras hibernicus* Moore & Hodson, 1958 from Sidi Amar (Moroccan Meseta).

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
MB.C.32217.1	41.9	29.3	18.4	5.0	-	0.70	1.59	0.12	-	-
MB.C.32217.2	23.2	19.1	10.4	5.3	4.5	0.82	1.84	0.23	1.54	0.56
MB.C.32217.3	20.2	15.9	9.2	4.4	4.0	0.79	1.74	0.22	1.55	0.57

C-shaped. This shift is clearly reflected in the ontogenetic trajectories. The ww/wh ratio increases nearly to 3.00 up to a conch diameter of 3 mm, then decreases almost continuously to around 1.60 at a diameter of 20 mm. Similarly, the uw/dm trajectory rises to 0.50 by 2.5 mm in conch diameter, followed by a gradual decline to 0.20 at 30 mm. A common feature across in all cross sections is the sinuous umbilical wall, which becomes more pronounced in varying degrees once the conch reaches a diameter larger than 9 mm.

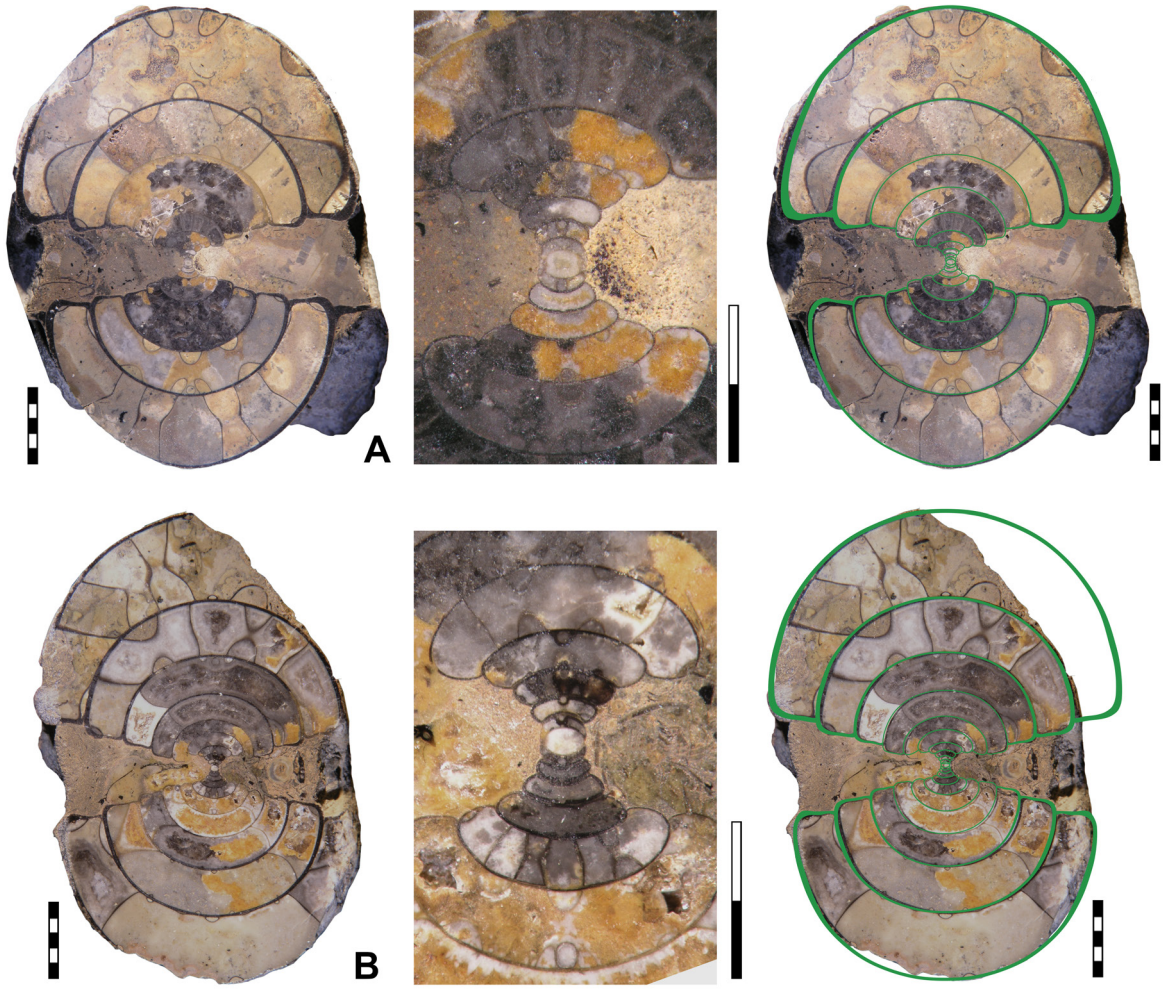

Fig. 16. *Hibernicoceras hibernicus* Moore & Hodson, 1958 from the upper horizon of Sidi Amar (Central Moroccan Meseta), all Korn and Ebbighausen 2011 Coll.; polished cross sections and vectorisation (partly with some corrections). **A**. Specimen MB.C.32217.4. **B**. Specimen MB.C.32217.5. Scale bar units = 1 mm.

Remarks

Moore & Hodson (1958) described the type species as *Hibernicoceras hibernicus*, using a masculine ending, although *Hibernicoceras* actually requires a neuter ending. The authors consistently used this spelling, so it must be assumed that it was intentional. Since Moore & Hodson (1958) did not clarify whether they used "*hibernicus*" as an adjective ("Irish") or as a noun ("the Irish"), the ending probably does not require a correction to "*hibernicum*" according to Article 34.2 of the ICZN Code (ICZN 1999).

The specimen illustrated by Liang & Wang (1991) as *Hibernicoceras hibernicum* does obviously not belong to this species, as it exhibits spiral lines on the flank.

Hibernicoceras hibernicus is distinguished from most other species in the genus primarily by its stout conch. The ww/wh ratio of approximately 0.75 at a 30 mm conch diameter is higher than that of many other species, which typically do not exceed a value of 0.70. This is especially true for species such

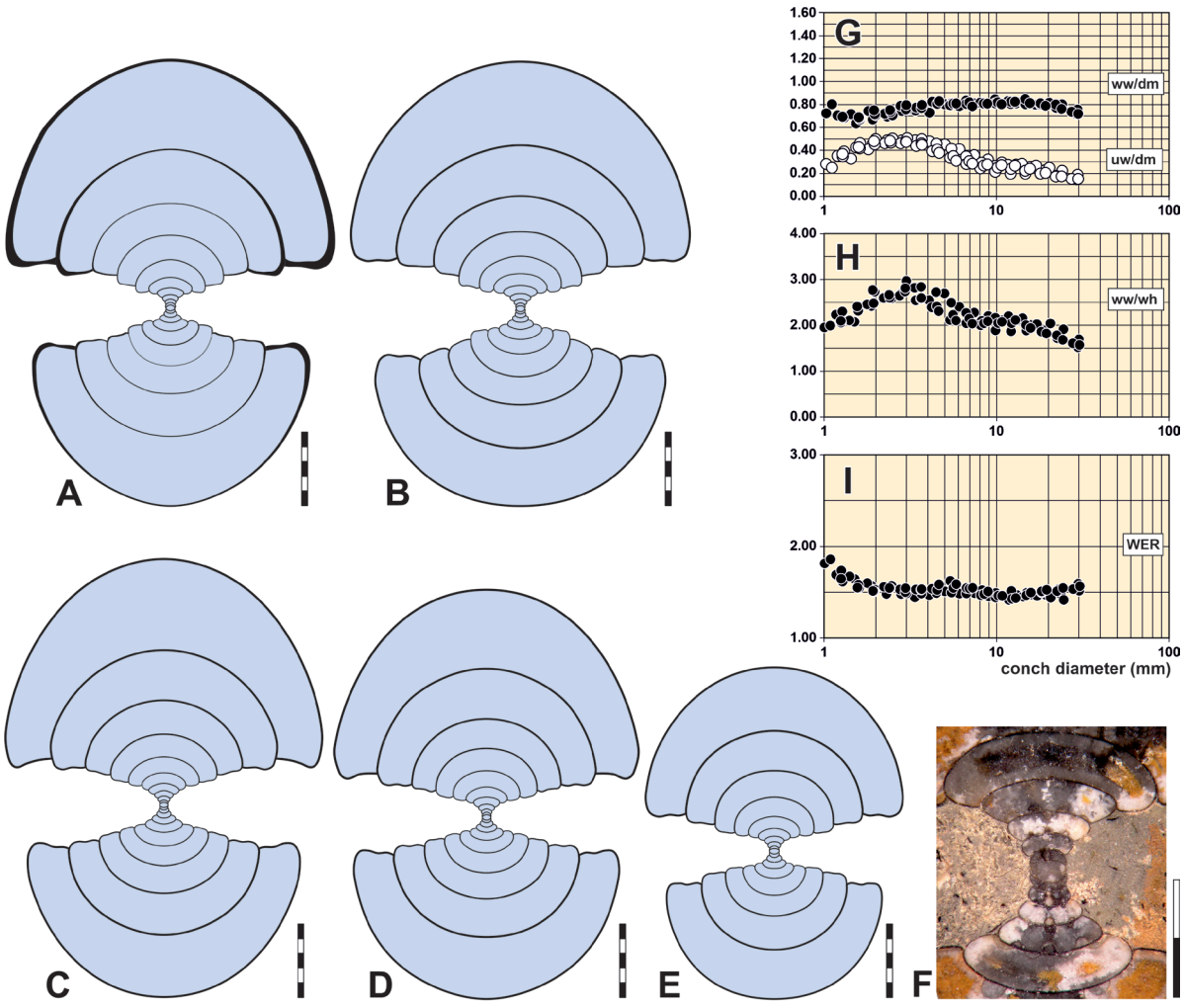

Fig. 17. *Hibernicoceras hibernicus* Moore & Hodson, 1958 from the upper horizon of Sidi Amar (Central Moroccan Meseta), all Korn and Ebbighausen 2011 Coll. **A**. Cross section of specimen MB.C.32217.4. **B**. Cross section of specimen MB.C.32217.6. **C**. Cross section of specimen MB.C.32217.7. **D**. Cross section of specimen MB.C.32217.8. **E**. Cross section of specimen MB.C.32217.9. **F**. Polished cross section of specimen MB.C.32217.6. **G–I**. Ontogenetic trajectories of the cardinal conch parameters. Scale bar units = 1 mm.

Table 10. Conch ontogeny of *Hibernicoceras hibernicus* Moore & Hodson, 1958 from Sidi Amar (Moroccan Meseta).

dm	conch shape	whorl cross section shape	whorl expansion
2 mm	thinly pachyconic; evolute (ww/dm ~ 0.70; uw/dm ~ 0.48)	very strongly depressed; moderately embracing (ww/wh ~ 2.60; IZR ~ 0.28)	low (WER ~ 1.55)
8 mm	thickly pachyconic; subinvolute (ww/dm ~ 0.80; uw/dm = 0.28)	strongly depressed; extremely embracing (ww/wh ~ 2.10; IZR ~ 0.50)	low (WER ~ 1.55)
15 mm	thickly pachyconic; subinvolute (ww/dm ~ 0.80; uw/dm = 0.25)	strongly depressed; extremely embracing (ww/wh ~ 2.05; IZR ~ 0.55)	very low (WER ~ 1.45)
30 mm	thinly pachyconic; subinvolute (ww/dm ~ 0.70; uw/dm ~ 0.18)	moderately depressed; extremely embracing (ww/wh ~ 1.65; IZR ~ 0.55)	very low (WER ~ 1.55)

as *H. mediocre*, *H. carraunense*, and *H. alentejoense* (Korn & Ebbighausen 2008), which have long-distance growth lines. The species is particularly characterised by a sigmoidal umbilical wall with a spiral groove, rarely seen in other species.

Hibernicoceras mediocre Moore & Hodson, 1958
Figs 18–19; Tables 11, A6

Hibernicoceras mediocris Moore & Hodson, 1958: 93, pl. 6 figs 1–2, text-fig. 5.

Hibernicoceras mediocris – Kumpera & Lang 1975: pl. 1 fig. 5.

non *Hibernicoceras mediocris* – Liang & Wang 1991: 99, pl. 22 figs 9–10, pl. 23 figs 1–8, pl. 24 figs 13–14, text-fig. 71.

Diagnosis

Species of *Hibernicoceras* with a thickly pachyconic conch at 5 mm diameter (ww/dm ~ 0.80), a thickly pachyconic conch at 10 mm diameter (ww/dm ~ 0.80) and a thinly pachyconic conch at 30 mm diameter (ww/dm ~ 0.65). Umbilicus very wide in early juvenile stage (uw/dm ~ 0.45 at 2 mm dm) and becoming continuously narrower throughout ontogeny (uw/dm ~ 0.15–0.20 at 10 mm dm, uw/dm ~ 0.15 at 30 mm dm); umbilical wall sigmoidal with shallow spiral groove. Ornamentation at 20 mm conch diameter with moderately wide-standing, rectiradiate growth-lines with low lateral projections. Spiral lines in a narrow zone on the inner flank; growth lines weakly crenulated on the flank but almost smooth on the venter. Suture line with a weakly Y-shaped, moderately wide external lobe in the adult stage (0.70–0.75 of the external lobe depth; 1.45 of the adventive lobe width), and a moderate median saddle (almost 0.45 of the external lobe depth). Ventrolateral saddle very narrowly rounded, adventive lobe with slightly sinuous flanks.

Type material

Holotype

IRELAND – **County Leitrim** • Townland of Carraun, north-east slope of Dough Mountain, two miles south-west of Kiltyclogher; beds a few feet above the highest beds with *G. sphaericostriatus* (Late Viséan); Moore and Hodson Coll.; GSM ZI3014; illustrated by Moore & Hodson (1958: pl. 6 figs 1–2), re-illustrated here in Fig. 18A.

Table 11. Conch ontogeny of *Hibernicoceras mediocre* Moore & Hodson, 1958 from Sidi Amar (Moroccan Meseta).

dm	conch shape	whorl cross section shape	whorl expansion
2 mm	thickly pachyconic; evolute (ww/dm ~ 0.75; uw/dm ~ 0.45)	very strongly depressed; widely embracing (ww/wh ~ 2.70; IZR ~ 0.32)	low (WER ~ 1.60)
8 mm	thickly pachyconic; subinvolute (ww/dm ~ 0.80; uw/dm = 0.20)	moderately depressed; extremely embracing (ww/wh ~ 1.70; IZR ~ 0.50)	low (WER ~ 1.65)
20 mm	thickly pachyconic; involute (ww/dm ~ 0.75; uw/dm = 0.12)	moderately depressed; extremely embracing (ww/wh ~ 1.60; IZR ~ 0.55)	low (WER ~ 1.65)

Material examined

MOROCCO – **Central Meseta** • 18 specs; Sidi Amar, southern side of the Tabaïnout mountain ridge; Late Viséan; 2011; Korn and Ebbighausen leg.; MB.C.32218.1 to MB.C.32218.18.

Description

Specimen MB.C.32218.1 (Fig. 18B) is an incomplete, fully chambered conch with a diameter of 32 mm. The conch is almost entirely covered by a recrystallised shell, which may also be encrusted. It is thinly pachyconic and involute (ww/dm = 0.65; uw/dm = 0.14), with a moderately high whorl expansion rate (WER = 1.90).

The two sectioned specimens MB.C.32218.2 and MB.C.32218.3 (Fig. 19A–B) are largely identical in terms of their conch geometry but differ in the development of the umbilical width. In specimen MB.C.32218.2, the umbilicus opens slowly after reaching a conch diameter of 8 mm, with the uw/dm ratio remaining almost constant at 0.19. In contrast, specimen MB.C.32218.3 exhibits a tubular umbilicus with a stagnant umbilical width, leading to a decreasing uw/dm ratio, which eventually reaches 0.11. Both specimens show a sinuous umbilical wall from a conch diameter of about 8 mm. In particular, specimen MB.C.32218.2 displays a distinct incurve in the middle of the umbilical wall.

Remarks

Moore & Hodson (1958) described the species as *Hibernicoceras mediocris*, i.e., with a masculine ending, although *Hibernicoceras* actually requires a neuter ending. As "*mediocris*/*mediocre*" is an

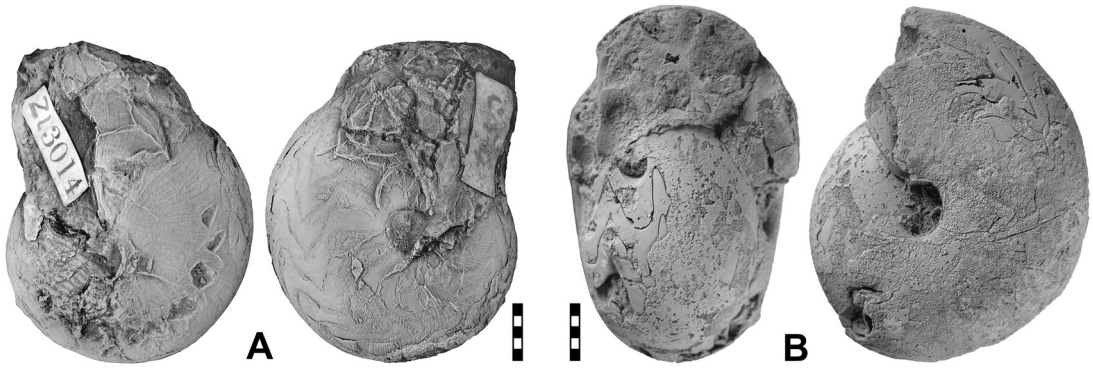

Fig. 18. *Hibernicoceras mediocre* Moore & Hodson, 1958. **A**. Holotype GSM ZI3014 (Moore and Hodson Coll.) from the Townland of Carraun (Ireland). **B**. Specimen MB.C.32218.1 (Korn and Ebbighausen 2011 Coll.) from the upper horizon of Sidi Amar (Central Moroccan Meseta). Scale bar units = 1 mm.

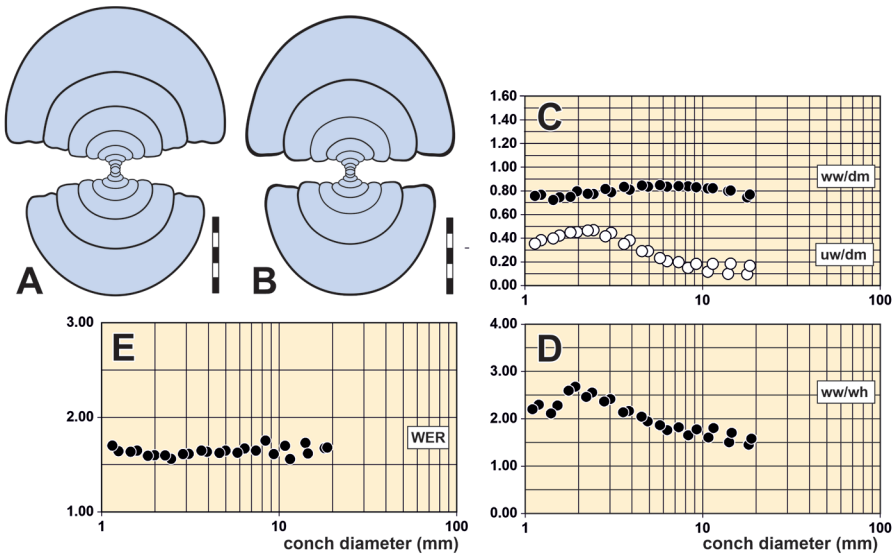

Fig. 19. *Hibernicoceras mediocre* Moore & Hodson, 1958 from Sidi Amar (Central Moroccan Meseta), all Korn and Ebbighausen 2011 Coll. **A**. Cross section of specimen MB.C.32218.2. **B**. Cross section of specimen MB.C.32218.3. **C–E**. Ontogenetic trajectories of the cardinal conch parameters. Scale bar units = 1 mm.

adjective, the ending needs to be corrected to "*mediocre*" according to Article 34.2 of the ICZN Code (ICZN 1999).

Hibernicoceras mediocre differs from most other species in the genus by its rectiradiate growth lines, which have a rather pronounced ventrolateral projection. Additionally, the growth lines in *H. mediocre* are finer than those found in most other species.

The specimens identified by Liang & Wang (1991) as *Hibernicoceras mediocris*, with a ww/dm ratio of about 0.70 at 40 mm conch diameter, appear to be too stout to be attributed to this species.

Superfamily Girtyoceratoidea Wedekind, 1918
Family Girtyoceratidae Wedekind, 1918

Genus ***Girtyoceras*** Wedekind, 1918

Type species

Adelphoceras meslerianum Girty, 1909; by original designation.

Remarks

The European and North African species of the genus *Girtyoceras* were compared by Korn & Ebbighausen (2008), who grouped them based on conch morphology and ornamentation. They noted that 16 species had been described from European material, but only a few of these species have been characterised in detail, particularly with regard to the ontogenetic development of their conch geometry and ornamentation. However, this ontogenetic approach is essential for accurately defining species within the genus, as distinguishing between species often requires comparing specimens of the same size or ontogenetic stage. Without ontogenetic series, it is difficult to recognise the subtle variations in conch shape and ornamentation that differentiate species of *Girtyoceras*.

Table 12. Conch dimensions and ratios of selected specimens of *Girtyoceras ibergense* Korn, 1992 from the Iberg in the Harz Mountains and from sample 3 of Sidi Lamine.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
GPIC C420	34.4	11.6	19.0	3.7	12.7	0.34	0.61	0.11	2.51	0.33
SMF-Mbg.4726	16.5	7.5	8.4	2.1	–	0.45	0.89	0.13	–	–
MB.C.32210.1	15.9	7.4	8.5	2.4	4.6	0.47	0.87	0.15	1.98	0.46
MB.C.32210.2	8.2	4.7	2.9	2.9	1.8	0.57	1.62	0.35	1.64	0.38

Girtyoceras ibergense Korn, 1992
Fig. 20; Table 12

Goniatites discus Roemer, 1852: 95, pl. 13 fig. 35.
Girtyoceras ibergense Korn in Gischler & Korn, 1992: 278, text-figs 4m–n, 5b, 6g–h.

Homoceras discus – Schmidt 1925: 577, pl. 21 fig. 16, pl. 24 figs 10–11.

non *Goniatites discus* Roemer, 1850: 39, pl. 6 fig. 7.

Diagnosis

Species of *Girtyoceras* with a discoidal, subinvolute conch at 15 mm diameter (ww/dm ~ 0.45; uw/dm ~ 0.15) and a thinly, involute conch at 35 mm diameter (ww/dm ~ 0.35; uw/dm ~ 0.10). Umbilical margin rounded. Venter rounded up to 12 mm conch diameter; sharpening of the venter begins at 30 mm dm. Internal mould in the preadult stage with very weak, slightly biconvex and rectiradiate constrictions. Without riblets.

Type material

Holotype

GERMANY – **Harz Mountains** • 'Grund' (most probably the Iberg near Bad Grund); "Posidonienkalk" (Late Viséan); Roemer Coll.; GPIC Nr. 420; illustrated by Roemer (1852: pl. 13 fig. 35) and Gischler & Korn (1992: text-fig. 7a).

Material examined

MOROCCO – **Central Meseta** • 2 specs; Sidi Lamine, sample 3; 2010; Korn and Ebbighausen leg.; MB.C.32210.1, MB.C.32210.2.

Description

Holotype GPIC420 (Fig. 20A) has a conch diameter of 35 mm. It is thinly discoidal and involute (ww/dm = 0.34; uw/dm = 0.11) with an extremely high coiling rate (WER = 2.51). At this stage, the venter is not yet acute, and the rounded umbilical margin shows no indication of a ridge. In some areas, remains of the shell are preserved; the fine growth lines follow a biconvex course with a pronounced ventrolateral projection. Constrictions appear as shallow notches on the flank. The suture line shows the typical course for *Girtyoceras*, with a V-shaped external lobe, a median saddle reaching half the height of the ventrolateral saddle and a V-shaped adventive lobe.

Specimen MB.C.32210.1 (Fig. 20C) is an incomplete conch with a diameter of 16 mm. It is thickly discoidal and subinvolute (ww/dm = 0.47; uw/dm = 0.15) with a moderate coiling rate (WER = 1.98). The internal mould is nearly smooth except for one rather weak constriction with a biconvex course.

Remarks

Roemer described species named *Goniatites discus* two times (Roemer 1850, 1852). These are demonstrably different species: the species established in 1850 comes from the Iberg Limestone of the Frasnian stage and is a gephuroceratid ammonoid; the form described in 1852 is a *Girtyoceras*. Thus, *Goniatites discus* Roemer, 1852 represents a homonym of *Goniatites discus* Roemer, 1850 and was revised under the new name *Girtyoceras ibergense* by Korn in Gischler & Korn (1992).

Although only a few specimens are available, it is possible to distinguish *G. ibergense* from other species of *Girtyoceras*. Stratigraphically younger species, such as *G. brueningianum* (Schmidt, 1925) and *G. goii* Korn, 1988, always display a distinct umbilical ridge, weak ribbing and a considerably earlier sharpening of the venter.

It is more challenging to differentiate it from species known from the Bowland Shales of England. Despite similarly weak ornamentation, *G. premeslerianum* Moore, 1946 and *G. platyforme* Moore, 1946 exhibit a 1.5 times wider umbilicus. *Girtyoceras simplex* Moore 1946 is distinguishable from *G. ibergense* by the tapering of the external side starting at a conch diameter of 23 mm.

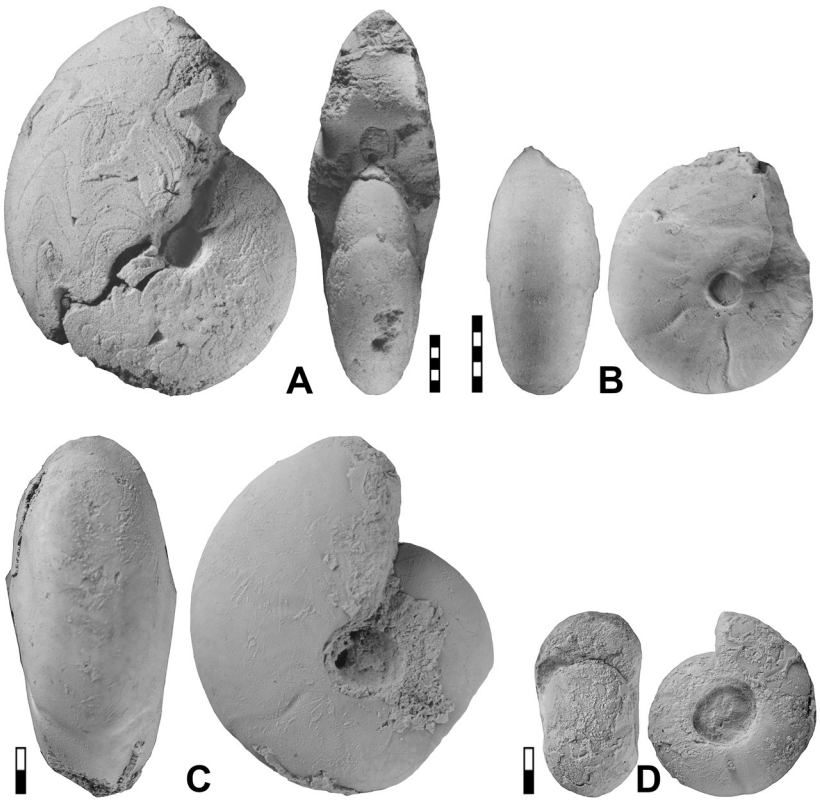

Fig. 20. *Girtyoceras ibergense* Korn, 1992. **A**. Holotype GPIC Nr. 420 (Roemer Coll.) from the Iberg (Harz Mountains, Germany). **B**. Specimen SMF-Mbg.4726 from the Iberg (Harz Mountains). **C**. Specimen MB.C.32210.1 (Korn and Ebbighausen 2010 Coll.) from sample 3 of Sidi Lamine (Central Moroccan Meseta). **D**. Specimen MB.C.32210.2 (Korn and Ebbighausen 2010 Coll.) from sample 3 of Sidi Lamine. Scale bar units = 1 mm.

Family indet.

gen. et sp. indet.
Fig. 21; Tables 13, A7

Material examined

MOROCCO – **Central Meseta** • 1 spec.; Sidi Amar, southern side of the Tabaïnout mountain ridge; coquina at the top of the Tabaïnout limestone (Late Viséan); 2011; Korn and Ebbighausen leg.; MB.C.32219; illustrated in Fig. 21A.

Description

Specimen MB.C.32219 allows the study of the conch ontogeny from the initial stage up to a diameter of 33 mm (Fig. 21A). Three stages with different whorl profiles can be distinguished. The first stage up to a conch diameter of 2.5 mm has a strongly depressed kidney-shaped profile. In the second stage, between 2.5 and 15 mm conch diameter, the profile is C-shaped with a distinct, tightly rounded umbilical wall created by an umbilical wall directed towards the venter. The third stage shows a rounding of the umbilical margin; the last half whorl is also characterised by a very rapid increase in the coiling rate (Fig. 21D). The umbilicus opens, albeit slowly, throughout ontogeny; the uw/dm trajectory describes a weakly triphasic course with a maximum value of about 0.35 reached between 2 and 7 mm conch diameter (Fig. 21B).

Remarks

Due to its peculiar conch ontogeny, it is difficult to place this specimen in a genus of Late Viséan ammonoids. Although the shape is similar to that of species of *Beyrichoceras* at 33 mm in diameter, the ontogeny is very different. In *Beyrichoceras*, the early whorls are evolute with a uw/dm value above 0.50, and thereafter the umbilicus becomes either tubular or even closed by wide overlapping of the flanks (Korn & Tilsley 2006). In specimen MB.C.32219 the uw/dm only reaches 0.37 and the umbilicus gradually opens throughout ontogeny. Therefore, this specimen can not be attributed to a distinct genus.

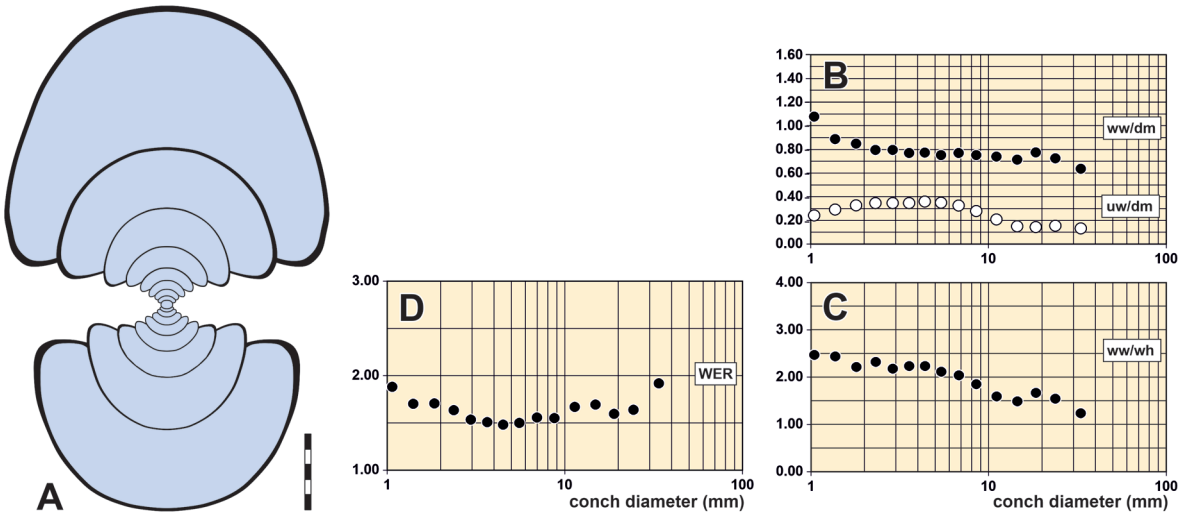

Fig. 21. gen. indet. sp. from Sidi Amar (Central Moroccan Meseta), specimen MB.C.32219 (Korn and Ebbighausen 2011 Coll.) **A**. Cross section. **B–D**. Ontogenetic trajectories of the cardinal conch parameters. Scale bar units = 1 mm.

Table 13. Conch ontogeny of gen. indet. sp. from Sidi Amar (Moroccan Meseta).

dm	conch shape	whorl cross section shape	whorl expansion
2 mm	thickly pachyconic; subevolute (ww/dm ~ 0.80; uw/dm ~ 0.35)	strongly depressed; widely embracing (ww/wh ~ 2.30; IZR ~ 0.35)	low (WER ~ 1.70)
8 mm	thickly pachyconic; subevolute (ww/dm ~ 0.80; uw/dm = 0.35)	moderately depressed; very widely embracing (ww/wh ~ 1.90; IZR ~ 0.50)	low (WER ~ 1.60)
15 mm	thickly pachyconic; subinvolute (ww/dm ~ 0.75; uw/dm = 0.15)	moderately depressed; very widely embracing (ww/wh ~ 1.55; IZR ~ 0.50)	low (WER ~ 1.70)
30 mm	thinly pachyconic; subinvolute (ww/dm ~ 0.65; uw/dm = 0.15)	weakly depressed; very widely embracing (ww/wh ~ 1.30; IZR ~ 0.50)	moderately high (WER ~ 1.90)

Discussion

Late Viséan ammonoids from the Central Moroccan Meseta are described for the first time. Several localities, such as Sidi Lamine, Sidi Amar, and Dechra Aït Abdallah, have yielded low-diversity assemblages, composed mainly of species already known from localities in southern Portugal, Ireland, northern England and the Rhenish Mountains. This clearly places the Moroccan Meseta within the Rhenohercynian-Subvariscan faunal province. The assemblages described from the Moroccan Meseta belong to a narrow stratigraphic interval, likely representing the *Goniatites crenistria* Zone, *Goniatites sphaericus* Zone, *Goniatites spirifer* Zone, and the *Arnsbergites gracilis* Zone.

Some of the ammonoids described here are preserved with exceptionally well-preserved inner whorls. For *Goniatites sphaericus* (Sowerby, 1814), a range of shell geometry variation can be observed, matching that seen in assemblages from the Rhenish Mountains.

The new species *Goniatites amarensis* sp. nov. is described and compared with the morphologically similar and well-known species *Goniatites crenistria* Phillips, 1836 from northern England and the Rhenish Mountains. The comparison between the two species highlights the importance of analysing shell ontogeny, as it allows for more precise differentiation of species based on their developmental stages and conch geometry.

Acknowledgements

We acknowledge the participation of Lucyna Leda (then Berlin) in our joint excursions to Morocco and Markus Brinkmann (MfN Berlin) for the mechanical preparation of the specimens. We thank Hartmut Knappe (Wernigerode) for donating comparative specimens from the Harz Mountains. Ian Somerville gave valuable information about the Sidi Amar locality and Ulrich Jansen (Frankfurt a.M.) as well as Alexander Gehler (Göttingen) provided information on original specimens in their collections. We are also greatly appreciative of the reviews by two anonymous reviewers.

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Appendix

Table A1. Conch dimensions and ratios of sectioned specimens of *Goniatites amarensis* sp. nov. from Sidi Amar (Moroccan Meseta).

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
MB.C.32215.4	29.03	22.88	13.76	4.83	6.04	0.79	1.66	0.17	1.59	0.56
	22.99	19.55	10.44	4.18	4.39	0.85	1.87	0.18	1.53	0.58
	18.60	16.85	8.37	3.54	3.40	0.91	2.01	0.19	1.50	0.59
	15.20	14.40	6.68	2.78	2.69	0.95	2.16	0.18	1.48	0.60
	12.52	12.09	5.74	2.34	2.28	0.97	2.11	0.19	1.49	0.60
	10.24	9.86	4.43	2.01	1.72	0.96	2.22	0.20	1.44	0.61
	8.52	8.51	3.79	1.60	1.48	1.00	2.24	0.19	1.47	0.61
	7.04	7.16	3.12	1.29	1.26	1.02	2.29	0.18	1.48	0.60
	5.78	6.12	2.63	1.16	1.09	1.06	2.33	0.20	1.52	0.59
	4.70	5.08	1.99	0.99	0.90	1.08	2.55	0.21	1.53	0.55
	3.80	4.28	1.72	0.82	0.73	1.13	2.49	0.21	1.53	0.58
	3.07	3.49	1.26	0.77	0.61	1.13	2.76	0.25	1.56	0.52
	2.46	3.00	1.04	0.63	0.47	1.22	2.88	0.26	1.52	0.55
	2.00	2.44	0.79	0.54	0.39	1.22	3.08	0.27	1.54	0.51
	1.61	2.00	0.66	0.44	0.35	1.24	3.01	0.28	1.64	0.47
	1.25	1.62	0.50	0.35	0.29	1.29	3.23	0.28	1.69	0.43
	0.97	1.18	0.41	0.24	0.23	1.22	2.91	0.25	1.74	0.43
	0.73	0.89	0.32	0.13	0.20	1.21	2.80	0.17	1.87	0.38
	0.54	0.77	0.29	–	0.19	1.44	2.65	–	2.39	0.35

Table A2 (continued on next page). Conch dimensions and ratios of sectioned specimens of *Goniatites sphaericus* (Sowerby, 1814) from Sidi Lamine.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
MB.C.32206.5	37.61	28.68	17.09	6.47	6.76	0.76	1.68	0.17	1.49	0.60
	30.86	25.44	14.06	4.72	5.41	0.82	1.81	0.15	1.47	0.62
	25.45	22.33	12.08	3.53	4.48	0.88	1.85	0.14	1.47	0.63
	20.96	18.74	9.84	2.62	3.73	0.89	1.90	0.12	1.48	0.62
	17.24	16.22	8.50	1.77	2.91	0.94	1.91	0.10	1.45	0.66
	14.33	13.39	6.96	1.36	2.66	0.93	1.92	0.09	1.51	0.62
	11.67	11.47	6.01	0.99	2.41	0.98	1.91	0.08	1.59	0.60
	9.26	9.37	4.67	0.75	1.68	1.01	2.00	0.08	1.49	0.64
	7.58	8.06	3.83	0.51	1.43	1.06	2.10	0.07	1.52	0.63
	6.15	6.44	3.24	0.28	1.22	1.05	1.99	0.05	1.56	0.62
	4.93	5.12	2.63	0.32	1.06	1.04	1.94	0.06	1.63	0.60
	3.86	4.09	1.98	0.34	0.84	1.06	2.07	0.09	1.64	0.57
	3.02	3.31	1.55	0.32	0.64	1.10	2.14	0.11	1.61	0.58
	2.38	2.60	1.15	0.41	0.49	1.10	2.26	0.17	1.59	0.58
	1.89	2.05	0.82	0.39	0.39	1.08	2.50	0.21	1.58	0.53
	1.50	1.65	0.68	0.31	0.38	1.10	2.44	0.20	1.79	0.44
	1.12	1.23	0.52	0.20	0.27	1.10	2.37	0.18	1.74	0.48
	0.85	0.95	0.40	0.09	0.23	1.12	2.38	0.11	1.86	0.43
	0.63	0.82	0.36	–	0.19	1.31	2.28	–	2.05	0.48
MB.C.32206.6	30.81	24.38	13.65	5.70	5.73	0.79	1.79	0.19	1.51	0.58
	25.08	20.60	11.46	4.09	4.62	0.82	1.80	0.16	1.50	0.60
	20.46	17.32	9.53	2.49	3.59	0.85	1.82	0.12	1.47	0.62
	16.87	14.65	8.43	1.48	3.36	0.87	1.74	0.09	1.56	0.60
	13.51	12.03	6.95	0.97	2.79	0.89	1.73	0.07	1.59	0.60
	10.72	9.80	5.59	0.76	2.28	0.91	1.75	0.07	1.61	0.59
	8.44	7.85	4.37	0.49	1.70	0.93	1.80	0.06	1.57	0.61
	6.74	6.42	3.58	0.31	1.50	0.95	1.79	0.05	1.65	0.58
	5.24	5.00	2.85	0.23	1.30	0.95	1.76	0.04	1.77	0.54
	3.95	3.97	2.17	0.27	1.02	1.01	1.83	0.07	1.82	0.53
	2.93	3.00	1.51	0.34	0.77	1.02	1.98	0.11	1.85	0.49
	2.15	2.32	1.08	0.38	0.54	1.08	2.15	0.18	1.78	0.50
	1.62	1.61	0.69	0.39	0.36	1.00	2.32	0.24	1.64	0.49
	1.26	1.24	0.53	0.34	0.30	0.99	2.35	0.27	1.73	0.43
	0.96	0.85	0.39	0.25	0.25	0.89	2.19	0.26	1.84	0.35
	0.71	0.72	0.33	0.05	0.19	1.02	2.22	0.08	1.85	0.43
	0.52	0.75	0.33	–	0.17	1.45	2.30	–	2.21	0.48

Table A2 (continued). Conch dimensions and ratios of sectioned specimens of *Goniatites sphaericus* (Sowerby, 1814) from Sidi Lamine.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
MB.C.32206.7	22.15	20.75	10.22	2.92	3.76	0.94	2.03	0.13	1.45	0.63
	18.39	17.66	9.01	1.90	3.28	0.96	1.96	0.10	1.48	0.64
	15.12	15.07	7.48	1.25	2.89	1.00	2.01	0.08	1.53	0.61
	12.23	12.53	6.39	0.93	2.55	1.02	1.96	0.08	1.60	0.60
	9.68	10.49	4.91	0.88	1.85	1.08	2.14	0.09	1.53	0.62
	7.83	8.68	3.89	0.75	1.44	1.11	2.23	0.10	1.50	0.63
	6.39	7.20	3.19	0.57	1.22	1.13	2.26	0.09	1.53	0.62
	5.17	5.67	2.63	0.50	1.07	1.10	2.16	0.10	1.59	0.59
	4.10	4.56	2.03		0.85	1.11	2.24	0.00	1.59	0.58

Table A3 (continued on next page). Conch dimensions and ratios of sectioned specimens of *Goniatites spirifer* Roemer, 1850 from the Winterberg near Bad Grund (Harz Mountains).

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
MB.C.32206.5	37.61	28.68	17.09	6.47	6.76	0.76	1.68	0.17	1.49	0.60
	30.86	25.44	14.06	4.72	5.41	0.82	1.81	0.15	1.47	0.62
	25.45	22.33	12.08	3.53	4.48	0.88	1.85	0.14	1.47	0.63
	20.96	18.74	9.84	2.62	3.73	0.89	1.90	0.12	1.48	0.62
	17.24	16.22	8.50	1.77	2.91	0.94	1.91	0.10	1.45	0.66
	14.33	13.39	6.96	1.36	2.66	0.93	1.92	0.09	1.51	0.62
	11.67	11.47	6.01	0.99	2.41	0.98	1.91	0.08	1.59	0.60
	9.26	9.37	4.67	0.75	1.68	1.01	2.00	0.08	1.49	0.64
	7.58	8.06	3.83	0.51	1.43	1.06	2.10	0.07	1.52	0.63
	6.15	6.44	3.24	0.28	1.22	1.05	1.99	0.05	1.56	0.62
	4.93	5.12	2.63	0.32	1.06	1.04	1.94	0.06	1.63	0.60
	3.86	4.09	1.98	0.34	0.84	1.06	2.07	0.09	1.64	0.57
	3.02	3.31	1.55	0.32	0.64	1.10	2.14	0.11	1.61	0.58
	2.38	2.60	1.15	0.41	0.49	1.10	2.26	0.17	1.59	0.58
	1.89	2.05	0.82	0.39	0.39	1.08	2.50	0.21	1.58	0.53
	1.50	1.65	0.68	0.31	0.38	1.10	2.44	0.20	1.79	0.44
	1.12	1.23	0.52	0.20	0.27	1.10	2.37	0.18	1.74	0.48
	0.85	0.95	0.40	0.09	0.23	1.12	2.38	0.11	1.86	0.43
	0.63	0.82	0.36	–	0.19	1.31	2.28	–	2.05	0.48
MB.C.32206.6	30.81	24.38	13.65	5.70	5.73	0.79	1.79	0.19	1.51	0.58
	25.08	20.60	11.46	4.09	4.62	0.82	1.80	0.16	1.50	0.60
	20.46	17.32	9.53	2.49	3.59	0.85	1.82	0.12	1.47	0.62
	16.87	14.65	8.43	1.48	3.36	0.87	1.74	0.09	1.56	0.60
	13.51	12.03	6.95	0.97	2.79	0.89	1.73	0.07	1.59	0.60
	10.72	9.80	5.59	0.76	2.28	0.91	1.75	0.07	1.61	0.59
	8.44	7.85	4.37	0.49	1.70	0.93	1.80	0.06	1.57	0.61
	6.74	6.42	3.58	0.31	1.50	0.95	1.79	0.05	1.65	0.58
	5.24	5.00	2.85	0.23	1.30	0.95	1.76	0.04	1.77	0.54
	3.95	3.97	2.17	0.27	1.02	1.01	1.83	0.07	1.82	0.53
	2.93	3.00	1.51	0.34	0.77	1.02	1.98	0.11	1.85	0.49
	2.15	2.32	1.08	0.38	0.54	1.08	2.15	0.18	1.78	0.50
	1.62	1.61	0.69	0.39	0.36	1.00	2.32	0.24	1.64	0.49
	1.26	1.24	0.53	0.34	0.30	0.99	2.35	0.27	1.73	0.43
	0.96	0.85	0.39	0.25	0.25	0.89	2.19	0.26	1.84	0.35
	0.71	0.72	0.33	0.05	0.19	1.02	2.22	0.08	1.85	0.43
	0.52	0.75	0.33	–	0.17	1.45	2.30	–	2.21	0.48

Table A3 (continued). Conch dimensions and ratios of sectioned specimens of *Goniatites spirifer* Roemer, 1850 from the Winterberg near Bad Grund (Harz Mountains).

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
MB.C.32206.7	22.15	20.75	10.22	2.92	3.76	0.94	2.03	0.13	1.45	0.63
	18.39	17.66	9.01	1.90	3.28	0.96	1.96	0.10	1.48	0.64
	15.12	15.07	7.48	1.25	2.89	1.00	2.01	0.08	1.53	0.61
	12.23	12.53	6.39	0.93	2.55	1.02	1.96	0.08	1.60	0.60
	9.68	10.49	4.91	0.88	1.85	1.08	2.14	0.09	1.53	0.62
	7.83	8.68	3.89	0.75	1.44	1.11	2.23	0.10	1.50	0.63
	6.39	7.20	3.19	0.57	1.22	1.13	2.26	0.09	1.53	0.62
	5.17	5.67	2.63	0.50	1.07	1.10	2.16	0.10	1.59	0.59
	4.10	4.56	2.03	–	0.85	1.11	2.24	0.00	1.59	0.58

Table A4. Conch dimensions and ratios of sectioned specimens of *Arnsbergites* sp. from Sidi Amar (Moroccan Meseta).

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
MB.C.32216	17.61	14.19	8.98	1.38	3.53	0.81	1.58	0.08	1.56	0.61
	14.07	11.98	7.25	1.09	2.80	0.85	1.65	0.08	1.56	0.61
	11.28	9.99	5.74	1.21	2.31	0.89	1.74	0.11	1.58	0.60
	8.97	8.05	4.33	1.22	1.78	0.90	1.86	0.14	1.56	0.59
	7.19	6.43	3.42	1.17	1.34	0.89	1.88	0.16	1.51	0.61
	5.85	5.24	2.61	1.38	1.11	0.90	2.01	0.24	1.52	0.57
	4.74	4.26	1.86	1.51	0.86	0.90	2.29	0.32	1.50	0.54
	3.88	3.35	1.37	1.57	0.73	0.86	2.45	0.40	1.52	0.47
	3.14	2.63	0.94	1.47	0.59	0.84	2.80	0.47	1.52	0.37
	2.55	2.07	0.74	1.25	0.50	0.81	2.80	0.49	1.55	0.32
	2.05	1.59	0.56	1.00	0.37	0.77	2.83	0.49	1.48	0.35
	1.69	1.19	0.49	0.75	0.33	0.71	2.43	0.44	1.55	0.32
	1.36	1.00	0.45	0.53	0.31	0.74	2.22	0.39	1.67	0.32
	1.05	0.79	0.38	0.32	0.27	0.75	2.08	0.31	1.83	0.27
	0.77	0.72	0.35	–	0.24	0.94	2.07	–	2.09	0.32

Table A5 (continued on next two pages). Conch dimensions and ratios of sectioned specimens of *Hibernicoceras hibernicus* Moore & Hodson, 1958 from Sidi Amar (Moroccan Meseta).

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
MB.C.32217.4	30.48	22.10	14.04	5.38	6.14	0.73	1.57	0.18	1.57	0.56
	24.35	18.66	11.07	4.79	4.78	0.77	1.69	0.20	1.55	0.57
	19.56	15.50	8.49	4.43	3.74	0.79	1.83	0.23	1.53	0.56
	15.82	12.92	6.64	4.14	2.90	0.82	1.95	0.26	1.50	0.56
	12.93	10.68	5.04	3.71	2.15	0.83	2.12	0.29	1.44	0.57
	10.78	8.68	4.18	3.14	1.87	0.81	2.08	0.29	1.46	0.55
	8.91	7.23	3.46	2.65	1.66	0.81	2.09	0.30	1.51	0.52
	7.25	5.71	2.80	2.20	1.43	0.79	2.04	0.30	1.55	0.49
	5.82	4.73	2.25	1.92	1.21	0.81	2.11	0.33	1.59	0.46
	4.62	3.84	1.66	1.83	0.95	0.83	2.31	0.40	1.59	0.43
	3.67	2.93	1.13	1.70	0.71	0.80	2.60	0.46	1.54	0.37
	2.96	2.36	0.84	1.44	0.58	0.80	2.81	0.49	1.55	0.31
	2.38	1.80	0.68	1.18	0.47	0.76	2.67	0.50	1.55	0.31
	1.91	1.44	0.52	0.94	0.36	0.76	2.77	0.49	1.52	0.31
	1.55	1.08	0.45	0.69	0.31	0.69	2.41	0.44	1.55	0.32
	1.25	0.87	0.42	0.48	0.28	0.70	2.10	0.39	1.65	0.33
	0.97	0.74	0.35	0.33	0.24	0.76	2.11	0.34	1.75	0.33
	0.73	0.63	0.29	0.07	0.17	0.86	2.15	0.09	1.72	0.41
	0.56	0.68	0.37	–	0.17	1.21	1.82	–	2.09	0.54
MB.C.32217.6	30.25	23.05	13.57	6.38	5.69	0.76	1.70	0.21	1.52	0.58
	24.55	19.74	10.30	6.00	3.94	0.80	1.92	0.24	1.42	0.62
	20.62	16.86	8.26	5.56	3.45	0.82	2.04	0.27	1.44	0.58
	17.17	13.76	6.79	4.93	2.97	0.80	2.03	0.29	1.46	0.56
	14.20	11.78	5.45	4.31	2.43	0.83	2.16	0.30	1.45	0.55
	11.77	9.79	4.44	3.48	1.89	0.83	2.21	0.30	1.42	0.57
	9.89	8.36	3.85	2.83	1.66	0.85	2.17	0.29	1.44	0.57
	8.23	6.75	3.21	2.57	1.56	0.82	2.10	0.31	1.52	0.51
	6.67	5.57	2.45	2.44	1.20	0.84	2.27	0.37	1.49	0.51
	5.46	4.44	1.78	2.35	1.00	0.81	2.50	0.43	1.50	0.44
	4.46	3.63	1.33	2.11	0.81	0.81	2.73	0.47	1.49	0.39
	3.66	2.90	1.02	1.87	0.66	0.79	2.84	0.51	1.49	0.35
	3.00	2.27	0.77	1.56	0.54	0.76	2.97	0.52	1.49	0.29
	2.46	1.75	0.68	1.27	0.50	0.71	2.59	0.52	1.57	0.26
	1.96	1.40	0.51	1.00	0.38	0.71	2.74	0.51	1.53	0.27
	1.58	1.08	0.44	0.76	0.31	0.68	2.42	0.48	1.55	0.30
	1.27	0.88	0.38	0.52	0.27	0.69	2.31	0.41	1.62	0.29
	1.00	0.73	0.37	0.30	0.26	0.73	1.96	0.30	1.82	0.31
	0.74	0.64	0.33	0.08	0.19	0.86	1.96	0.11	1.77	0.43
	0.56	0.65	0.34	–	0.16	1.16	1.93	–	1.94	0.53

Table A5 (continued). Conch dimensions and ratios of sectioned specimens of *Hibernicoceras hibernicus* Moore & Hodson, 1958 from Sidi Amar (Moroccan Meseta).

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
MB.C.32217.7	29.82	21.55	14.18	5.15	6.21	0.72	1.52	0.17	1.60	0.56
	23.61	18.53	10.48	5.01	4.22	0.78	1.77	0.21	1.48	0.60
	19.38	15.38	8.12	4.81	3.41	0.79	1.90	0.25	1.47	0.58
	15.98	12.95	6.45	4.45	2.84	0.81	2.01	0.28	1.48	0.56
	13.14	10.69	5.07	3.91	2.30	0.81	2.11	0.30	1.47	0.55
	10.83	8.79	4.16	3.40	1.86	0.81	2.11	0.31	1.46	0.55
	8.97	7.24	3.28	3.05	1.54	0.81	2.21	0.34	1.46	0.53
	7.43	6.04	2.65	2.80	1.35	0.81	2.28	0.38	1.49	0.49
	6.09	4.80	1.99	2.60	1.09	0.79	2.41	0.43	1.49	0.45
	4.99	4.02	1.49	2.33	0.93	0.81	2.70	0.47	1.51	0.37
	4.06	2.98	1.17	2.00	0.71	0.73	2.55	0.49	1.47	0.39
	3.35	2.52	0.89	1.68	0.57	0.75	2.82	0.50	1.45	0.37
	2.78	2.08	0.78	1.39	0.50	0.75	2.69	0.50	1.48	0.36
	2.29	1.60	0.61	1.15	0.41	0.70	2.61	0.50	1.48	0.33
	1.88	1.27	0.52	0.89	0.38	0.68	2.43	0.47	1.57	0.27
	1.50	0.96	0.46	0.66	0.33	0.64	2.08	0.44	1.65	0.29
	1.17	0.83	0.37	0.43	0.27	0.71	2.24	0.37	1.69	0.27
	0.90	0.67	0.37	0.28	0.24	0.74	1.83	0.31	1.84	0.35
	0.66	0.58	0.26	0.13	0.15	0.88	2.27	0.20	1.65	0.43
	0.51	0.57	0.27	–	0.16	1.10	2.07	–	2.12	0.41
MB.C.32217.8	27.85	20.70	12.85	4.88	5.38	0.74	1.61	0.18	1.54	0.58
	22.47	18.05	10.12	4.39	4.21	0.80	1.78	0.20	1.51	0.58
	18.27	14.86	7.97	4.01	3.41	0.81	1.86	0.22	1.51	0.57
	14.85	12.62	6.29	3.62	2.60	0.85	2.01	0.24	1.47	0.59
	12.26	10.14	4.95	3.20	2.01	0.83	2.05	0.26	1.43	0.59
	10.25	8.42	4.11	2.78	1.78	0.82	2.05	0.27	1.46	0.57
	8.47	6.88	3.36	2.45	1.51	0.81	2.04	0.29	1.48	0.55
	6.95	5.71	2.66	2.26	1.35	0.82	2.15	0.33	1.54	0.49
	5.60	4.55	2.03	2.06	1.10	0.81	2.23	0.37	1.55	0.46
	4.50	3.64	1.51	1.91	0.86	0.81	2.42	0.42	1.53	0.43
	3.64	2.81	1.09	1.74	0.70	0.77	2.58	0.48	1.53	0.36
	2.95	2.24	0.82	1.44	0.54	0.76	2.74	0.49	1.50	0.34
	2.40	1.78	0.68	1.16	0.47	0.74	2.60	0.48	1.55	0.31
	1.93	1.39	0.56	0.90	0.36	0.72	2.48	0.47	1.51	0.36
	1.57	1.09	0.47	0.68	0.32	0.69	2.32	0.43	1.58	0.31
	1.25	0.87	0.42	0.46	0.30	0.70	2.06	0.37	1.74	0.28
	0.95	0.71	0.37	0.28	0.24	0.75	1.91	0.29	1.78	0.36
	0.71	0.62	0.30	0.09	0.17	0.88	2.06	0.13	1.74	0.43
	0.54	0.62	0.32	–	0.16	1.15	1.96	–	2.07	0.48

Table A5 (continued). Conch dimensions and ratios of sectioned specimens of *Hibernicoceras hibernicus* Moore & Hodson, 1958 from Sidi Amar (Moroccan Meseta).

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
MB.C.32217.9	22.57	17.49	10.16	4.51	4.32	0.77	1.72	0.20	1.53	0.58
	18.25	14.64	7.89	3.99	3.35	0.80	1.85	0.22	1.50	0.58
	14.90	12.01	6.37	3.27	2.72	0.81	1.89	0.22	1.50	0.57
	12.19	9.87	5.27	2.67	2.29	0.81	1.87	0.22	1.52	0.57
	9.90	8.05	4.25	2.34	1.80	0.81	1.89	0.24	1.50	0.58
	8.10	6.63	3.31	2.15	1.42	0.82	2.00	0.27	1.47	0.57
	6.68	5.41	2.64	2.02	1.31	0.81	2.05	0.30	1.55	0.50
	5.37	4.28	2.02	1.90	1.16	0.80	2.12	0.35	1.63	0.43
	4.21	3.48	1.45	1.73	0.82	0.83	2.40	0.41	1.54	0.44
	3.39	2.64	1.03	1.54	0.65	0.78	2.55	0.45	1.53	0.37
	2.74	2.17	0.82	1.30	0.53	0.79	2.65	0.48	1.53	0.36
	2.21	1.61	0.62	1.06	0.44	0.73	2.60	0.48	1.56	0.28
	1.77	1.33	0.54	0.75	0.37	0.75	2.46	0.43	1.60	0.31
	1.40	1.01	0.48	0.48	0.32	0.72	2.11	0.35	1.67	0.33
	1.08	0.87	0.44	0.29	0.29	0.81	1.99	0.27	1.86	0.34
	0.79	0.66	0.35	0.14	0.23	0.83	1.86	0.17	2.00	0.34
	0.56	0.65	0.31	–	0.18	1.15	2.11	–	2.15	0.42

Table A6. Conch dimensions and ratios of sectioned specimens of *Hibernicoceras mediocre* Moore & Hodson, 1958 from Sidi Amar (Moroccan Meseta).

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
MB.C.32218.2	18.99	14.48	8.95	3.31	4.26	0.76	1.62	0.17	1.66	0.52
	14.73	11.72	6.73	2.84	3.09	0.80	1.74	0.19	1.60	0.54
	11.64	9.50	5.16	2.22	2.27	0.82	1.84	0.19	1.54	0.56
	9.37	7.72	4.26	1.78	1.95	0.82	1.81	0.19	1.59	0.54
	7.42	6.19	3.33	1.52	1.61	0.83	1.86	0.20	1.63	0.52
	5.82	4.89	2.58	1.39	1.23	0.84	1.90	0.24	1.61	0.52
	4.59	3.85	1.85	1.36	0.97	0.84	2.08	0.30	1.61	0.48
	3.62	2.99	1.38	1.28	0.78	0.83	2.17	0.35	1.63	0.43
	2.84	2.30	0.96	1.18	0.59	0.81	2.40	0.42	1.59	0.38
	2.25	1.73	0.69	1.04	0.46	0.77	2.49	0.47	1.58	0.34
	1.79	1.33	0.51	0.80	0.36	0.74	2.62	0.45	1.58	0.28
	1.42	1.02	0.48	0.57	0.30	0.72	2.15	0.40	1.62	0.36
	1.12	0.84	0.38	0.40	0.26	0.75	2.23	0.36	1.68	0.32
	0.86	0.66	0.34	0.18	0.22	0.76	1.92	0.21	1.80	0.36
	0.64	0.64	0.34	–	0.18	1.00	1.90	–	1.93	0.47
MB.C.32218.3	18.34	13.55	9.09	1.93	4.09	0.74	1.49	0.11	1.66	0.55
	14.25	11.28	7.32	1.54	3.35	0.79	1.54	0.11	1.71	0.54
	10.90	8.87	5.40	1.36	2.49	0.81	1.64	0.12	1.68	0.54
	8.41	7.00	4.14	1.33	2.02	0.83	1.69	0.16	1.73	0.51
	6.39	5.29	2.94	1.36	1.42	0.83	1.80	0.21	1.65	0.52
	4.97	4.12	2.08	1.47	1.08	0.83	1.98	0.29	1.63	0.48
	3.89	3.12	1.42	1.49	0.83	0.80	2.20	0.38	1.62	0.41
	3.06	2.39	0.98	1.36	0.64	0.78	2.45	0.45	1.60	0.35
	2.42	1.86	0.72	1.13	0.47	0.77	2.58	0.47	1.54	0.34
	1.95	1.54	0.57	0.88	0.40	0.79	2.71	0.45	1.58	0.30
	1.55	1.15	0.50	0.66	0.34	0.74	2.31	0.42	1.63	0.32
	1.21	0.92	0.40	0.47	0.26	0.76	2.33	0.39	1.62	0.34
	0.95	0.74	0.35	0.28	0.23	0.77	2.11	0.29	1.75	0.34
	0.72	0.61	0.32	0.12	0.18	0.84	1.88	0.16	1.80	0.44
	0.54	0.61	0.28	–	0.17	1.14	2.17	–	2.08	0.41

Table A7. Conch dimensions and ratios of sectioned specimens of gen. indet. sp. from Sidi Amar (Moroccan Meseta).

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
MB.C.32219	33.37	21.46	17.21	4.85	9.34	0.64	1.25	0.15	1.93	0.46
	24.03	17.58	11.31	4.04	5.36	0.73	1.55	0.17	1.66	0.53
	18.67	14.56	8.68	2.94	3.98	0.78	1.68	0.16	1.62	0.54
	14.69	10.58	7.06	2.41	3.46	0.72	1.50	0.16	1.71	0.51
	11.23	8.36	5.23	2.48	2.58	0.74	1.60	0.22	1.69	0.51
	8.65	6.56	3.53	2.51	1.75	0.76	1.86	0.29	1.57	0.50
	6.90	5.35	2.61	2.32	1.41	0.78	2.05	0.34	1.58	0.46
	5.49	4.16	1.96	1.98	1.04	0.76	2.12	0.36	1.52	0.47
	4.45	3.47	1.55	1.65	0.82	0.78	2.24	0.37	1.50	0.47
	3.63	2.82	1.26	1.30	0.69	0.78	2.24	0.36	1.53	0.45
	2.94	2.36	1.08	1.05	0.58	0.80	2.18	0.36	1.56	0.46
	2.36	1.89	0.81	0.84	0.52	0.80	2.33	0.36	1.65	0.35
	1.83	1.57	0.70	0.62	0.44	0.85	2.22	0.34	1.72	0.38
	1.40	1.25	0.51	0.42	0.33	0.89	2.45	0.30	1.72	0.35
	1.07	1.15	0.46	0.27	0.29	1.08	2.48	0.25	1.89	0.37
	0.77	0.89	0.33	–	0.21	1.15	2.68	–	1.90	0.36