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The ammonoids from the Argiles de Timimoun of Timimoun (Early and Middle Viséan; Gourara, Algeria)

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Abstract

Twenty-seven ammonoid species are described from the Argiles de Timimoun of Timimoun (Gourara, Algeria). The following taxa are newly described: *Rhnetites* n. gen., *Rhnetites rhnetensis* n. sp., *Rhnetites ouladallalensis* n. sp., *Parahammatocyclus mutaris* n. sp., *Bollandoceras nitens* n. sp., *Bollandoceras subangulare* n. sp., *Bollandoceras politum* n. sp., *Bollandoceras aridum* n. sp., *Bollandoceras zuhara* n. sp., *Bollandoceras mirrih* n. sp., *Benimehlalites* n. gen., *Benimehlalites benimehlalensis* n. sp., *Benimehlalites belkassemensis* n. sp., *Benimehlalites brinkmanni* n. sp., *Pachybollandoceras* n. gen., *Pachybollandoceras intraevolutum* n. sp., *Pachybollandoceras repens* n. sp., Bollanditinae n. subfam., *Gourarites* n. gen., *Gourarites hagaraswad* n. sp., *Gourarites hagarkarim* n. sp., *Gourarites mustari* n. sp., *Gourarites zuhal* n. sp., *Semibollandites* n. gen., *Semibollandites kamil* n. sp., *Semibollandites pauculus* n. sp., *Semibollandites qawiy* n. sp., *Timimounia* n. gen., *Timimounia timimounensis* n. sp., *Timimounia lunula* n. sp., Daaitidae n. fam., *Daaites* n. gen., *Daaites daaensis* n. sp., *Dimorphoceras lanceolobatum* n. sp., *Nomismoceras salim* n. sp., and *Nomismoceras waltoni* n. sp. The species occur in three successive horizons and can be attributed to the *Bollandites-Bollandoceras* Genus Zone (Early and Middle Viséan). They represent the most diverse ammonoid fauna known from this time interval.

Introduction

The Early and Middle Viséan is a time interval within the late Palaeozoic from which the ammonoid record is poorly known. Well-described ammonoid faunas of this time have been recorded from only a few places worldwide, and most of these assemblages show a low faunal diversity (AMMON database; Korn & Ilg 2009). Therefore, each new record is valuable and contributes significantly to our knowledge of the evolutionary history of the ammonoids within the Early Carboniferous.

Riley (1990) coined the term *Bollandites-Bollandoceras* Genus Zone for the interval between the last occurrence of the genus *Ammonellipsites* and the first occurrence of *Goniatites*. This concept was accepted by Korn et al. (2007), who used this biostratigraphic unit for the North African succession of ammonoids. The *Bollandites-Bollandoceras* Genus Zone, however, is a unit that so far has been poorly defined, being characterised by the lack of distinctive genera rather than the occurrence of characteristic faunas. The two name-giving genera are not restricted to this zone; they are still very common in early Asbian assemblages (for a revision of the B2 zone in the North of England, see Korn & Tilsley 2006). In the following monograph, some new forms will be described and may help to fill some gaps in the diversity of the Palaeozoic ammonoids.

So far the richest faunas from the time interval under discussion are known from the North of England. Riley (1996) described Early and Middle Viséan (late Chadian to Holkerian in the British chronostratigraphic scheme) ammonoids from the Craven Basin in Lancashire; they came from several successive horizons (in ascending order):

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Hodder Mudstone Formation, Leagram Mudstone Member (lower portion) (late Chadian):

Ammonellipsites clitheroensis	= *Ammonellipsites clitheroensis*
Helicocyclus divergens	= *Helicocyclus divergens*
Rotopericyclus postremus	= *Rotopericyclus postremus*
Eonomismoceras planum	= *Eonomismoceras planum*
Beyrichoceratoides inflatus	= *Dzhaprakoceras inflatum*
Dzhaprakoceras deflexum	= *Dzhaprakoceras deflexum*
Dzhaprakoceras bellmanense	= *Bollandoceras bellmanense*
Dzhaprakoceras catena	= *Dzhaprakoceras catena*
Dzhaprakoceras flexum	= *Dzhaprakoceras flexum*
Dzhaprakoceras hispanicum	= *Dzhaprakoceras* cf. *hispanicum*
Dzhaprakoceras subglobosum	= *Dzhaprakoceras* cf. *subglobosum*
Dzhaprakoceras levis	= *Dzhaprakoceras levis*
Dzhaprakoceras paracatena	= *Dzhaprakoceras paracatena*
Dzhaprakoceras westheadi	= *Bollandoceras westheadi*
Dzhaprakoceras undulatum	= *Bollandoceras undulatum*
Merocanites quadrilobus	= *Merocanites quadrilobus*
Michiganites sp.	= *Michiganites* sp.

A similar but less diverse assemblage was recorded from the Peak district (Tilsley & Korn 2009)

Hodder Mudstone Formation, Chaigley Limestone Member (Arundian):

Parahammatocyclus chaigleyensis	= *Parahammatocyclus chaigleyensis*
Dzhaprakoceras hispanicum	= *Dzhaprakoceras* cf. *hispanicum*

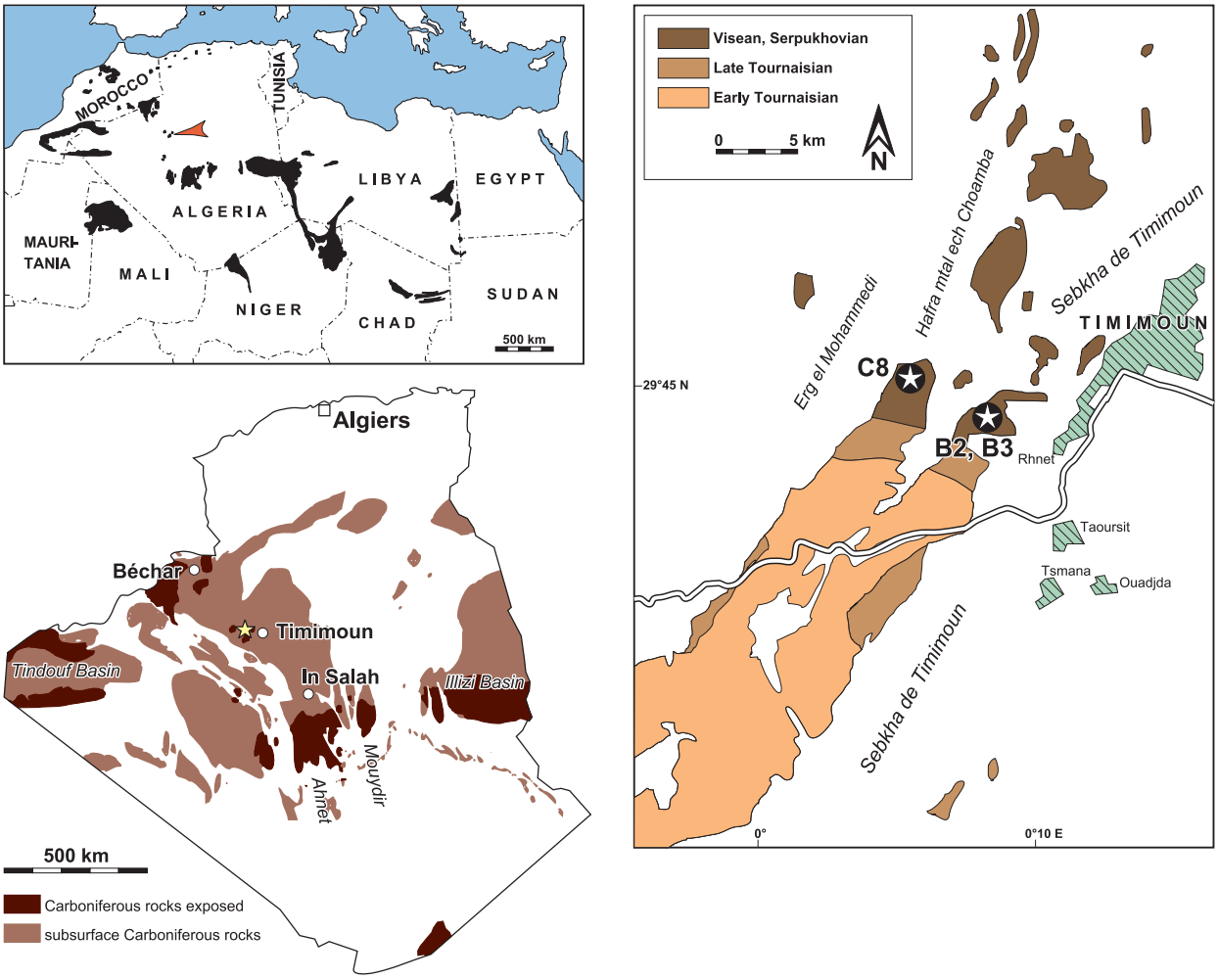


Figure 1. The outcrop of Palaeozoic rocks in northern Africa and Iberia and the geographic position (marked by an asterisk) of the fossil localities in the Grès de Kahla supérieur near Timimoun.

Beyrichoceratoides sp. 2	= *Bollandoceras* sp.
Bollandoceras sp. 1	= *Bollandoceras* sp.
Bollandoceras sp. 2	= *Bollandoceras* sp.
Bollandites? sp.	= *Bollandites* ? sp.

Hodderense Limestone Formation (Holkerian):

Bollandites varians	= *Bollandites varians*
Bollandoceras hodderense	= *Bollandoceras hodderense*
Nomismoceras rotiforme	= *Nomismoceras* sp.
Dimorphoceras leagramense	= *Dimorphoceras leagramense*
Merocanites cf. *applanatus*	= *Merocanites* cf. *applanatus*

Additional faunas, but with less precise stratigraphic affiliation, were reported from various other places:

North Urals (Kusina 1973, 1980; Shimansky & Kusina 1977) – some localities near the Komi River yielded species of the genera *Bollandoceras* (?), *Bollandites* (?), *Hammatocyclus*, *Rhiphaeocyclus*, *Helicocyclus*, and *Dzhaprakoceras*. These may have a late Chadian age.

Northern Ireland (Padget 1952) – *Bollandoceras furiense* was recorded from the Fury River.

Wales (George & Ponsford 1935) – The possible record of the genera *Eurites*, *Intoceras*, *Kozhimites*, *Bollandites*, and *Merocanites* near Gower may indicate a late Chadian age.

Ukraine – Findings at the Mokraya Volnovakha River (Kusina 1991) included *Bollandites donetsensis*, *Bollandites mediocris*, *Bollandoceras stylense*, and *Dimorphoceras* sp.; they may be a time equivalent of the assemblages from Timimoun.

Yunnan – Liang & Zhu (1988) and Wang et al. (1998) described various ammonoid species from the Baoshan Block. It is probably a mixed fauna from late Chadian to Late Viséan age. The presence of the genera *Bollandoceras*, *Bollandites*, and *Michiganites* may indicate that parts of the fauna have an Early or Middle Viséan age.

New South Wales – an ammonoid described as *Beyrichoceras trevallynense* by Brown et al. (1964) and Roberts (1965) from Trevallyn may belong to *Bollandites*.

Tien Shan of Kyrgyzstan (Librovitch 1927; Popov 1965, 1968, 1975) – The highest of the seven stratigraphic units yielded *Bollandoceras librovitchi* and *B. tianshanicum*; they may have an Early or Middle Viséan age.

Early and Middle Viséan ammonoids from North Africa have been listed and figured several times, but an extensive monographic description does not exist. Ammonoids of this age were reported from the following regions:

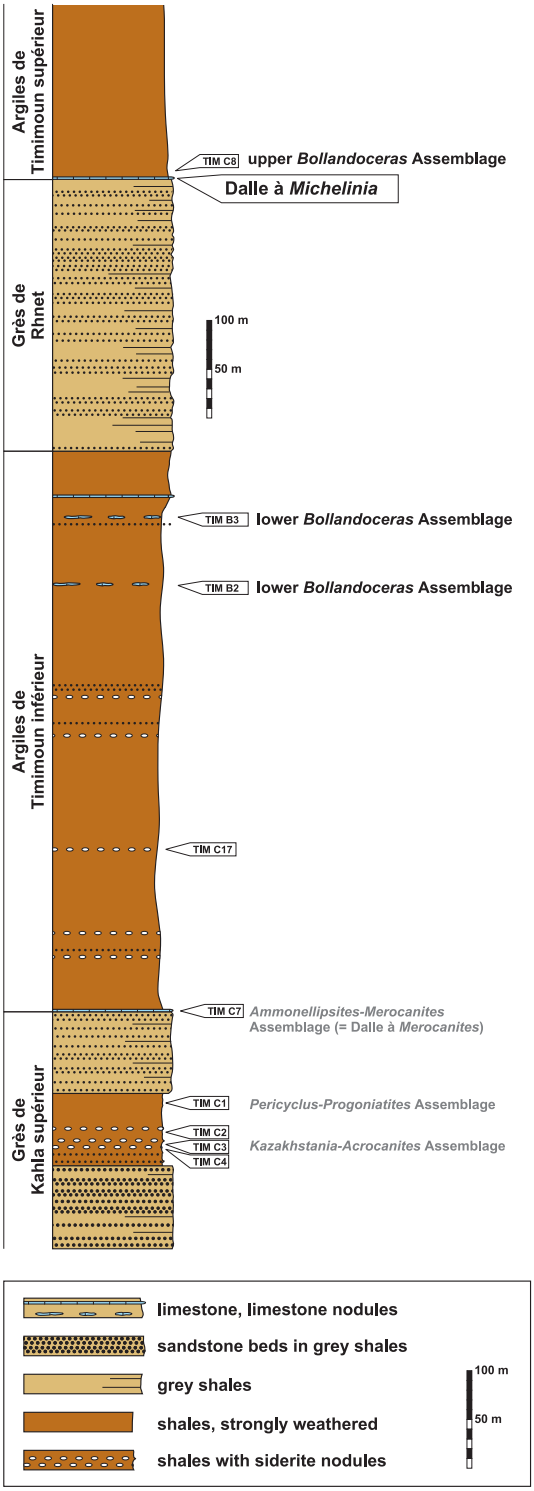


Figure 2. Stratigraphic section of the Early Carboniferous (Mississippian) rock succession near Timimoun with the position of the assemblages from the Argiles de Timimoun.

Saoura Valley of north-western Algeria (Pareyn 1961) – Rather poor ammonoid assemblages are known from several horizons, in ascending order:
Horizon S2a (Djorf el Morhabar Sud) – with *Eurites*, *Dzhaprakoceras*, and *Michiganites*; it is possibly a late Chadian fauna.
Horizon S2b (Djebel Ioucha) – with *Muensteroceras*, *Dzhaprakoceras*, and *Michiganites*; it is possibly also a late Chadian fauna.
Horizon S2b (Banc de Mazzer) – *Merocanites ogivalis* is not particularly indicative.

Ahnet of south Algeria – Conrad (1984) illustrated some specimens belonging to the genera *Bollandoceras* and *Bollandites*.

Gourara of western Algeria – Conrad (1984) figured specimens, which belong to the genera *Bollandoceras* and *Bollandites*, in limonitic preservation from the Argiles de Timimoun supérieur. We re-investigated this horizon; it was the most prolific fossil horizon for Early and Middle Viséan ammonoids of the area west of Timimoun. Furthermore, two additional faunal beds with calcareous ammonoids were discovered below this horizon.

Western Libya (Massa et al. 1974) – *Bollandoceras* cf. *hodderense* may indicate a Middle Viséan age.

It was particularly the third occurrence, 13 km west-southwest of Timimoun, which turned out to be very productive for ammonoid faunas; it yielded a large suite of material during the field trips by the present authors. This fauna will be described here for the first time to complement the monographs of the early Late Tournaisian (Korn et al. 2010a, 2010b) and latest Tournaisian/earliest Viséan (Ebbighausen et al. 2010; Korn et al. 2010c) assemblages from the Central Sahara of Algeria.

Geological setting and stratigraphy

The ammonoid faunas described here come from three localities (TIM-B2, TIM-B3, TIM-C8) 10 km west-southwest, 9.5 km west-southwest, and 13.3 km west of Timimoun (Gourara, western Algeria), at the south-western margin of the Grand Erg Occidental (Figs 1, 2). Carboniferous sedimentary rocks are exposed between the sand dunes of the Grand Erg, extending over a distance of approximately 40 km in a SW–NE erosion window that ranges in width between a few hundred metres and 10 km. The rocks are gently inclined towards the north-east (usually 20° to 35°). Their succession (Conrad 1984) consists mainly of shales with several intercalated sandstone formations; carbonates are very rare and restricted to distinct horizons.

The material described in this monograph comes from three horizons, of which two samples (localities B2 and B3) have a position in the upper portion of the Argiles de Timimoun inférieur, 140 and 65 m below the base of the Grès du Rhnet, and one sample (locality C8) is located at the base of the Argiles de Timimoun supérieur, immediately above the Dalle à *Michelinia* (a 2.70 m thick unit of nodular limestone containing numerous colonies of the tabulate coral *Michelinia*).

All three samples show the genus *Bollandoceras* to be the dominant ammonoid genus. This alone is not a criterion for a precise stratigraphic attribution of the assemblages, but the co-occurrence with the genus *Para-*

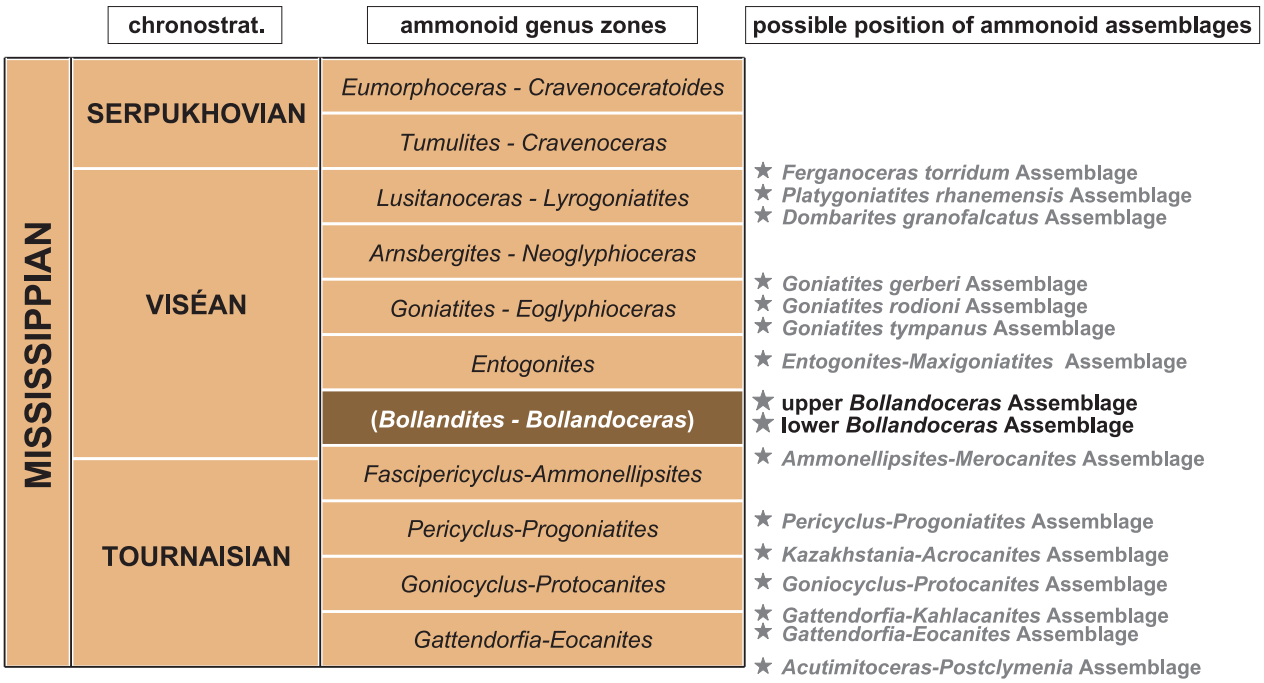


Figure 3. Stratigraphic scheme of the Early Carboniferous (Mississippian) chronostratigraphy and ammonoid zonation, with correlation of the North African ammonoid assemblages (after Korn et al. 2004, 2007). Highlighted the position of the assemblages from the Argiles de Timimoun.

hammatocyclus (stratigraphically in the middle of the three samples) allows a correlation with the Arundian Chaigley Limestone of Northern England. Another criterion for a correlation of the assemblages from Timimoun is the lack of characteristic Late Viséan genera such as *Goniatites* and *Entogonites* (Korn 1988, 1997; Korn et al. 2005). We therefore propose an Early and Middle Viséan age for the assemblages (Fig. 3).

Material

A total of more than 1,000 specimens were investigated from the Argiles de Timimoun, 870 of these were examined in detail. They were collected during two field sessions 2002 and 2003 from three localities belonging to three different horizons. The material is deposited in the fossil cephalopod collection of the Museum für Naturkunde, Berlin (MB.C. prefix).

Locality and sample TIM-B2, 10 km west-southwest of Timimoun (29.2292° N; 0.1356° E); 140 m below the top of the Argiles de Timimoun inférieur:

Rhnetites rhnetensis n. sp.	9 specimens (MB.C.18680.1–9)
Rhnetites ouladallalensis n. sp.	14 specimens (MB.C.18681.1–14)
Bollandoceras nitens n. sp.	37 specimens (MB.C.18682.1–37)
Bollandoceras subangulare n. sp.	31 specimens (MB.C.18683.1–31)
Benimehlalites belkassemensis n. sp.	2 specimens (MB.C.18684.1–2)

Locality and sample TIM-B3, 10 km west-southwest of Timimoun (29.2327° N; 0.1381° E); 65 m below the top of the Argiles de Timimoun inférieur:

Parahammatocyclus mutaris n. sp.	7 specimens (MB.C.18685.1–7)
Bollandoceras politum n. sp.	12 specimens (MB.C.18686.1–12)
Bollandoceras aridum n. sp.	8 specimens (MB.C.18687.1–8)
Benimehlalites brinkmanni n. sp.	11 specimens (MB.C.18688.1–11)
Benimehlalites benimehlalensis n. sp.	9 specimens (MB.C.18689.1–9)
Daaites daaensis n. sp.	11 specimens (MB.C.18690.1–11)

Locality and sample TIM-C8, 13.3 km west of Timimoun (29.2533° N; 0.0953° E); base of the Argiles de Timimoun supérieur:

Bollandoceras zuhara n. sp.	108 specimens (MB.C.18691.1–108)
Bollandoceras mirrih n. sp.	119 specimens (MB.C.18692.1–119)
Pachybollandoceras intraevolutum n. sp.	16 specimens (MB.C.18693.1–16)
Pachybollandoceras repens n. sp.	23 specimens (MB.C.18694.1–23)
Gourarites hagaraswad n. sp.	53 specimens (MB.C.18695.1–53)
Gourarites hagarkarim n. sp.	141 specimens (MB.C.18696.1–141)
Gourarites mustari n. sp.	26 specimens (MB.C.18697.1–26)
Gourarites zuhal n. sp.	34 specimens (MB.C.18698.1–34)
Semibollandites kamil n. sp.	37 specimens (MB.C.18699.1–37)
Semibollandites pauculus n. sp.	6 specimens (MB.C.18700.1–6)
Semibollandites qawiy n. sp.	55 specimens (MB.C.18701.1–55)
Timimounia timimounensis n. sp.	70 specimens (MB.C.18702.1–70)
Timimounia lunula n. sp.	83 specimens (MB.C.18703.1–83)
Dimorphoceras lanceolobatum n. sp.	4 specimens (MB.C.18704.1–4)
Nomismoceras salim n. sp.	25 specimens (MB.C.18705.1–25)
Nomismoceras waltoni n. sp.	19 specimens (MB.C.18706.1–19)
Michiganites sp.	1 specimen (MB.C.18707)

Systematic descriptions

The descriptive part of this monograph will mainly focus on the illustration and morphometric analysis of the species with particular attention being paid to their ontogenetic development. For this purpose, we produced more than 120 cross sections (of which nearly 80 are illustrated here). The key for the description of the species, including explanation of methods, is published by Korn (2010). Sutural terminology follows Korn et al. (2003a).

Suborder **Goniatitina** Hyatt, 1884
Superfamily **Pericyclaceae** Hyatt, 1900
Family **Rotopericyclidae** Korn, Bockwinkel & Ebbighausen, 2010

Subfamily **Rotopericyclinae** Korn, Bockwinkel & Ebbighausen, 2010

For a detailed diagnosis of the subfamily, see Korn et al. (2010a).

Rhnetites **n. gen.**

Derivation of name. After the village Rhnet, a suburb of Timimoun.

Type species. Rhnetites rhnetensis n. sp.

Genus definition. Genus of the subfamily Rotopericyclinae with significant ontogenetic changes of the conch: conch ontogeny with minor to major ontogenetic transformations mainly of the opening rate of the umbilicus (Fig. 4); inner whorls subinvolute or involute, sudden opening of the umbilicus in the intermediate stage as a result of reduction of the whorl height and enlargement of the whorl width. Suture line with very narrow, subparallel external lobe with incurved flanks.

Included species.
ouladallalensis: *Rhnetites ouladallalensis* n. sp.: Gourara, Algeria.
rhnetensis: *Rhnetites rhnetensis* n. sp.: Gourara, Algeria.

Discussion. Rhnetites shows some similarities with *Bollandites*, but differs significantly in the development of the conch geometry. The conch ontogeny begins with an evolute stage in *Bollandites* and later stages show a more or less rapid decrease of the uw/dm ratio. Contrary to this, *Rhnetites* shows a striking rapid opening of the umbilicus in the middle growth stage, resulting in significantly higher uw/dm ratios.

The new genus resembles *Benimehlalites* in the striking ontogenetic trajectories with the sudden opening of the umbilicus in an intermediate or adult growth stage. The main differences between the two genera are the involute juvenile whorls in *Rhnetites* (which are subevolute in *Benimehlalites*) and the shape of the external lobe (with subparallel, incurved flanks in *Rhnetites* and diverging, sinuous flanks in *Benimehlalites*).

Eurites Kusina, 1974 and *Trimorphoceras* Ebbighausen, Korn & Bockwinkel, 2010 differ in the narrower external lobe that possesses almost perfectly parallel flanks.

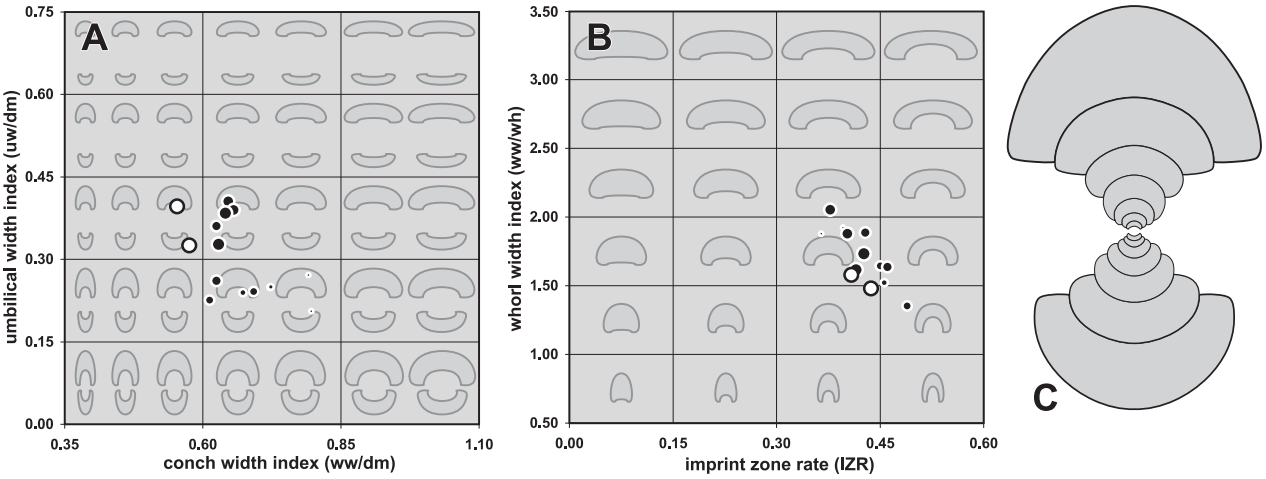


Figure 4. Ontogenetic trajectories of *Rhnetites*, exemplified for *Rhnetites rhnetensis* n. sp. from locality TIM-B2. **A.** Ontogenetic development of the conch width index (ww/dm) and umbilical width index (uw/dm). **B.** Ontogenetic development of the imprint zone rate (IZR) and whorl width index (ww/wh). **C.** Cross section of paratype MB.C.18680.3; ×2.5. [Black dots represent ontogenetic stages of cross section MB.C.18680.3, white dots represent the reference specimens (Tab. 2).]

Rhnetites rhnetensis n. sp.

Figures 5, 6

Derivation of name. After the village Rhnet, a suburb of Timimoun.

Holotype. Specimen MB.C.18680.1, illustrated in Figure 5A.

Type locality and horizon. Sebkha de Timimoun, locality TIM-B2 (10 km west-southwest of Timimoun, Algeria); lower part of the Lower *Bollandoceras-Bollandites* Assemblage.

Material. Nine specimens, conch diameter between 13 and 25 mm.

Diagnosis. *Rhnetites* with moderately strong ontogenetic changes of conch geometry: conch pachyconic in the early juvenile stage and continuously becoming discoidal at 20 mm dm; juvenile stage subinvolute with opening of the umbilicus at 6 mm dm, subevolute above 8 mm dm;

Figure 5. *Rhnetites rhnetensis* n. sp. from locality TIM-B2; all ×1.5. **A.** Holotype MB.C.18680.1. **B.** Paratype MB.C.18680.2.

aperture low in all stages except for an early juvenile stage with moderately high aperture; umbilical margin rounded in juveniles and angular in the adult stage. Steinkern with almost straight constrictions. Suture line with very narrow external lobe with subparallel flanks and very low to low median saddle; ventrolateral saddle broadly rounded, asymmetric; adventive lobe broadly V-shaped, symmetric with gently curved flanks.

Table 1. Conch ontogeny (Figs 6A–C, F–H) of *Rhnetites rhnetensis* n. sp.

dm	conch shape	whorl cross section shape	aperture
3 mm	thinly to thickly pachyconic; subinvolute (ww/dm = 0.65–0.75; uw/dm = 0.15–0.25)	weakly to moderately depressed; very strongly embracing (ww/wh = 1.45–1.55; IZR = 0.45–0.50)	low to moderate (WER = 1.70–1.85)
8 mm	thinly pachyconic; subevolute (ww/dm = 0.60–0.70; uw/dm = 0.30–0.40)	moderately depressed; strongly to very strongly embracing (ww/wh = 1.80–2.00; IZR = 0.40–0.50)	low (WER = 1.50–1.60)
20 mm	thickly discoidal to thinly pachyconic; subevolute (ww/dm = 0.55–0.65; uw/dm = 0.30–0.40)	moderately depressed; strongly embracing (ww/wh = 1.50–1.70; IZR = 0.40–0.45)	low (WER = 1.55–1.70)

Table 2. Conch dimensions (in mm) and proportions for reference specimens of *Rhnetites rhnetensis* n. sp.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
holotype MB.C.18680.1	24.5	14.1	9.5	8.0	5.4	0.58	1.48	0.33	1.64	0.44
paratype MB.C.18680.2	20.3	11.3	7.1	8.1	4.2	0.55	1.58	0.40	1.59	0.41

Table 3. Suture line proportions (Figs 6D, E) for *Rhnetites rhnetensis* n. sp.

specimen	at dm	EL w/d	EL/VLS	EL/AL	MS h	VLS w/h	remarks
holotype MB.C.18680.1	20.0 mm	0.43	0.52	0.64	0.19	0.82	
paratype MB.C.18680.5	6.0 mm	0.55	0.75	0.83	0.28	0.74	A lobe slightly pouched

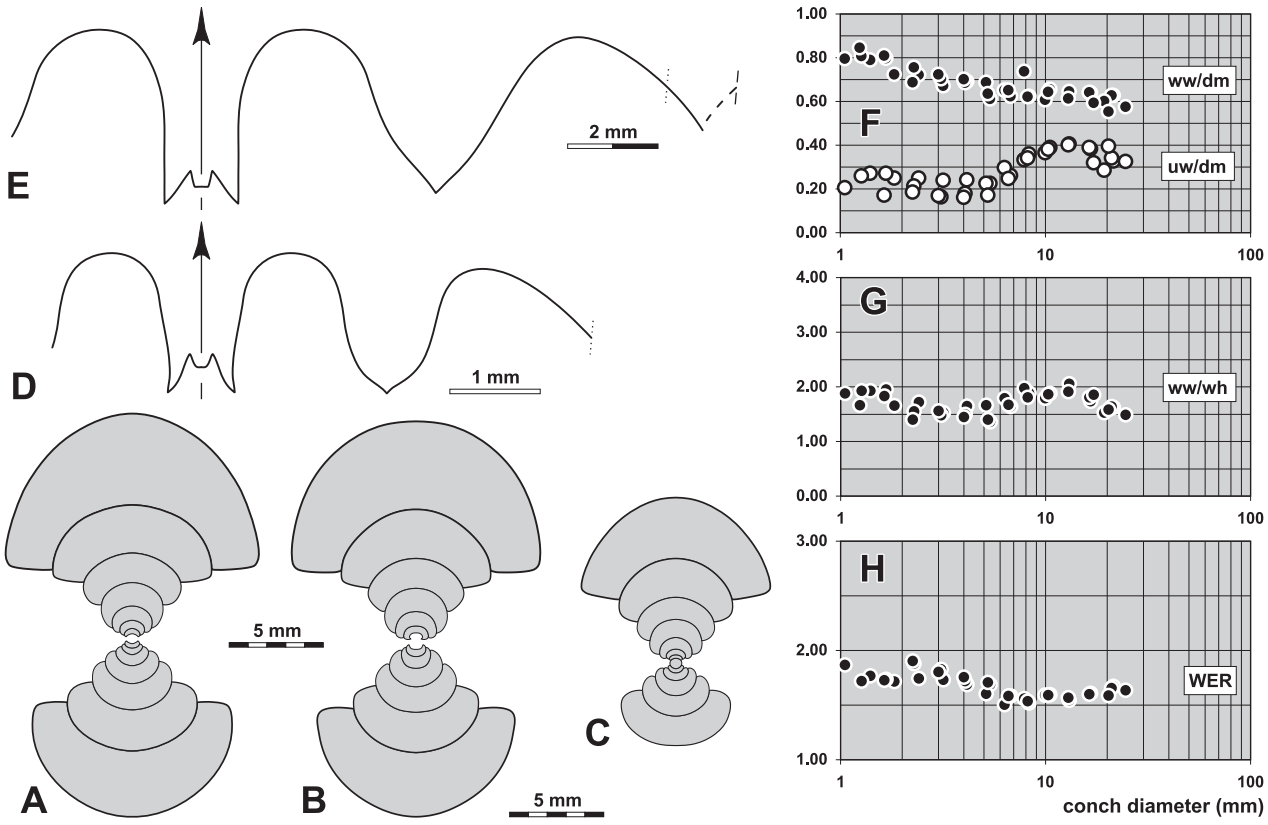


Figure 6. *Rhnetites rhnetensis* n. sp. from locality TIM-B2. **A.** Cross section of paratype MB.C.18680.3; ×2.5. **B.** Cross section of paratype MB.C.18680.4; ×2.5. **C.** Cross section of paratype MB.C.18680.5; ×2.5. **D.** Suture line of paratype MB.C.18680.5, at 6.0 mm dm, 4.0 mm ww, 2.5 mm wh; ×12.0. **E.** Suture line of holotype MB.C.18680.1, at 20.0 mm dm, 13.0 mm ww, 10.0 mm wh; ×6.0. **F–H.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm), whorl width index (ww/wh), and whorl expansion rate (WER) of all available specimens.

Discussion. The two species *Rhnetites rhnetensis* and *Rhnetites ouladallalensis* are very similar and are best separated by their ontogenetic traits. The umbilicus begins to widen at 10 mm conch diameter in *Rhnetites ouladallalensis*, but already at 6 mm dm in *Rhnetites rhnetensis*. Additionally, the aperture is much higher in *Rhnetites ouladallalensis* (WER = 2.00 at 20 mm dm) than in *Rhnetites rhnetensis* (WER = 1.60 at 20 mm dm).

Rhnetites ouladallalensis n. sp.

Figures 7, 8

Derivation of name. After the village Oulad Allal, a suburb of Timimoun.

Holotype. Specimen MB.C.18681.1, illustrated in Figure 7.

Type locality and horizon. Sebkha de Timimoun, locality TIM-B2 (10 km west-southwest of Timimoun, Algeria); lower part of the Lower *Bollandoceras-Bollandites* Assemblage.

Material. 14 specimens, conch diameter between 13 and 25 mm.

Diagnosis. Rhnetites with minor ontogenetic changes of conch geometry: conch pachyconic throughout ontogeny with slight increase of the whorl width index between 5 and 12 mm dm; juvenile stage subinvolute with opening of the umbilicus at 8 mm dm, subevolute above 12 mm dm; aperture low in all stages except for an early juvenile stage with moderately high aperture; umbilical margin rounded in juveniles and angular in the adult stage. Ornament with fine growth lines standing in wide distances, course concavo-convex with shallow ventral sinus; steinkern with concavo-convex constrictions standing in irregular distances of approximately 90º. Suture line with very narrow, barely diverging external lobe with slightly incurved flanks and very low median saddle; ventrolateral saddle rounded; adventive lobe V-shaped, symmetric and slightly pouched.

Table 4. Conch ontogeny (Figs 8A–C, E–G) of *Rhnetites ouladallalensis* n. sp.

dm	conch shape	whorl cross section shape	aperture
3 mm	thinly to thickly pachyconic; subinvolute (ww/dm = 0.65–0.75; uw/dm = 0.15–0.25)	weakly to moderately depressed; strongly to very strongly embracing (ww/wh = 1.45–1.65; IZR = 0.40–0.50)	low to moderate (WER = 1.65–2.00)
8 mm	thinly pachyconic; subinvolute (ww/dm = 0.62–0.70; uw/dm = 0.20–0.25)	moderately depressed; very strongly embracing (ww/wh = 1.50–1.75; IZR = 0.45–0.50)	low (WER = 1.60–1.75)
20 mm	thinly pachyconic; subevolute (ww/dm = 0.60–0.70; uw/dm = 0.35–0.40)	moderately depressed; strongly embracing (ww/wh = 1.80–2.00; IZR = 0.35–0.45)	low (WER = 1.50–1.65)

Table 5. Conch dimensions (in mm) and proportions for reference specimens of *Rhnetites ouladallalensis* n. sp.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
holotype MB.C.18681.1	17.6	11.1	5.6	5.9	3.9	0.63	1.97	0.33	1.65	0.31
paratype MB.C.18681.5	12.3	8.6	4.2	4.6	2.3	0.70	2.04	0.38	1.52	0.45

Table 6. Suture line proportions (Fig. 8D) for *Rhnetites ouladallalensis* n. sp.

specimen	at dm	EL w/d	EL/VLS	EL/AL	MS h	VLS w/h	remarks
holotype MB.C.18681.1	15.5 mm	0.40	0.61	0.61	0.14	0.65	A lobe wider than VL saddle

Discussion. For comparison with *Rhnetites rhnetensis*, see above.

Figure 7. *Rhnetites ouladallalensis* n. sp. from locality TIM-B2; holotype MB.C.18681.1; ×2.5.

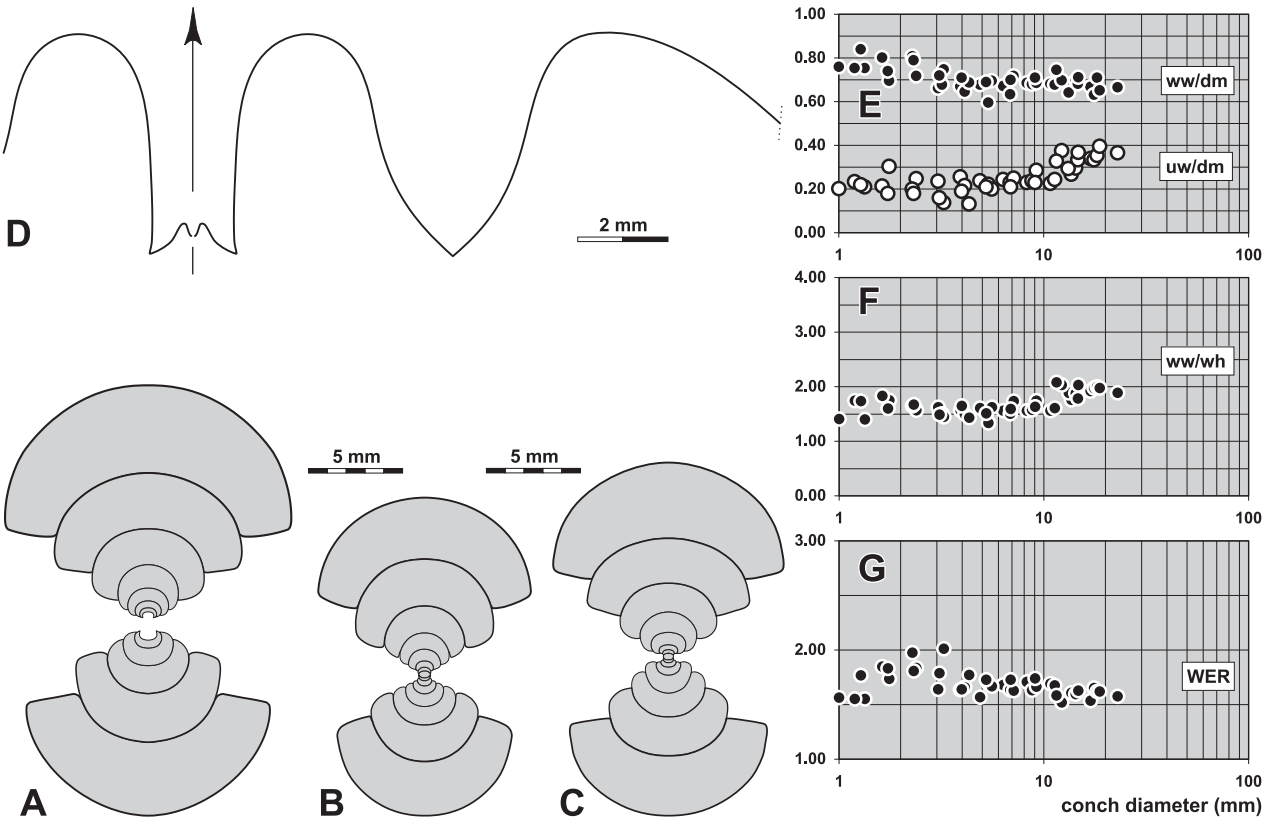


Figure 8. *Rhnetites ouladallalensis* n. sp. from locality TIM-B2. **A.** Cross section of paratype MB.C.18681.2; ×2.5. **B.** Cross section of paratype MB.C.18681.3; ×2.5. **C.** Cross section of paratype MB.C.18681.4; ×2.5. **D.** Suture line of holotype MB.C.18681.1, at 15.5 mm dm, 11.2 mm ww, 4.7 mm wh; ×6.0. **E–G.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm), whorl width index (ww/wh), and whorl expansion rate (WER) of all available specimens.

Parahammatocyclus Riley, 1996

Type species. *Parahammatocyclus chaigleyensis* Riley, 1996

Diagnosis. Genus of the subfamily Rotopericyclinae with pachyconic, subevolute to evolute conch; conch ontogeny with increasing ww/dm ratio and decrease of the uw/dm ratio in the adult stage (Fig. 9). Suture line with very narrow, slightly diverging external lobe with slightly sinuous flanks and hook-shaped secondary prongs.

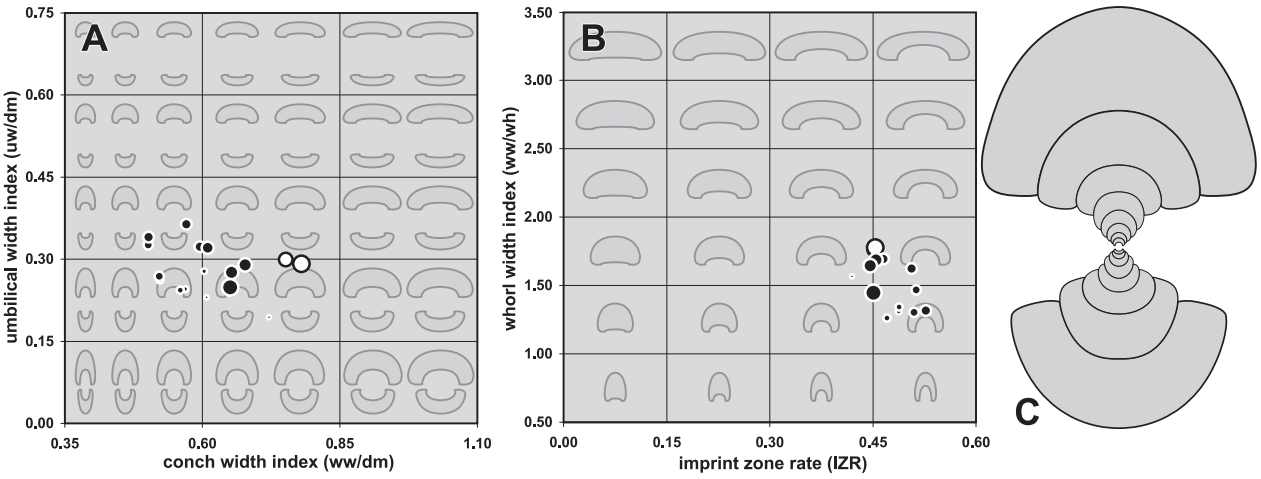


Figure 9. Ontogenetic trajectories of *Parahammatocyclus*, exemplified for *Parahammatocyclus mutaris* n. sp. from locality TIM-B3. **A.** Ontogenetic development of the conch width index (ww/dm) and umbilical width index (uw/dm). **B.** Ontogenetic development of the imprint zone rate (IZR) and whorl width index (ww/wh). **C.** Cross section of paratype MB.C.18685.3; ×2.0. [Black dots represent ontogenetic stages of cross section MB.C.18685.3, white dots represent the reference specimens (Tab. 8).]

Included species.
chaigleyensis: *Parahammatocyclus chaigleyensis* Riley, 1996: Lancashire. Great Britain.
mutaris: *Parahammatocyclus mutaris* n. sp.: Gourara, Algeria.

Discussion. Parahammatocyclus differs from *Rhnetites* n. gen. in the wider, more narrowly umbilicate conch and particularly in the diverging flanks of the external lobe. *Bollandites* has a superficially similar conch, but differs in the closure of the umbilicus, which in *Parahammatocyclus* continuously becomes wider during ontogeny.

Parahammatocyclus mutaris n. sp.

Figures 10, 11

Derivation of name. From Latin mutaris = to transmute, because of the striking ontogeny.

Holotype. Specimen MB.C.18685.1, illustrated in Figure 10A.

Type locality and horizon. Sebkha de Timimoun, locality TIM-B3 (10 km west-southwest of Timimoun, Algeria); upper part of the Lower *Bollandoceras-Bollandites* Assemblage.

Material. Seven specimens, conch diameter between 19 and 42 mm.

Diagnosis. Parahammatocyclus with thickly discoidal and subinvolute conch at 2–5 mm dm, becoming pachyconic and subevolute in later stages; aperture very low or low up to 18 mm dm and slightly increasing in the adult stage; umbilical margin rounded in juveniles but angular and sharp in the middle and adult stage. Steinkern smooth except for shallow, almost linear constrictions in small stages; in the middle stage the steinkern possesses faint umbilical nodes. Suture line with very narrow, slightly diverging external lobe with sinuous flanks and low median saddle; ventrolateral saddle broadly rounded; adventive lobe symmetrically V-shaped and slightly pouched.

Table 7. Conch ontogeny (Figs 11A, B, D–F) of *Parahammatocyclus mutaris* n. sp.

dm	conch shape	whorl cross section shape	aperture
3 mm	thickly discoidal; subinvolute (ww/dm ~ 0.55; uw/dm ~ 0.25)	weakly depressed; very strongly embracing (ww/wh ~ 1.35; IZR ~ 0.50)	low (WER ~ 1.60)
8 mm	thickly discoidal; subevolute (ww/dm = 0.50–0.60; uw/dm = 0.30–0.35)	moderately depressed; very strongly embracing (ww/wh = 1.50–1.65; IZR = 0.50–0.55)	low (WER = 1.50–1.55)
20 mm	thinly to thickly pachyconic; subinvolute to subevolute (ww/dm = 0.65–0.80; uw/dm = 0.25–0.35)	moderately depressed; very strongly embracing (ww/wh = 1.65–1.95; IZR = 0.45–0.50)	low (WER = 1.60–1.75)
35 mm	thickly pachyconic; subinvolute (ww/dm = 0.72–0.80; uw/dm = 0.18–0.30)	moderately depressed; very strongly embracing (ww/wh = 1.50–1.75; IZR = 0.45–0.50)	moderate (WER = 1.75–1.90)

Table 8. Conch dimensions (in mm) and proportions for reference specimens of *Parahammatocyclus mutaris* n. sp.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
holotype MB.C.18685.1	36.6	28.5	16.0	10.7	8.8	0.78	1.78	0.29	1.73	0.45
paratype MB.C.18685.2	24.4	18.4	10.4	7.3	5.7	0.75	1.76	0.30	1.70	0.45

Table 9. Suture line proportions (Fig. 11C) for *Parahammatocyclus mutaris* n. sp.

specimen	at dm	EL w/d	EL/VLS	EL/AL	MS h	VLS w/h	remarks
paratype MB.C.18685.5	25.8 mm	0.41	0.56	0.79	0.25	0.73	A lobe with slightly convex flanks

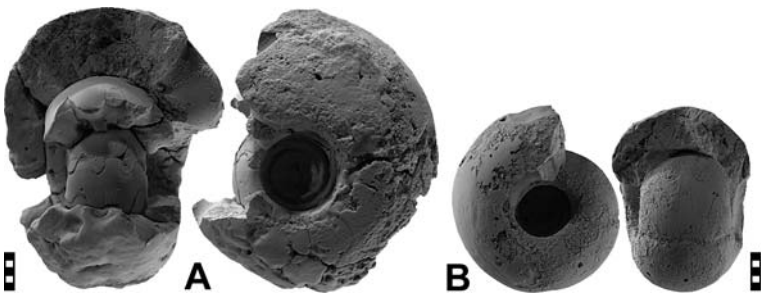


Figure 10. *Parahammatocyclus mutaris* n. sp. from locality TIM-B3; all ×1.0. **A.** Holotype MB.C.18685.1. **B.** Paratype MB.C.18685.2.

Discussion. Parahammatocyclus mutaris can easily be separated from the other species of the assemblage by its pachyconic conch and its wide umbilicus in the adult stage as well as by the very narrow external lobe. It differs from *P. chaigleyensis* Riley, 1996 in the much narrower umbilicus of the juvenile stage, the umbilical nodes, and the narrower external lobe.

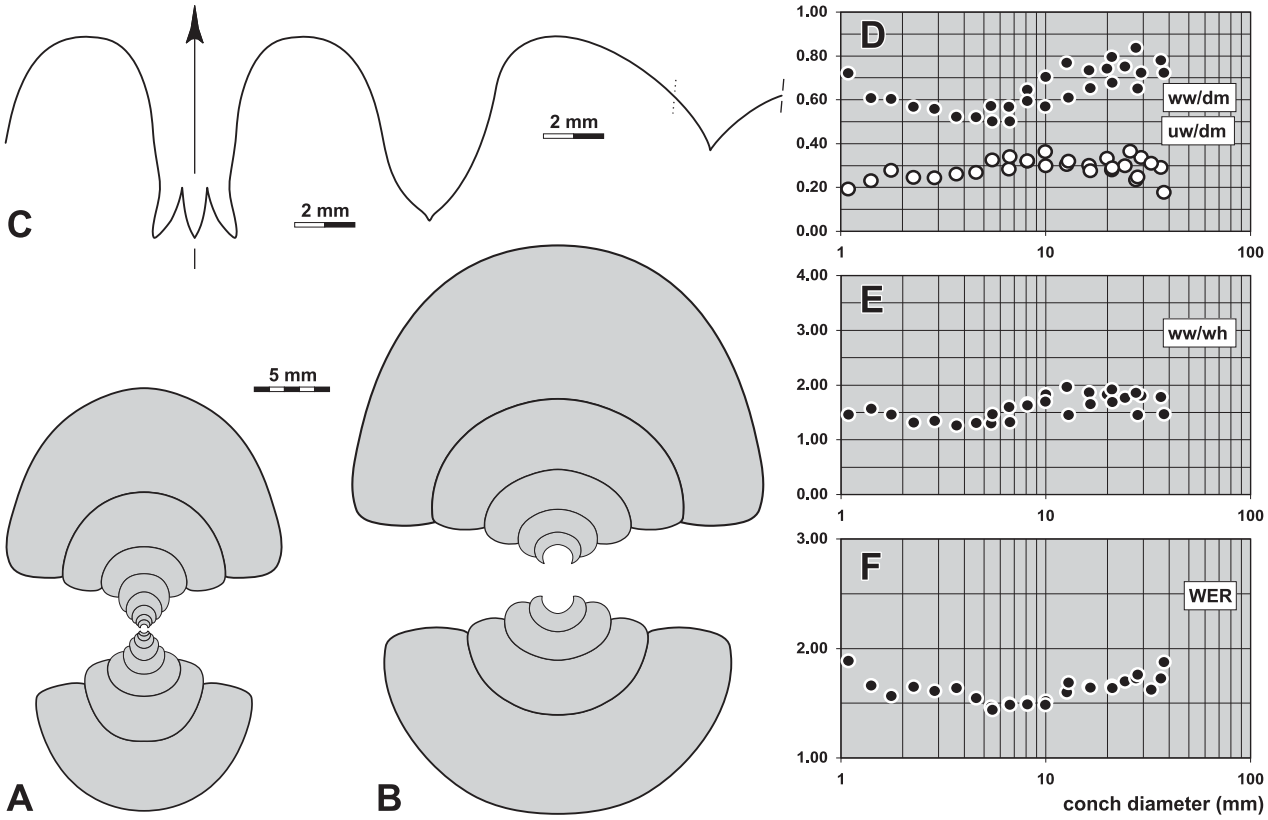


Figure 11. *Parahammatocyclus mutaris* n. sp. from locality TIM-B3. **A.** Cross section of paratype MB.C.18685.3; ×2.0. **B.** Cross section of paratype MB.C.18685.4; ×2.0. **C.** Suture line of paratype MB.C.18685.5, at 25.8 mm dm, 20.0 mm ww, 10.0 mm wh; ×4.0. **D–F.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm), whorl width index (ww/wh), and whorl expansion rate (WER) of all available specimens.

Family **Maxigoniatitidae** Korn, Klug & Mapes, 1999

Subfamily **Maxigoniatitinae** Korn, Klug & Mapes, 1999

Subfamily definition. Maxigoniatitidae with a widely umbilicate juvenile and intermediate stage with weakly or moderately depressed whorl cross section. Ornament usually with biconvex, fine growth lines and spiral lines in some genera. Suture line with V-shaped external lobe, flanks of the external lobe usually strongly sinuous.

Included genera.
Benimehlalites n. gen.
Beyrichoceras Foord, 1903
Bollandoceras Bisat, 1952
Maxigoniatites Korn, Klug & Mapes, 1999
Pachybollandoceras n. gen.

Bollandoceras Bisat, 1952

Type species. Goniatites micronotus Phillips, 1836 (original designation).

Genus definition. Genus of the subfamily Maxigoniatitinae with moderate to major ontogenetic changes of conch morphology (Figs 12, 13); adult conch discoidal with rapidly expanding whorls (WER above 2.10 in stages larger than 10 mm conch diameter); umbilicus moderately wide to wide in juveniles and narrow or almost closed in the adult stage. Shell ornament consisting of fine biconvex growth lines with a rather deep ventral sinus; steinkern often with constrictions parallel to the growth lines. Suture line with very narrow to narrow, V-shaped external lobe with gently sinuous, slightly diverging flanks; secondary prongs of the external lobe hook-shaped; median saddle very low or low; ventrolateral saddle usually broadly rounded; adventive lobe V-shaped, often much shallower than the external lobe.

Included species.
aridum: *Bollandoceras aridum* n. sp.: Gourara, Algeria.
bashatchense: *Bollandites bashatchensis* Popov, 1965, p. 38. Tien Shan.
bellmanense: *Dzhaprakoceras bellmanense* Riley, 1996, p. 51. Lancashire.
boreus: *Bollandites boreus* Kusina, 1980, p. 60. North Urals.
crowdecotense: *Bollandoceras crowdecotense* Korn & Tilsley, 2006, p. 131. Derbyshire.
fordi: *Bollandoceras fordi* Korn & Tilsley, 2006, p. 127. Derbyshire.
furiense: *Bollandoceras furiense* Padget, 1952, p. 864. Ireland.
globosum: *Bollandoceras globosum* Bisat, 1952, p. 177. Yorkshire.
hodderense: *Beyrichoceras hodderense* Bisat, 1924, p. 84. Lancashire.
inopinum: *Bollandoceras inopinum* Ruzhencev, 1975, p. 39. Verkhoyan.
kaindynense: *Bollandites* ? *kaindynense* Popov, 1965, p. 40. Tien Shan.
librovitchi: *Beyrichoceras librovitchi* Popov, 1965, p. 43. Tien Shan.
mackellari: *Beyrichoceras mackellari* Campbell, Brown & Coleman, 1983, p. 89. Queensland.
micronotoide: *Bollandoceras micronotoides* Bisat, 1934, p. 290. Yorkshire.
micronotum: *Goniatites micronotus* Phillips, 1836, p. 234. Yorkshire.
minusculum: *Dzhaprakoceras* ? *minusculum* Kusina, 1980, p. 55. North Urals.
mirrih: *Bollandoceras mirrih* n. sp.: Gourara, Algeria.
nitens: *Bollandoceras nitens* n. sp.: Gourara, Algeria.
parvum: *Bollandoceras parvum* Kusina in Kusina & Lazarev, 1994, p. 166. Mongolia.
politum: *Bollandoceras politum* n. sp.: Gourara, Algeria.
stylense: *Bollandoceras stylense* Kusina in Kusina & Poletaev, 1991, p. 40. Donets Basin.
subangulare: *Bollandoceras subangulare* n. sp.: Gourara, Algeria.
submicronotum: *Bollandoceras submicronotum* Bisat, 1934, p. 291. Derbyshire. [Synonym of *B. micronotum*]
suursureni: *Bollandoceras suursureni* Kusina in Kusina & Lazarev, 1994, p. 167. Mongolia.
tianshanicum: *Beyrichoceras tianshanicum* Popov, 1965, p. 44. Tien Shan.
undulatum: *Dzhaprakoceras undulatum* Riley, 1996, p. 66. Lancashire.
westheadi: *Dzhaprakoceras westheadi* Riley, 1996, p. 66. Lancashire.
zuhara: *Bollandoceras zuhara* n. sp.: Gourara, Algeria.

Discussion. Bollandoceras was introduced for species related to *Beyrichoceras*, but lacking a spiral ornament and possessing a lower median saddle in the suture line. The three species originally included in the '*Beyrichoceras micronotum* group' were separated by Bisat (1934) on the basis of conch morphology and the presence or absence of constrictions.

When Bisat (1952) created the genus *Bollandoceras* for this species group, he also added species such as "*Goniatites excavatus* Phillips, 1836" (which is a girtyoceratid ammonoid) and *B. globosum* Bisat, 1952. Riley (1996) followed this species concept, and also included *B. hodderense* (Bisat, 1924) and a number of other species in *Bollandoceras*. Such a definition of the genus would mean that two rather different and easily separable conch morphologies are united within one taxon: conchs with rapidly expanding whorls as in the type species, and conchs with slowly expanding whorls as in species such as "*Beyrichoceras hodderense* Bisat, 1924".

Popov (1968), Riley (1996), and Korn & Tilsley (2006) published cross sections of species of *Bollandoceras*, but some of the species were described without knowledge of the morphology of the inner whorls. Numerous cross sections were therefore made as part of this study.

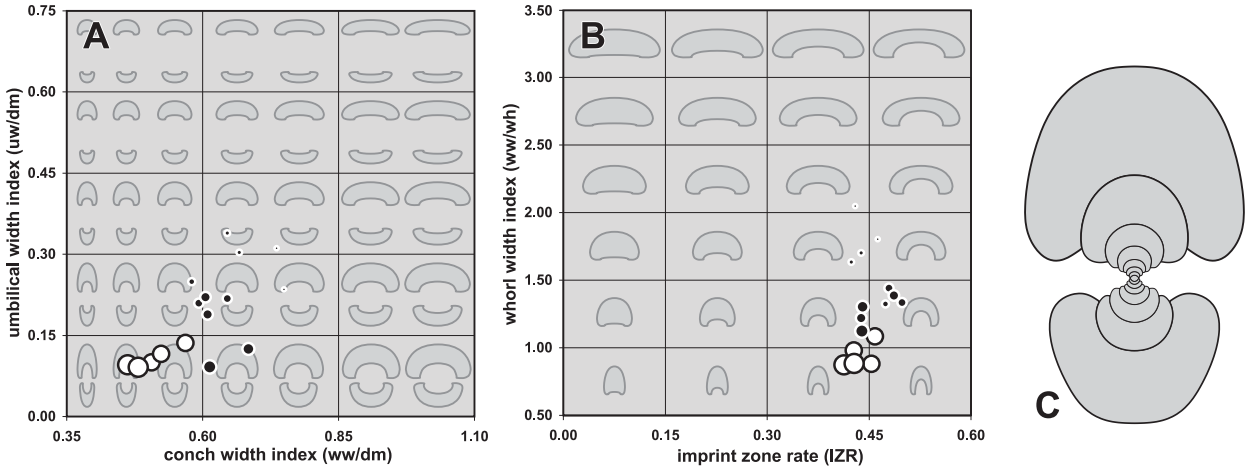


Figure 12. Ontogenetic trajectories of *Bollandoceras*, exemplified for *Bollandoceras politum* n. sp. from locality TIM-B3. **A.** Ontogenetic development of the conch width index (ww/dm) and umbilical width index (uw/dm). **B.** Ontogenetic development of the imprint zone rate (IZR) and whorl width index (ww/wh). **C.** Cross section of paratype MB.C.18686.4; ×2.5. [Black dots represent ontogenetic stages of cross section MB.C.18686.4, white dots represent the reference specimens (Tab. 17).]

Three of the species (*B. bellmanense*, *B. undulatum*, *B. westheadi*) described under the genus *Dzhaprakoceras* by Riley (1996) show an external lobe with diverging, slightly sinuous flanks and hook-shaped secondary prongs of the external lobe. They fall into the genus *Bollandoceras*, when the external lobe is the main distinguishing character between the two genera. The three species have a late Chadian age and co-occur with *Ammonellipsites*.

The new genus *Gourarites* resembles *Bollandoceras* in the adult conch, but differs in the presence of a juvenile growth stage with a very wide, crescent-shaped whorl cross section.

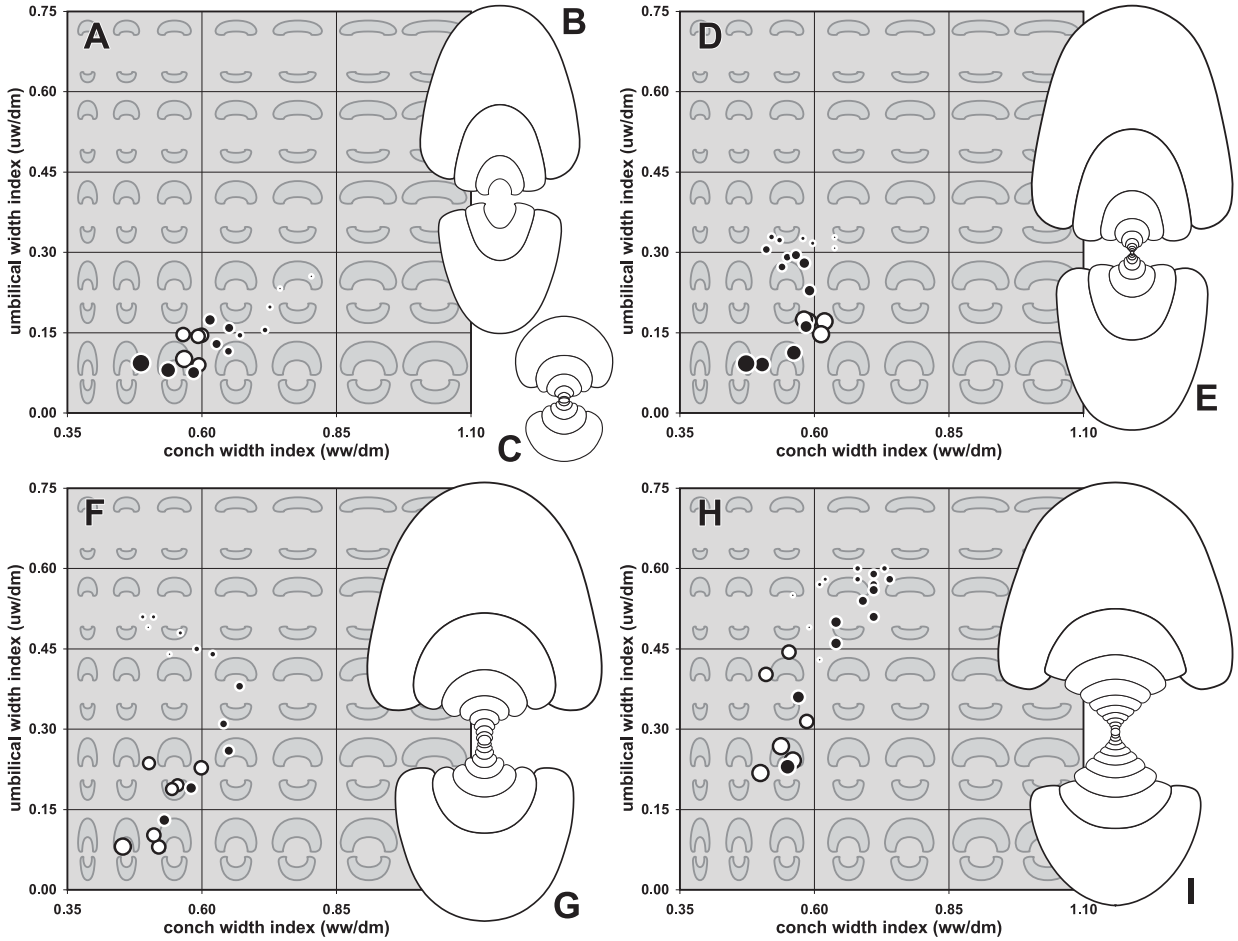


Figure 13. Ontogenetic trajectories in development of the conch width index (ww/dm) and umbilical width index (uw/dm) of *Bollandoceras* and *Gourarites*. **A**–**C.** *B. nitens* n. sp. from locality TIM-B2 with cross sections of paratypes MB.C.18682.10 (B; ×1.0) and MB.C.18682.8 (C; ×2.5). **D**, **E.** *B. aridum* n. sp. from locality TIM-B3 with cross sections of paratype MB.C.18687.3 (E; ×1.0). **F**, **G.** *B. zuhara* n. sp. from locality TIM-C8 with cross sections of paratype MB.C.18691.8 (G; ×4.0). **H**, **I.** *G. zuhal* n. sp. from locality TIM-C8 with cross sections of paratype MB.C.18698.3 (I; ×2.0). [Black dots represent ontogenetic stages of the figured cross sections, white dots represent the reference specimens listed in the tables of the species.]

Bollandoceras nitens n. sp.

Figures 14, 15

Derivation of name. From Latin nitens = shiny, because of the preservation.

Holotype. Specimen MB.C.18682.1, illustrated in Figure 14A.

Type locality and horizon. Sebkha de Timimoun, locality TIM-B2 (10 km west-southwest of Timimoun, Algeria); lower part of the Lower *Bollandoceras-Bollandites* Assemblage.

Material. 37 specimens, conch diameter between 12 and 45 mm. Most of the specimens are fully chambered and exfoliated; the steinkern surface is usually smooth except for a few very weak constrictions and periodically strengthened growth lines that show faint impressions. Shell remains are rarely preserved in the material.

Diagnosis. Bollandoceras with minor ontogenetic changes of conch geometry: conch subinvolute to involute throughout ontogeny with a trend towards decrease of the uw/dm ratio in the adult stage; conch becoming almost continuously more slender during ontogeny: thickly pachyconic in the early juvenile stage and discoidal at 45 mm dm, decrease of the ww/dm ratio slightly decelerated between 3 and 13 mm dm; aperture moderately high in juveniles and becoming higher in later ontogeny; umbilical margin rounded in juveniles and subangular in the adult stage; umbilical wall flattened and oblique in the adult stage. Ornament with fine growth lines, course slightly biconvex with moderately deep ventral

sinus; steinkern smooth except for shallow constrictions standing in irregular distances or 90° apart. Suture line with very narrow, slightly diverging external lobe with slightly sinuous flanks and low median saddle; ventrolateral saddle broadly rounded; adventive lobe V-shaped, slightly asymmetric.

Table 10. Conch ontogeny (Figs 15A–E, H–J) of *Bollandoceras nitens* n. sp.

dm	conch shape	whorl cross section shape	aperture
3 mm	thinly to thickly pachyconic; involute to subinvolute (ww/dm = 0.65–0.75; uw/dm = 0.10–0.25)	weakly to moderately depressed; strongly to very strongly embracing (ww/wh = 1.35–1.65; IZR = 0.40–0.50)	moderate (WER = 1.75–2.00)
8 mm	thinly pachyconic; subinvolute (ww/dm = 0.60–0.70; uw/dm = 0.15–0.25)	weakly to moderately depressed; strongly to very strongly embracing (ww/wh = 1.30–1.60; IZR = 0.40–0.50)	moderate (WER = 1.75–2.00)
20 mm	thickly discoidal to thinly pachyconic; involute (ww/dm = 0.55–0.65; uw/dm = 0.08–0.15)	weakly depressed; strongly embracing (ww/wh = 1.00–1.25; IZR = 0.40–0.45)	moderate to high (WER = 1.90–2.20)
40 mm	thickly discoidal to thinly pachyconic; involute (ww/dm ~ 0.50; uw/dm ~ 0.08)	weakly compressed; strongly embracing (ww/wh ~ 0.95; IZR ~ 0.42)	high (WER ~ 2.05)

Table 11. Conch dimensions (in mm) and proportions for reference specimens of *Bollandoceras nitens* n. sp.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
holotype MB.C.18682.1	33.1	18.7	18.2	3.3	10.5	0.57	1.03	0.10	2.15	0.42
paratype MB.C.18682.2	23.5	13.9	11.8	3.4	7.2	0.59	1.18	0.14	2.08	0.39
paratype MB.C.18682.4	20.4	11.5	10.4	3.0	5.6	0.57	1.11	0.15	1.91	0.46
paratype MB.C.18682.11	18.6	11.1	10.3	1.7	6.0	0.59	1.08	0.09	2.18	0.41
paratype MB.C.18682.3	18.5	11.1	9.0	2.7	5.4	0.60	1.23	0.15	1.99	0.40

Table 12. Suture line proportions (Figs 15F, G) for *Bollandoceras nitens* n. sp.

specimen	at dm	EL w/d	EL/VLS	EL/AL	MS h	VLS w/h	remarks
holotype MB.C.18682.1	28.5 mm	0.47	0.71	0.80	0.20	0.67	A lobe almost symmetric
paratype MB.C.18682.5	21.0 mm	0.46	0.67	0.80	0.21	0.68	

Discussion. Bollandoceras nitens belongs together with the other species of the genus, which possess a very short openly umbilicate juvenile stage and which also have a very narrow external lobe. The new species differs, for instance, from the rather similar species *B. politum* of the next higher horizon near Timimoun in the narrower umbilicate inner whorls and the narrower external lobe (EL/h = 0.45 in *B. nitens* and 0.55 in *B. politum*) and in the stouter conch. *B. aridum* has a similar conch but differs in the wider umbilicate juvenile stage and the wider external lobe. The co-occurring *B. subangulare* has a wider umbilicus (uw/dm > 0.20 at 20 mm dm).

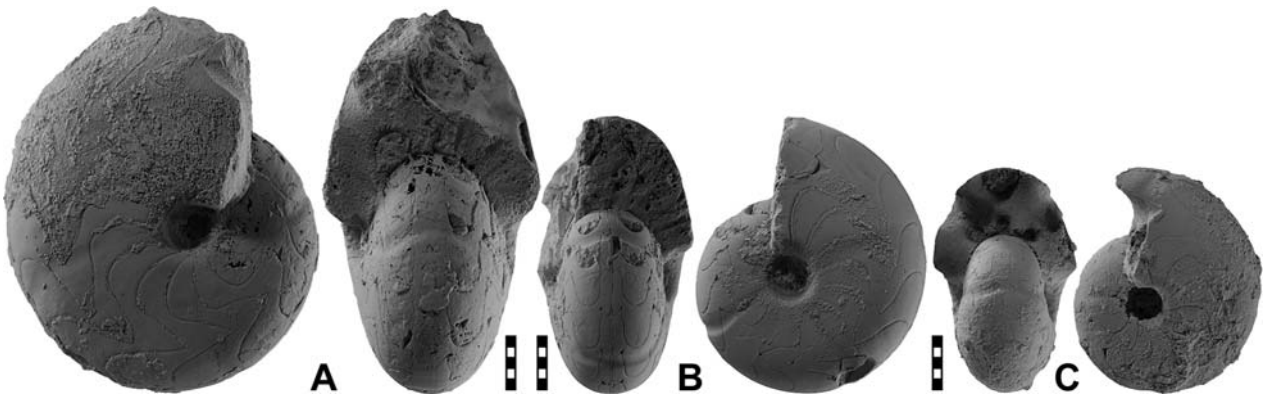


Figure 14. *Bollandoceras nitens* n. sp. from locality TIM-B2; all ×1.5. **A.** Holotype MB.C.18682.1. **B.** Paratype MB.C.18682.2. **C.** Paratype MB.C.18682.4.

Species probably belonging to *Bollandoceras* have been described by Popov (1965, 1968) from the Tien Shan of Kyrgyzstan under the genus name *Bollandites*. Popov had only a few specimens and hence it is not clear if all the species described by him are justified or represent intraspecific variability. However, three of the species (*B. bashatchensis*, *B. narynensis*, and *B. shabyrensis*) possess an external lobe with almost parallel flanks, and *B. kokdzharensis* has a much more compressed conch.

Some of the species attributed to *Dzhaprakoceras* by Riley (1996) probably also belong to *Bollandoceras*. Of these, *B. undulatum*, *B. westheadi*, and *B. bellmanense* show a wider umbilicus than *B. nitens*.

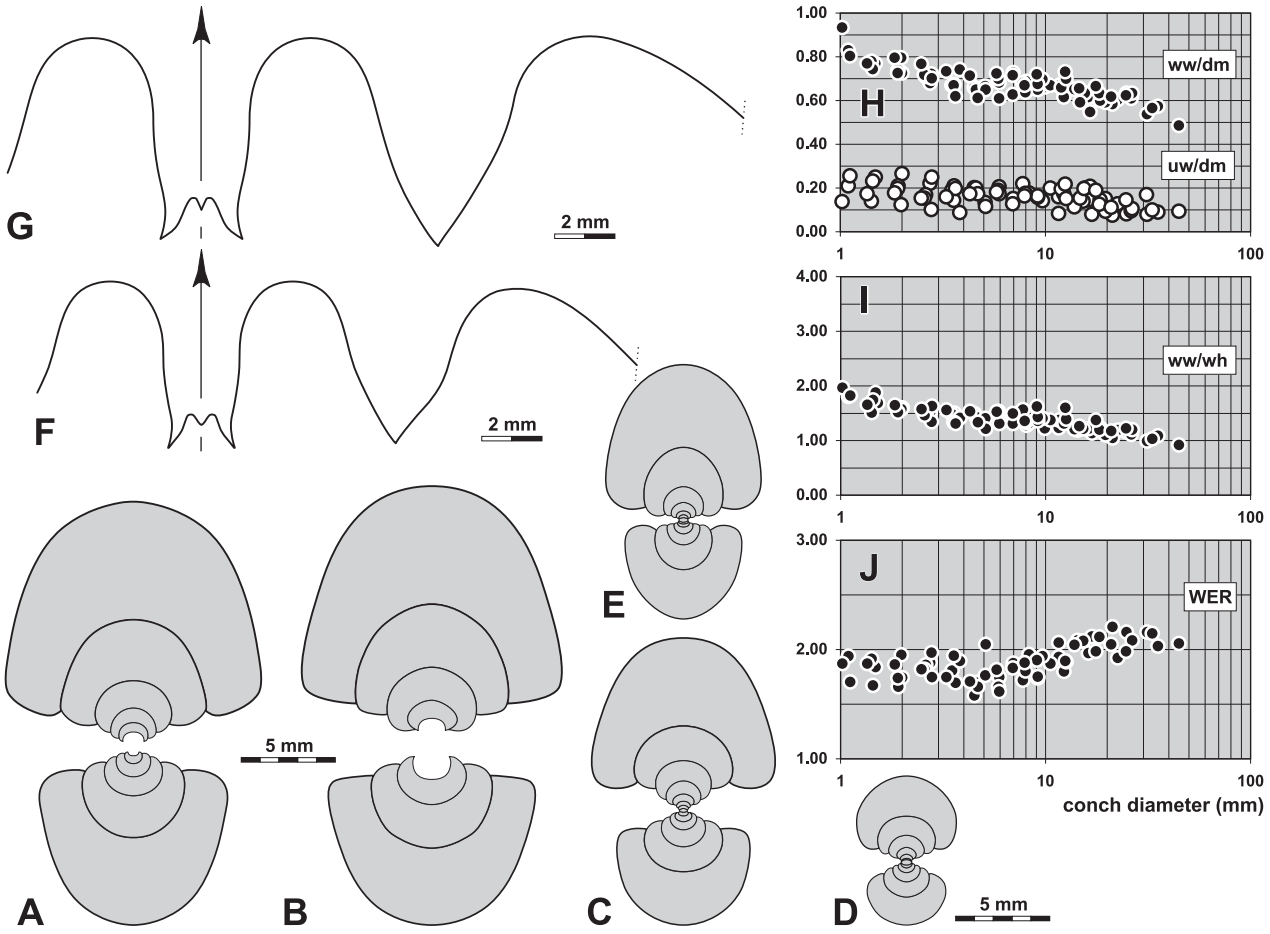


Figure 15. *Bollandoceras nitens* n. sp. from locality TIM-B2. **A.** Cross section of paratype MB.C.18682.5; ×2.5. **B.** Cross section of paratype MB.C.18682.6; ×2.5. **C.** Cross section of paratype MB.C.18682.7; ×2.5. **D.** Cross section of paratype MB.C.18682.8; ×2.5. **E.** Cross section of paratype MB.C.18682.9; ×2.5. **F.** Suture line of paratype MB.C.18682.5, at 21.0 mm dm, 12.5 mm ww, 10.5 mm wh; ×4.0. **G.** Suture line of holotype MB.C.18682.1, at 28.5 mm dm, 15.3 mm ww, 14.3 mm wh; ×4.0. **H–J.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm), whorl width index (ww/wh), and whorl expansion rate (WER) of all available specimens.

Bollandoceras subangulare n. sp.

Figures 16, 17

Derivation of name. From Latin angulus, because of the subangular umbilical margin.

Holotype. Specimen MB.C.18683.1, illustrated in Figure 16A.

Type locality and horizon. Sebkha de Timimoun, locality TIM-B2 (10 km west-southwest of Timimoun, Algeria); lower part of the Lower *Bollandoceras-Bollandites* Assemblage.

Material. 31 specimens, conch diameter between 10 and 47 mm. Furthermore, 12 specimens, which cannot be attributed with certainty to the new species.

Diagnosis. Bollandoceras with major ontogenetic changes of conch geometry: conch subinvolute to subevolute throughout ontogeny with a trend towards a decrease of the uw/dm ratio in the adult stage; conch becoming discontinuously more slender during ontogeny: thickly pachyconic in the early juvenile stage and discoidal above 25 mm dm with a slight increase of the ww/dm ratio between 5 and 15 mm dm; aperture low in juveniles and continuously becoming high during ontogeny; umbilical margin rounded in juveniles and subangular in the adult stage; umbilical wall flattened and oblique in the adult stage. Ornament with fine growth lines, course slightly biconvex with moderately deep ventral sinus; steinkern smooth except for rather strong constrictions. Suture line with narrow, slightly diverging external lobe with slightly sinuous flanks and very low median saddle; ventrolateral saddle broadly rounded and asymmetric; adventive lobe V-shaped, almost symmetric.

Table 13. Conch ontogeny (Figs 17A–D, G–I) of *Bollandoceras subangulare* n. sp.

dm	conch shape	whorl cross section shape	aperture
3 mm	thickly discoidal to thinly pachyconic; subinvolute to subevolute (ww/dm = 0.55–0.65; uw/dm = 0.25–0.40)	weakly to moderately depressed; strongly to very strongly embracing (ww/wh = 1.35–1.80; IZR = 0.40–0.55)	low (WER = 1.50–1.65)
8 mm	thickly discoidal to thinly pachyconic; subinvolute (ww/dm = 0.55–0.65; uw/dm = 0.20–0.30)	weakly to moderately depressed; strongly to very strongly embracing (ww/wh = 1.30–1.60; IZR = 0.40–0.50)	low to moderate (WER = 1.55–1.80)
20 mm	thickly discoidal to thinly pachyconic; subinvolute (ww/dm = 0.55–0.65; uw/dm = 0.20–0.30)	weakly depressed; strongly embracing (ww/wh = 1.30–1.50; IZR = 0.40–0.45)	moderate (WER = 1.85–1.95)
40 mm	thickly discoidal; subinvolute (ww/dm ~ 0.50; uw/dm ~ 0.15)	weakly depressed; strongly embracing (ww/wh ~ 1.00; IZR ~ 0.40)	high (WER ~ 2.05)

Table 14. Conch dimensions (in mm) and proportions for reference specimens of *Bollandoceras subangulare* n. sp.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
paratype MB.C.18683.10	31.2	16.6	14.0	5.7	8.6	0.53	1.19	0.18	1.91	0.39
holotype MB.C.18683.1	28.5	15.1	14.0	7.0	7.9	0.53	1.08	0.25	1.91	0.44
paratype MB.C.18683.3	19.4	11.8	8.2	5.1	4.4	0.61	1.44	0.26	1.68	0.46
paratype MB.C.18683.2	17.7	10.7	8.0	4.1	4.3	0.61	1.34	0.23	1.75	0.46
paratype MB.C.18683.4	17.3	10.9	7.1	5.4	4.3	0.63	1.52	0.31	1.77	0.40

Table 15. Suture line proportions (Figs 17E, F) for *Bollandoceras subangulare* n. sp.

specimen	at dm	EL w/d	EL/VLS	EL/AL	MS h	VLS w/h	remarks
paratype MB.C.18683.10	20.0 mm	0.55	0.64	0.86	0.16	0.85	
paratype MB.C.18683.9	8.0 mm	0.50	0.62	0.68	0.13	0.82	A lobe rather wide

Discussion. Bollandoceras subangulare belongs together with the other species of the genus, which possess a rather wide umbilicus in the adult stage. It differs from the co-occurring *B. nitens* mainly in the wider umbilicus (uw/dm = 0.20–0.25 at 20 mm dm in *B. subangulare* and only 0.10–0.15 in *B. nitens*). Furthermore, *B. subangulare* has rather strong steinkern constrictions, which separates it from *B. nitens*.

Some of the species, such as *B. hagaraswad* and *B. hagarkarim* from horizon C8 have a similarly wide umbilicus in large specimens, but differ from *B. subangulare* in their much longer evolute juvenile stage.

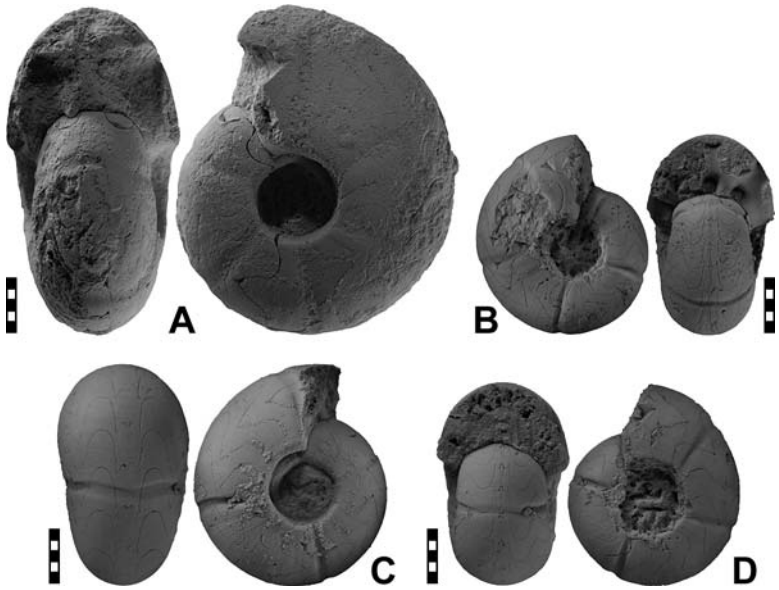


Figure 16. *Bollandoceras subangulare* n. sp. from locality TIM-B2; all × 1.5. **A.** Holotype MB.C.18683.1. **B.** Paratype MB.C.18683.2. **C.** Paratype MB.C.18683.3. **D.** Paratype MB.C.18683.4.

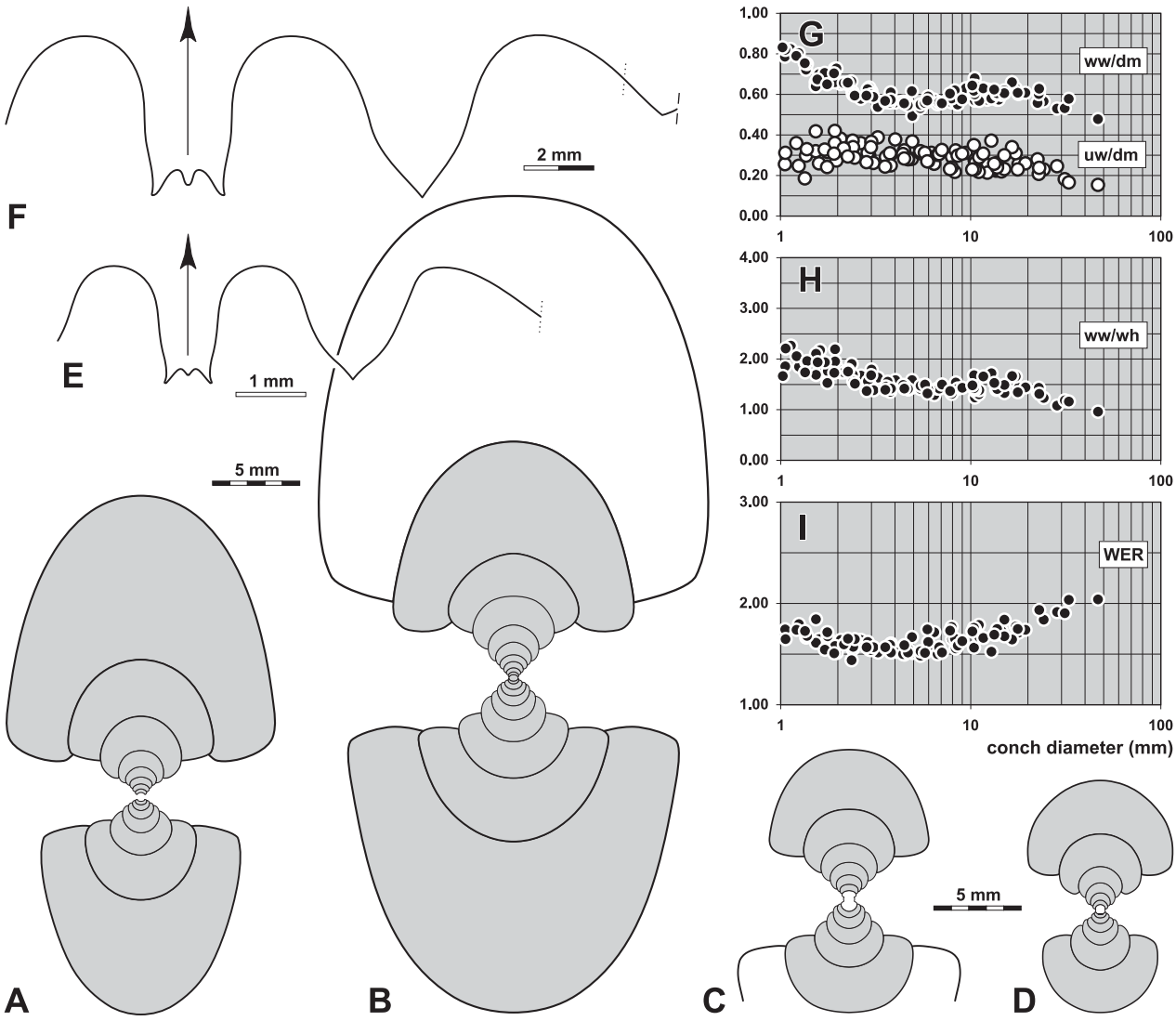


Figure 17. *Bollandoceras subangulare* n. sp. from locality TIM-B2. **A.** Cross section of paratype MB.C.18683.5; ×2.5. **B.** Cross section of paratype MB.C.18683.6; ×2.5. **C.** Cross section of paratype MB.C.18683.7; ×2.5. **D.** Cross section of paratype MB.C.18683.8; ×2.5. **E.** Suture line of paratype MB.C.18683.9, at 8.0 mm dm, 4.7 mm ww, 3.3 mm wh; ×6.0. **F.** Suture line of paratype MB.C.18683.10, at 19.8 mm dm, 13.8 mm ww, 9.0 mm wh; ×4.0. **G–I.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm), whorl width index (ww/wh), and whorl expansion rate (WER) of all available specimens.

Bollandoceras politum **n. sp.**

Figures 18, 19

Derivation of name. From Latin politus = smoothed, because of the ornament.

Holotype. Specimen MB.C.18686.1, illustrated in Figure 18A.

Type locality and horizon. Sebkha de Timimoun, locality TIM-B3 (10 km west-southwest of Timimoun, Algeria); upper part of the Lower *Bollandoceras-Bollandites* Assemblage.

Material. 12 specimens, conch diameter between 20 and 50 mm.

Diagnosis. Bollandoceras with minor ontogenetic changes of conch geometry: conch subevolute in early juveniles and involute in the adult stage; conch becoming discontinuously more slender during ontogeny: thinly pachyconic in the early juvenile stage and discoidal at 45 mm dm, stable ww/dm ratio between 4 and 16 mm dm; aperture low in juveniles and moderately high to high above 10 mm dm; umbilical margin narrowly rounded in the adult stage. Steinkern smooth except for shallow, slightly biconvex constrictions with moderately deep ventral sinus in small stages; constrictions in the adult stage restricted to outer flanks and venter. Suture line with narrow, slightly diverging external lobe with moderately sinuous flanks and very low median saddle; ventrolateral saddle broadly rounded; adventive lobe broadly V-shaped, nearly symmetric.

Table 16. Conch ontogeny (Figs 19A–D, F–H) of *Bollandoceras politum* n. sp.

dm	conch shape	whorl cross section shape	aperture
3 mm	thickly discoidal to thinly pachyconic; subinvolute (ww/dm = 0.55–0.65; uw/dm = 0.25–0.30)	weakly depressed; very strongly embracing (ww/wh = 1.30–1.40; IZR = 0.45–0.55)	low (WER = 1.60–1.70)
8 mm	thickly discoidal; involute to subinvolute (ww/dm = 0.55–0.60; uw/dm = 0.10–0.20)	weakly depressed; very strongly embracing (ww/wh = 1.10–1.30; IZR = 0.45–0.50)	moderate (WER = 1.75–2.00)
20 mm	thickly discoidal to thinly pachyconic; involute (ww/dm = 0.55–0.65; uw/dm = 0.08–0.15)	weakly depressed; strongly embracing (ww/wh = 1.00–1.25; IZR = 0.40–0.45)	moderate to high (WER = 1.90–2.15)
45 mm	thickly discoidal; involute (ww/dm ~ 0.50; uw/dm ~ 0.10)	weakly compressed; strongly embracing (ww/wh ~ 0.90; IZR ~ 0.45)	high (WER ~ 2.10)

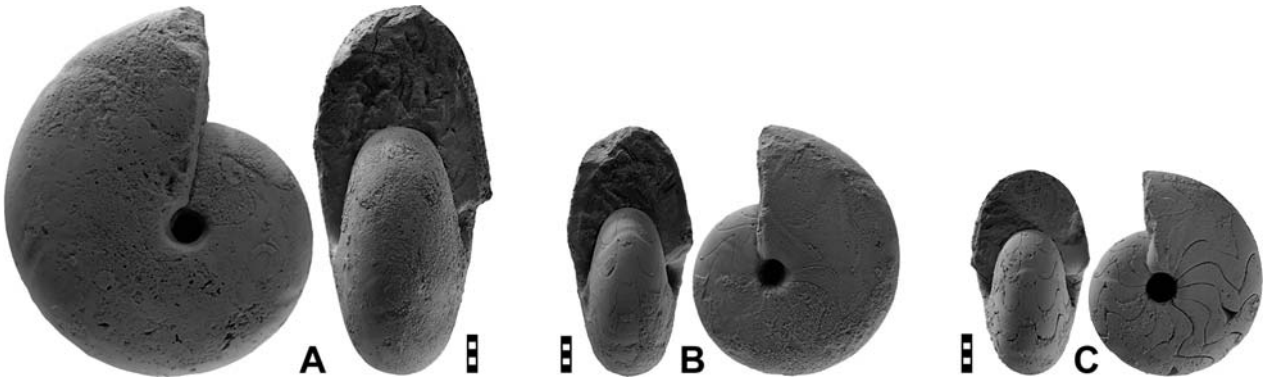


Figure 18. *Bollandoceras politum* n. sp. from locality TIM-B3; all ×1.0. **A.** Holotype MB.C.18686.1. **B.** Paratype MB.C.18686.2. **C.** Paratype MB.C.18686.3.

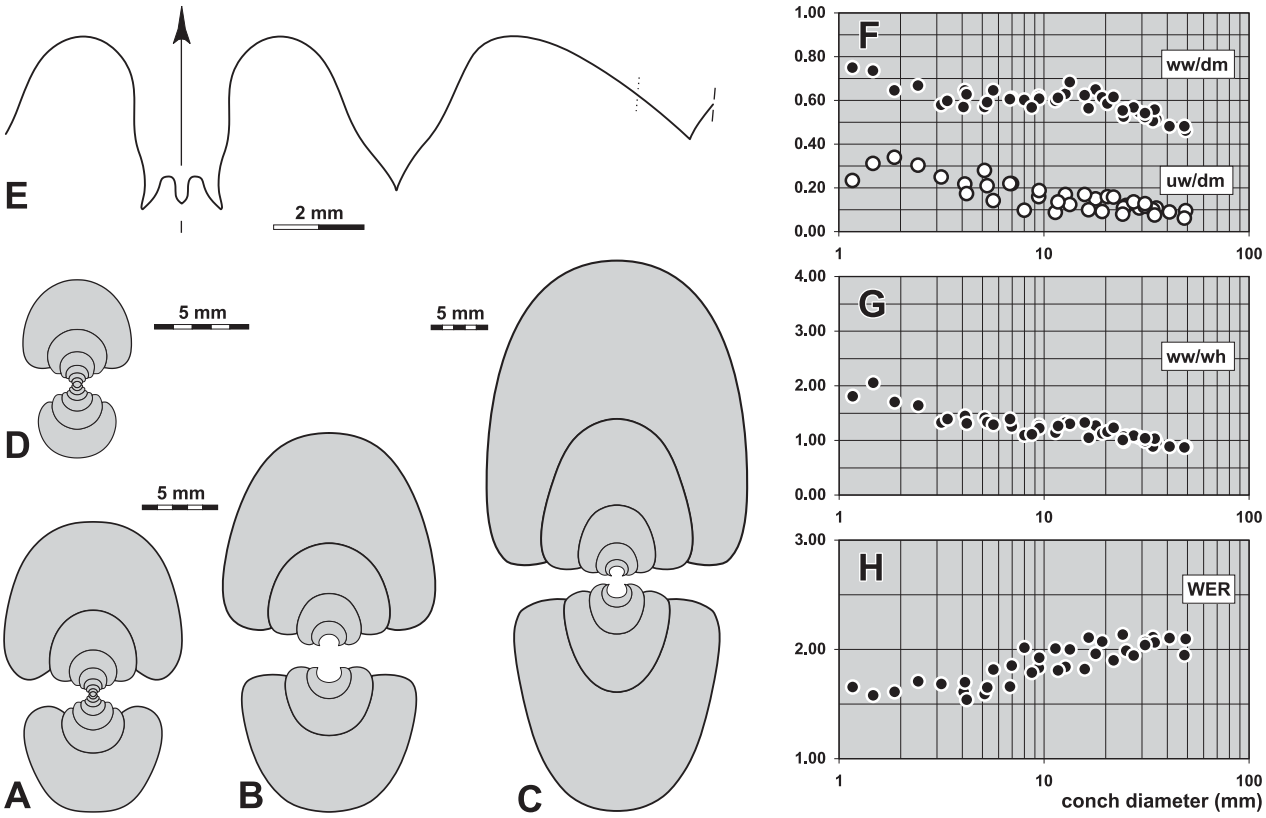


Figure 19. *Bollandoceras politum* n. sp. from locality TIM-B3. **A.** Cross section of paratype MB.C.18686.4; ×2.0. **B.** Cross section of paratype MB.C.18686.5; ×2.0. **C.** Cross section of paratype MB.C.18686.6; ×1.5. **D.** Cross section (inner whorls) of paratype MB.C.18686.4; ×2.5. **E.** Suture line of paratype MB.C.18686.7, at 8.6 mm ww, 8.5 mm wh; ×6.0. **F–H.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm), whorl width index (ww/wh), and whorl expansion rate (WER) of all available specimens.

Table 17. Conch dimensions (in mm) and proportions for reference specimens of *Bollandoceras politum* n. sp.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
holotype MB.C.18686.1	49.0	22.6	25.8	4.7	15.1	0.46	0.88	0.10	2.10	0.41
paratype MB.C.18686.8	40.9	19.7	22.2	3.7	12.7	0.48	0.89	0.09	2.10	0.43
paratype MB.C.18686.2	34.0	17.2	19.4	3.4	10.6	0.51	0.89	0.10	2.11	0.45
paratype MB.C.18686.7	31.1	16.3	16.5	3.6	9.5	0.52	0.98	0.12	2.07	0.43
paratype MB.C.18686.3	27.4	15.6	14.3	3.7	7.7	0.57	1.09	0.14	1.95	0.46

Table 18. Suture line proportions (Fig. 19E) for *Bollandoceras politum* n. sp.

specimen	at dm	EL w/d	EL/VLS	EL/AL	MS h	VLS w/h
paratype MB.C.18686.7	14.0 mm	0.55	0.78	0.98	0.19	0.71

Discussion. Bollandoceras politum has the most slender conch shape and the narrowest umbilicus out of all the species from assemblage TIM-B3. At about 40 mm conch diameter, *B. politum* has a ww/dm ratio of 0.50 and a uw/dm ratio of 0.10, whereas *B. aridum* is stouter (ww/dm = 0.60) and more widely umbilicate (uw/dm = 0.15).

B. nitens from assemblage TIM-B2 has a similar conch shape, but differs from *B. politum* in the narrower umbilicate inner whorls and the narrower external lobe (EL w/d = 0.45 in *B. nitens* and 0.55 in *B. politum*).

Specimens from the Tien Shan described by Popov (1965, 1968) and there attributed to *Bollandites* are similar to the Algerian material, but most of them (*B. bashatchensis*, *B. narynensis*, and *B. shabyrensis*) show an external lobe that has almost parallel flanks and are thus closer to *Dzhaprakoceras*. *B. kokdzharensis* shows an external lobe with diverging flanks, but the first species differs from *B. politum* in the rursiradiate constriction.

Bollandoceras aridum **n. sp.**

Figures 20, 21

Derivation of name. From Latin aridum = dry, referring to the Sebkha de Timimoun.

Holotype. Specimen MB.C.18687.1, illustrated in Figure 20.

Type locality and horizon. Sebkha de Timimoun, locality TIM-B3 (10 km west-southwest of Timimoun, Algeria); upper part of the Lower *Bollandoceras-Bollandites* Assemblage.

Material. Eight specimens, conch diameter between 29 and 56 mm.

Diagnosis. Bollandoceras with major ontogenetic changes of conch geometry: conch subevolute in juveniles up to 8 mm dm and then continuously becoming involute in the adult stage; conch becoming discontinuously more slender during ontogeny: thinly pachyconic in the early juvenile stage and discoidal at 45 mm dm, increasing ww/dm ratio between 4 and 18 mm dm; aperture very low or low in juveniles and moderately high to high above 20 mm dm; umbilical margin rounded in juveniles and more pronounced in the adult stage. Ornament with very fine growth lines, course almost linear across the flanks and a shallow, rounded sinus on the venter; steinkern smooth except for very shallow, slightly biconvex constrictions. Suture line with narrow, slightly diverging external lobe with sinuous flanks, and low median saddle; ventrolateral saddle broadly rounded; adventive lobe V-shaped, symmetric.

Table 19. Conch ontogeny (Figs 21A–C, E–G) of *Bollandoceras aridum* n. sp.

dm	conch shape	whorl cross section shape	aperture
3 mm	thickly discoidal; subevolute (ww/dm = 0.50–0.55; uw/dm = 0.30–0.40)	weakly to moderately depressed; very strongly embracing (ww/wh = 1.35–1.60; IZR = 0.45–0.55)	very low to low (WER = 1.45–1.55)
8 mm	thickly discoidal; subevolute (ww/dm = 0.50–0.60; uw/dm = 0.30–0.40)	weakly depressed; very strongly embracing (ww/wh = 1.40–1.50; IZR = 0.45–0.50)	low (WER = 1.50–1.60)
20 mm	thickly discoidal to thinly pachyconic; subinvolute (ww/dm = 0.55–0.70; uw/dm = 0.15–0.25)	weakly depressed; very strongly embracing (ww/wh = 1.15–1.45; IZR = 0.45–0.50)	moderate (WER = 1.80–2.00)
45 mm	thinly to thickly discoidal; involute (ww/dm = 0.45–0.55; uw/dm = 0.08–0.15)	weakly compressed to weakly depressed; very strongly embracing (ww/wh = 0.90–1.10; IZR = 0.45–0.50)	high (WER = 2.00–2.10)

Table 20. Conch dimensions (in mm) and proportions for reference specimens of *Bollandoceras aridum* n. sp.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
paratype MB.C.18687.4	37.9	23.5	18.3	6.5	10.5	0.62	1.28	0.17	1.91	0.43
holotype MB.C.18687.1	36.2	21.3	18.5	6.2	11.1	0.59	1.15	0.17	2.08	0.40
paratype MB.C.18687.6	29.2	17.0	15.6	5.1	8.7	0.58	1.09	0.17	2.03	0.44
paratype MB.C.18687.5	28.9	17.7	15.3	4.3	8.1	0.61	1.16	0.15	1.93	0.47

Table 21. Suture line proportions (Fig. 21D) for *Bollandoceras aridum* n. sp.

	at dm	EL w/d	EL/VLS	EL/AL	MS h	VLS w/h	remarks
holotype MB.C.18687.1	35.0 mm	0.66	0.85	1.14	0.23	0.78	A lobe barely pouched

Figure 20. *Bollandoceras aridum* n. sp. from locality TIM-B3; holotype MB.C.18687.1; × 1.0.

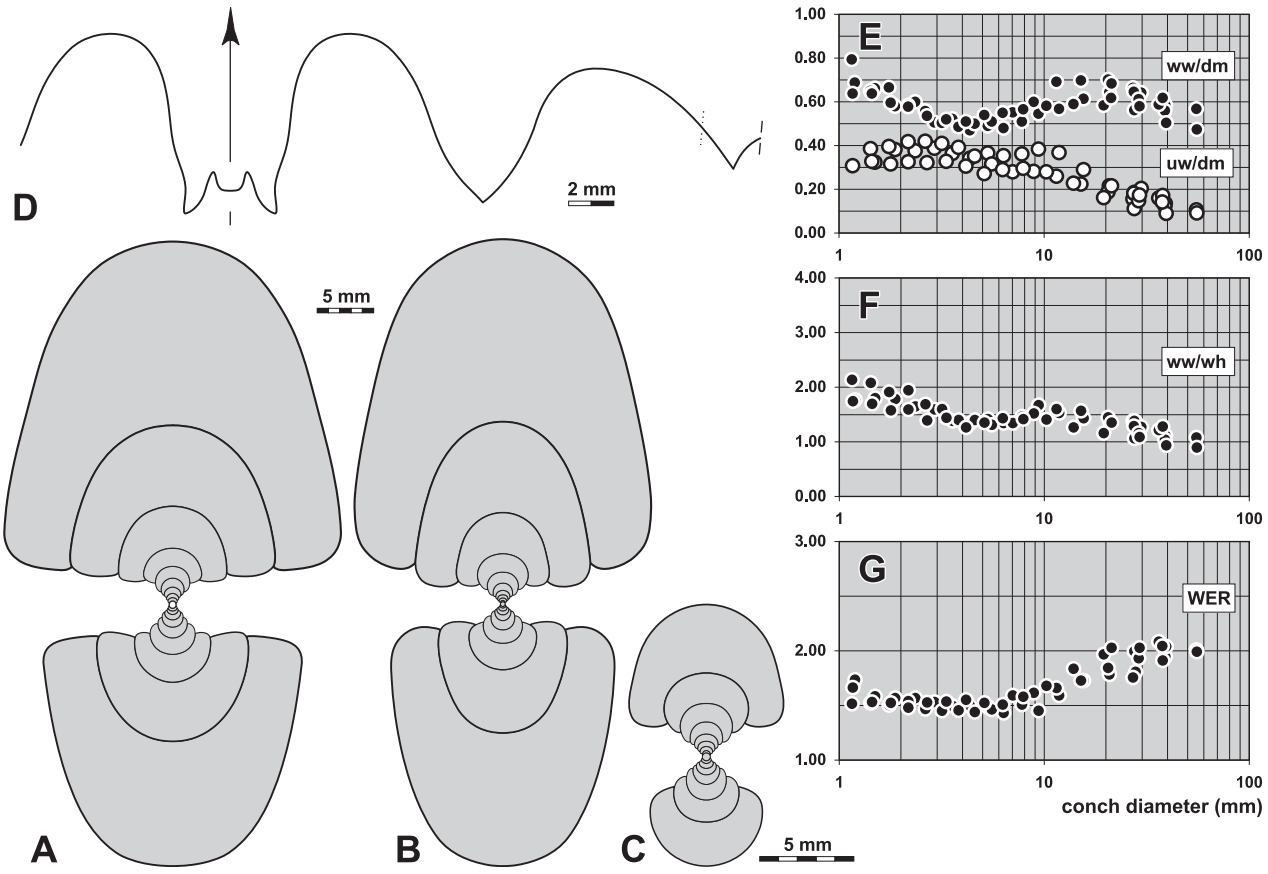


Figure 21. *Bollandoceras aridum* n. sp. from locality TIM-B3. **A.** Cross section of paratype MB.C.18687.2; × 1.5. **B.** Cross section of paratype MB.C.18687.3; × 1.5. **C.** Cross section of the inner whorls of the same specimen; × 2.5. **D.** Suture line of holotype MB.C.18687.1, at 35.0 mm dm, 22.5 mm ww, 17.5 mm wh; × 3.0. **E–G.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm), whorl width index (ww/wh), and whorl expansion rate (WER) of all available specimens.

Discussion. The co-occurring species *B. politum* has a laterally more compressed and narrower umbilicate conch (see discussion under this species). The species described by Popov (1965, 1968) from the Tien Shan differ in the external lobe with almost parallel-sided flanks and the narrower conch. *B. subangulare* has a wider umbilicus in the adult stage. The species of *Bollandoceras* from horizon TIM-C8 (*B. zuhara*, *B. mirrih*) show a wider umbilicate juvenile stage.

Bollandoceras zuhara n. sp.

Figures 22, 23

Derivation of name. From the Arabic zuhara = Venus.

Holotype. Specimen MB.C.18691.1, illustrated in Figure 22A.

Type locality and horizon. Sebkha de Timimoun, locality TIM-C8 (13.3 km west of Timimoun, Algeria); Upper *Bollandoceras-Bollandites* Assemblage.

Material. 108 specimens, conch diameter between 8 and 30 mm.

Diagnosis. Bollandoceras with major ontogenetic changes of conch geometry: conch evolute in the early juvenile stage (2–3 mm dm) and then rapidly becoming involute at 20 mm dm; conch thickly discoidal in the early juvenile stage, thickly discoidal to thinly pachyconic in the intermediate stage (4–10 mm dm) and thinly discoidal at 30 mm dm; aperture very low in juveniles and then rapidly increasing (being high at 20 mm dm); umbilical margin broadly or narrowly rounded in all stages. Steinkern smooth except for shallow, biconvex constrictions and traces of biconvex growth lines. Suture line with narrow, slightly diverging external lobe with strongly sinuous flanks and very low median saddle; ventrolateral saddle broadly rounded; small adventive lobe V-shaped, symmetric.

Table 22. Conch ontogeny (Figs 23A–E, H–J) of *Bollandoceras zuhara* n. sp.

dm	conch shape	whorl cross section shape	aperture
2 mm	thickly discoidal; evolute (ww/dm = 0.50–0.58; uw/dm = 0.45–0.55)	moderately depressed; strongly embracing (ww/wh = 1.65–2.00; IZR = 0.40–0.45)	very low to low (WER = 1.40–1.55)
8 mm	thickly discoidal to thinly pachyconic; subinvolute (ww/dm = 0.55–0.70 uw/dm = 0.22–0.30)	weakly depressed; strongly embracing (ww/wh = 1.15–1.40; IZR = 0.40–0.45)	moderate (WER = 1.70–1.90)
20 mm	thinly to thickly discoidal; involute (ww/dm = 0.45–0.55; uw/dm = 0.08–0.15)	weakly compressed to weakly depressed; strongly embracing (ww/wh = 0.85–1.25; IZR = 0.40–0.45)	high (WER = 2.00–2.15)

Table 23. Conch dimensions (in mm) and proportions for reference specimens of *Bollandoceras zuhara* n. sp.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
holotype MB.C.18691.1	30.5	13.8	16.3	2.5	9.4	0.45	0.85	0.08	2.09	0.42
paratype MB.C.18691.2	21.6	11.3	12.2	1.7	6.5	0.52	0.93	0.08	2.05	0.47
paratype MB.C.18691.12	16.6	8.5	8.9	1.7	4.9	0.51	0.95	0.10	2.02	0.45
paratype MB.C.18691.3	12.8	7.1	6.6	2.5	3.8	0.55	1.08	0.20	2.04	0.42
paratype MB.C.18691.13	11.0	5.5	4.7	2.6	2.9	0.50	1.17	0.24	1.84	0.39
paratype MB.C.18691.4	10.1	5.5	4.9	1.9	3.0	0.54	1.12	0.19	2.02	0.39

Table 24. Suture line proportions (Figs 23F, G) for *Bollandoceras zuhara* n. sp.

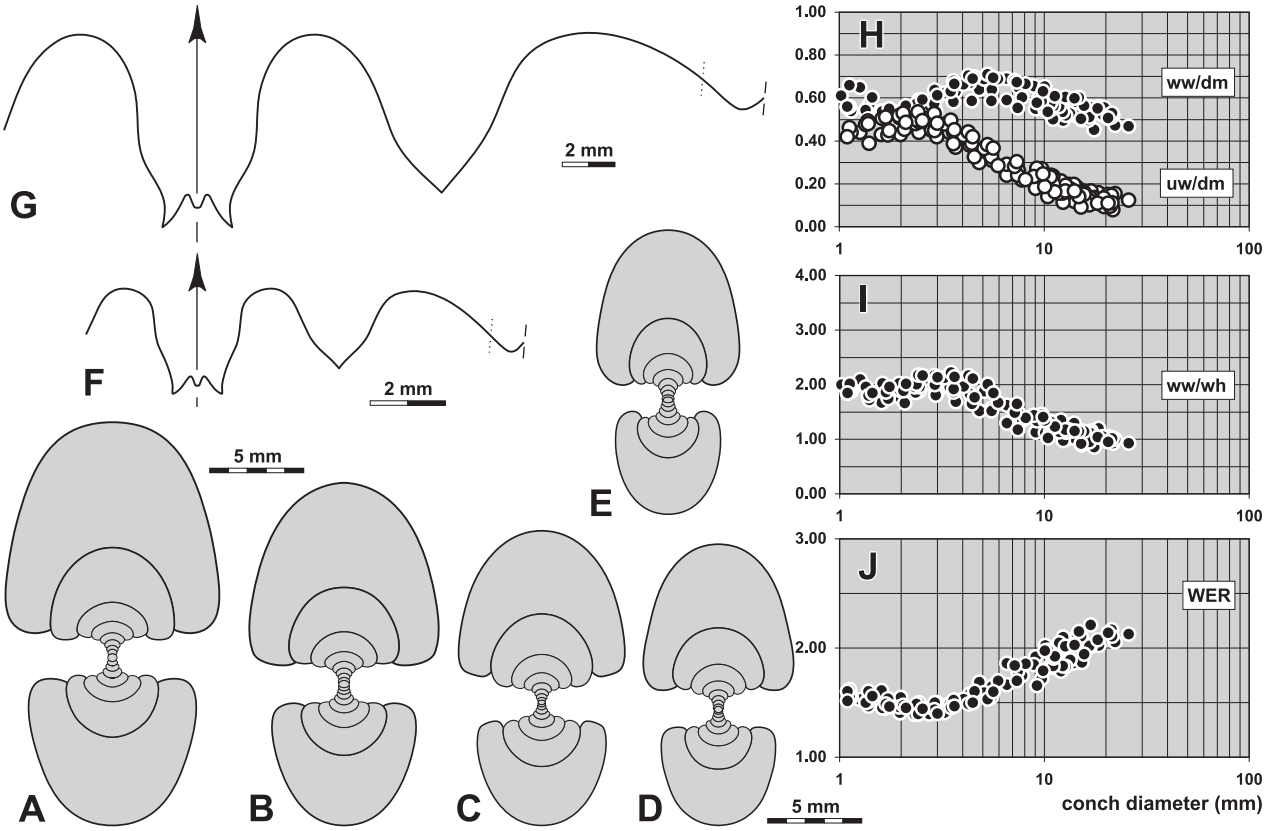
specimen	at dm	EL w/d	EL/VLS	EL/AL	MS h	VLS w/h	remarks
paratype MB.C.18691.11	29.0 mm	0.62	0.89	1.06	0.17	0.69	prongs of the E lobe very narrow
paratype MB.C.18691.10	11.8 mm	0.77	1.09	1.22	0.18	0.70	E lobe moderately wide

Discussion. Bollandoceras zuhara is the most involute *Bollandoceras* species from assemblage TIM-C8. It differs from all other co-occurring species in the shorter evolute growth interval (ending at about 3 mm conch diameter). *B. mirrih* is the most similar in terms of morphology; in this species the evolute juvenile growth interval ends at 4 mm dm; larger specimens possess always a wider umbilicus than *B. zuhara*.

B. zuhara differs from the species of the genus that occur in the stratigraphically lower assemblages TIM-B2 and TIM-B3 in the wider umbilicate inner whorls (uw/dm = 0.40–0.50 at 2–3 mm dm). The uw/dm ratios of the species *B. nitens*, *B. subangulare*, *B. politum*, and *B. aridum* ranges, at this diameter, between 0.25 and 0.35.

This new species shows closer resemblance with the stratigraphically younger representatives of the genus, such as the type species *B. micronotum* (Phillips, 1836). This species, however, has a higher median saddle and an adult conch with a subangular ventrolateral margin separating the flanks from the slightly flattened venter.

Figure 22. *Bollandoceras zuhara* n. sp. from locality TIM-C8; all ×2.5. **A.** Holotype MB.C.18691.1. **B.** Paratype MB.C.18691.2. **C.** Paratype MB.C.18691.3. **D.** Paratype MB.C.18691.4.



Bollandoceras mirrih n. sp.

Figures 24, 25

Derivation of name. From the Arabic mirrih = Mars.

Holotype. Specimen MB.C.18692.1, illustrated in Figure 24A.

Type locality and horizon. Sebkha de Timimoun, locality TIM-C8 (13.3 km west of Timimoun, Algeria); Upper *Bollandoceras-Bollandites* Assemblage.

Material. 119 specimens, conch diameter between 8 and 25 mm.

Diagnosis. Bollandoceras with major ontogenetic changes of the conch geometry: conch evolute in the early juvenile stage (1.5–3 mm dm) and then rapidly becoming involute or subinvolute at 20 mm dm; conch thickly discoidal in the early juvenile stage, thinly to thickly pachyconic in the intermediate stage (4–10 mm dm) and again thickly discoidal at 20 mm dm; aperture very low in juveniles and then rapidly increasing (moderately high to high at 20 mm dm); umbilical margin rounded in juveniles and subangular in the adult stage. Steinkern smooth except for shallow, slightly biconvex constrictions and traces of biconvex growth lines. Suture line with narrow, slightly diverging external lobe with strongly sinuous flanks and low median saddle; ventrolateral saddle broadly rounded; small adventive lobe V-shaped, symmetric.

Table 25. Conch ontogeny (Figs 25A–C, G–J) of *Bollandoceras mirrih* n. sp.

dm	conch shape	whorl cross section shape	aperture
2 mm	thickly discoidal; evolute (ww/dm = 0.50–0.60; uw/dm = 0.50–0.55)	moderately to strongly depressed; strongly embracing (ww/wh = 1.80–2.20; IZR = 0.30–0.40)	very low (WER = 1.40–1.50)
8 mm	thinly to thickly pachyconic; subinvolute to subevolute (ww/dm = 0.65–0.75; uw/dm = 0.25–0.35)	moderately depressed; strongly embracing (ww/wh = 1.50–2.00; IZR = 0.35–0.45)	low to moderate (WER = 1.60–1.85)
20 mm	thinly to thickly discoidal; involute to subinvolute (ww/dm = 0.45–0.60; uw/dm = 0.08–0.20)	weakly compressed to weakly depressed; strongly embracing (ww/wh = 0.90–1.20; IZR = 0.35–0.40)	moderate to high (WER = 1.90–2.25)

Table 26. Conch dimensions (in mm) and proportions for reference specimens of *Bollandoceras mirrih* n. sp.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
paratype MB.C.18692.11	25.7	14.0	12.1	4.4	7.8	0.54	1.16	0.17	2.06	0.36
holotype MB.C.18692.1	23.8	12.5	11.1	4.3	6.9	0.52	1.12	0.18	1.98	0.38
paratype MB.C.18692.9	21.0	10.1	10.0	3.4	6.1	0.48	1.01	0.16	1.99	0.39
paratype MB.C.18692.2	15.4	9.6	7.2	3.0	4.8	0.62	1.33	0.20	2.09	0.34
paratype MB.C.18692.10	14.0	8.0	6.3	3.4	3.8	0.57	1.28	0.25	1.89	0.39
paratype MB.C.18692.3	11.9	7.7	5.5	2.3	3.7	0.64	1.39	0.19	2.08	0.34

Table 27. Suture line proportions (Figs 25D–F) for *Bollandoceras mirrih* n. sp.

specimen	at dm	EL w/d	EL/VLS	EL/AL	MS h	VLS w/h	remarks
paratype MB.C.18692.8	c. 28.0 mm	0.59	0.89	1.02	0.22	0.67	
paratype MB.C.18692.7	22.7 mm	0.60	0.84	1.01	0.21	0.71	
paratype MB.C.18692.2	13.4 mm	0.65	0.99	0.94	0.14	0.66	median saddle very low

Discussion. For a comparison with *Bollandoceras zuhara*, see under that species. *B. mirrih* differs from the species of the genus found in assemblages TIM-B2 and TIM-B3 in the much wider umbilicate inner whorls.

B. hodderense (Bisat, 1924) shows a similar conch geometry but possesses a shorter evolute juvenile stage. Adult specimens differ in the narrow external lobe of *B. hodderense*.

The co-occurring *Gourarites hagaraswad* and *G. mustari* differ in the longer evolute juvenile stage and the wider umbilicus at 20 mm conch diameter. Both species show a strong whorl overlap onto the umbilicus in the adult stage, causing a sudden decrease of the uw/dm ratio.

◀

Figure 23. *Bollandoceras zuhara* n. sp. from locality TIM-C8. **A.** Cross section of paratype MB.C.18691.5; ×4.0. **B.** Cross section of paratype MB.C.18691.6; ×4.0. **C.** Cross section of paratype MB.C.18691.7; ×4.0. **D.** Cross section of paratype MB.C.18691.8; ×4.0. **E.** Cross section of paratype MB.C.18691.9; ×4.0. **F.** Suture line of paratype MB.C.18691.10, at 11.8 mm dm, 6.4 mm ww, 7.0 mm wh; ×5.0. **G.** Suture line of paratype MB.C.18691.11, at 29.0 mm dm, 16.0 mm wh; ×3.5. **H–J.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm), whorl width index (ww/wh), and whorl expansion rate (WER) of all available specimens.

Figure 24. *Bollandoceras mirrih* n. sp. from locality TIM-C8; all ×2.5. **A.** Holotype MB.C.18692.1. **B.** Paratype MB.C.18692.2. **C.** Paratype MB.C.18692.3.

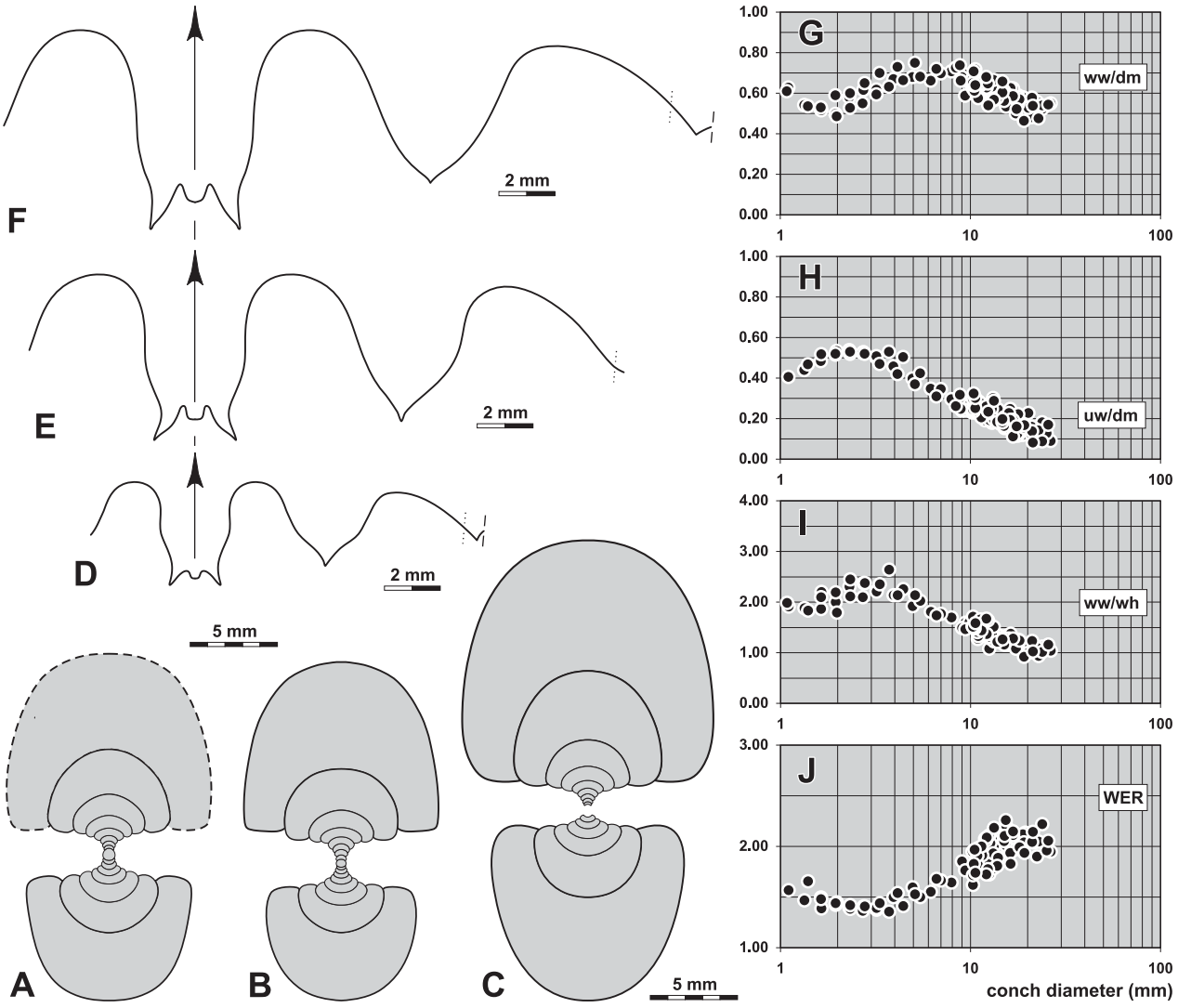


Figure 25. *Bollandoceras mirrih* n. sp. from locality TIM-C8. **A.** Cross section of paratype MB.C.18692.4; ×2.5. **B.** Cross section of paratype MB.C.18692.5; ×2.5. **C.** Cross section of paratype MB.C.18692.6; ×2.5. **D.** Suture line of paratype MB.C.18692.2, at 13.4 mm dm, 8.2 mm ww, 6.4 mm wh; ×4.0. **E.** Suture line of paratype MB.C.18692.7, at 22.7 mm dm, 13.3 mm ww, 12.9 mm wh; ×4.0. **F.** Suture line of paratype MB.C.18692.8, at 13.9 mm ww, 13.6 mm wh; ×4.0. **G–J.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm), whorl width index (ww/wh), and whorl expansion rate (WER) of all available specimens.

Benimehlalites n. gen.

Derivation of name. After the village Beni Mehlal, a suburb of Timimoun.

Type species. Benimehlalites brinkmanni n. sp.

Diagnosis. Genus of the subfamily Maxigoniatitinae with thickly discoidal to pachyconic conch; conch ontogeny with striking transformations (Fig. 26); early juveniles subevolute and subsequent decrease of the uw/dm ratio; sudden opening of the umbilicus in the preadult stage by reduction of the whorl height and enlargement of the whorl width. Suture line with very narrow or narrow, diverging external lobe with sinuous flanks.

Included species.
belkassemensis: *Benimehlalites belkassemensis* n. sp.: Gourara, Algeria.
benimehlalensis: *Benimehlalites benimehlalensis* n. sp.: Gourara, Algeria.
brinkmanni: *Benimehlalites brinkmanni* n. sp.: Gourara, Algeria.
? *kaindynense*: *Bollandites*? *kaindynense* (Popov, 1965): Tien Shan, Kyrgyzstan.

Discussion. Benimehlalites possesses a suture line similar to *Bollandoceras*, but the ontogeny of the conch shows conspicuous differences. *Benimehlalites* has a thickly discoidal or pachyconic adult conch (thinly discoidal in *Bollandoceras*) and an umbilicus that shows an accelerated opening rate in the middle growth stage. The genus *Pachybollandoceras* has a similar adult conch, but differs in the evolute juvenile stage.

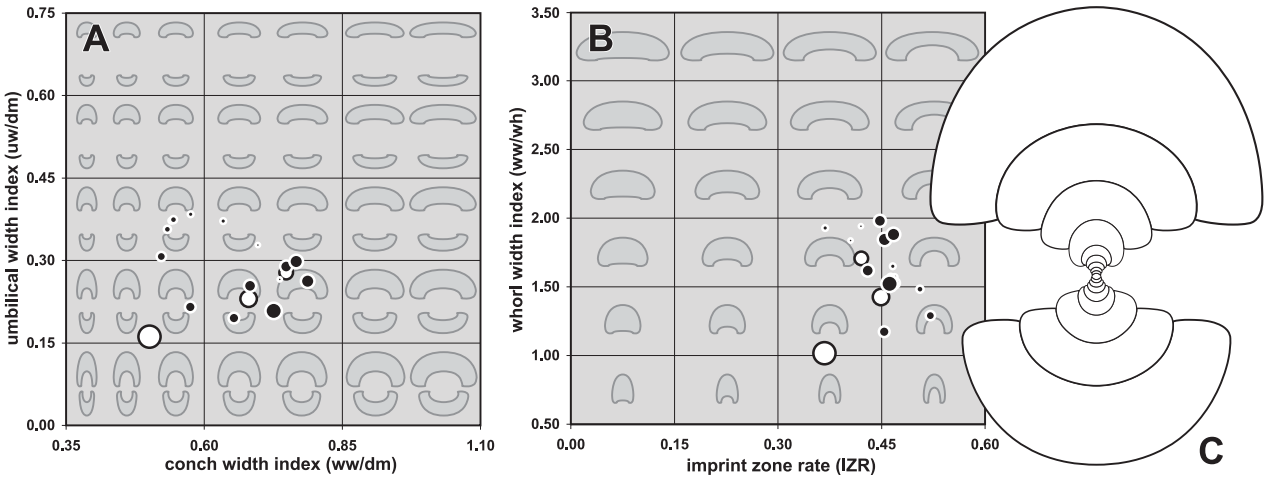


Figure 26. Ontogenetic trajectories of *Benimehlalites*, exemplified for *Benimehlalites brinkmanni* n. sp. from locality TIM-B3. **A.** Ontogenetic development of the conch width index (ww/dm) and umbilical width index (uw/dm). **B.** Ontogenetic development of the imprint zone rate (IZR) and whorl width index (ww/wh). **C.** Cross section of paratype MB.C.18688.5; ×2.0. [Black dots represent ontogenetic stages of cross section MB.C.18688.4, white dots represent the reference specimens (Tab. 29).]

Benimehlalites brinkmanni n. sp.

Figures 27, 28

Derivation of name. After Markus Brinkmann (Berlin), to honour his preparation work on the specimens.

Holotype. Specimen MB.C.18688.1, illustrated in Figure 27A.

Type locality and horizon. Sebkha de Timimoun, locality TIM-B3 (10 km west-southwest of Timimoun, Algeria); upper part of the Lower *Bollandoceras-Bollandites* Assemblage.

Material. 11 specimens, conch diameter between 20 and 103 mm.

Diagnosis. Benimehlalites with very significant ontogenetic changes of conch geometry: conch pachyconic in the early juvenile stage (1 mm dm), thereafter thickly discoidal (2–7 mm dm), pachyconic (8–40 mm dm), and finally thickly discoidal in the adult stage; juvenile stage (1–4 mm dm) subevolute, followed by a subinvolute stage (4–16 mm dm), another subevolute stage (at 20 mm dm), and a final subinvolute adult stage; aperture strongly varying in height during ontogeny, low in juveniles and discontinuously increasing to moderate; umbilical margin rounded in all stages, only temporarily subangular. Steinkern smooth, occasionally with very weak constrictions. Suture line with narrow, rather strongly diverging external lobe with strongly sinuous flanks and low median saddle; ventrolateral saddle broadly rounded; shallow adventive lobe V-shaped, symmetric.

Table 28. Conch ontogeny (Figs 28A–C, E–G) of *Benimehlalites brinkmanni* n. sp.

dm	conch shape	whorl cross section shape	aperture
3 mm	thickly discoidal; subevolute (ww/dm = 0.48–0.55; uw/dm = 0.32–0.38)	weakly to moderately depressed; very strongly embracing (ww/wh = 1.25–1.60; IZR = 0.45–0.50)	low (WER = 1.50–1.60)
8 mm	thickly discoidal to thinly pachyconic; subinvolute (ww/dm = 0.55–0.65 uw/dm = 0.15–0.20)	weakly depressed; very strongly embracing (ww/wh = 1.20–1.50; IZR = 0.45–0.50)	low (WER = 1.65–1.75)
20 mm	thinly to thickly pachyconic; subinvolute to subevolute (ww/dm = 0.65–0.80; uw/dm = 0.25–0.35)	moderately depressed; very strongly embracing (ww/wh = 1.50–2.00; IZR = 0.45–0.50)	moderate (WER = 1.75–1.90)
35 mm	thinly pachyconic; subinvolute (ww/dm = 0.60–0.70; uw/dm = 0.20–0.25)	weakly depressed; very strongly embracing (ww/wh = 1.30–1.50; IZR = 0.45–0.50)	moderate (WER = 1.75–1.85)
100 mm	thickly discoidal; subinvolute (ww/dm ~ 0.50; uw/dm ~ 0.16)	weakly depressed; strongly embracing (ww/wh ~ 1.05; IZR ~ 0.36)	high (WER ~ 2.10)

Table 29. Conch dimensions (in mm) and proportions for reference specimens of *Benimehlalites brinkmanni* n. sp.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
holotype MB.C.18688.1	102.7	51.0	49.7	16.2	31.9	0.50	1.03	0.16	2.10	0.36
paratype MB.C.18688.2	35.1	23.9	16.7	8.1	9.2	0.68	1.43	0.23	1.84	0.45
paratype MB.C.18688.3	24.5	18.3	10.7	6.8	6.2	0.75	1.71	0.28	1.79	0.42

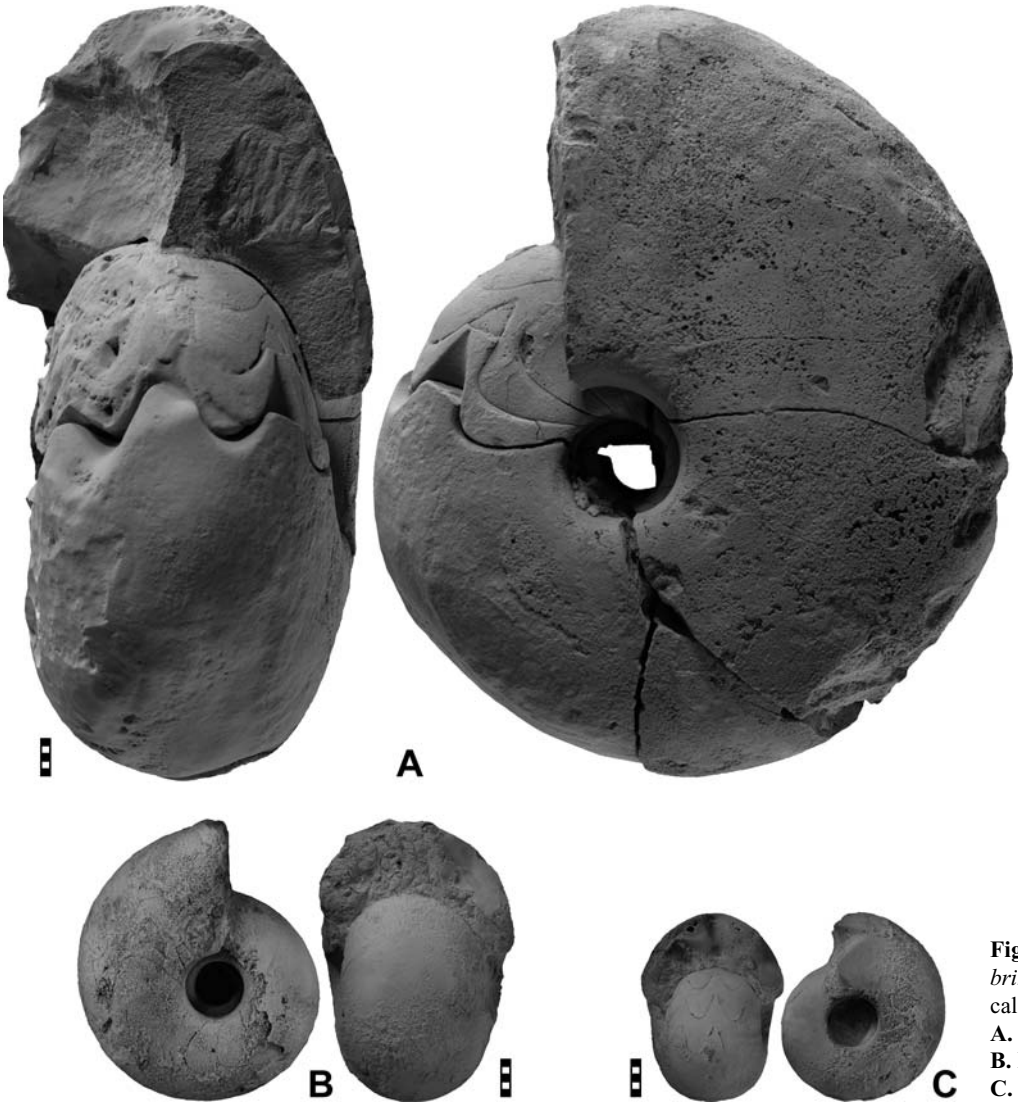


Figure 27. *Benimehlalites brinkmanni* n. sp. from locality TIM-B3; all ×1.0. **A.** Holotype MB.C.18688.1. **B.** Paratype MB.C.18688.2. **C.** Paratype MB.C.18688.3.

Table 30. Suture line proportions (Fig. 28D) for *Benimehlalites brinkmanni* n. sp.

specimen	at dm	EL w/d	EL/VLS	EL/AL	MS h	VLS w/h	remarks
paratype MB.C.18688.3	17.0 mm	0.62	0.69	1.02	0.23	0.89	A lobe much shallower than E lobe

Discussion. Benimehlalites benimehlalensis differs in the less pronounced ontogenetic changes of the whorl cross section, which in *Benimehlalites brinkmanni* are particularly conspicuous at 7–10 mm conch diameter, where the umbilicus suddenly opens, caused by a significant reduction of the whorl height and compensation by strongly increasing whorl width. The external lobe of *Benimehlalites benimehlalensis* has much weaker diverging flanks. *Benimehlalites belkassemensis* differs in its strong steinkern constrictions.

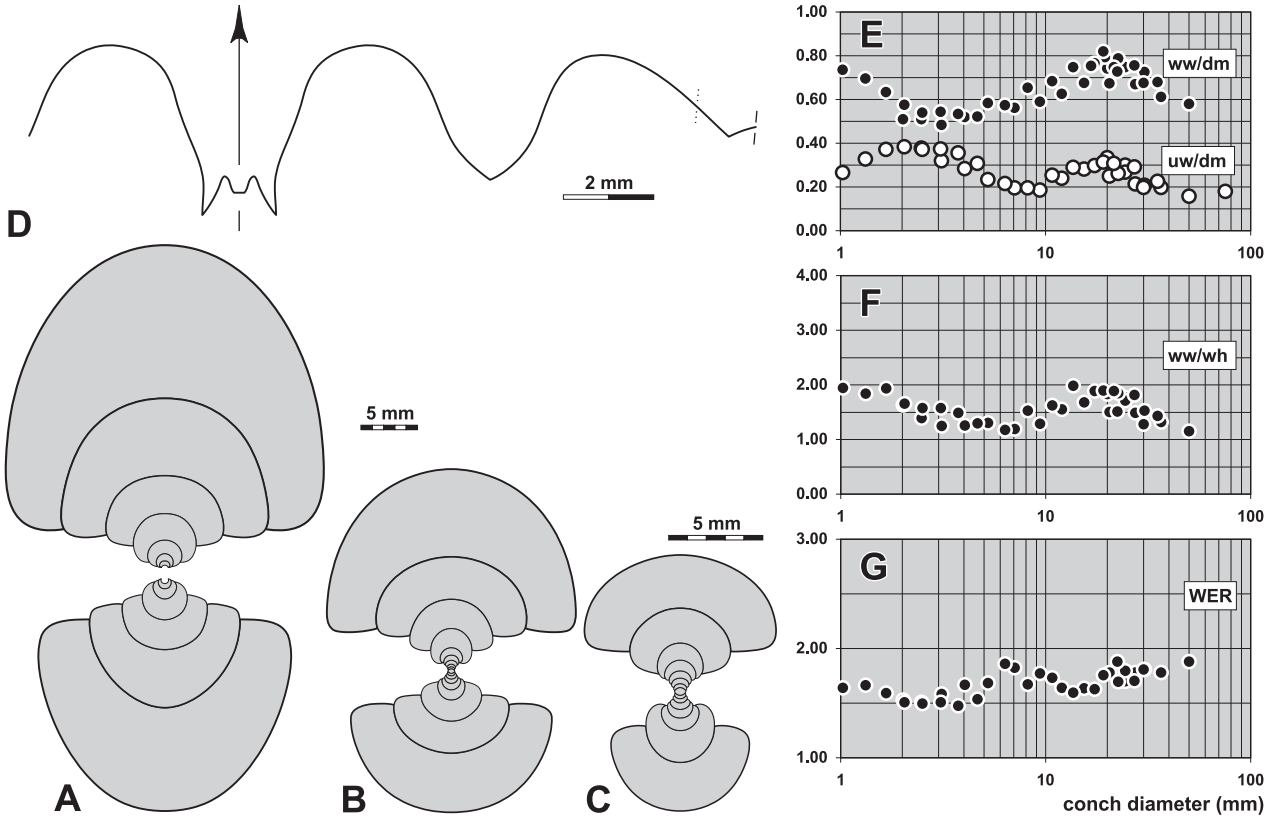


Figure 28. *Benimehlalites brinkmanni* n. sp. from locality TIM-B3. **A.** Cross section of paratype MB.C.18688.4; ×1.5. **B.** Cross section of paratype MB.C.18688.5; ×1.5. **C.** Cross section (inner whorls) of the same specimen; ×2.5. **D.** Suture line of paratype MB.C.18688.3, at 17.0 mm dm, 13.0 mm ww, 6.5 mm wh; ×6.0. **E–G.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm), whorl width index (ww/wh), and whorl expansion rate (WER) of all available specimens.

Benimehlalites benimehlalensis n. sp.

Figures 29, 30

Derivation of name. After the village Beni Mehlal, a suburb of Timimoun.

Holotype. Specimen MB.C.18689.1, illustrated in Figure 29A.

Type locality and horizon. Sebkha de Timimoun, locality TIM-B3 (10 km west-southwest of Timimoun, Algeria); upper part of the Lower *Bollandoceras-Bollandites* Assemblage.

Material. Nine specimens, conch diameter between 20 and 53 mm.

Diagnosis. Benimehlalites with significant ontogenetic changes in its conch geometry: conch thickly discoidal in the juvenile stage (1–5 mm dm), thereafter thinly pachyconic (6–20 mm dm), and finally thickly discoidal in the adult stage; juvenile stage (1–2.5 mm dm) subevolute, thereafter subinvolute to involute with an increase at 20 mm dm and a final involute adult stage; aperture very low to low in juveniles (1–4 mm dm) and then suddenly increasing to moderately high in the preadult stage and high in the adult stage; umbilical margin rounded in all stages. Steinkern smooth except for very shallow, almost straight constrictions in the intermediate stage. Suture line with very narrow, slightly diverging external lobe with slightly sinuous flanks and very low median saddle; ventrolateral saddle broadly rounded; adventive lobe V-shaped, symmetric.

Table 31. Conch ontogeny (Figs 30A, C–E) of *Benimehlalites benimehlalensis* n. sp.

dm	conch shape	whorl cross section shape	aperture
3 mm	thickly discoidal; subevolute (ww/dm ~ 0.57; uw/dm ~ 0.30)	weakly depressed; very strongly embracing (ww/wh ~ 1.45; IZR ~ 0.54)	low (WER ~ 1.50)
8 mm	thinly pachyconic; involute (ww/dm ~ 0.60 uw/dm ~ 0.10)	weakly depressed; very strongly embracing (ww/wh ~ 1.20; IZR ~ 0.50)	moderate (WER ~ 1.80)
20 mm	thinly to thickly pachyconic; subinvolute (ww/dm = 0.65–0.75; uw/dm = 0.15–0.30)	weakly to moderately depressed; very strongly embracing (ww/wh = 1.40–1.75; IZR = 0.45–0.50)	moderate (WER = 1.75–2.00)
35 mm	thickly discoidal; involute (ww/dm ~ 0.57; uw/dm ~ 0.14	weakly depressed; very strongly embracing (ww/wh ~ 1.15; IZR ~ 0.45)	high (WER ~ 2.00)

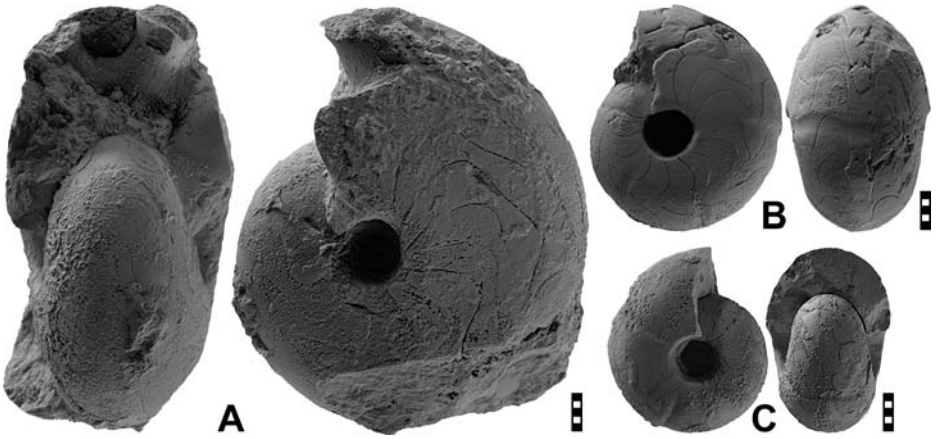


Figure 29. *Benimehlalites benimehlalensis* n. sp. from locality TIM-B3; all ×1.0. **A.** Holotype MB.C.18689.1. **B.** Paratype MB.C.18689.2. **C.** Paratype MB.C.18689.3.

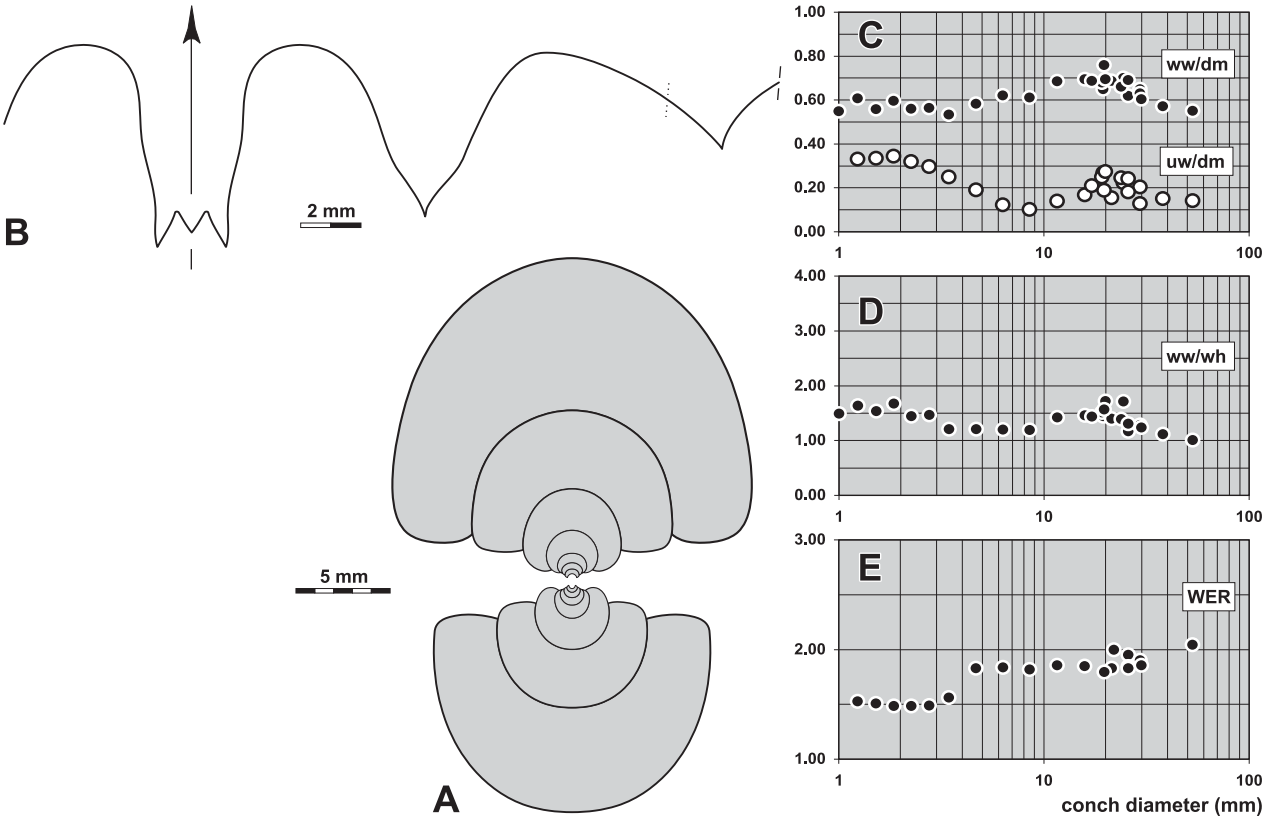


Figure 30. *Benimehlalites benimehlalensis* n. sp. from locality TIM-B3. **A.** Cross section of paratype MB.C.18689.4; ×2.5. **B.** Suture line of paratype MB.C.18689.2, at 28.0 mm dm, 18.0 mm ww, 14.5 mm wh; ×4.0. **C–E.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm), whorl width index (ww/wh), and whorl expansion rate (WER) of all available specimens.

Table 32. Conch dimensions (in mm) and proportions for reference specimens of *Benimehlalites brinkmanni* n. sp.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
holotype MB.C.18689.1	52.9	29.2	29.0	7.5	15.9	0.55	1.01	0.14	2.04	0.45
paratype MB.C.18689.2	29.3	18.5	14.4	6.0	8.5	0.63	1.28	0.20	1.98	0.41
paratype MB.C.18689.3	25.8	16.1	12.2	6.2	6.8	0.63	1.32	0.24	1.85	0.44
paratype MB.C.18689.5	24.4	17.1	10.4	5.5	6.1	0.70	1.64	0.22	1.77	0.42

Table 33. Suture line proportions (Fig. 30B) for *Benimehlalites brinkmanni* n. sp.

specimen	at dm	EL w/d	EL/VLS	EL/AL	MS h	VLS w/h	remarks
paratype MB.C.18689.2	28.0 mm	0.49	0.69	1.05	0.17	0.71	A lobe as deep as E lobe

Discussion. Benimehlalites benimehlalensis shows some affinities to the stouter species of the genus *Bollandoceras*, but differs in the adult re-opening of the umbilicus. *Benimehlalites benimehlalensis* possesses a less stout conch than the type species and less striking ontogenetic changes in the whorl cross section. *Benimehlalites belkassemensis* differs in its strong steinkern constrictions and its wider external lobe.

Benimehlalites belkassemensis n. sp.

Figures 31, 32

Derivation of name. After the ruin Zrîbet Sidi el Hadj Belkassem near Timimoun.

Holotype. Specimen MB.C.18684.1, illustrated in Figure 31.

Type locality and horizon. Sebkha de Timimoun, locality TIM-B2 (10 km west-southwest of Timimoun, Algeria); lower part of the Lower *Bollandoceras-Bollandites* Assemblage.

Material. Two specimens, conch diameters 38 and 51 mm.

Diagnosis. Benimehlalites with major ontogenetic changes of the conch geometry: conch globular in the early juvenile stage and discontinuously becoming thinly pachyconic at 20 mm dm, slight increase of the ww/dm ratio between 4 and 16 mm dm; early juvenile stage subinvolute and involute at 4 mm dm, becoming subinvolute or subevolute above 6 mm dm and throughout later ontogeny; aperture height very variable between low and high; umbilical margin rounded in juveniles and angular in the middle and adult stage. Steinkern with constrictions with convex course. Suture line with narrow, slightly diverging external lobe with strongly sinuous flanks, very narrow secondary prongs, and low median saddle; ventrolateral saddle broadly rounded; adventive lobe V-shaped, symmetric and slightly pouched.

Table 34. Conch ontogeny (Figs 32A, B, D–F) of *Benimehlalites belkassemensis* n. sp.

dm	conch shape	whorl cross section shape	aperture
3 mm	thickly pachyconic; subinvolute (ww/dm ~ 0.74; uw/dm ~ 0.16)	weakly depressed; strongly embracing (ww/wh ~ 1.40; IZR ~ 0.40)	high (WER ~ 2.05)
8 mm	thinly pachyconic; subinvolute (ww/dm ~ 0.70; uw/dm ~ 0.18)	moderately depressed; very strongly embracing (ww/wh ~ 1.60; IZR ~ 0.50)	low (WER ~ 1.70)
20 mm	thinly pachyconic; subevolute (ww/dm ~ 0.70; uw/dm ~ 0.32)	moderately depressed; strongly embracing (ww/wh ~ 1.80; IZR ~ 0.42)	low (WER ~ 1.65)
35 mm	thinly pachyconic; subinvolute (ww/dm ~ 0.65; uw/dm ~ 0.25)	moderately depressed; strongly embracing (ww/wh ~ 1.50; IZR ~ 0.45)	high (WER ~ 2.15)

Table 35. Conch dimensions (in mm) and proportions for reference specimens of *Benimehlalites belkassemensis* n. sp.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
holotype MB.C.18684.1	51.6	–	23.6	12.9	16.5	–	–	0.25	2.16	0.30
dto.	37.2	23.2	15.5	11.8	–	0.62	1.50	0.32	–	–

Table 36. Suture line proportions (Fig. 32C) for *Benimehlalites belkassemensis* n. sp.

specimen	at dm	EL w/d	EL/VLS	EL/AL	MS h	VLS w/h	remarks
holotype MB.C.18684.1	32.0 mm	0.57	0.70	0.91	0.20	0.81	E lobe prongs hook-shaped

Discussion. Benimehlalites belkassemensis differs in its strong steinkern constrictions and the stronger curved flanks of the external lobe from the two species *Benimehlalites brinkmanni* and *Benimehlalites benimehlalensis*, which occur in the higher horizon TIM-B3.

Figure 31. *Benimehlalites belkassemensis* n. sp. from locality TIM-B2; holotype MB.C.18684.1; × 1.25.

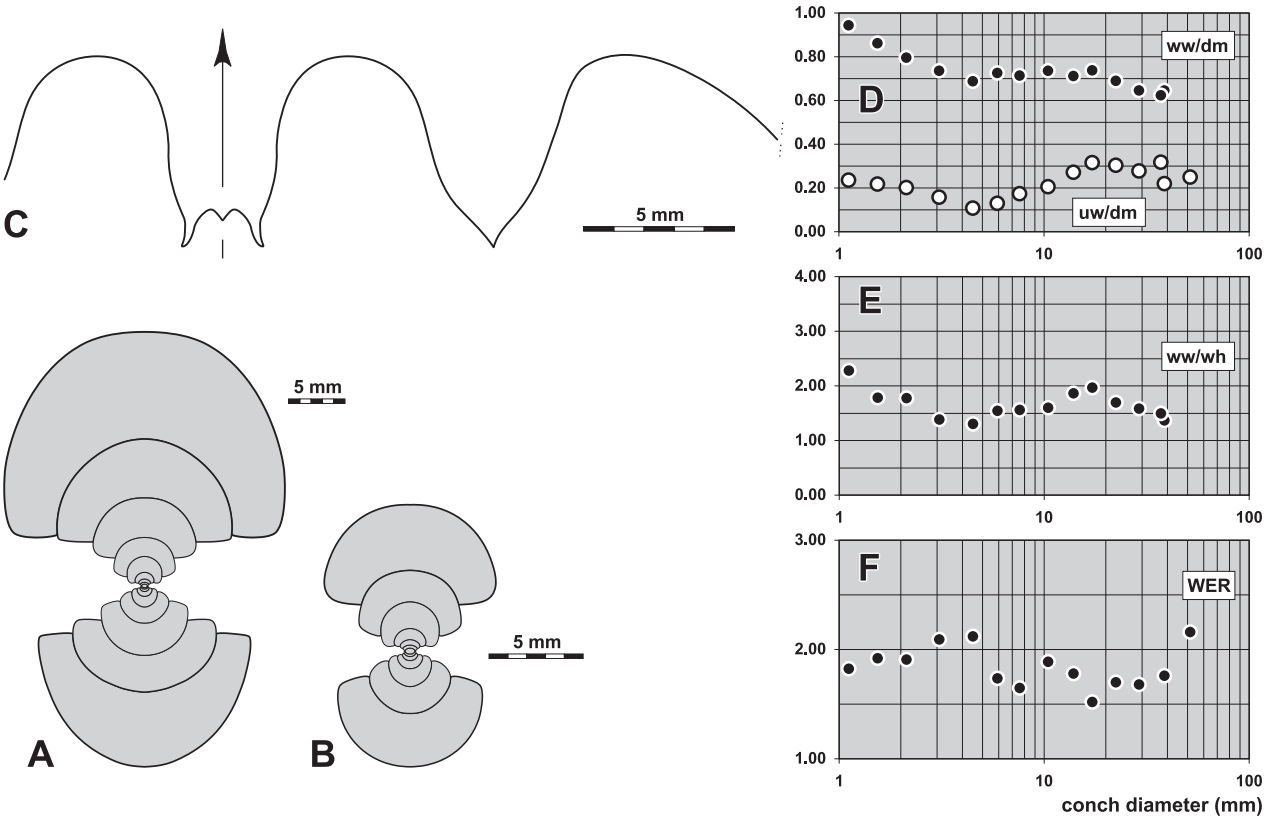


Figure 32. *Benimehlalites belkassemensis* n. sp. from locality TIM-B2. **A.** Cross section of paratype MB.C.18684.2; × 1.5. **B.** Cross section (inner whorls) of the same specimen; × 2.5. **C.** Suture line of holotype MB.C.18684.1, at 32.0 mm dm, 21.0 mm ww, 10.0 mm wh; × 4.0. **D–F.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm), whorl width index (ww/wh), and whorl expansion rate (WER) of all available specimens.

Pachybollandoceras n. gen.

Derivation of name. Reference to the genus *Bollandoceras*, which possesses a more slender conch.

Type species. Pachybollandoceras intraevolutum n. sp.

Diagnosis. Genus of the subfamily Maxigoniatitinae with pachyconic adult conch; conch ontogeny with striking transformations (Fig. 33); early juveniles evolute and rapid decrease of the uw/dm ratio early in ontogeny; slight opening of the umbilicus in the preadult stage by reduction of

the whorl height and enlargement of the whorl width. Suture line with narrow, diverging external lobe with sinuous flanks and very low median saddle.

Included species.
intraevolutum: *Pachybollandoceras intraevolutum* n. sp.: Gourara, Algeria.
repens: *Pachybollandoceras repens* n. sp.: Gourara, Algeria.

Discussion. *Pachybollandoceras* possesses a suture line similar to *Bollandoceras*, but the ontogeny of the conch shows conspicuous differences. *Pachybollandoceras* has a pachyconic adult conch (discoidal in *Bollandoceras*) and the umbilicus closes much faster. Contrary to *Bollandoceras*, *Pachybollandoceras* shows irregular widening of the conch in the adult stage.

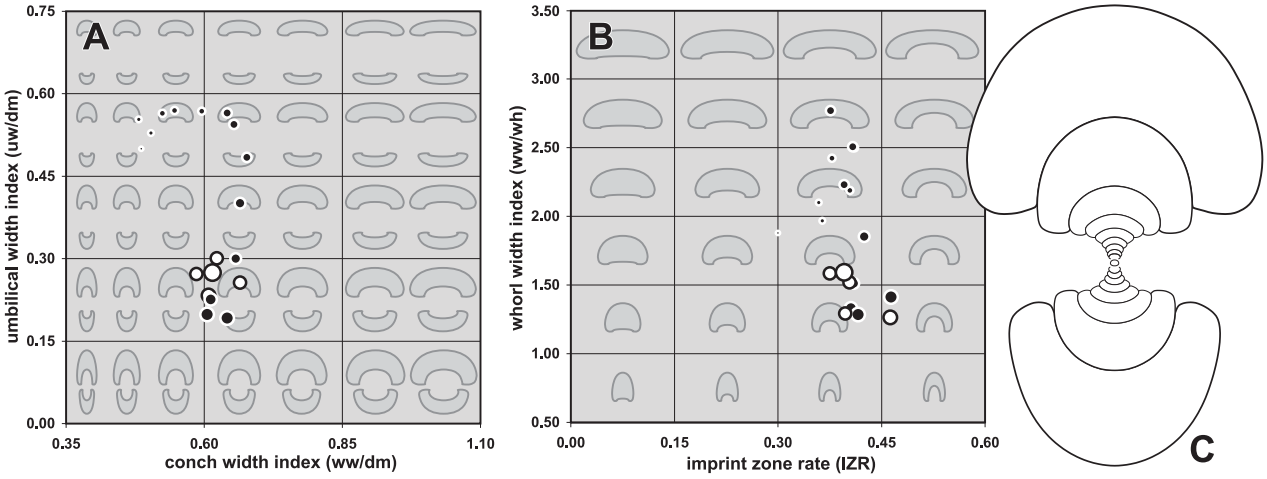


Figure 33. Ontogenetic trajectories of *Pachybollandoceras*, exemplified for *P. intraevolutum* n. sp. from locality TIM-C8. **A.** Ontogenetic development of the conch width index (ww/dm) and umbilical width index (uw/dm). **B.** Ontogenetic development of the imprint zone rate (IZR) and whorl width index (ww/wh). **C.** Cross section of paratype MB.C.18693.4; ×2.5. [Black dots represent ontogenetic stages of cross section MB.C.18693.4, white dots represent the reference specimens (Tab. 38).]

Pachybollandoceras intraevolutum n. sp.

Figures 34, 35

Derivation of name. Named after the very evolute inner whorls.

Holotype. Specimen MB.C.18693.1, illustrated in Figure 34A.

Type locality and horizon. Sebkha de Timimoun, locality TIM-C8 (13.3 km west of Timimoun, Algeria); Upper *Bollandoceras-Bollandites* Assemblage.

Material. 16 specimens, conch diameter between 10 and 26 mm.

Diagnosis. *Pachybollandoceras* with major ontogenetic changes of its conch geometry: conch evolute in the juvenile and intermediate stage (at 1–6 mm dm) and then becoming subevolute at 10 mm dm; conch thickly discoidal in the early juvenile stage and thinly pachyconic in stages above 4 mm dm; aperture very low in juveniles (2–6 mm dm) and then slowly increasing (moderately high 20 mm dm); umbilical margin rounded in juveniles and subangular in the adult stage. Steinkern with shallow, nearly linear constrictions. Suture line with narrow, diverging external lobe with sinuous flanks and very low median saddle; ventrolateral saddle broadly rounded; adventive lobe V-shaped, almost symmetric.

Table 37. Conch ontogeny (Figs 35A, B, E–G) of *Pachybollandoceras intraevolutum* n. sp.

dm	conch shape	whorl cross section shape	aperture
2 mm	thickly discoidal; evolute (ww/dm ~ 0.50; uw/dm ~ 0.55)	strongly depressed; strongly embracing (ww/wh ~ 2.05; IZR ~ 0.35)	very low (WER ~ 1.40)
8 mm	thinly pachyconic; subevolute (ww/dm ~ 0.68; uw/dm ~ 0.35	moderately depressed; strongly embracing (ww/wh ~ 1.70; IZR = 0.42)	low (WER ~ 1.70)
20 mm	thinly pachyconic; subinvolute (ww/dm = 0.60–0.65; uw/dm = 0.20–0.30)	weakly to moderately depressed; strongly to very strongly embracing (ww/wh = 1.30–1.60; IZR = 0.40–0.50)	moderate (WER = 1.65–1.90)

Figure 34. *Pachybollandoceras intraevolutum* n. sp. from locality TIM-C8; all ×2.5. **A.** Holotype MB.C.18693.1. **B.** Paratype MB.C.18693.2. **C.** Paratype MB.C.18693.3.

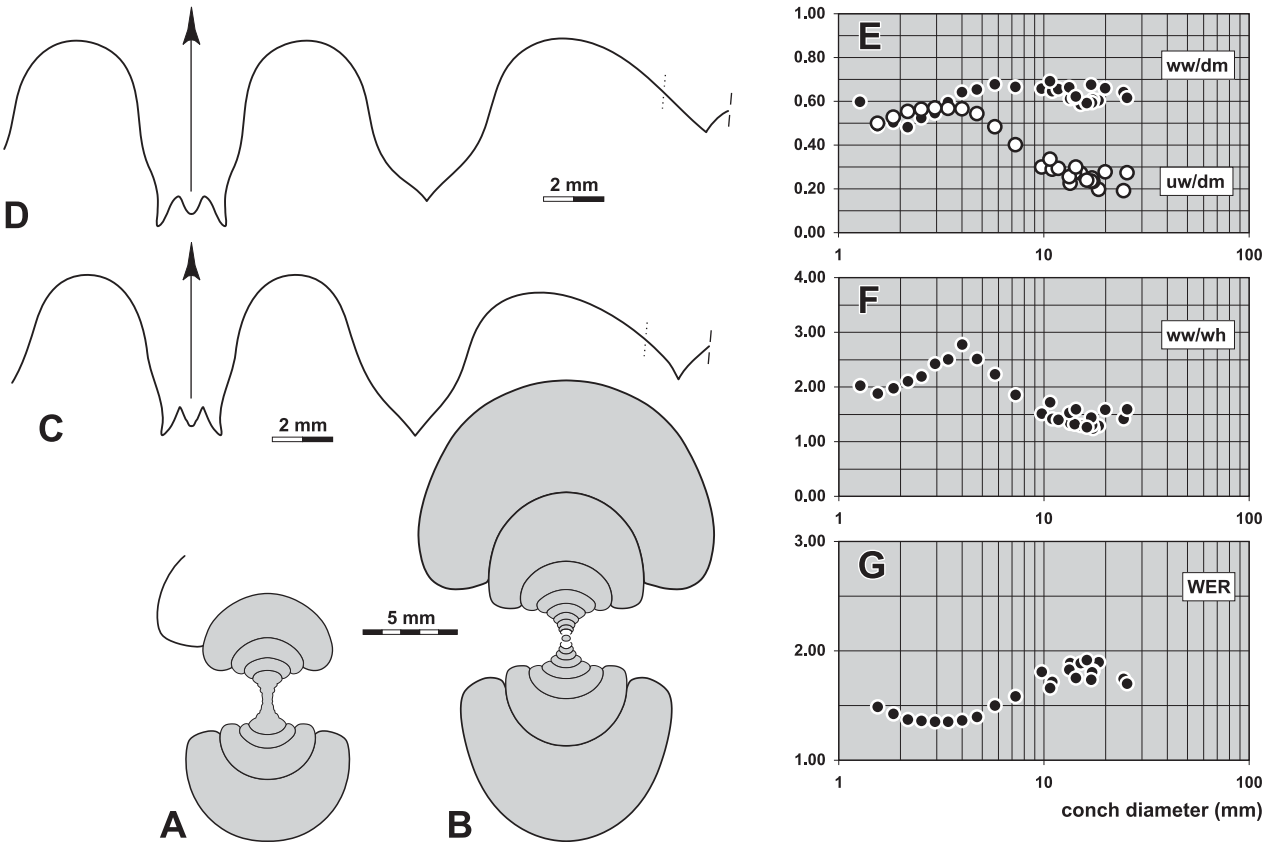


Figure 35. *Pachybollandoceras intraevolutum* n. sp. from locality TIM-C8. **A.** Cross section of paratype MB.C.18693.5; ×2.5. **B.** Cross section of paratype MB.C.18693.4; ×2.5. **C.** Suture line of holotype MB.C.18693.1, at 20.0 mm dm, 10.4 mm ww; ×4.0. **D.** Suture line of paratype MB.C.18693.4, at 12.2 mm ww, 10.4 mm wh; ×4.0. **E–G.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm), whorl width index (ww/wh), and whorl expansion rate (WER) of all available specimens.

Table 38. Conch dimensions (in mm) and proportions for reference specimens of *Pachybollandoceras intraevolutum* n. sp.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
holotype MB.C.18693.1	25.4	15.6	9.8	7.0	5.9	0.62	1.60	0.27	1.70	0.40
paratype MB.C.18693.2	17.3	10.5	8.3	4.0	4.5	0.61	1.27	0.23	1.81	0.46
paratype MB.C.18693.3	15.1	8.9	6.8	4.1	4.1	0.59	1.30	0.27	1.89	0.40
paratype MB.C.18693.7	14.3	8.9	5.6	4.3	3.5	0.62	1.59	0.30	1.75	0.38
paratype MB.C.18693.6	13.3	8.8	5.8	3.4	3.5	0.66	1.52	0.26	1.83	0.40

Table 39. Suture line proportions (Figs 35C, D) for *Pachybollandoceras intraevolutum* n. sp.

specimen	at dm	EL w/d	EL/VLS	EL/AL	MS h	VLS w/h	remarks
paratype MB.C.18693.4	c. 22.0 mm	0.54	0.76	0.86	0.16	0.72	A lobe pouched
holotype MB.C.18693.1	c. 20.0 mm	0.54	0.72	0.80	0.17	0.75	A lobe V-shaped

Discussion. Pachybollandoceras intraevolutum is separated from *P. repens* in the wider umbilicus in the adult stage (uw/dm $>$ 0.20). The suture line of *P. intraevolutum* shows an external lobe with much stronger sinuous flanks.

Pachybollandoceras repens n. sp.

Figures 36, 37

Derivation of name. From Latin repens = suddenly, because of the sudden widening of the conch.

Holotype. Specimen MB.C.18694.1, illustrated in Figure 36A.

Type locality and horizon. Sebkha de Timimoun, locality TIM-C8 (13.3 km west of Timimoun, Algeria); Upper *Bollandoceras-Bollandites* Assemblage.

Material. 23 specimens, conch diameter between 7 and 20 mm.

Diagnosis. Pachybollandoceras with major ontogenetic changes of its conch geometry: conch evolute in the juvenile stage (at 1–3 mm dm) and then becoming subevolute at 6 mm dm; conch thickly discoidal in the early juvenile stage and thinly pachyconic in stages above 3 mm dm; aperture very low in juveniles (2–4 mm dm) and then slowly increasing (moderately high 20 mm dm); umbilical margin rounded in juveniles and subangular in the adult stage. Steinkern with very shallow, nearly linear constrictions. Suture line with narrow, diverging external lobe with slightly sinuous flanks and very low median saddle; ventrolateral saddle broadly rounded; adventive lobe V-shaped, asymmetric.

Table 40. Conch ontogeny (Figs 37A, C–E) of *Pachybollandoceras repens* n. sp.

dm	conch shape	whorl cross section shape	aperture
2 mm	thickly discoidal; evolute (ww/dm ~ 0.48; uw/dm ~ 0.53)	moderately depressed; strongly embracing (ww/wh ~ 1.95; IZR ~ 0.40)	very low (WER ~ 1.40)
8 mm	thinly pachyconic; subinvolute (ww/dm ~ 0.68; uw/dm ~ 0.25)	weakly depressed; very strongly embracing (ww/wh ~ 1.40; IZR ~ 0.45)	moderate (WER ~ 1.80)
20 mm	thinly pachyconic; subinvolute (ww/dm ~ 0.65; uw/dm ~ 0.20)	weakly depressed; very strongly embracing (ww/wh ~ 1.45; IZR ~ 0.50)	low (WER ~ 1.70)

Table 41. Conch dimensions (in mm) and proportions for reference specimens of *Pachybollandoceras repens* n. sp.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
holotype MB.C.18694.1	19.8	13.1	8.8	3.8	4.5	0.66	1.49	0.19	1.67	0.49
paratype MB.C.18694.4	14.4	9.4	6.2	3.7	3.7	0.65	1.51	0.25	1.79	0.41
paratype MB.C.18694.5	13.0	9.2	6.0	3.7	3.2	0.70	1.53	0.28	1.74	0.48
paratype MB.C.18694.6	11.0	7.1	5.0	3.2	2.6	0.65	1.42	0.29	1.71	0.48
paratype MB.C.18694.2	10.9	7.5	4.4	2.8	–	0.69	1.71	0.26	–	–

Table 42. Suture line proportions (Fig. 37B) for *Pachybollandoceras repens* n. sp.

specimen	at dm	EL w/d	EL/VLS	EL/AL	MS h	VLS w/h	remarks
holotype MB.C.18694.1	17.2 mm	0.59	0.70	1.20	0.17	0.85	flanks of E lobe slightly sinuous

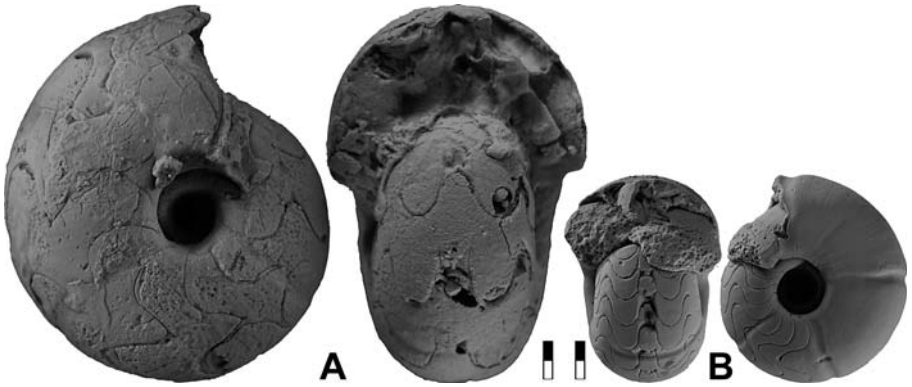


Figure 36. *Pachybollandoceras repens* n. sp. from locality TIM-C8; all ×2.5. **A.** Holotype MB.C.18694.1. **B.** Paratype MB.C.18694.2.

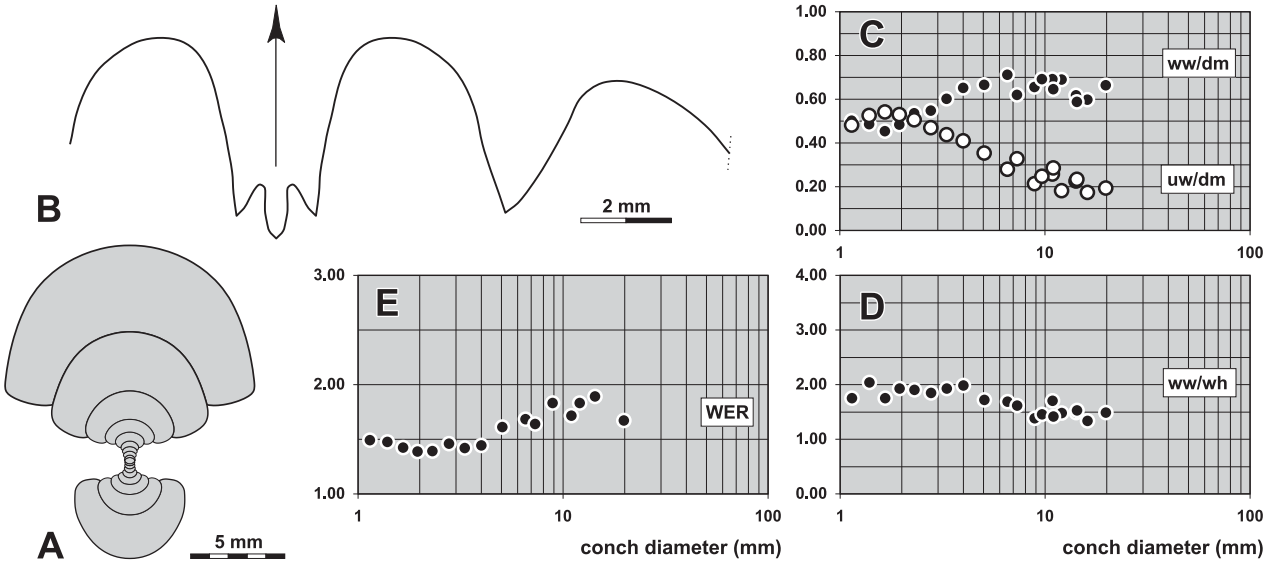


Figure 37. *Pachybollandoceras repens* n. sp. from locality TIM-C8. **A.** Cross section of paratype MB.C.18694.3; ×2.5. **B.** Suture line of holotype MB.C.18694.1, at 17.2 mm dm, 11.4 mm ww, 8.1 mm wh; ×6.0. **C–E.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm), whorl width index (ww/wh), and whorl expansion rate (WER) of all available specimens.

Subfamily **Bollanditinae** n. subfam.

Subfamily definition. Maxigoniatitidae with a widely umbilicate juvenile and intermediate stage with a moderately to very strongly depressed whorl cross section. Ornament with almost linear, rather coarse growth lines. Suture line with V-shaped external lobe, flanks of the external lobe strongly sinuous in the early forms, sinuosity disappears in the advanced forms.

Included genera.
Bollandites Bisat, 1952
Gourarites n. gen.
Semibollandites n. gen.
Timimounia n. gen.

Discussion. The new subfamily represents a side branch of the family Maxigoniatitidae, in which the morphological evolution includes significant widening of the umbilicus and the lowering of the aperture causing very strongly depressed whorl cross sections. The suture line shows the transformation of the external lobe, from strongly sinuous flanks to concavely incurved flanks.

Gourarites n. gen.

Derivation of name. After the region of Gourara.

Type species. Gourarites hagarkarim n. sp.

Genus definition. Genus of the subfamily Bollanditinae with major ontogenetic changes of conch morphology (Figs 13, 38); adult conch discoidal with rapidly expanding whorls (WER above 2.10 in stages with a conch diameter larger than 10 mm); juvenile whorls with very broad

crescent-shaped whorl cross section; umbilicus wide to very wide in juveniles and narrow or almost closed in the adult stage; sudden closure of the umbilicus by strong whorl overlap. Steinkern with constrictions parallel to the growth lines. Suture line with very narrow to narrow, V-shaped external lobe with gently sinuous, slightly diverging flanks; secondary prongs of the external lobe hook-shaped; median saddle very low or low; ventrolateral saddle usually broadly rounded; adventive lobe V-shaped, often much shallower than the external lobe.

Included species.
hagaraswad: *Gourarites hagaraswad* n. sp.: Gourara, Algeria.
hagarkarim: *Gourarites hagarkarim* n. sp.: Gourara, Algeria.
mustari: *Gourarites mustari* n. sp.: Gourara, Algeria.
zuhal: *Gourarites zuhal* n. sp.: Gourara, Algeria.

Discussion. *Gourarites* differs from *Bollandites* and *Timimounia* in the strongly sinuous flanks of the external lobe and from *Semibollandites* in the much less widely umbilicate juvenile stage.

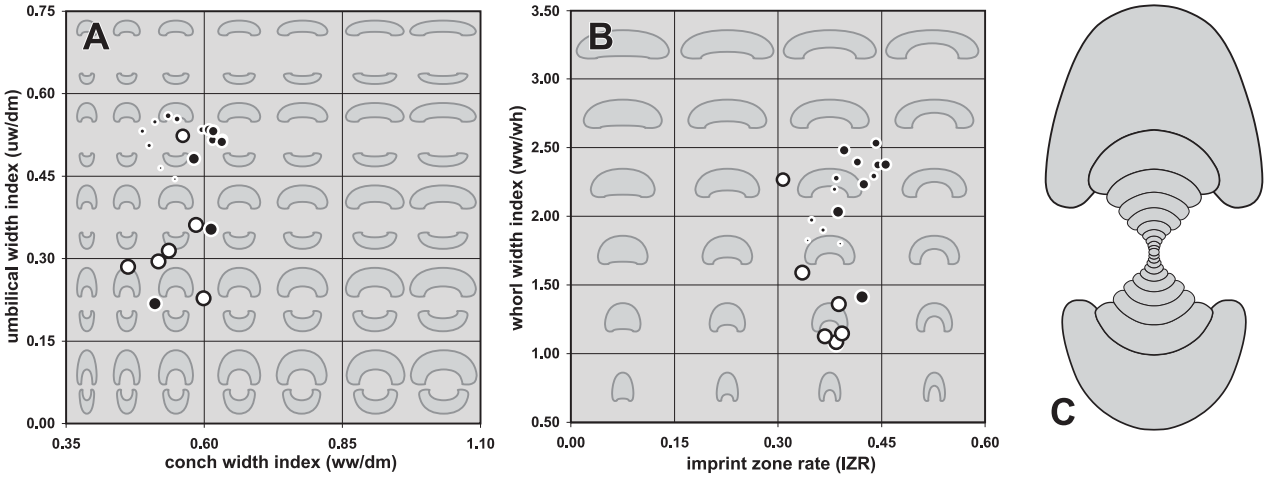


Figure 38. Ontogenetic trajectories of *Gourarites*, exemplified for *G. hagarkarim* n. sp. from locality TIM-C8. **A.** Ontogenetic development of the conch width index (ww/dm) and umbilical width index (uw/dm). **B.** Ontogenetic development of the imprint zone rate (IZR) and whorl width index (ww/wh). **C.** Cross section of paratype MB.C.18696.6; ×2.5. [Black dots represent ontogenetic stages of cross section MB.C.18696.6, white dots represent the reference specimens (Tab. 47).]

Gourarites hagaraswad n. sp.

Figures 39, 40

Derivation of name. From the Arabic hagar aswad = black stone; referring to the limonitic preservation.

Holotype. Specimen MB.C.18695.1, illustrated in Figure Fig. 39A.

Type locality and horizon. Sebkha de Timimoun, locality TIM-C8 (13.3 km west of Timimoun, Algeria); Upper *Bollandoceras-Bollandites* Assemblage.

Material. 53 specimens, conch diameter between 9 and 25 mm.

Diagnosis. Gourarites with major ontogenetic changes of conch geometry: conch evolute in the early juvenile stage (1.5–4 mm dm) and subevolute or subinvolute at 20 mm dm; conch thickly discoidal in the early juvenile stage and thickly discoidal to thinly pachyconic in larger stages (4–20 mm dm); aperture very low in juveniles (2–8 mm dm) and then rapidly increasing (moderately high to high at 20 mm dm); umbilical margin rounded in juveniles and subangular in later stages. Steinkern with shallow, slightly biconvex constrictions and traces of biconvex growth lines. Suture line with narrow, slightly diverging external lobe with strongly sinuous flanks and very low to low median saddle; ventrolateral saddle broadly rounded; small adventive lobe V-shaped, symmetric.

Table 43. Conch ontogeny (Figs 40A, B, E–G) of *Gourarites hagaraswad* n. sp.

dm	conch shape	whorl cross section shape	aperture
2 mm	thickly discoidal; evolute (ww/dm = 0.50–0.55; uw/dm = 0.50–0.55)	moderately to strongly depressed; strongly embracing (ww/wh = 1.75–2.20; IZR = 0.33–0.40)	very low (WER = 1.40–1.50)
8 mm	thinly pachyconic; subevolute (ww/dm = 0.60–0.70; uw/dm = 0.35–0.45)	moderately to strongly depressed; strongly to very strongly embracing (ww/wh = 1.80–2.10; IZR = 0.40–0.48)	very low to low (WER = 1.40–1.60)
20 mm	thickly discoidal; subinvolute (ww/dm = 0.50–0.60; uw/dm = 0.18–0.28)	weakly to moderately depressed; strongly embracing (ww/wh = 1.10–1.60; IZR = 0.30–0.40)	moderate to high (WER = 1.80–2.15)

Table 44. Conch dimensions (in mm) and proportions for reference specimens of *Gourarites hagaraswad* n. sp.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
holotype MB.C.18695.1	19.6	9.9	9.0	5.1	5.4	0.50	1.10	0.26	1.90	0.40
paratype MB.C.18695.6	16.9	10.9	7.3	4.4	4.2	0.65	1.50	0.26	1.76	0.43
paratype MB.C.18695.7	15.5	9.8	6.3	4.2	3.7	0.63	1.56	0.27	1.74	0.40
paratype MB.C.18695.2	13.6	7.2	5.2	5.2	3.3	0.53	1.37	0.38	1.73	0.38
paratype MB.C.18695.8	13.4	8.6	6.6	3.5	4.0	0.64	1.30	0.26	2.03	0.39
paratype MB.C.18695.3	10.9	6.4	3.8	4.1	2.5	0.59	1.70	0.37	1.69	0.34

Figure 39. *Gourarites hagaraswad* n. sp. from locality TIM-C8; all ×2.5. **A.** Holotype MB.C.18695.1. **B.** Paratype MB.C.18695.2. **C.** Paratype MB.C.18695.3.

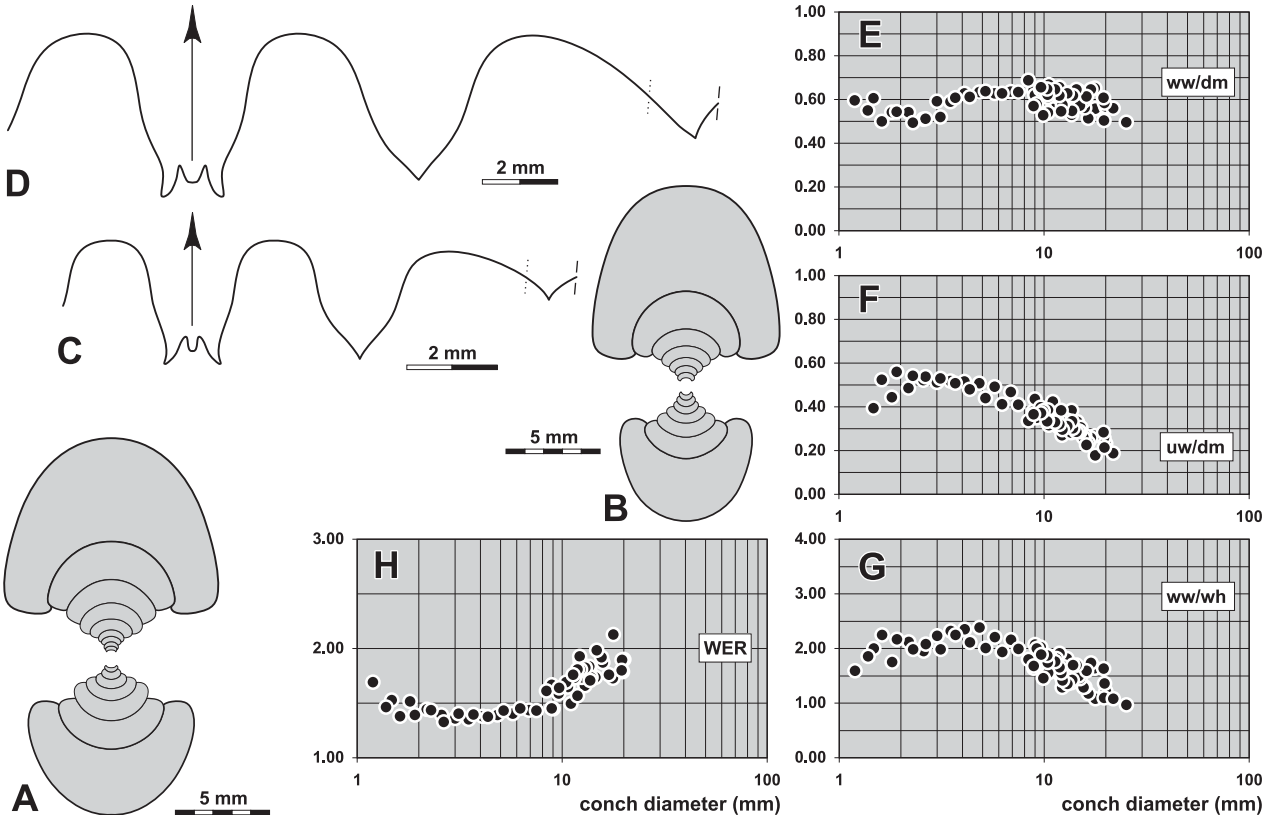


Figure 40. *Gourarites hagaraswad* n. sp. from locality TIM-C8. **A.** Cross section of paratype MB.C.18695.4; ×2.5. **B.** Cross section of paratype MB.C.18695.5; ×2.5. **C.** Suture line of paratype MB.C.18695.2, at 13.1 mm dm, 7.3 mm ww; ×6.0. **D.** Suture line of holotype MB.C.18695.1, at 18.5 mm dm, 10.0 mm ww; ×5.0. **E–H.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm), whorl width index (ww/wh), and whorl expansion rate (WER) of all available specimens.

Table 45. Suture line proportions (Figs 40C, D) for *Gourarites hagaraswad* n. sp.

specimen	at dm	EL w/d	EL/VLS	EL/AL	MS h	VLS w/h	remarks
holotype MB.C.18695.1	18.5 mm	0.62	0.76	1.01	0.19	0.82	
paratype MB.C.18695.2	13.1 mm	0.65	0.90	1.02	0.22	0.72	A lobe almost as deep as E lobe

Discussion. Gourarites hagaraswad has a morphological position between *Bollandoceras mirrih* (which possesses a shorter evolute juvenile stage; see above) and *G. hagarkarim* (with a longer evolute juvenile stage). *G. hagarkarim* in particular, is very similar, and this species is only clearly separable when the ontogeny of the umbilicus is studied. In *G. hagaraswad*, the uw/dm ratio begins to decrease already in a very early growth stage (at 2–3 mm dm), whereas in *G. hagarkarim* the uw/dm ratio remains high (around 0.50) until 10 mm conch diameter.

Gourarites hagarkarim n. sp.

Figures 41, 42

Derivation of name. From the Arabic hagar karim = noble stone.

Holotype. Specimen MB.C.18696.1, illustrated in Figure 41B.

Type locality and horizon. Sebkha de Timimoun, locality TIM-C8 (13.3 km west of Timimoun, Algeria); Upper *Bollandoceras-Bollandites* Assemblage.

Material. 141 specimens, conch diameter between 9 and 23 mm.

Diagnosis. Gourarites with major ontogenetic changes of conch geometry: conch evolute in the juvenile and intermediate stage (1.5–9 mm dm) and then becoming subinvolute to subevolute at 20 mm dm; conch thickly discoidal in the early juvenile stage and thickly discoidal to thinly pachyconic in larger stages; aperture very low in juveniles (2–10 mm dm) and then rapidly increasing (moderately high to high at 20 mm dm);

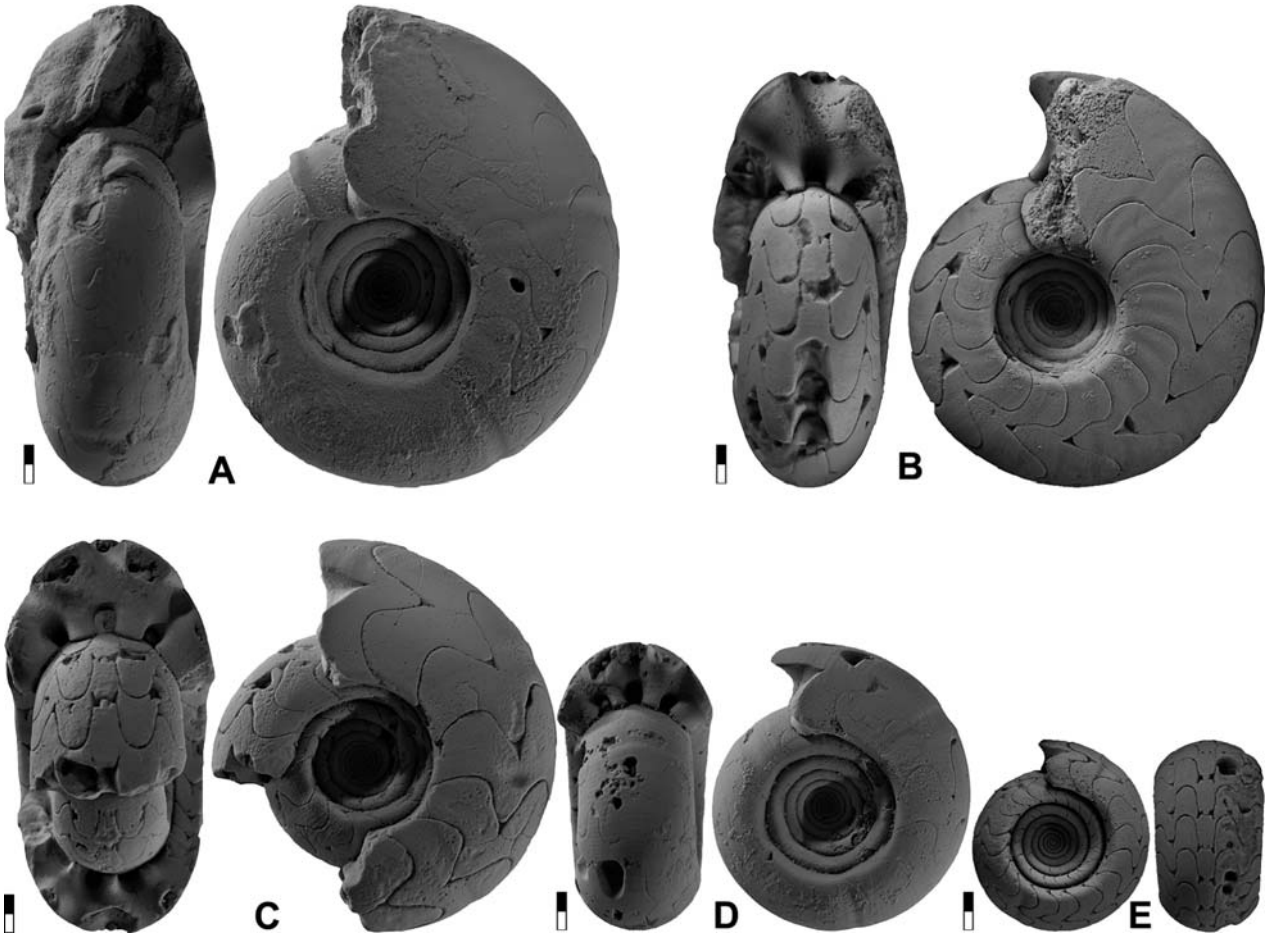


Figure 41. *Gourarites hagarkarim* n. sp. from locality TIM-C8; all ×2.5. **A.** Paratype MB.C.18696.2. **B.** Holotype MB.C.18696.1. **C.** Paratype MB.C.18696.3. **D.** Paratype MB.C.18696.4. **E.** Paratype MB.C.18696.5.

umbilical margin rounded in juveniles and subangular in later stages. Steinkern with shallow, slightly biconvex constrictions and traces of biconvex growth lines. Suture line with narrow, slightly diverging external lobe with strongly sinuous flanks and low median saddle; ventrolateral saddle broadly rounded; small adventive lobe V-shaped, symmetric.

Table 46. Conch ontogeny (Figs 42A–E, H–K) of *Gourarites hagarkarim* n. sp.

dm	conch shape	whorl cross section shape	aperture
2 mm	thinly to thickly discoidal; evolute (ww/dm = 0.45–0.60; uw/dm = 0.50–0.55)	moderately to strongly depressed; strongly embracing (ww/wh = 1.75–2.25; IZR = 0.35–0.45)	very low (WER = 1.35–1.45)
8 mm	thickly discoidal to thinly pachyconic; evolute (ww/dm = 0.55–0.65; uw/dm = 0.45–0.55)	strongly depressed; strongly to very strongly embracing (ww/wh = 2.00–2.50; IZR = 0.40–0.50)	very low (WER = 1.35–1.50)
20 mm	thickly discoidal; subinvolute to subevolute (ww/dm = 0.50–0.60; uw/dm = 0.25–0.35)	weakly to moderately depressed; strongly embracing (ww/wh = 1.10–1.80; IZR = 0.33–0.43)	moderate to high (WER = 1.75–2.15)

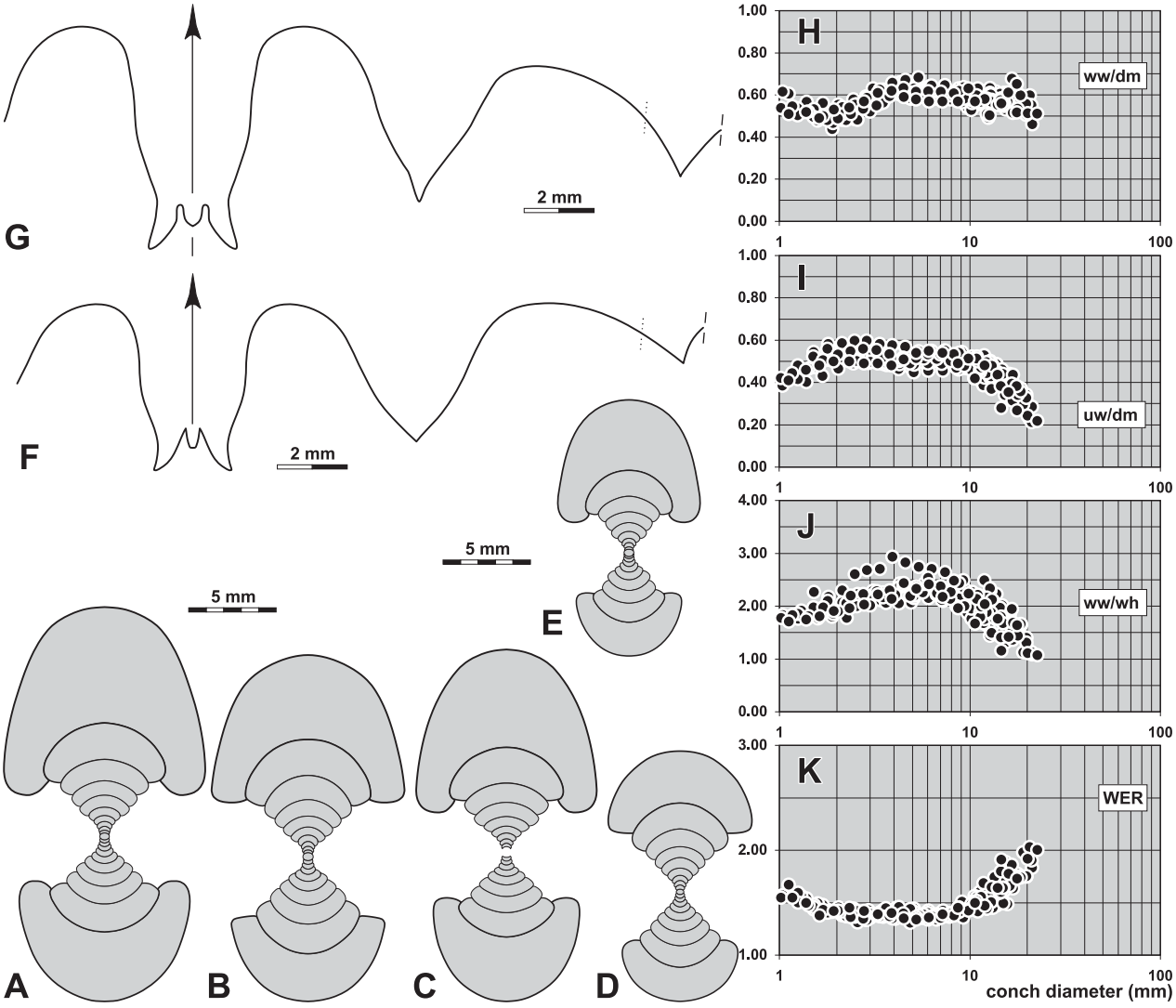


Figure 42. *Gourarites hagarkarim* n. sp. from locality TIM-C8. **A.** Cross section of paratype MB.C.18696.6; ×2.5. **B.** Cross section of paratype MB.C.18696.7; ×2.5. **C.** Cross section of paratype MB.C.18696.8; ×2.5. **D.** Cross section of paratype MB.C.18696.9; ×2.5. **E.** Cross section of paratype MB.C.18696.10; ×2.5. **F.** Suture line of paratype MB.C.18696.6, at 20.0 mm dm, 11.5 mm ww; ×6.0. **G.** Suture line of paratype MB.C.18696.11, at 21.0 mm dm, 11.1 mm ww, 11.3 mm wh; ×5.0. **H–K.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm), whorl width index (ww/wh), and whorl expansion rate (WER) of all available specimens.

Table 47. Conch dimensions (in mm) and proportions for reference specimens of *Gourarites hagarkarim* n. sp.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
paratype MB.C.18696.2	25.3	11.1	11.3	8.4	6.9	0.44	0.98	0.33	1.89	0.39
holotype MB.C.18696.1	21.2	9.8	9.0	6.1	5.6	0.46	1.09	0.29	1.83	0.38
paratype MB.C.18696.3	21.0	10.7	7.7	7.8	4.5	0.51	1.39	0.37	1.62	0.42
paratype MB.C.18696.13	20.6	12.3	10.7	4.7	6.5	0.60	1.15	0.23	2.13	0.39
paratype MB.C.18696.12	19.0	9.8	8.7	5.6	5.5	0.52	1.13	0.30	1.98	0.37
paratype MB.C.18696.15	17.9	10.5	6.6	6.5	4.4	0.59	1.59	0.36	1.75	0.34
paratype MB.C.18696.14	16.7	9.0	6.6	5.3	4.0	0.54	1.36	0.31	1.73	0.39
paratype MB.C.18696.4	15.5	8.3	4.9	7.4	3.2	0.53	1.68	0.48	1.59	0.35
paratype MB.C.18696.5	10.3	5.8	2.5	5.4	1.8	0.56	2.27	0.52	1.46	0.31

Table 48. Suture line proportions (Figs 42F, G) for *Gourarites hagarkarim* n. sp.

specimen	at dm	EL w/d	EL/VLS	EL/AL	MS h	VLS w/h	remarks
paratype MB.C.18696.11	21.0 mm	0.50	0.80	1.13	0.20	0.63	A lobe very small
paratype MB.C.18696.6	20.0 mm	0.62	0.82	1.00	0.25	0.75	

Discussion. Gourarites hagarkarim is similar to *G. hagaraswad* but differs in the longer widely umbilicate ontogeny. In *G. hagaraswad*, the uw/dm ratio begins to decrease already at a very early growth stage (2–3 mm dm), whereas in *G. hagarkarim* the uw/dm ratio remains high (around 0.50) until reaching a conch diameter of 10 mm. Another distinguishing character is the strong whorl overlap in *G. hagarkarim*, where the umbilicus is closing at 12–14 mm conch diameter.

The two other co-occurring species *G. mustari* and *G. zuhal* differ in their wider whorl cross sections in the juvenile and intermediate stages, visible in the ww/wh diagrams. In *G. hagarkarim*, the ww/wh value usually does not exceed 2.50, whereas it ranges, in *G. mustari* and *G. zuhal*, between 2.50 and 3.50.

***Gourarites mustari* n. sp.**

Figures 43, 44

Derivation of name. From the Arabic mustari = Jupiter.

Holotype. Specimen MB.C.18697.1, illustrated in Figure 43A.

Type locality and horizon. Sebkha de Timimoun, locality TIM-C8 (13.3 km west of Timimoun, Algeria); Upper *Bollandoceras-Bollandites* Assemblage.

Material. 26 specimens, conch diameter between 12 and 31 mm.

Diagnosis. Gourarites with major ontogenetic changes of conch geometry: conch evolute in the juvenile and intermediate stage (1.5–9 mm dm) and then becoming subinvolute at 20 mm dm; conch thickly discoidal in the early juvenile stage and thinly to thickly pachyconic in larger stages with a trend towards a thickly discoidal conch in the adult stage; aperture very low in juveniles (2–8 mm dm) and then rapidly increasing (moderately high to high at 20 mm dm); umbilical margin rounded in juveniles and subangular or angular in later stages. Steinkern with shallow, slightly biconvex constrictions and traces of biconvex growth lines. Suture line with narrow, slightly diverging external lobe with moderately sinuous flanks and low median saddle; ventrolateral saddle broadly rounded; small adventive lobe V-shaped, slightly asymmetric.

Table 49. Conch ontogeny (Figs 44A–D, G–J) of *Gourarites mustari* n. sp.

dm	conch shape	whorl cross section shape	aperture
2 mm	thickly discoidal to thinly pachyconic; evolute (ww/dm = 0.50–0.65; uw/dm = 0.50–0.60)	strongly to very strongly depressed; strongly embracing (ww/wh = 2.20–2.70; IZR = 0.30–0.40)	very low (WER = 1.30–1.50)
8 mm	thinly to thickly pachyconic; evolute (ww/dm = 0.60–0.75; uw/dm = 0.45–0.55)	strongly to very strongly depressed; strongly embracing (ww/wh = 2.00–2.70; IZR = 0.35–0.45)	very low (WER = 1.40–1.50)
20 mm	thickly discoidal; subinvolute (ww/dm = 0.55–0.60; uw/dm = 0.18–0.28)	weakly depressed; strongly embracing (ww/wh = 1.00–1.50; IZR = 0.35–0.45)	moderate to high (WER = 1.75–2.15)

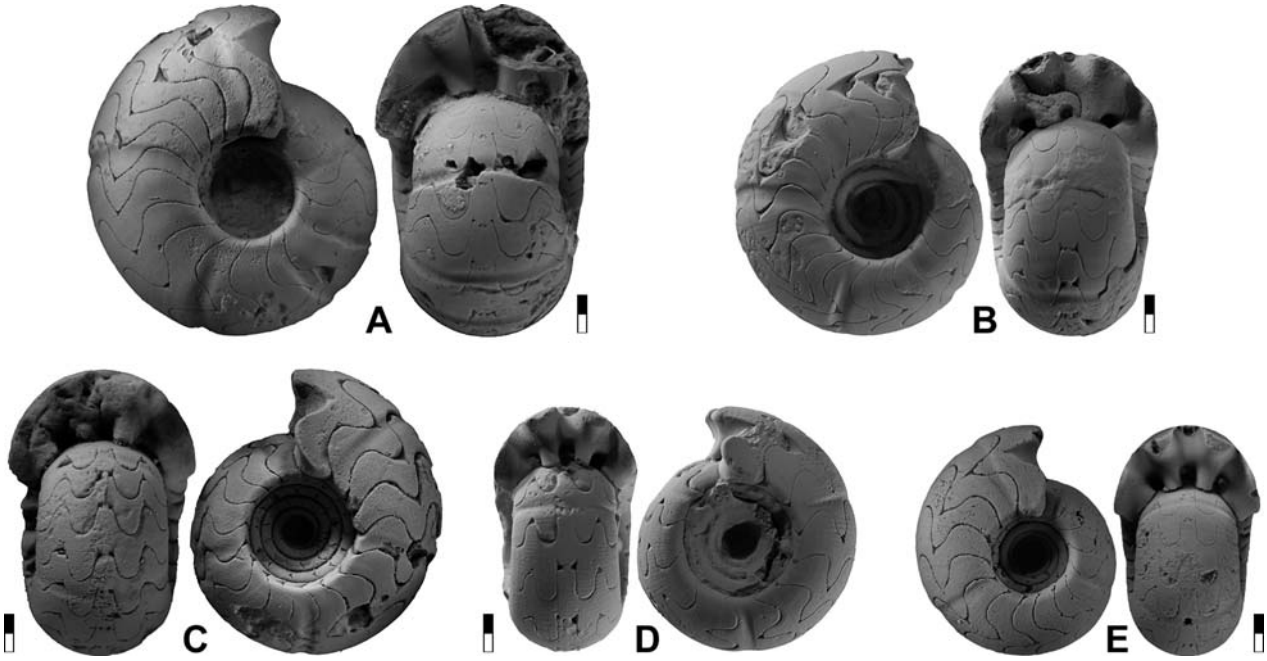


Figure 43. *Gourarites mustari* n. sp. from locality TIM-C8; all ×2.5. **A.** Holotype MB.C.18697.1. **B.** Paratype MB.C.18697.2. **C.** Paratype MB.C.18697.3. **D.** Paratype MB.C.18697.4. **E.** Paratype MB.C.18697.5.

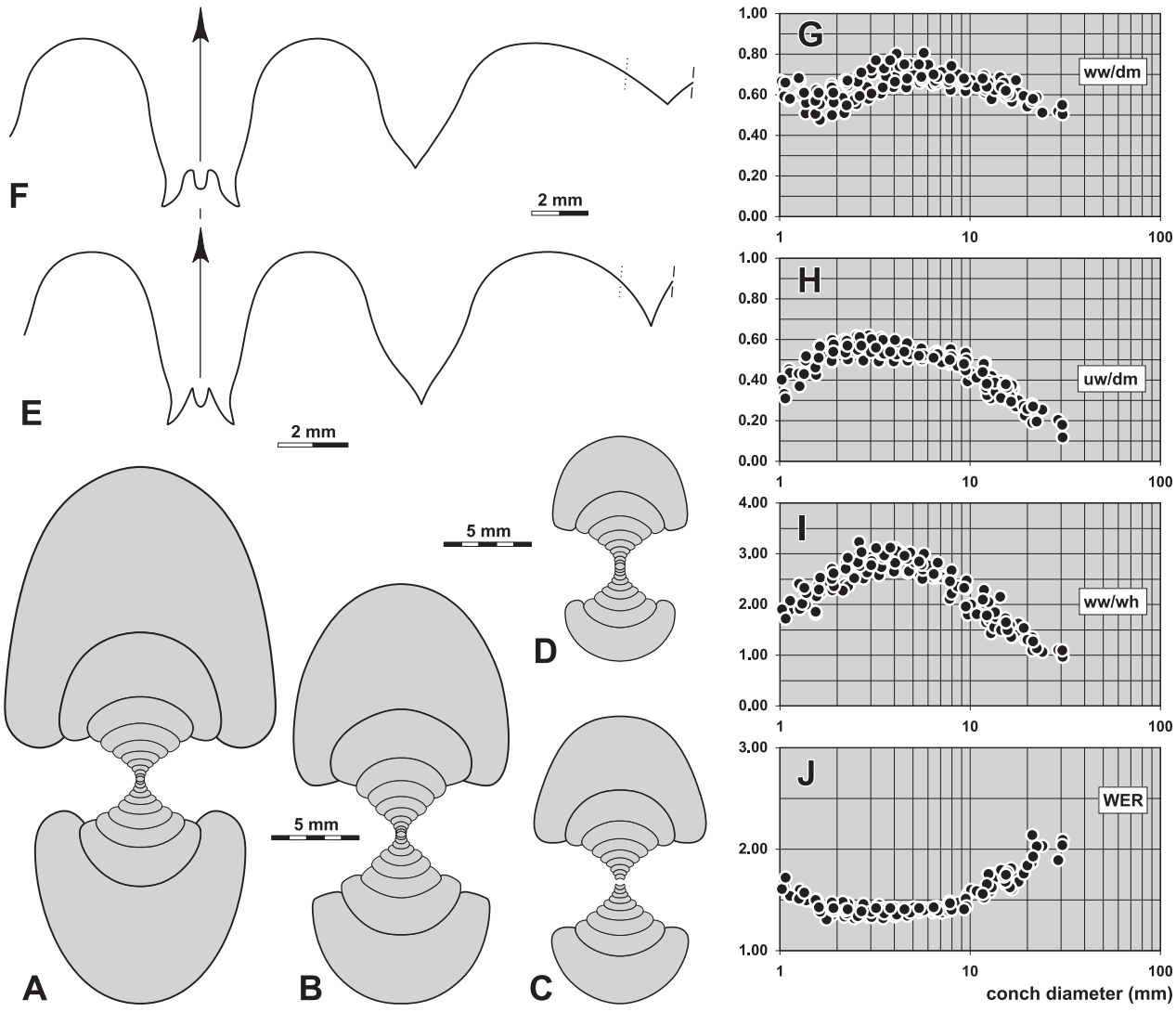


Table 50. Conch dimensions (in mm) and proportions for reference specimens of *Gourarites mustari* n. sp.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
paratype MB.C.18697.11	20.0	10.8	8.3	5.1	5.3	0.54	1.31	0.26	1.84	0.37
holotype MB.C.18697.1	17.9	10.9	6.7	5.4	4.1	0.61	1.63	0.30	1.68	0.39
paratype MB.C.18697.2	15.4	9.2	5.5	5.0	3.6	0.60	1.68	0.33	1.70	0.35
paratype MB.C.18697.3	15.3	9.8	5.7	5.4	3.5	0.64	1.73	0.35	1.68	0.38
paratype MB.C.18697.4	13.0	7.5	4.2	5.5	2.8	0.58	1.79	0.42	1.63	0.33
paratype MB.C.18697.5	12.3	7.7	4.6	4.0	2.7	0.63	1.67	0.33	1.64	0.41

Table 51. Suture line proportions (Figs 44E, F) for *Gourarites mustari* n. sp.

specimen	at dm	EL w/d	EL/VLS	EL/AL	MS h	VLS w/h	remarks
paratype MB.C.18697.9	22.0 mm	0.60	0.76	1.30	0.22	0.79	ventral flank of A lobe curved
paratype MB.C.18697.7	18.0 mm	0.51	0.66	0.97	0.21	0.77	

Discussion. Gourarites hagaraswad is a similar species with respect to conch ontogeny, but differs in the slender conch shape (ww/dm = 0.50–0.60 at 10 mm dm) from *G. mustari* (ww/dm = 0.60–0.70 at the same diameter). Better distinguishing characters can be seen in the development of the umbilicus. *G. hagaraswad* shows, already at 10 mm dm, a reduction of the uw/dm ratio to 0.30–0.40, whereas this change occurs much later in *G. mustari* (at 15–18 mm).

G. hagarkarim and *G. zuhal* differ from *G. mustari* in the more rapidly closing umbilicus in the intermediate stage. Both species show very strong overlap of the whorls onto the umbilicus at about 15 mm conch diameter. *G. zuhal* has a much narrower external lobe than *G. mustari*.

Gourarites zuhal n. sp.

Figures 45, 46

Derivation of name. From the Arabic zuhal = Saturn.

Holotype. Specimen MB.C.18698.1, illustrated in Figure Fig. 45A.

Type locality and horizon. Sebkha de Timimoun, locality TIM-C8 (13.3 km west of Timimoun, Algeria); Upper *Bollandoceras-Bollandites* Assemblage.

Material. 34 specimens, conch diameter between 13 and 31 mm.

Diagnosis. Gourarites with major ontogenetic changes of conch geometry: conch evolute in the juvenile and intermediate stage (from 1.5–12 mm dm) and then becoming subevolute at 20 mm dm; conch thickly discoidal in the early juvenile stage and thinly pachyconic in larger stages with a trend towards a thickly discoidal conch in the adult stage; aperture very low in juveniles (2–12 mm dm) and then rapidly increasing (moderately high 20 mm dm); umbilical margin rounded in juveniles and subangular or angular in later stages; umbilicus rapidly becoming narrow by strong whorl overlap. Steinkern with shallow, slightly biconvex constrictions and traces of biconvex growth lines. Suture line with very narrow, slightly diverging external lobe with weakly sinuous flanks and low median saddle; ventrolateral saddle broadly rounded; adventive lobe V-shaped, almost symmetric.

Table 52. Conch ontogeny (Figs 46A–D, G–J) of *Gourarites zuhal* n. sp.

dm	conch shape	whorl cross section shape	aperture
2 mm	thinly pachyconic; evolute (ww/dm = 0.60–0.70; uw/dm = 0.50–0.60)	strongly to very strongly depressed; strongly embracing (ww/wh = 2.30–3.00; IZR = 0.30–0.40)	very low (WER = 1.35–1.40)
8 mm	thinly pachyconic; evolute (ww/dm = 0.65–0.70; uw/dm = 0.55–0.60	very strongly to extremely depressed; strongly embracing (ww/wh = 2.60–3.20; IZR = 0.35–0.45)	very low (WER = 1.35–1.45)
20 mm	thickly discoidal to thinly pachyconic; subevolute (ww/dm = 0.50–0.65; uw/dm = 0.30–0.40)	weakly to moderately depressed; strongly embracing (ww/wh = 1.30–1.60; IZR = 0.35–0.45)	low to moderate (WER = 1.70–1.85)

◄

Figure 44. *Gourarites mustari* n. sp. from locality TIM-C8. **A.** Cross section of paratype MB.C.18697.6; ×2.5. **B.** Cross section of paratype MB.C.18697.7; ×2.5. **C.** Cross section of paratype MB.C.18697.8; 132.5. **D.** Cross section of paratype MB.C.18697.10; ×2.5. **E.** Suture line of paratype MB.C.18697.7, at 18.0 mm dm, 10.2 mm ww, 7.8 mm wh; ×5.0. **F.** Suture line of paratype MB.C.18697.9, at 22.0 mm dm, 13.4 mm ww, 11.7 mm wh; ×4.0. **G–J.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm), whorl width index (ww/wh), and whorl expansion rate (WER) of all available specimens.

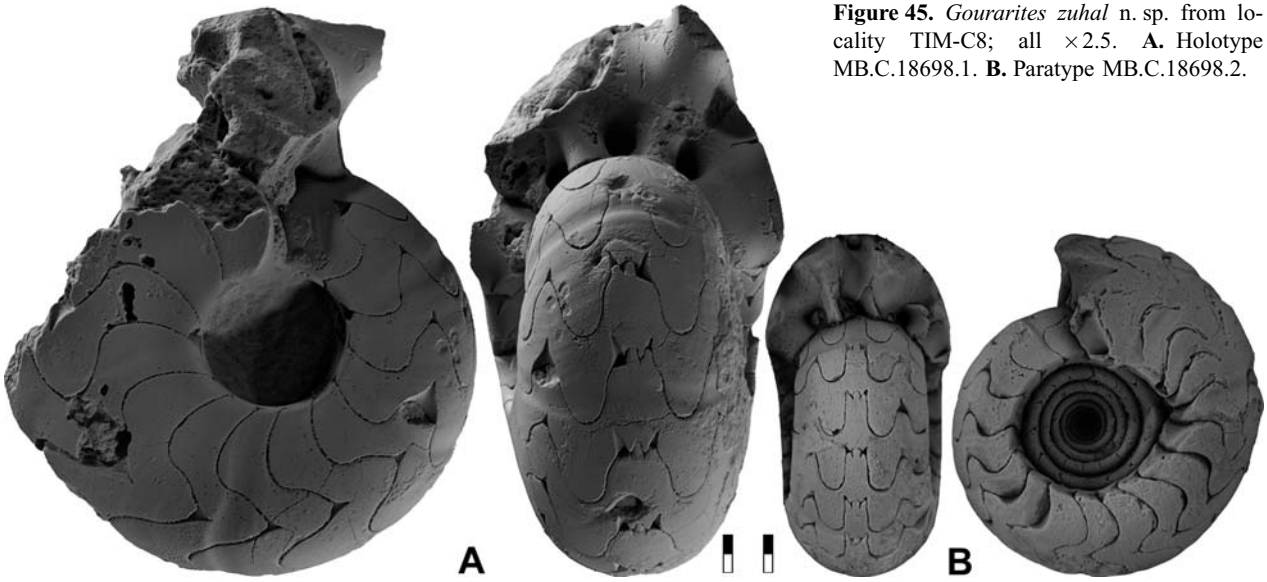


Figure 45. *Gourarites zuhal* n. sp. from locality TIM-C8; all ×2.5. **A.** Holotype MB.C.18698.1. **B.** Paratype MB.C.18698.2.

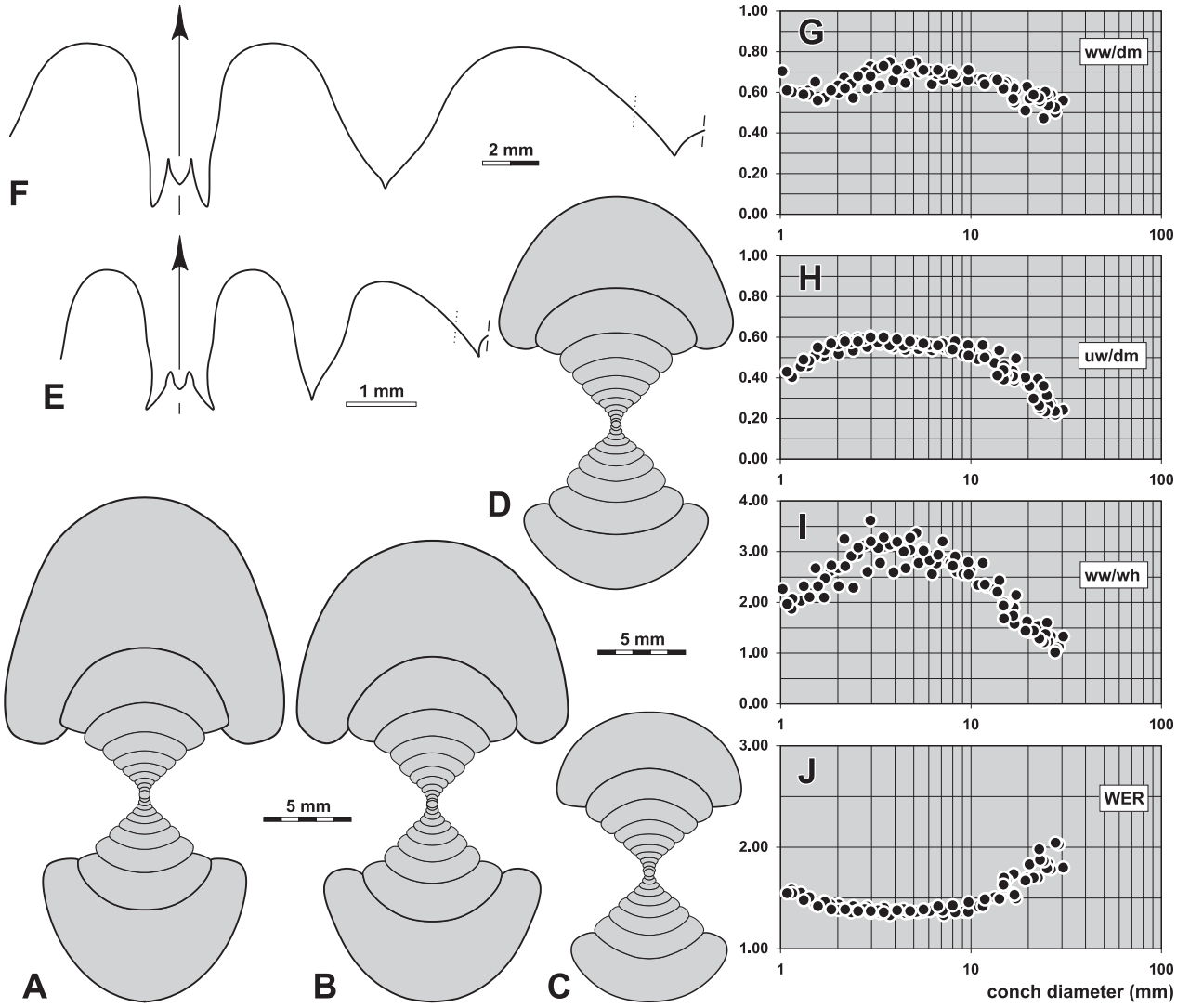


Figure 46. *Gourarites zuhal* n. sp. from locality TIM-C8. **A.** Cross section of paratype MB.C.18698.3; ×2.5. **B.** Cross section of paratype MB.C.18698.4; ×2.5. **C.** Cross section of paratype MB.C.18698.5; ×2.5. **D.** Cross section of paratype MB.C.18698.6; ×2.5. **E.** Suture line of paratype MB.C.18698.5, at 6.0 mm dm, 4.1 mm ww, 2.0 mm wh; ×10.0. **F.** Suture line of paratype MB.C.18698.4, at 25.0 mm dm, 15.0 mm ww, 14.0 mm wh; ×4.0. **G–J.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm), whorl width index (ww/wh), and whorl expansion rate (WER) of all available specimens.

Table 54. Conch dimensions (in mm) and proportions for reference specimens of *Gourarites zuhal* n. sp.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
holotype MB.C.18698.1	30.5	17.1	12.9	7.4	7.8	0.56	1.33	0.24	1.80	0.40
paratype MB.C.18698.9	27.8	13.9	13.0	6.1	8.4	0.50	1.07	0.22	2.04	0.36
paratype MB.C.18698.10	25.4	13.7	11.1	6.8	6.7	0.54	1.24	0.27	1.84	0.40
paratype MB.C.18698.7	25.1	14.7	9.2	7.9	6.4	0.59	1.60	0.31	1.79	0.31
paratype MB.C.18698.2	19.3	9.8	6.8	7.8	4.4	0.51	1.44	0.40	1.67	0.36
paratype MB.C.18698.8	19.0	10.5	5.8	8.5	3.8	0.55	1.82	0.44	1.56	0.34

Table 54. Suture line proportions (Figs 46E, F) for *Gourarites zuhal* n. sp.

specimen	at dm	EL w/d	EL/VLS	EL/AL	MS h	VLS w/h	remarks
paratype MB.C.18698.4	25.0 mm	0.46	0.60	0.75	0.22	0.77	A lobe symmetrically V-shaped
paratype MB.C.18698.5	6.0 mm	0.47	0.80	1.30	0.24	0.59	A lobe very narrow

Discussion. Gourarites zuhal differs from the similar *G. mustari* in the rapid decrease of the uw/dm ratio by remarkable whorl overlap in the intermediate stage at 14–18 mm dm. Another criterion to separate the two species is the narrower external lobe in *G. zuhal*, which has only 0.45 of the external lobe width, in contrast to 0.55 in *G. mustari*.

G. hagarkarim also shows strong whorl overlap onto the umbilicus, but differs in the shorter evolute ontogenetic stage, ending at about 8 mm dm in *G. hagarkarim* and at 12 mm in *G. zuhal*. The narrower external lobe in *G. zuhal* is another distinguishing character.

Semibollandites n. gen.

Derivation of name. Reference to the genus *Bollandites*, which may be a descendent.

Type species. *Semibollandites kamil* n. sp.

Genus definition. Genus of the subfamily Bollanditinae with major ontogenetic changes of conch morphology (Fig. 47); adult conch pachyconic with slowly expanding whorls (WER less than 1.70 in stages larger than 10 mm conch diameter); conch evolute in juveniles and subevolute in the adult stage. Suture line with narrow, V-shaped external lobe with gently sinuous, diverging flanks; secondary prongs of the external lobe hook-shaped; median saddle usually very low; ventrolateral saddle narrowly to broadly rounded; adventive lobe V-shaped.

Included species.
varians: *Bollandites varians* Riley, 1996: 76. Lancashire.
kamil: *Semibollandites kamil* n. sp.: Gourara, Algeria.
pauculus: *Semibollandites pauculus* n. sp.: Gourara, Algeria.
qawiy: *Semibollandites qawiy* n. sp.: Gourara, Algeria.
? *trevallynensis*: *Beyrichoceras trevallynense* Brown, Campbell & Roberts, 1964: 689. New South Wales.

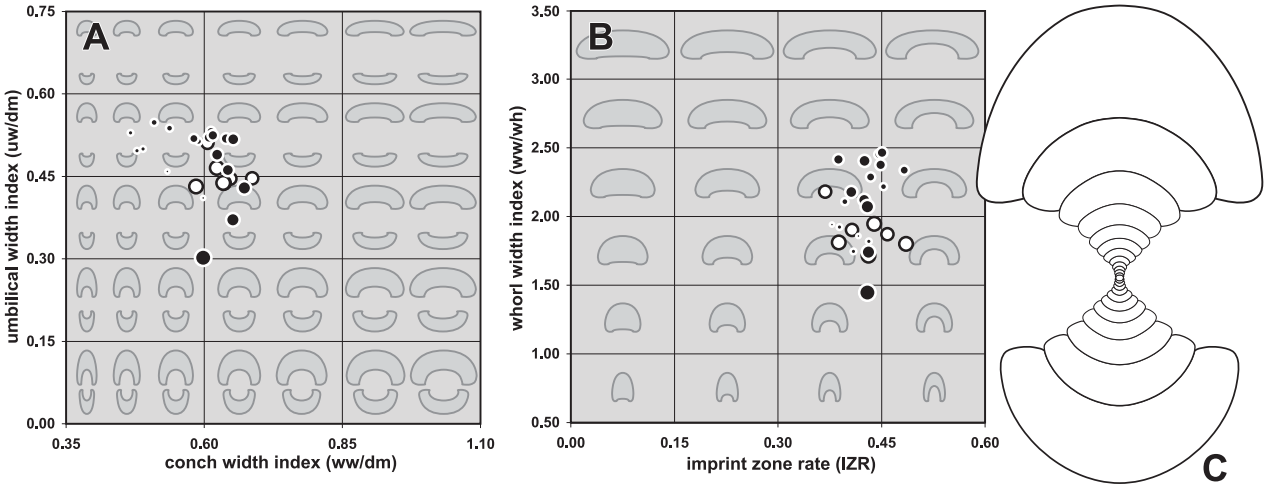


Figure 47. Ontogenetic trajectories of *Semibollandites*, exemplified for *S. kamil* n. sp. from locality TIM-B3. **A.** Ontogenetic development of the conch width index (ww/dm) and umbilical width index (uw/dm). **B.** Ontogenetic development of the imprint zone rate (IZR) and whorl width index (ww/wh). **C.** Cross section of paratype MB.C.18699.5; ×2.5. [Black dots represent ontogenetic stages of cross section MB.C.18699.5, white dots represent the reference specimens (Tab. 56).]

Discussion. Semibollandites differs from *Gourarites* and *Bollandites* in the absence of adult narrowing of the uw/dm ratio. *Timimounia* has an even wider umbilicus than *Semibollandites*; an adult narrowing of the umbilicus does not occur in that genus either. The main difference between the two genera is the shape of the external lobe, which is V-shaped in *Semibollandites* and nearly parallel-sided in *Timimounia*.

Semibollandites kamil n. sp.

Figures 48, 49

Derivation of name. From the Arabic al-kamil = the perfect.

Holotype. Specimen MB.C.18699.1, illustrated in Figure 48B.

Type locality and horizon. Sebkha de Timimoun, locality TIM-C8 (13.3 km west of Timimoun, Algeria); Upper *Bollandoceras-Bollandites* Assemblage.

Material. 37 specimens, conch diameter between 8 and 32 mm.

Diagnosis. Semibollandites with moderate ontogenetic changes of conch geometry: conch evolute in the juvenile and preadult stage (1.5–13 mm dm) and subevolute at 20 mm dm; conch thickly discoidal in the early juvenile stage and thinly pachyconic in larger stages; aperture very low in the juvenile and preadult stage (2–13 mm dm) and then slowly increasing; umbilical margin subangular in juveniles and subangular or angular in later stages. Steinkern with shallow, almost straight constrictions and traces of concavo-convex growth lines. Suture line with narrow, strongly diverging external lobe with slightly sinuous flanks and very low median saddle; ventrolateral saddle broadly rounded; adventive lobe V-shaped, asymmetric.

Table 55. Conch ontogeny (Figs 49A, B, E–H) of *Semibollandites kamil* n. sp.

dm	conch shape	whorl cross section shape	aperture
2 mm	thickly discoidal; evolute (ww/dm = 0.48–0.60; uw/dm = 0.50–0.55)	moderately depressed; strongly embracing (ww/wh = 1.70–2.00; IZR = 0.38–0.45)	very low (WER = 1.40–1.50)
8 mm	thinly pachyconic; evolute (ww/dm = 0.60–0.65; uw/dm = 0.50–0.56	strongly to very strongly depressed; strongly to very strongly embracing (ww/wh = 2.10–2.70; IZR = 0.35–0.50)	very low (WER = 1.30–1.40)
20 mm	thinly pachyconic; subevolute to evolute (ww/dm = 0.60–0.70; uw/dm = 0.35–0.50)	moderately to strongly depressed; strongly embracing (ww/wh = 1.50–2.20; IZR = 0.35–0.45)	very low to low (WER = 1.45–1.55)

Table 56. Conch dimensions (in mm) and proportions for reference specimens of *Semibollandites kamil* n. sp.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
paratype MB.C.18699.8	23.5	13.8	8.0	10.1	4.6	0.59	1.72	0.43	1.54	0.43
paratype MB.C.18699.2	17.7	11.1	6.5	6.7	3.8	0.63	1.71	0.38	1.61	0.42
paratype MB.C.18699.3	17.2	10.9	5.6	7.5	3.1	0.64	1.95	0.44	1.50	0.44
holotype MB.C.18699.1	17.2	10.9	6.0	7.5	3.7	0.63	1.82	0.44	1.62	0.39
paratype MB.C.18699.4	15.0	10.3	5.4	6.7	3.2	0.69	1.91	0.45	1.62	0.41
paratype MB.C.18699.7	13.9	9.0	4.8	6.2	2.6	0.65	1.88	0.45	1.51	0.46
paratype MB.C.18699.9	13.7	8.3	3.8	7.0	2.4	0.61	2.18	0.51	1.47	0.37

Table 57. Suture line proportions (Figs 49C, D) for *Semibollandites kamil* n. sp.

specimen	at dm	EL w/d	EL/VLS	EL/AL	MS h	VLS w/h	remarks
paratype MB.C.18699.6	c. 22.0 mm	0.54	0.76	0.86	0.16	0.72	A lobe with curved ventral flank
holotype MB.C.18699.1	c. 20.0 mm	0.54	0.72	0.80	0.17	0.75	E lobe almost parallel-sided

Discussion. Semibollandites kamil differs from *Timimounia timimounensis* in the narrower umbilicus in the adult stage (uw/dm = 0.25–0.35 at 25 mm dm in *S. kamil* and more than 0.40 in *T. timimounensis*). This difference is caused by the ontogenetic reduction of the uw/dm ratio, which in *S. kamil* slowly begins at about 10 mm conch diameter and becomes more rapid at 16 mm dm, whereas this process is much slower in *B. timimounensis*.

T. lunula has a much wider umbilicus than *S. kamil* and also differs in the very wide, ventrally depressed whorl cross section. The other two species *S. pauculus* and *S. qawiy* show ontogenetic traits characterised by an increase of the uw/dm ratio, and are thus clearly separated from *S. kamil*.

▶

Figure 49. *Semibollandites kamil* n. sp. from locality TIM-C8. **A.** Cross section of paratype MB.C.18699.5; ×2.5. **B.** Cross section of paratype MB.C.18699.6; ×2.5. **C.** Suture line of holotype MB.C.18699.1, at 15.0 mm dm, 10.0 mm ww, 5.5 mm wh; ×6.0. **D.** Suture line of paratype MB.C.18699.6, at 13.1 mm ww, 9.5 mm wh; ×5.0. **E–H.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm), whorl width index (ww/wh), and whorl expansion rate (WER) of all available specimens.

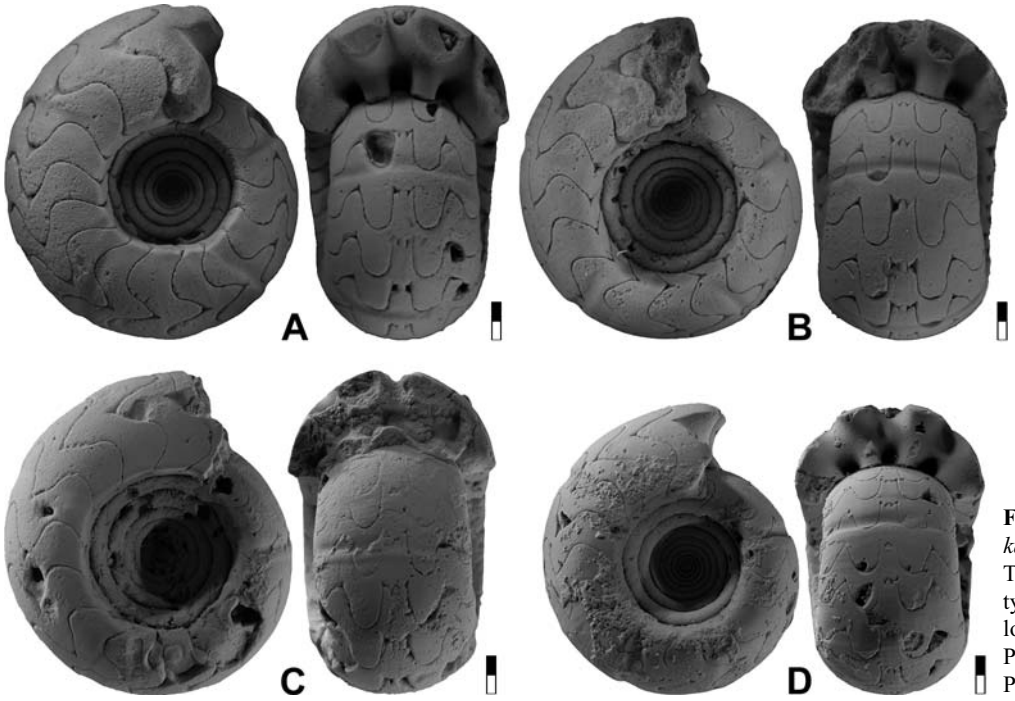
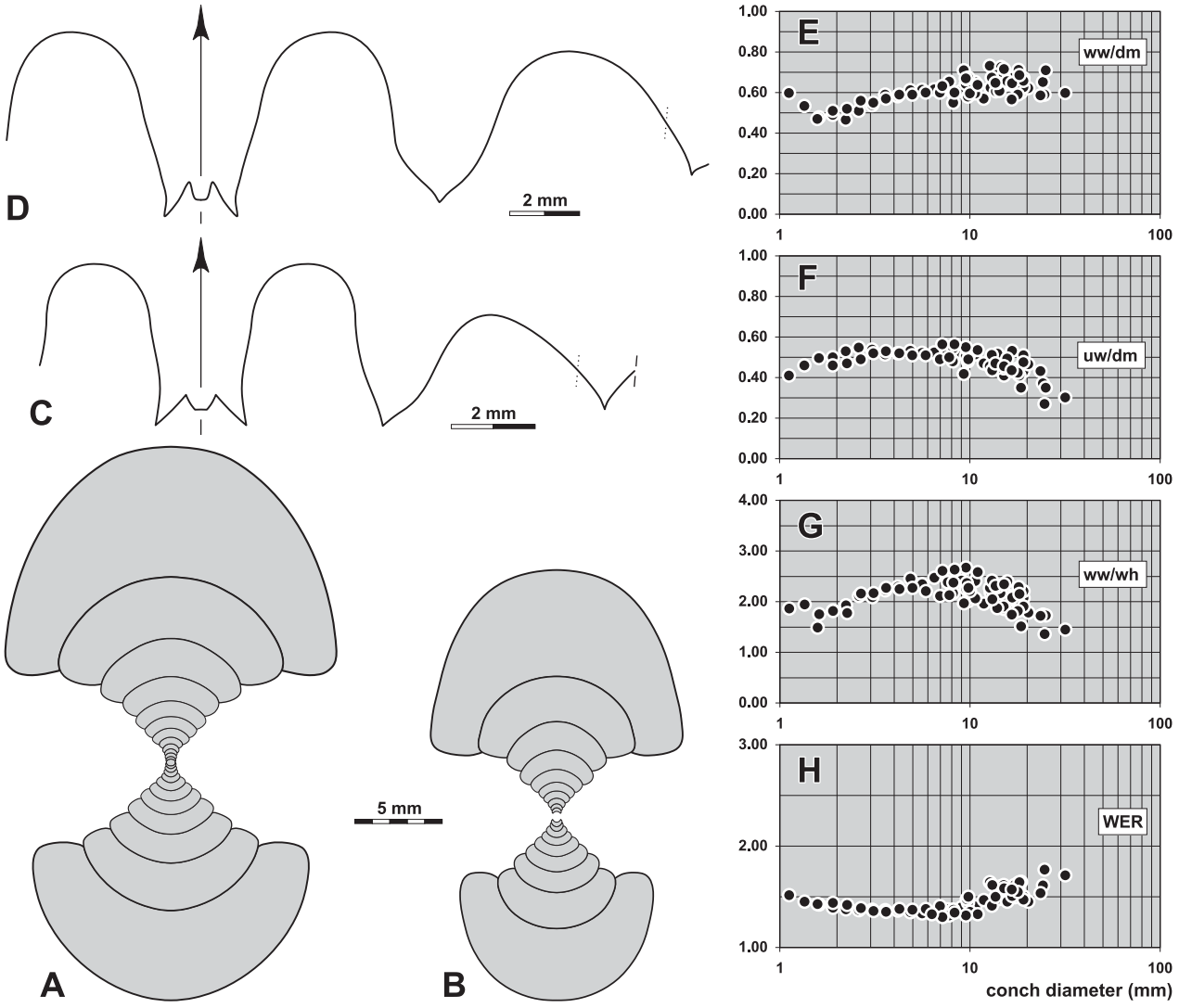


Figure 48. *Semibollandites kamil* n. sp. from locality TIM-C8; all × 2.5. **A.** Paratype MB.C.18699.2. **B.** Holotype MB.C.18699.1. **B.** Paratype MB.C.18699.3. **C.** Paratype MB.C.18699.4.



Semibollandites pauculus n. sp.

Figures 50, 51

Derivation of name. From Latin pauculus = very few.

Holotype. Specimen MB.C.18700.1, illustrated in Figure 50A.

Type locality and horizon. Sebkha de Timimoun, locality TIM-C8 (13.3 km west of Timimoun, Algeria); Upper *Bollandoceras-Bollandites* Assemblage.

Material. Six specimens, conch diameter between 11 and 21 mm.

Diagnosis. Semibollandites with major ontogenetic changes of conch geometry: conch evolute in the juvenile stage (from 1.5–4 mm dm) and then becoming subevolute at 20 mm dm; conch thickly discoidal in early juveniles and becoming in later stages pachyconic; aperture very low in juveniles (2–6 mm dm) and then slowly increasing but still low at 20 mm dm; umbilical margin rounded in juveniles and subangular in later stages. Steinkern with shallow, slightly backwardly extending constrictions. Suture line with narrow, moderately to strongly diverging external lobe with almost straight flanks and a very low median saddle; ventrolateral saddle broadly rounded; adventive lobe V-shaped, symmetric with strongly convex flanks.

Table 58. Conch ontogeny (Figs 51A, B, E–H) of *Semibollandites pauculus* n. sp.

dm	conch shape	whorl cross section shape	aperture
2 mm	thickly discoidal; evolute (ww/dm = 0.50–0.60; uw/dm = 0.45–0.55)	strongly depressed; strongly embracing (ww/wh = 2.00–2.50; IZR = 0.35–0.45)	very low (WER = 1.35–1.45)
8 mm	thinly pachyconic; subevolute (ww/dm = 0.60–0.70; uw/dm = 0.35–0.40)	moderately depressed; strongly embracing (ww/wh = 1.75–1.90; IZR = 0.40–0.45)	low (WER = 1.50–1.65)
20 mm	thickly pachyconic; subevolute (ww/dm = 0.72–0.75; uw/dm = 0.30–0.40)	moderately to strongly depressed; strongly embracing (ww/wh = 1.80–2.20; IZR = 0.35–0.45)	low (WER = 1.55–1.70)

Table 59. Conch dimensions (in mm) and proportions for reference specimens of *Semibollandites pauculus* n. sp.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
holotype MB.C.18700.1	17.0	12.2	6.5	6.5	3.9	0.72	1.88	0.38	1.68	0.40
paratype MB.C.18700.6	12.3	8.8	3.8	5.0	2.4	0.72	2.32	0.41	1.55	0.36
paratype MB.C.18700.2	11.5	8.3	3.7	4.9	2.3	0.72	2.24	0.43	1.56	0.38

Table 60. Suture line proportions (Figs 51C, D) for *Semibollandites pauculus* n. sp.

specimen	at dm	EL w/d	EL/VLS	EL/AL	MS h	VLS w/h	remarks
paratype MB.C.18700.4	13.5 mm	0.55	0.63	0.95	0.15	0.87	E lobe moderately strong diverging
paratype MB.C.18700.5	12.0 mm	0.65	0.80	1.00	0.23	0.80	

Discussion. Semibollandites pauculus differs from the co-occurring species *S. kamil* in the presence of a growth interval (between 3 and 8 mm dm) with a rather strong reduction of the uw/dm ratio and a subsequent re-opening of the umbilicus. Much closer in appearance is *S. qawiy*, but in this species, the umbilicus is much narrower in the juvenile stage (uw/dm = 0.40–0.45 at 6 mm dm in *S. pauculus* but 0.32–0.37 in *S. qawiy*).

Figure 50. *Semibollandites pauculus* n. sp. from locality TIM-C8; all ×2.5. **A.** Holotype MB.C.18700.1. **B.** Paratype MB.C.18700.2.

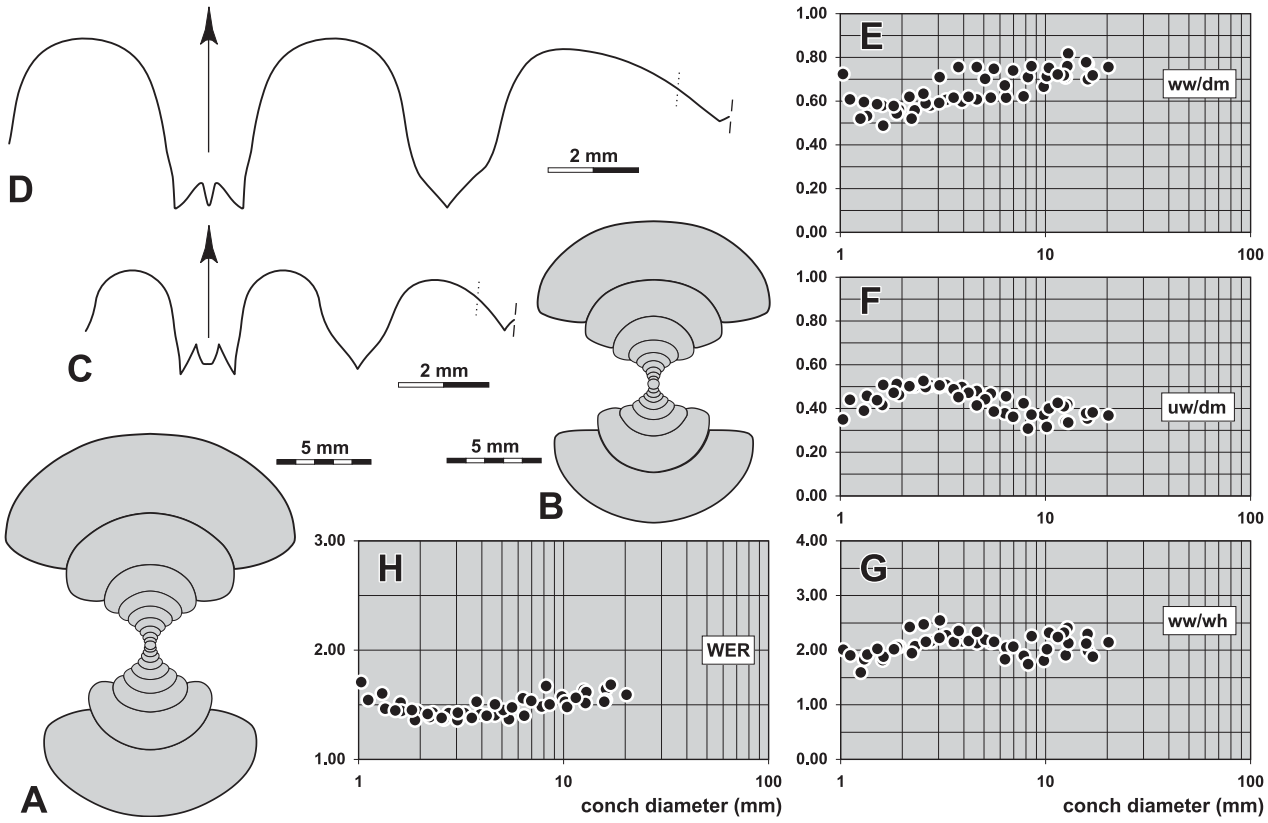


Figure 51. *Semibollandites pauculus* n. sp. from locality TIM-C8. **A.** Cross section of paratype MB.C.18700.3; ×2.5. **B.** Cross section of paratype MB.C.18700.4; ×2.5. **C.** Suture line of paratype MB.C.18700.5, at 12.0 mm dm, 7.3 mm ww; ×6.0. **D.** Suture line of paratype MB.C.18700.4, at 13.5 mm dm, 11.4 mm ww, 6.2 mm wh; ×6.0. **E–H.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm), whorl width index (ww/wh), and whorl expansion rate (WER) of all available specimens.

Semibollandites qawiy n. sp.

Figures 52, 53

Derivation of name. From the Arabic al-qawiy = the strong, because of the conch shape.

Holotype. Specimen MB.C.18701.1, illustrated in Figure Fig. 52A.

Type locality and horizon. Sebkha de Timimoun, locality TIM-C8 (13.3 km west of Timimoun, Algeria); Upper *Bollandoceras-Bollandites* Assemblage.

Material. 55 specimens, conch diameter between 7 and 22 mm.

Diagnosis. Semibollandites with moderate ontogenetic changes of conch geometry: conch evolute in the early juvenile stage (at 2 mm dm) and then becoming subevolute at 20–30 mm dm; conch thickly discoidal in early juveniles and becoming in later stages pachyconic; aperture very low to low throughout ontogeny; umbilical margin rounded in juveniles and angular in later stages. Steinkern with shallow, backwardly directed constrictions. Suture line with narrow, strongly diverging external lobe with incurved flanks and very low median saddle; ventrolateral saddle narrowly rounded; adventive lobe V-shaped, symmetric.

Discussion. Semibollandites qawiy resembles the co-occurring species *S. pauculus*, but differs in the narrower umbilicus at comparable growth stages (for a comparison, see under that species).

Table 61. Conch ontogeny (Figs 53A–D, H–K) of *Semibollandites qawiy* n. sp.

dm	conch shape	whorl cross section shape	aperture
2 mm	thinly to thickly pachyconic; evolute (ww/dm = 0.60–0.75; uw/dm = 0.45–0.55)	strongly depressed; strongly embracing (ww/wh = 2.00–2.50; IZR = 0.30–0.35)	very low to low (WER = 1.40–1.55)
8 mm	thinly to thickly pachyconic; subevolute (ww/dm = 0.70–0.80; uw/dm = 0.30–0.40)	moderately to strongly depressed; strongly embracing (ww/wh = 1.90–2.20; IZR = 0.35–0.45)	low (WER = 1.50–1.70)
20 mm	thinly to thickly pachyconic; subevolute (ww/dm = 0.65–0.75; uw/dm = 0.30–0.40)	moderately depressed; strongly embracing (ww/wh = 1.60–2.00; IZR = 0.40–0.45)	low (WER = 1.50–1.70)

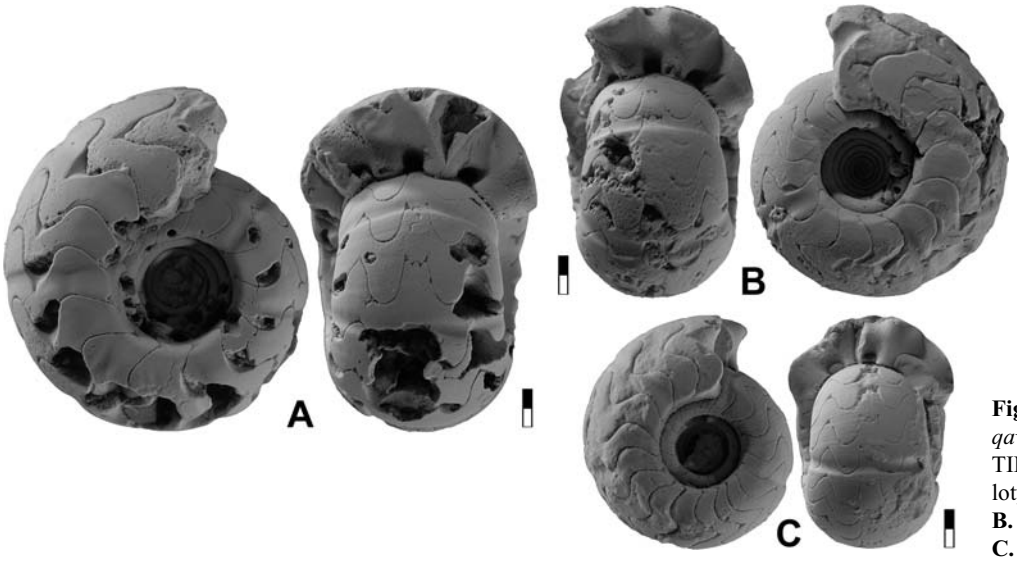


Figure 52. *Semibollandites qawiy* n. sp. from locality TIM-C8; all ×2.5. **A.** Holotype MB.C.18701.1. **B.** Paratype MB.C.18701.2. **C.** Paratype MB.C.18701.3.

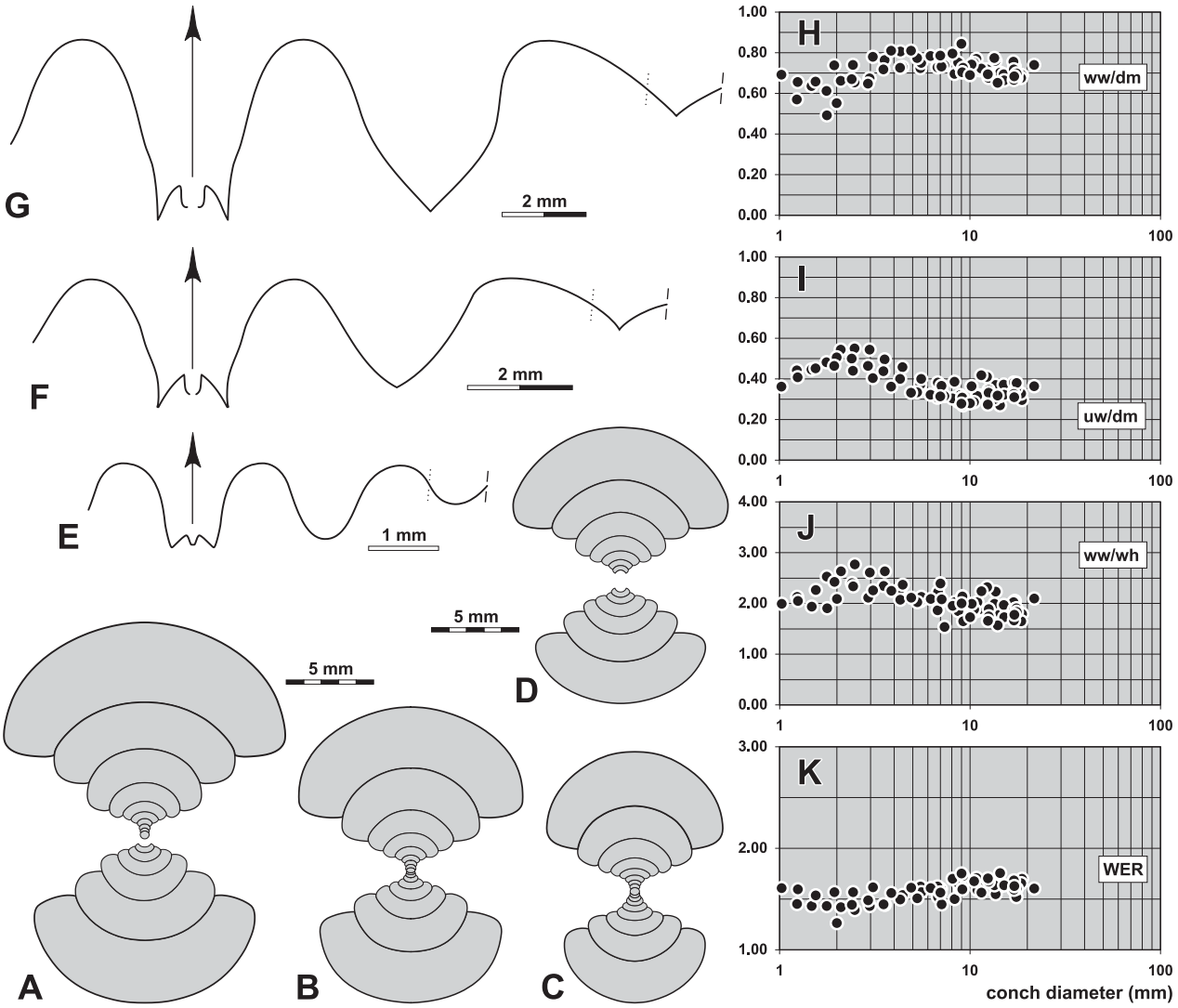


Figure 53. *Semibollandites qawiy* n. sp. from locality TIM-C8. **A.** Cross section of paratype MB.C.18701.4; ×2.5. **B.** Cross section of paratype MB.C.18701.5; ×2.5. **C.** Cross section of paratype MB.C.18701.6; ×2.5. **D.** Cross section of paratype MB.C.18701.7; ×2.5. **E.** Suture line of paratype MB.C.18701.8, at 5.2 mm dm, 3.8 mm ww; ×10.0. **F.** Suture line of paratype MB.C.18701.5, at 8.8 mm ww, 4.8 mm wh; ×7.5. **G.** Suture line of paratype MB.C.18701.9, at 19.0 mm dm, 13.0 mm ww; ×6.0. **H–K.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm), whorl width index (ww/wh), and whorl expansion rate (WER) of all available specimens.

Table 62. Conch dimensions (in mm) and proportions for reference specimens of *Semibollandites qawiy* n. sp.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
holotype MB.C.18701.1	18.6	12.6	7.6	6.1	4.2	0.68	1.65	0.33	1.66	0.45
paratype MB.C.18701.11	17.6	12.3	6.7	6.7	3.7	0.70	1.84	0.38	1.60	0.45
paratype MB.C.18701.10	17.0	11.3	6.8	5.5	3.5	0.67	1.66	0.33	1.59	0.48
paratype MB.C.18701.2	15.1	10.0	5.8	4.9	3.3	0.66	1.73	0.32	1.63	0.43
paratype MB.C.18701.3	12.5	8.7	5.0	4.2	2.8	0.70	1.75	0.33	1.67	0.43
paratype MB.C.18701.12	12.4	8.6	5.2	3.4	2.9	0.69	1.65	0.27	1.70	0.44
paratype MB.C.18701.13	9.2	6.7	4.1	2.5	2.2	0.73	1.64	0.27	1.73	0.46

Table 63. Suture line proportions (Figs 53E–G) for *Semibollandites qawiy* n. sp.

specimen	at dm	EL w/d	EL/VLS	EL/AL	MS h	VLS w/h	remarks
paratype MB.C.18701.9	19.0 mm	0.57	0.85	0.82	0.19	0.68	
paratype MB.C.18701.7	15.5 mm	0.67	0.75	0.86	0.15	0.88	E lobe strongly diverging
paratype MB.C.18701.5	c. 13.0 mm	0.75	0.86	0.92	0.25	0.87	A lobe very wide
paratype MB.C.18701.8	5.2 mm	0.73	0.86	0.95	0.14	0.85	A lobe rounded

Timimounia n. gen.

Derivation of name. After Timimoun, where the material was found.

Type species. *Timimounia timimounensis* n. sp.

Genus definition. Genus of the subfamily Bollanditinae with minor ontogenetic changes of conch morphology (Fig. 54); adult conch pachyconic with slowly expanding whorls (WER less than 1.60 in stages larger than 10 mm conch diameter); conch evolute throughout ontogeny. Suture line in the adult stage with very narrow, subparallel-sided, weakly divergent external lobe with slightly incurved flanks; median saddle usually very low; ventrolateral saddle rounded; adventive lobe V-shaped.

Included species.

lunula: *Timimounia lunula* n. sp.: Gourara, Algeria.
timimounensis: *Timimounia timimounensis* n. sp.: Gourara, Algeria.

Discussion. Timimounia is the only genus of the subfamily with an evolute conch throughout ontogeny. It differs from *Semibollandites* also in the shape of the external lobe, which has subparallel flanks in *Timimounia* but is V-shaped in *Semibollandites*.

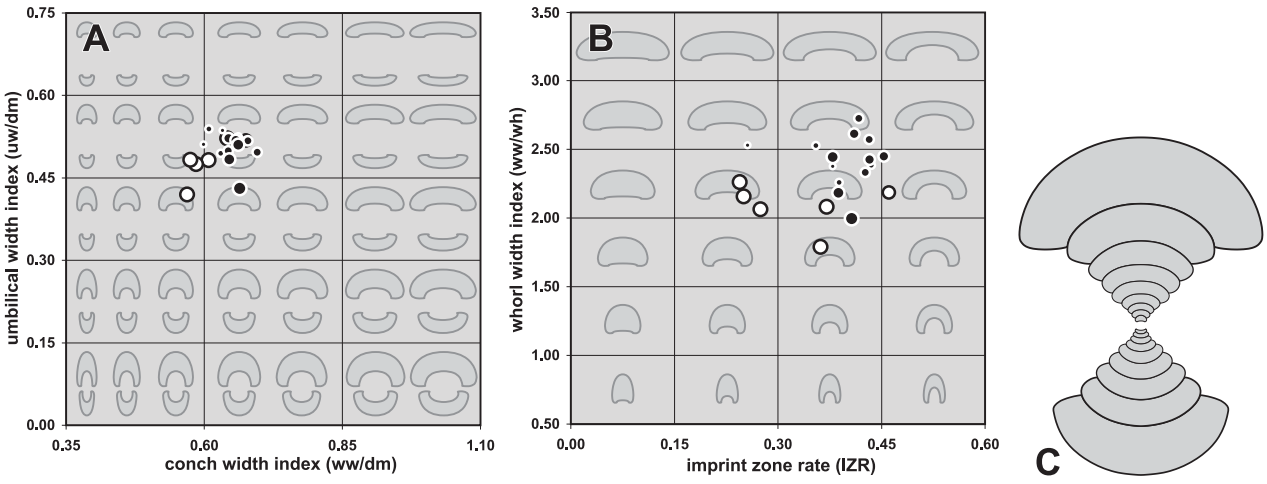


Figure 54. Ontogenetic trajectories of *Timimounia*, exemplified for T. *timimounensis* n. sp. from locality TIM-B3. **A.** Ontogenetic development of the conch width index (ww/dm) and umbilical width index (uw/dm). **B.** Ontogenetic development of the imprint zone rate (IZR) and whorl width index (ww/wh). **C.** Cross section of paratype MB.C.18702.4; ×2.5. [Black dots represent ontogenetic stages of cross section MB.C.18702.4, white dots represent the reference specimens (Tab. 65).]

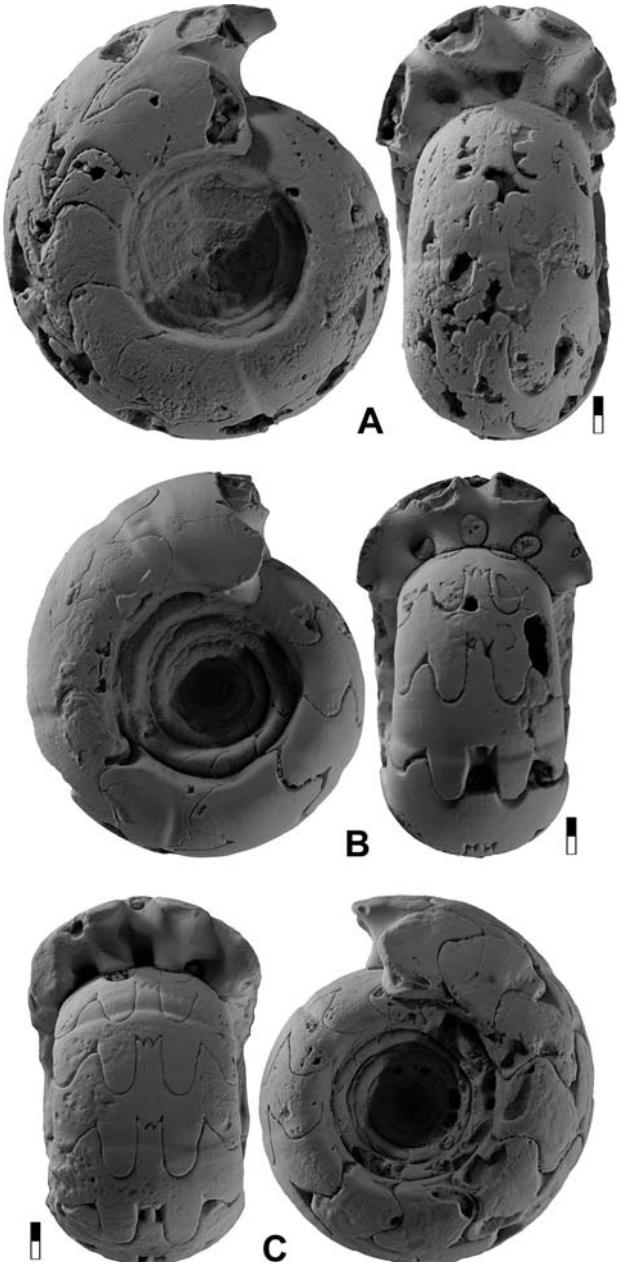
Timimounia timimounensis n. sp.

Figures 55, 56

Derivation of name. After Timimoun, where the material was found.

Holotype. Specimen MB.C.18702.1, illustrated in Figure 55A.

Type locality and horizon. Sebkha de Timimoun, locality TIM-C8 (13.3 km west of Timimoun, Algeria); Upper *Bollandoceras-Bollandites* Assemblage.



Material. 70 specimens, conch diameter between 8 and 25 mm.

Diagnosis. Timimounia with minor ontogenetic changes of conch geometry: conch evolute in the juvenile and preadult stage (1.5–14 mm dm) and evolute at 20 mm dm; conch thickly discoidal or thinly pachyconic throughout ontogeny, larger stages stouter than juveniles; aperture very low in juveniles (2–15 mm dm) and then slowly increasing but still relatively low at 20 mm dm; umbilical margin subangular in juveniles and angular in later stages. Steinkern with shallow, almost straight constrictions and traces of concavo-convex growth lines. Suture line with very narrow, almost parallel-sided external lobe with slightly incurved flanks and very low median saddle; ventrolateral saddle rounded; small adventive lobe V-shaped, almost symmetric.

Figure 55. *Timimounia timimounensis* n. sp. from locality TIM-C8; all ×2.5. **A.** Holotype MB.C.18702.1. **B.** Paratype MB.C.18702.2. **C.** Paratype MB.C.18702.3.

Table 64. Conch ontogeny (Figs 56A–D, G–J) of *Timimounia timimounensis* n. sp.

dm	conch shape	whorl cross section shape	aperture
2 mm	thickly discoidal to thinly pachyconic; evolute (ww/dm = 0.48–0.65; uw/dm = 0.48–0.60)	strongly depressed; strongly embracing (ww/wh = 2.00–2.50; IZR = 0.30–0.40)	very low (WER = 1.40–1.45)
8 mm	thinly pachyconic; evolute (ww/dm = 0.60–0.70; uw/dm = 0.50–0.58	very strongly depressed; strongly to very strongly embracing (ww/wh = 2.50–2.90; IZR = 0.35–0.50)	very low (WER = 1.35–1.45)
20 mm	thickly discoidal to thinly pachyconic; evolute (ww/dm = 0.58–0.68; uw/dm = 0.45–0.50)	moderately to strongly depressed; strongly embracing (ww/wh = 1.80–2.20; IZR = 0.30–0.45)	low (WER = 1.50–1.60)

Table 65. Conch dimensions (in mm) and proportions for reference specimens of *Timimounia timimounensis* n. sp.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
holotype MB.C.18702.1	24.1	13.7	7.6	10.1	4.9	0.57	1.80	0.42	1.57	0.36
paratype MB.C.18702.2	20.9	12.7	6.1	10.1	3.8	0.61	2.09	0.48	1.50	0.37
paratype MB.C.18702.8	20.6	12.1	5.6	9.8	4.2	0.59	2.16	0.48	1.57	0.25
paratype MB.C.18702.3	20.3	12.6	7.0	9.5	3.6	0.62	1.81	0.47	1.48	0.49
paratype MB.C.18702.9	18.5	10.6	5.1	8.9	3.7	0.57	2.07	0.48	1.57	0.27
paratype MB.C.18702.10	15.9	10.2	4.5	8.3	3.4	0.64	2.27	0.52	1.62	0.24
paratype MB.C.18702.11	10.7	7.2	3.3	5.6	1.8	0.68	2.19	0.52	1.44	0.46

Table 66. Suture line proportions (Figs 56E, F) for *Timimounia timimounensis* n. sp.

specimen	at dm	EL w/d	EL/VLS	EL/AL	MS h	VLS w/h	remarks
paratype MB.C.18702.2	19.5 mm	0.38	0.64	0.83	0.17	0.60	A lobe with curved ventral flank
holotype MB.C.18702.5	14.0 mm	0.41	0.57	0.89	0.14	0.72	A lobe almost symmetric

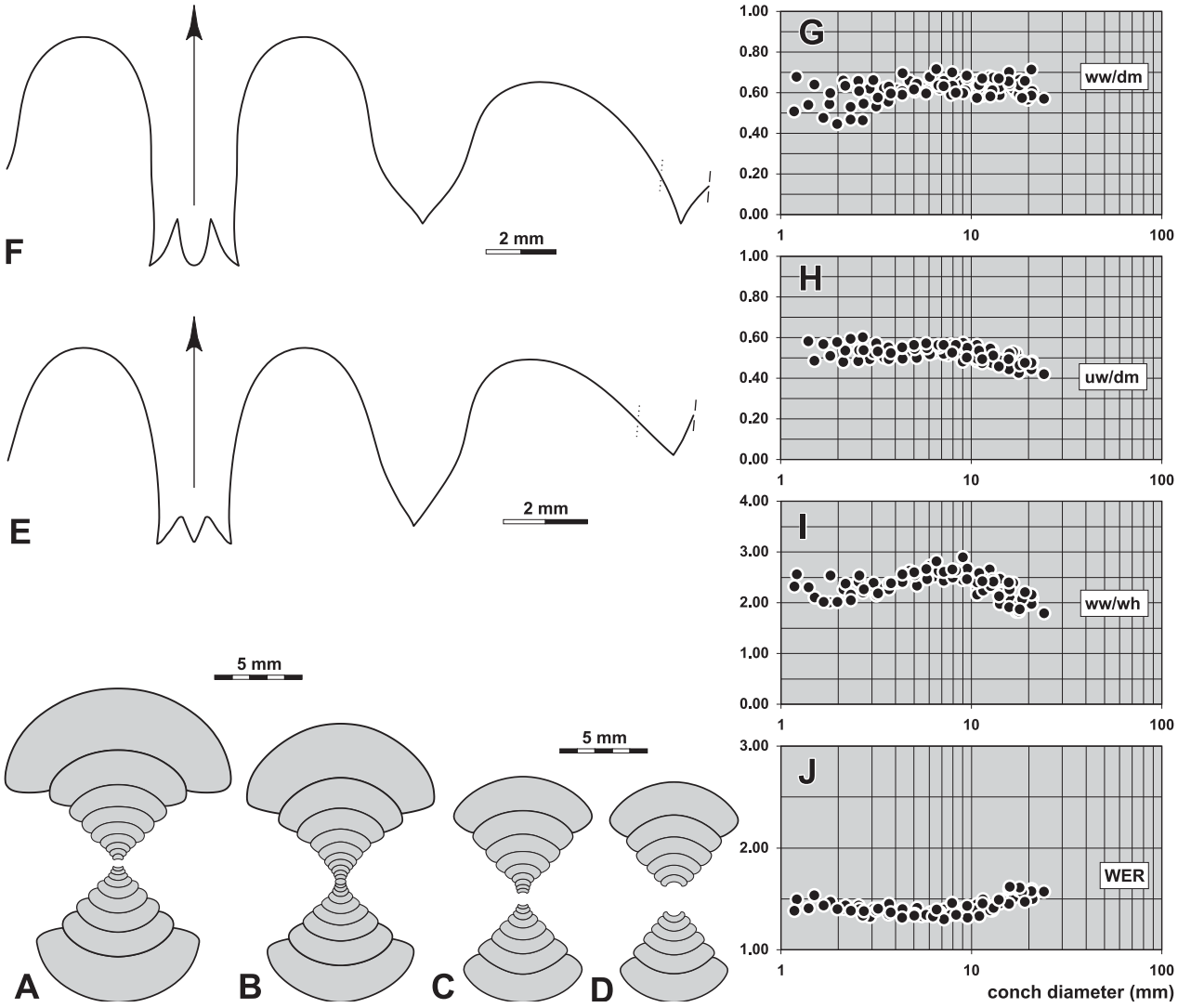


Figure 56. *Timimounia timimounensis* n. sp. from locality TIM-C8. **A.** Cross section of paratype MB.C.18702.4; ×2.5. **B.** Cross section of paratype MB.C.18702.5; ×2.5. **C.** Cross section of paratype MB.C.18702.6; ×2.5. **D.** Cross section of paratype MB.C.18702.7; ×2.5. **E.** Suture line of paratype MB.C.18702.5, at 14.0 mm dm, 9.5 mm ww, 4.2 mm wh; ×6.0. **F.** Suture line of paratype MB.C.18702.2, at 19.5 mm dm, 11.5 mm ww, 6.0 mm wh; ×5.0. **G–J.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm), whorl width index (ww/wh), and whorl expansion rate (WER) of all available specimens.

Discussion. Timimounia timimounensis has a position morphologically between *Semibollandoceras kamil* and *T. lunula*. It has a wider umbilicus, caused by slower ontogenetic reduction of the uw/dm ratio, than *S. kamil*, but, in the adult stage, it has a narrower umbilicus than *T. lunula*. The suture line of *T. timimounensis* has a very narrow external lobe with subparallel flanks, in contrast to *S. kamil* that possesses a wider external lobe with diverging flanks. *T. lunula* differs in the ventrally very strongly depressed whorl cross section from *T. timimounensis*.

Timimounia lunula n. sp.

Figures 57, 58

Derivation of name. From Latin lunula = half moon, because of the whorl cross section shape.

Holotype. Specimen MB.C.18703.1, illustrated in Figure 57A.

Type locality and horizon. Sebkha de Timimoun, locality TIM-C8 (13.3 km west of Timimoun, Algeria); Upper *Bollandoceras-Bollandites* Assemblage.

Material. 83 specimens, conch diameter between 8 and 18 mm.

Diagnosis. Timimounia with minor ontogenetic changes of conch geometry: conch pachyconic and evolute throughout ontogeny; umbilical margin angular in all growth stages larger than 1.5 mm. Steinkern with shallow, almost straight constrictions and traces of almost linear growth lines. Suture line with very narrow, weakly diverging external lobe with incurved flanks and very low median saddle; ventrolateral saddle broadly rounded; adventive lobe V-shaped, symmetric.

Table 67. Conch ontogeny (Figs 58A–C, G–J) of *Timimounia lunula* n. sp.

dm	conch shape	whorl cross section shape	aperture
2 mm	thinly to thickly pachyconic; evolute (ww/dm = 0.65–0.75; uw/dm = 0.50–0.55)	very strongly depressed; strongly embracing (ww/wh = 2.70–3.00; IZR = 0.30–0.40)	very low (WER = 1.40–1.45)
8 mm	thinly to thickly pachyconic; evolute (ww/dm = 0.65–0.75; uw/dm = 0.50–0.58)	very strongly to extremely depressed; strongly embracing (ww/wh = 2.70–3.30; IZR = 0.30–0.40)	very low (WER = 1.35–1.45)
20 mm	thinly to thickly pachyconic; evolute (ww/dm = 0.60–0.80; uw/dm = 0.50–0.55)	strongly to very strongly depressed; strongly embracing (ww/wh = 2.40–2.80; IZR = 0.30–0.40)	very low to low (WER = 1.45–1.55)

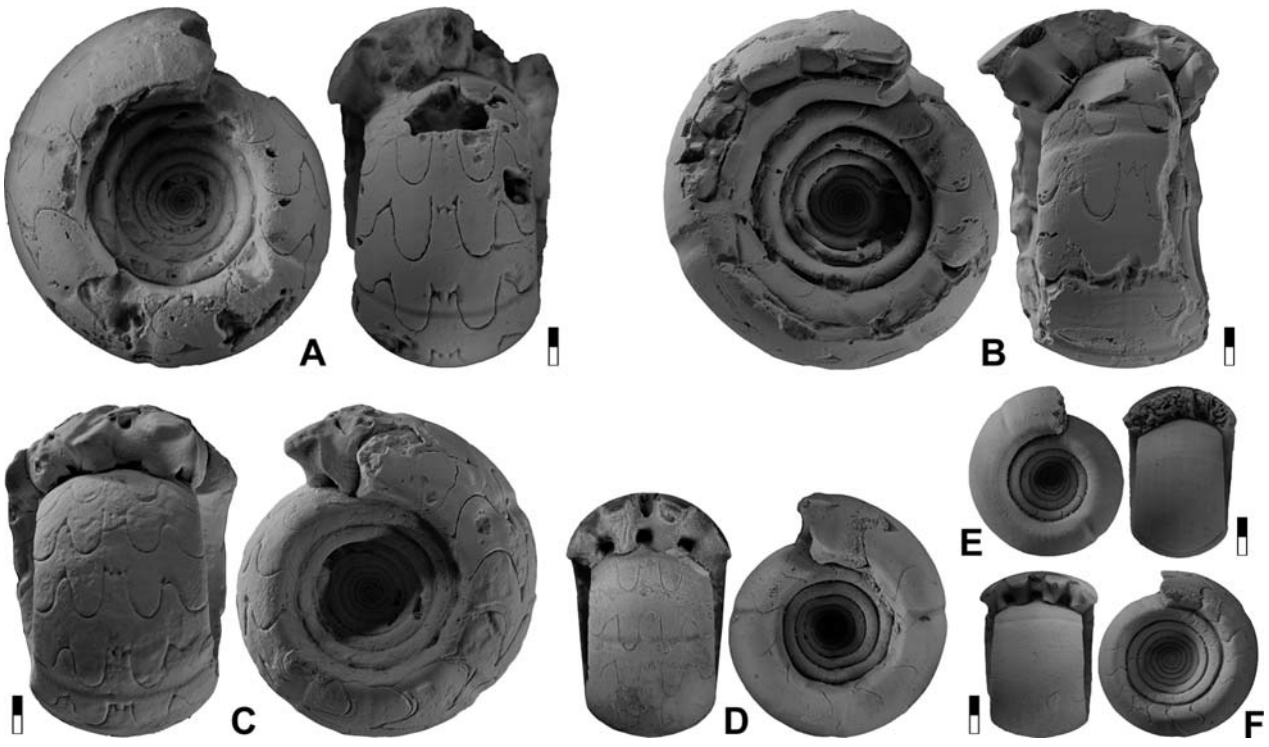


Figure 57. *Timimounia lunula* n. sp. from locality TIM-C8; all ×2.5. **A.** Holotype MB.C.18703.1. **B.** Paratype MB.C.18703.2. **C.** Paratype MB.C.18703.3. **D.** Paratype MB.C.18703.4. **E.** Paratype MB.C.18703.5. **F.** Paratype MB.C.18703.6.

Table 68. Conch dimensions (in mm) and proportions for reference specimens of *Timimounia lunula* n. sp.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
holotype MB.C.18703.1	19.0	12.1	4.7	9.6	3.5	0.64	2.57	0.51	1.50	0.26
paratype MB.C.18703.3	17.8	12.4	5.1	9.0	3.3	0.70	2.43	0.51	1.50	0.36
paratype MB.C.18703.11	17.4	12.0	4.2	8.1	3.2	0.69	2.86	0.47	1.50	0.24
paratype MB.C.18703.4	12.6	8.4	3.0	6.2	2.3	0.67	2.80	0.49	1.50	0.23
paratype MB.C.18703.6	8.8	6.0	1.4	5.2	1.2	0.68	4.29	0.59	1.34	0.14
paratype MB.C.18703.5	8.8	5.7	1.9	4.4	1.6	0.65	2.97	0.50	1.50	0.17

Table 69. Suture line proportions (Figs 58D–F) for *Timimounia lunula* n. sp.

specimen	at dm	EL w/d	EL/VLS	EL/AL	MS h	VLS w/h	remarks
paratype MB.C.18703.2	17.0 mm	0.43	0.62	0.79	0.17	0.70	A lobe almost symmetric
paratype MB.C.18703.7	9.9 mm	0.69	0.91	1.27	0.17	0.76	E lobe narrow
paratype MB.C.18703.10	9.0 mm	0.72	1.11	1.24	0.21	0.65	E lobe narrow

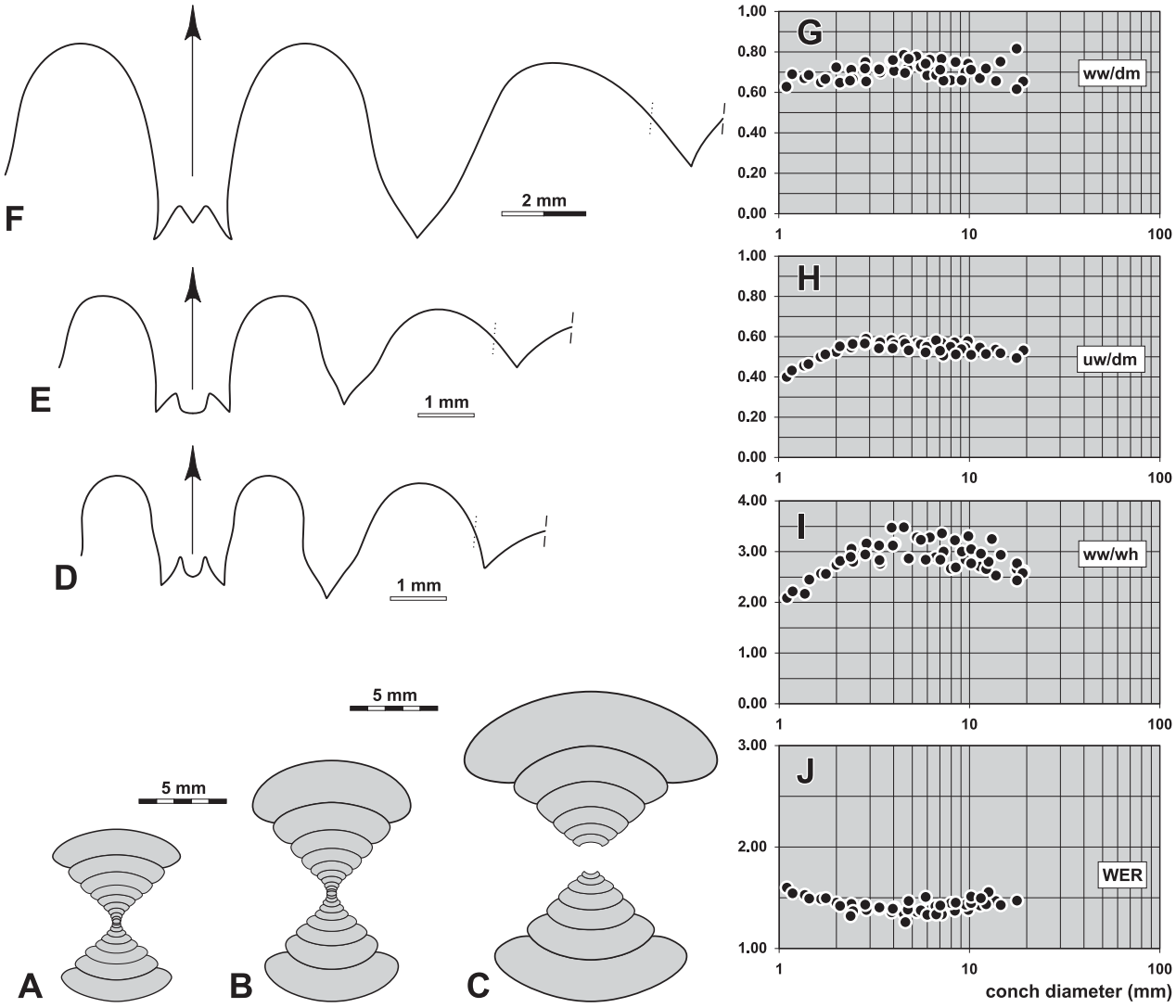


Figure 58. *Timimounia lunula* n. sp. from locality TIM-C8. **A.** Cross section of paratype MB.C.18703.7; ×2.5. **B.** Cross section of paratype MB.C.18703.8; ×2.5. **C.** Cross section of paratype MB.C.18703.9; ×2.5. **D.** Suture line of paratype MB.C.18703.10, at 9.0 mm dm, 7.3 mm ww; ×8.0. **E.** Suture line of paratype MB.C.18703.7, at 9.9 mm dm, 7.2 mm ww, 2.1 mm wh; ×8.0. **F.** Suture line of paratype MB.C.18703.2, at 17.0 mm dm, 10.5 mm ww, 4.2 mm wh; ×6.0. **G–J.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm), whorl width index (ww/wh), and whorl expansion rate (WER) of all available specimens.

Discussion. Timimounia lunula is the widest umbilicate of all the species from the ammonoid assemblage at TIM-C8. It shows, between 2 and 20 mm conch diameter, an almost isometric growth, in which the cardinal conch parameters are almost stable. All the other species, including those of the genera *Semibollandites* and *Timimounia*, show at least an adult stage modification, e.g. in a reduction of the uw/dm ratio. The whorl cross section is very low with depressed venter and differs also from the other species.

Superfamily **Dimorphoceratacea**e Hyatt, 1884

Included families.
Dimorphoceratidae Hyatt, 1884.
Berkhoceratidae Librovitch, 1957.
Daaitidae n. fam.

Family **Daaitidae** n. fam.

Subfamily definition. Dimorphoceratacea with a thinly discoidal conch. Suture line with moderately wide V-shaped external lobe, secondary prongs of the external lobe asymmetrically V-shaped with stronger curved ventral side; flanks of the external lobe sinuous, ventrolateral saddle narrowly rounded; adventive lobe less deep than the external lobe.

Included genera.
Winchelloceras Ruzhencev, 1965
Daaites n. gen.

Discussion. The new family is characterised by the unsubdivided prongs of the external lobe, which show only an indication of an incipient subdivision.

Daaites n. gen.

Type species. Daaites daaensis n. sp.

Derivation of name. After Sidi ed Daâ near Timimoun.

Diagnosis. Genus of the family Daaitidae with discoidal conch and closed umbilicus (Fig. 59). Shell almost smooth, no steinkern constrictions. Suture line with moderately wide, strongly diverging external lobe with strongly sinuous flanks; prongs of the external lobe asymmetric, indicating incipient subdivision; adventive lobe asymmetric with convex flanks.

Included species.
daaensis: *Daaites daaensis* n. sp.: Gourara, Algeria.

Discussion. The new genus differs from *Winchelloceras* in the absence of steinkern constrictions, in the stronger converging flanks, and in the higher aperture. However both genera do possess a very similar suture line.

Daaites differs from genera such as *Eogonioloboceras* Librovitch, 1957 and *Arcanoceras* Ruzhencev, 1965 in the much more asymmetric prongs of the external lobe, which in the two aforementioned genera are almost V-shaped. The new genus differs also in its closed umbilicus from these two genera. In general conch shape, *Daaites* shows close resemblance to the genus *Dimorphoceras*, and the shape of the external lobe may suggest close relationships.

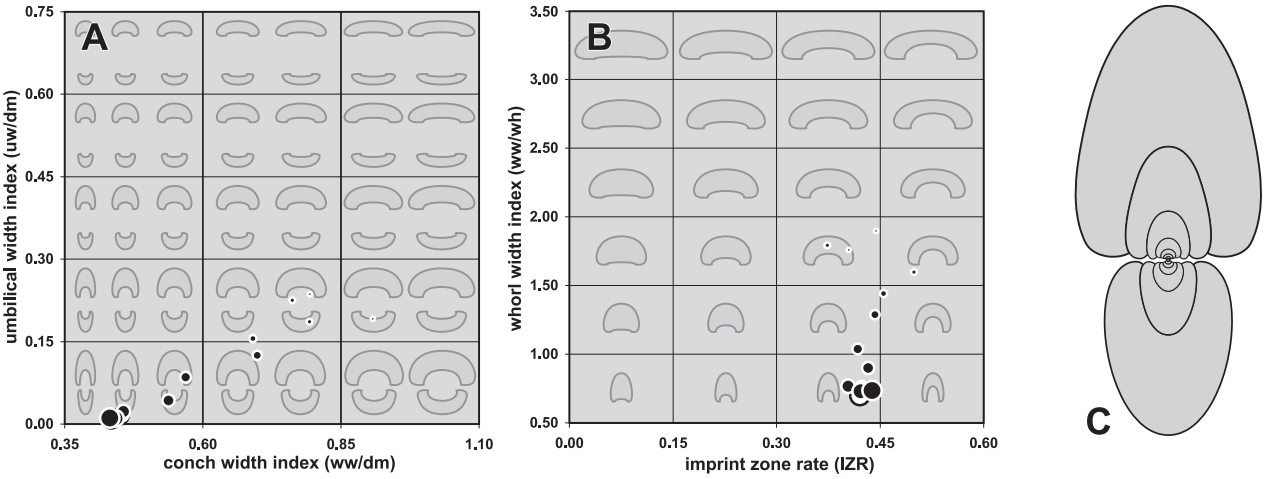


Figure 59. Ontogenetic trajectories of *Daaites*, exemplified for *Daaites daaensis* n. sp. from locality TIM-B3. **A.** Ontogenetic development of the conch width index (ww/dm) and umbilical width index (uw/dm). **B.** Ontogenetic development of the imprint zone rate (IZR) and whorl width index (ww/wh). **C.** Cross section of paratype MB.C.18690.6; × 1.0. [Black dots represent ontogenetic stages of cross section MB.C.18690.6, white dots represent the reference specimens (Tab. 71).]

Daaites daaensis n. sp.

Figures 60, 61

Derivation of name. After Sidi ed Daâ near Timimoun.

Holotype. Specimen MB.C.18690.1, illustrated in Figure 60B.

Type locality and horizon. Sebkha de Timimoun, locality TIM-B3 (10 km west-southwest of Timimoun, Algeria); upper part of the Lower *Bollandoceras-Bollandites* Assemblage.

Material. Eleven specimens, conch diameter between 26 and 58 mm.

Diagnosis. Daaites with thickly pachyconic and subinvolute conch in early juveniles, thereafter continuous development to a thinly discoidal and involute conch at 20 mm dm, adult conch (20–60 mm dm) with almost no changes in conch geometry; aperture moderate in juveniles and rapidly becoming very high at 10–20 mm dm. Steinkern smooth. Suture line with moderately wide, strongly diverging external lobe with slightly sinuous flanks and low median saddle; ventrolateral saddle narrowly rounded; adventive lobe asymmetrically V-shaped and slightly pouched.

Table 70. Conch ontogeny (Figs 61A–C, E–G) of *Daaites daaensis* n. sp.

dm	conch shape	whorl cross section shape	aperture
3 mm	thickly pachyconic; involute to subinvolute (ww/dm = 0.70–0.80; uw/dm = 0.12–0.18)	weakly depressed; very strongly embracing (ww/wh = 1.40–1.50; IZR = 0.45–0.50)	moderate (WER = 1.80–1.95)
8 mm	thickly discoidal; involute (ww/dm = 0.55–0.60 uw/dm = 0.08–0.12)	weakly depressed; strongly embracing (ww/wh = 1.00–1.10; IZR = 0.40–0.45)	high (WER = 2.10–2.20)
20 mm	thinly discoidal; involute (ww/dm = 0.40–0.45; uw/dm = 0.00–0.05)	weakly compressed; strongly embracing (ww/wh = 0.75–0.80; IZR = 0.40–0.45)	very high (WER = 2.30–2.40)
50 mm	thinly discoidal; involute (ww/dm = 0.40–0.45; uw/dm = 0.00–0.05)	weakly compressed; strongly embracing (ww/wh = 0.75–0.80; IZR = 0.40–0.45)	very high (WER = 2.25–2.45)

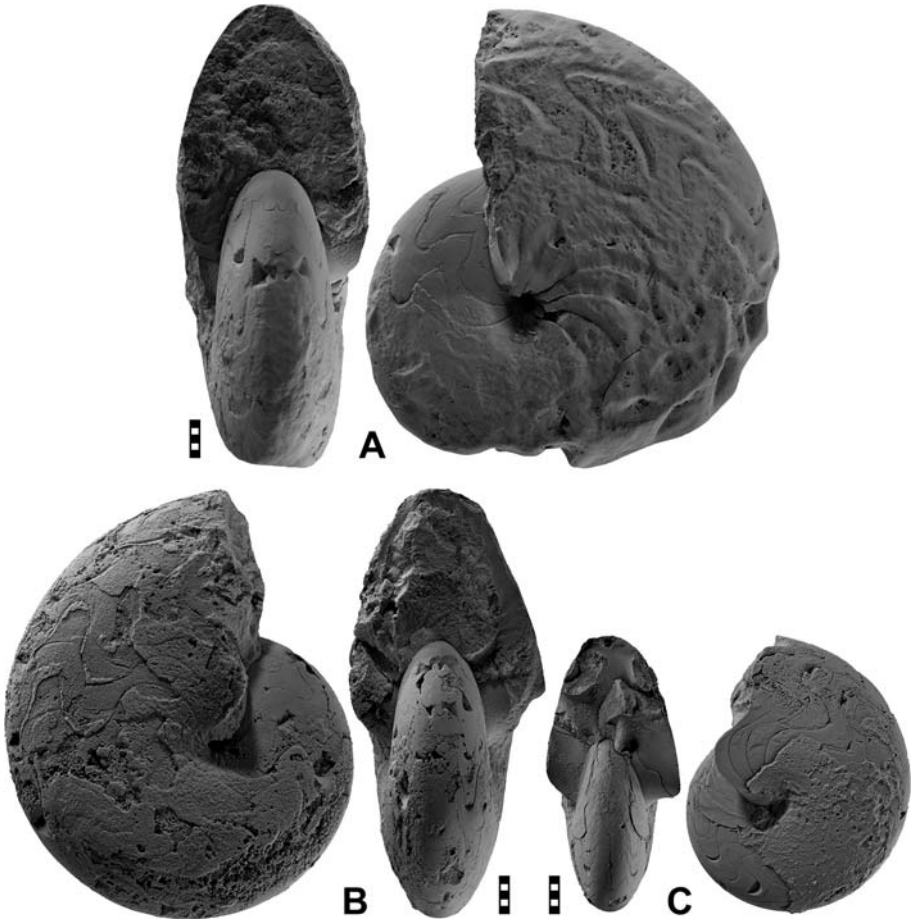


Figure 60. *Daaites daaensis* n. sp. from locality TIM-B3; all ×1.0. **A.** Paratype MB.C.18690.2. **B.** Holotype MB.C.18690.1. **C.** Paratype MB.C.18690.3.

Table 71. Conch dimensions (in mm) and proportions for reference specimens of *Daaites daaensis* n. sp.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
holotype MB.C.18690.1	56.3	24.4	34.8	0.5	20.2	0.43	0.70	0.01	2.43	0.42
paratype MB.C.18690.3	35.6	16.0	21.6	0.5	12.3	0.45	0.74	0.01	2.33	0.43

Table 72. Suture line proportions (Fig. 61D) for *Daaites daaensis* n. sp.

specimen	at dm	EL w/d	EL/VLS	EL/AL	MS h	VLS w/h	remarks
paratype MB.C.18690.2	c. 33.0 mm	1.20	2.34	2.34	0.33	0.51	A lobe with curved ventral flank

Discussion. Daaites daaensis cannot be confused easily with any other species from the assemblages found near Timimoun. Its involute lenticular conch and the wide external lobe make it unique among the faunas. A similar suture line can be seen in species of the genus *Eogoniolobocera*s, but here the prongs of the external lobe are rather symmetric. The conch of *Eogoniolobocera*s is narrowly umbilicate and possesses rather strong constrictions, which are absent in *Daaites daaensis*.

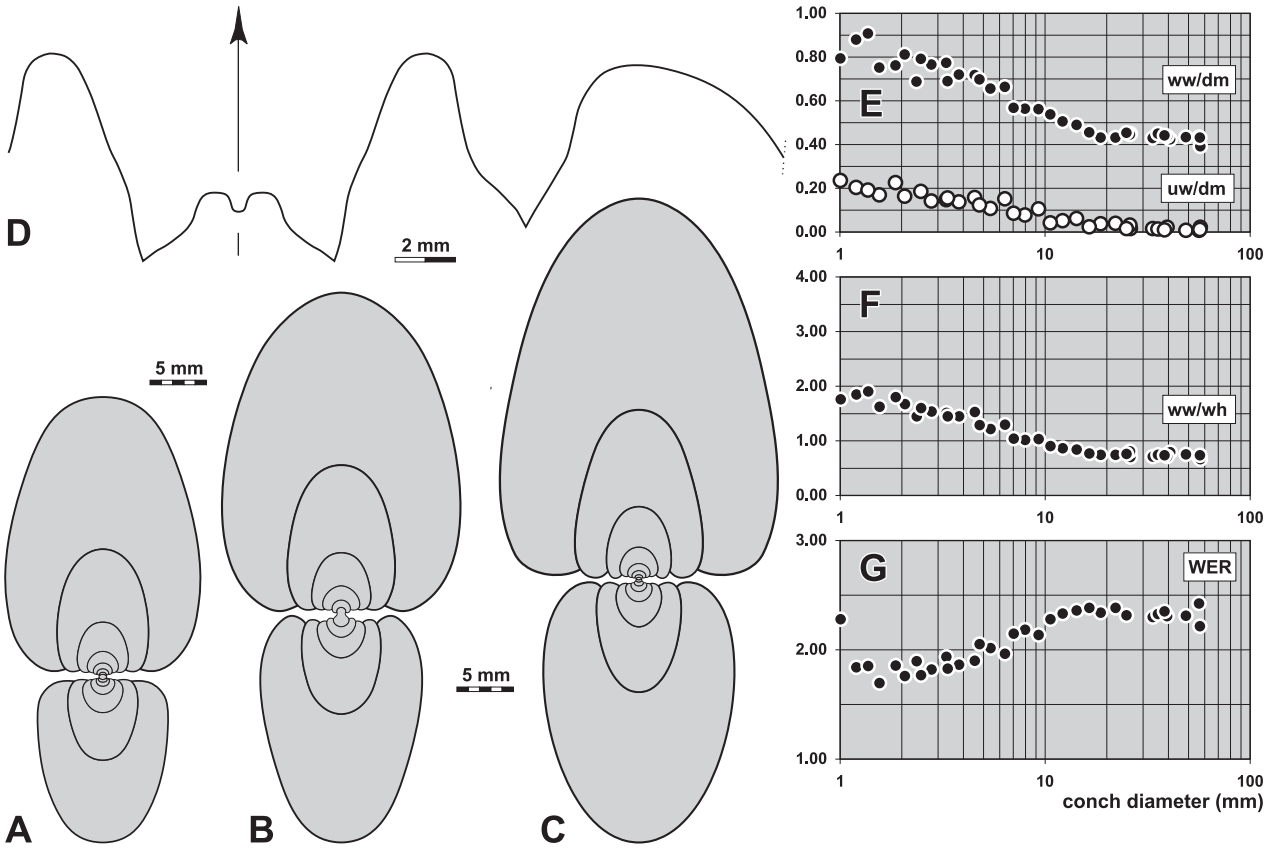


Figure 61. *Daaites daaensis* n. sp. from locality TIM-B3. **A.** Cross section of paratype MB.C.18690.4; ×1.5. **B.** Cross section of paratype MB.C.18690.5; ×1.5. **C.** Cross section of paratype MB.C.18690.6; ×1.5. **D.** Suture line of paratype MB.C.18690.2, at cA. 33 mm dm, 13.9 mm ww, 19.3 mm wh; ×3.5. **E–G.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm), whorl width index (ww/wh), and whorl expansion rate (WER) of all available specimens.

Family **Dimorphoceratidae** Hyatt, 1884

Subfamily **Dimorphoceratinae** Hyatt, 1884

Included genera.
Dimorphoceras Hyatt, 1884.
Trizonoceras Girty, 1909.
Asturoceras Ruzhencev & Bogoslovskaya, 1969.

Dimorphoceras Hyatt, 1884

Type species. Goniatites gilbertsoni Phillips, 1836 (SD Foord & Crick 1897).

Genus definition. Genus of the family Dimorphoceratidae with an undivided adventive lobe and an external lobe that is subdivided into two tertiary lobes.

Included species.
algens: *Dimorphoceras algens* Gordon, 1957, p. 55. Alaska.
brancoi: *Dimorphoceras Brancoi* Holzapfel, 1889, p. 38. Rhenish Mountains.
dnieperense: *Dimorphoceras dnieperense* Kusina in Kusina & Poletaev 1957, p. 41. Donets Basin.
gilbertsoni: *Goniatites Gilbertsoni* Phillips, 1836, p. 236. Lancashire.
holzapfeli: *Dimorphoceras Holzapfeli* Haug, 1898, p. 109. Rhenish Mountains. [synonym of *D. brancoi*]
lanceolobatum: *Dimorphoceras lanceolobatum* n. sp.: Gourara, Algeria.
leagramense: *Dimorphoceras leagramense* Riley, 1996, p. 22. Lancashire.
? *carina*: *Dimorphoceras carina* Phillips 1836, p. 237. Lancashire.

Dimorphoceras lanceolobatum n. sp.

Figures 62, 63

Derivation of name. After the shape of the adventive lobe.

Holotype. Specimen MB.C.18704.1, illustrated in Figure 62.

Type locality and horizon. Sebkha de Timimoun, locality TIM-C8 (13.3 km west of Timimoun, Algeria); Upper *Bollandoceras-Bollandites* Assemblage.

Material. Four phragmocones, all with a conch diameter of approximately 10 mm.

Diagnosis. Dimorphoceras with a thinly discoidal conch and narrowly rounded venter at 10 mm dm; aperture very high. Suture line with moderately high median saddle, subacute primary and secondary prongs of the external lobe, rounded and symmetric ventrolateral saddle, and deep symmetric adventive lobe with lanceolate shape.

Table 73. Conch ontogeny (Figs 63A, B, E, F) of *Dimorphoceras lanceolobatum* n. sp.

dm	conch shape	whorl cross section shape	aperture
2 mm	thinly pachyconic; involute (ww/dm = 0.65–0.70; uw/dm = 0.10–0.12)	weakly depressed; very strongly embracing (ww/wh = 1.30–1.50; IZR = 0.45–0.50)	moderate (WER = 1.80–1.90)
5 mm	thickly discoidal; involute (ww/dm = 0.50–0.55; uw/dm = 0.05–0.10)	weakly compressed; strongly embracing (ww/wh = 0.90–1.00; IZR = 0.40–0.45)	very high (WER = 2.25–2.35)
10 mm	thinly discoidal; involute (ww/dm = 0.40–0.48; uw/dm = 0.00–0.05)	weakly compressed; strongly embracing (ww/wh = 0.70–0.75; IZR = 0.40–0.45)	very high (WER = 2.40–2.50)

Table 74. Conch dimensions (in mm) and proportions for reference specimens of *Dimorphoceras lanceolobatum* n. sp.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
holotype MB.C.18704.1	9.5	3.8	5.6	0.4	3.4	0.40	0.69	0.04	2.41	0.39

Table 75. Suture line proportions (Figs 63C, D) for *Dimorphoceras lanceolobatum* n. sp.

specimen	at dm	EL w/d	EL/VLS	EL/AL	MS h	VLS w/h	remarks
paratype MB.C.18704.2	9.1 mm	1.74	2.94	3.47	0.53	0.59	
holotype MB.C.18704.1	c. 8.5 mm	1.53	2.97	3.49	0.52	0.51	

Discussion. The new species differs in its stouter conch and the lanceolate and acute adventive lobe from the British species *D. leagramense* Riley, 1996, which may occur in a similar stratigraphic position. Other species with a rounded adventive lobe are *D. gilbertsoni* (Phillips, 1836) and *D. algens* Gordon, 1957; they are thus clearly separated from *D. lanceolobatum*. *D. brancoi* Holzapfel, 1889 has an acute adventive lobe, but this is strikingly asymmetric in contrast to the lanceolate adventive lobe in the new species.

The two species *D. kathleenae* Moore, 1936 and *D. leitrimense* Moore, 1958 are from stratigraphically much younger horizons (Brigantian); both differ from the new species in the incipient subdivision of the ventral prong of the subdivided external lobe.

Figure 62. *Dimorphoceras lanceolobatum* n. sp. from locality TIM-C8. – Holotype MB.C.18704.1; × 6.0.

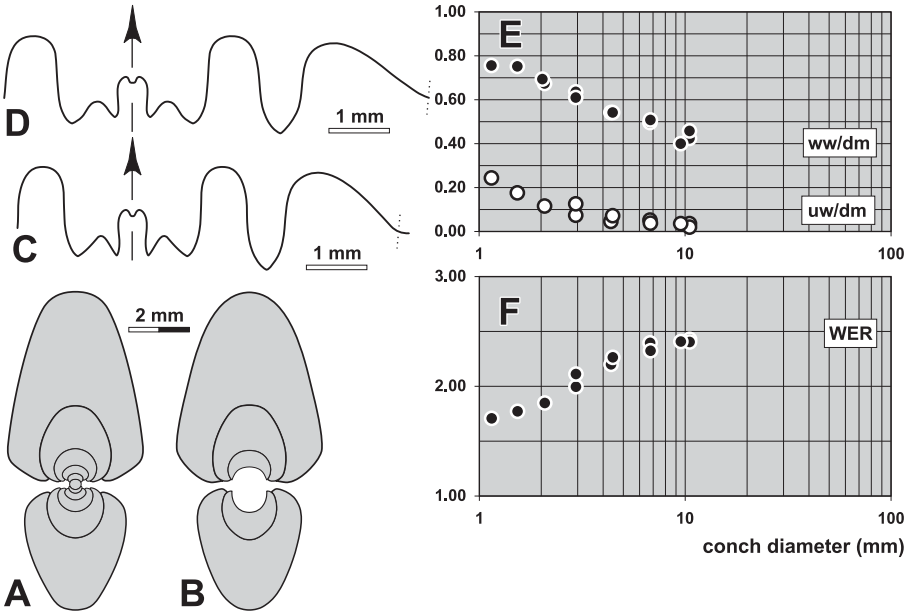


Figure 63. *Dimorphoceras lanceolobatum* n. sp. from locality TIM-C8. **A.** Cross section of paratype MB.C.18704.2; × 4.0. **B.** Cross section of paratype MB.C.18704.3; × 4.0. **C.** Suture line of paratype MB.C.18706.5, at 4.0 mm dm, 2.0 mm ww; × 10.0. **D.** Suture line of holotype MB.C.18704.1, at 9.1 mm dm, 2.6 mm ww, 2.2 mm wh; × 10.0. **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.

Superfamily **Nomismocerataceae** Librovitch, 1957

Family **Nomismoceratidae** Librovitch, 1957

Included genera.
Pseudonomismoceras Frech, 1899.
Eonomismoceras Kusina, 1974.
Nomismoceras Hyatt, 1884.
Cavilentia Ruzhencev & Bogoslovskaya, 1971.
Applanoceras Yang, 1986 [synonym of *Cavilentia* Ruzhencev & Bogoslovskaya, 1971].
Beleutoceras Ruzhencev & Bogoslovskaya, 1971.
Simmonoceras Kusina, 1974.

Nomismoceras Hyatt, 1884

Type species. *Goniatites vittiger* Phillips, 1836 (subsequent designation by Foord & Crick 1897).

Genus definition. Genus of the family Nomismoceratidae with extremely discoidal, evolute conch; whorl cross section laterally compressed with flattened flanks, usually with a ventrolateral groove; growth lines strongly biconvex.

Included species.
frechi: *Nomismoceras Frechi* Schmidt, 1925, p. 556; Lower Silesia.
germanicum: *Nomismoceras germanicum* Schmidt, 1925, p. 557; Rhenish Mountains. [synonym of *N. vittiger*]
marshallense: *Nomismoceras marshallense* Gordon, 1965, p. 248; Arkansas.
paprothae: *Fayettevillea paprothae* Kullmann in Horn, Kullmann & Oliveira, 1989, p. 489; South Portugal. [synonym of *N. vittiger*]
rotiforme: *Goniatites rotiformis* Phillips, 1836, p. 237; Yorkshire.

salim: *Nomismoceras salim* n. sp.; Gourara, Algeria.
spirorbis: *Goniatites spirorbis* Phillips, 1836, p. 237; Yorkshire. [synonym of *N. vittiger*]
vittiger: *Goniatites vittiger* Phillips, 1836, p. 237; Yorkshire.
waltoni: *Nomismoceras waltoni* n. sp.; Gourara, Algeria.
? *infracostatum*: *Nomismoceras infracostatum* Schindewolf, 1951, p. 94; Harz.
? *kiliani*: *Nomismoceras Kiliani* Fromaget, 1931, p. 660; Laos.

Nomismoceras salim n. sp.

Figures 64, 65

Derivation of name. From the Arabic al-salim = the faultless.

Holotype. Specimen MB.C.18705.1, illustrated in Figure 64A.

Type locality and horizon. Sebkha de Timimoun, locality TIM-C8 (13.3 km west of Timimoun, Algeria); Upper *Bollandoceras-Bollandites* Assemblage.

Material. 25 specimens, conch diameter between 7 and 16 mm.

Diagnosis. Nomismoceras with thickly discoidal and evolute conch in early juveniles, rapidly becoming extremely discoidal and evolute at 12–15 mm dm; aperture low, whorl expansion rate slowly increasing from 1.50 in early juveniles to 1.60–1.80 at 12–15 mm dm. Adult stage with flattened flanks, ventrolateral groove and narrowly rounded venter. Steinkern without constrictions.

Table 76. Conch ontogeny (Figs 65A, B, D, E) of *Nomismoceras salim* n. sp.

dm	conch shape	whorl cross section shape	aperture
2 mm	thickly discoidal; evolute (ww/dm = 0.48–0.55; uw/dm = 0.55–0.60)	strongly depressed; moderately embracing (ww/wh = 2.00–2.20; IZR = 0.20–0.25)	low (WER = 1.50–1.55)
8 mm	extremely discoidal; evolute (ww/dm = 0.25–0.30; uw/dm = 0.45–0.55)	weakly compressed; moderately embracing (ww/wh = 0.80–1.00; IZR = 0.20–0.25)	low (WER = 1.60–1.70)
15 mm	extremely discoidal; evolute (ww/dm = 0.15–0.20; uw/dm = 0.48–0.55)	weakly compressed; moderately embracing (ww/wh = 0.50–0.60; IZR = 0.15–0.22)	low to moderate (WER = 1.70–1.80)

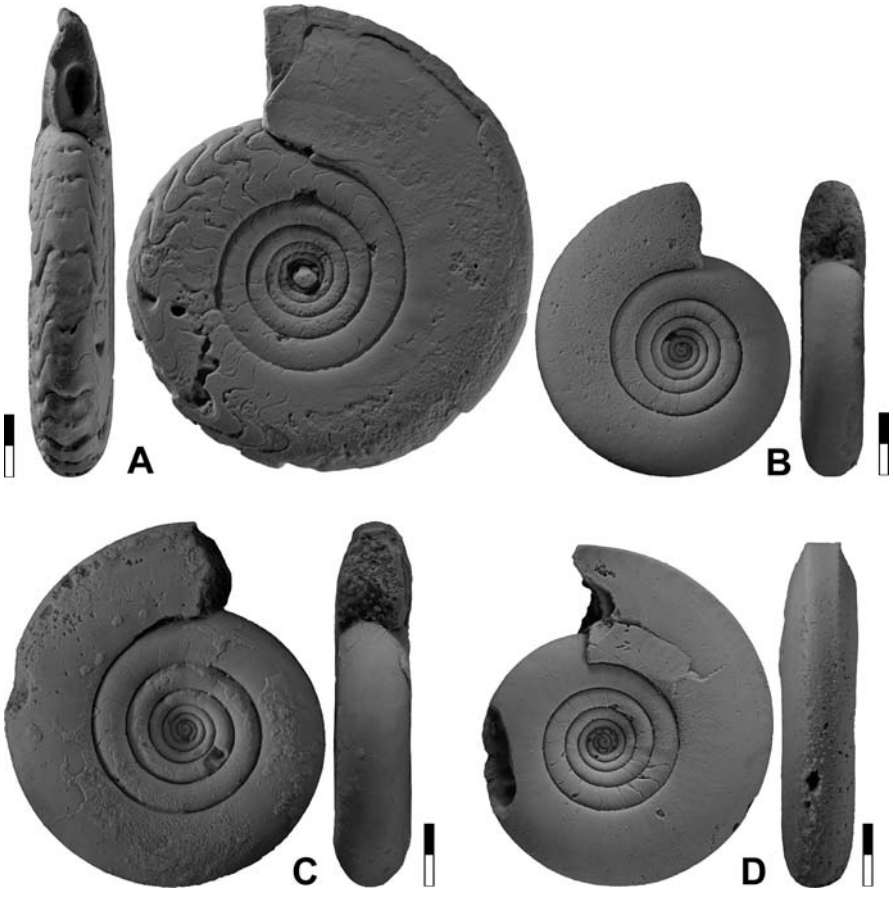


Figure 64. *Nomismoceras salim* n. sp. from locality TIM-C8; all ×4.0. **A.** Holotype MB.C.18705.1. **B.** Paratype MB.C.18705.2. **C.** Paratype MB.C.18705.3. **D.** Paratype MB.C.18705.4.

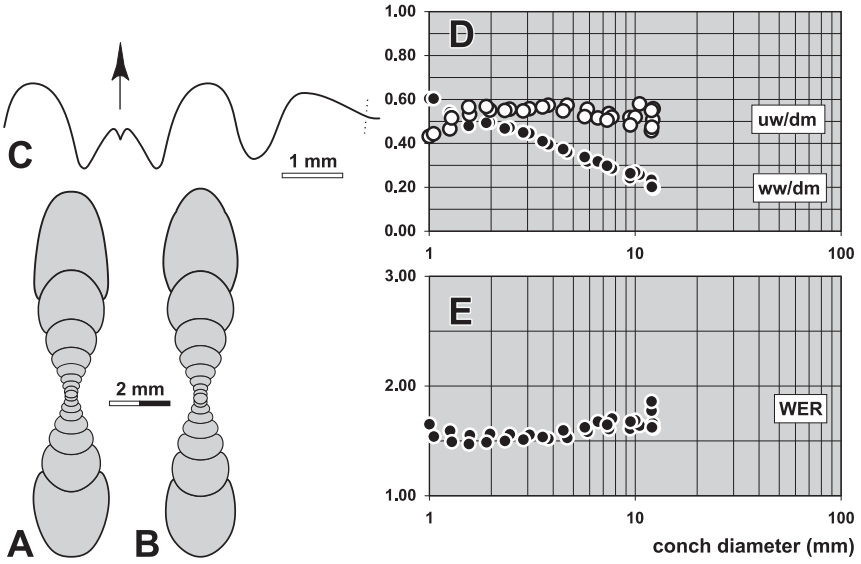


Figure 65. *Nomismoceras salim* n. sp. from locality TIM-C8. **A.** Cross section of paratype MB.C.18705.5; ×4.0. **B.** Cross section of paratype MB.C.18705.6; ×4.0. **C.** Suture line of paratype MB.C.18705.6, at 2.4 mm ww, 3.3 mm wh; ×8.0. **D**, **E.** Ontogenetic development of the conch width index (ww/dm), umbilical width index (uw/dm), and whorl expansion rate (WER) of all available specimens.

Table 77. Conch dimensions (in mm) and proportions for reference specimens of *Nomismoceras salim* n. sp.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
holotype MB.C.18705.1	15.9	2.6	4.6	7.7	3.7	0.16	0.56	0.49	1.71	0.19
paratype MB.C.18705.3	12.5	2.5	3.3	6.6	2.5	0.20	0.74	0.53	1.55	0.25
paratype MB.C.18705.4	11.5	2.5	3.5	5.4	2.9	0.22	0.70	0.47	1.78	0.18
paratype MB.C.18705.2	9.8	2.1	2.9	4.9	2.4	0.21	0.72	0.49	1.73	0.19

Table 78. Suture line proportions (Fig. 65C) for *Nomismoceras salim* n. sp.

specimen	at dm	EL w/d	EL/VLS	EL/AL	MS h	VLS w/h	remarks
paratype MB.C.18705.6	c. 10.0 mm	1.20	1.56	2.38	0.47	0.77	A lobe subacute

Discussion. Nomismoceras vittiger (Phillips, 1836) closely resembles the new species, but differs in the more compressed conch shape in comparable growth stages. At 4 mm conch diameter, for instance, the ww/dm ratio is 0.40 in *N. salim* but 0.32 in *N. vittiger*. Additionally the umbilicus is wider in *N. salim* (uw/dm = 0.50 at 15 mm dm) than in *N. vittiger* (uw/dm = 0.45). *N. rotiforme* (Phillips, 1836) differs in the shallow ribs on the flanks.

Nomismoceras waltoni n. sp.

Figures 66, 67

Derivation of name. After Sonny Walton (Potsdam), for his assistance in preparing the manuscript.

Holotype. Specimen MB.C.18706.1, illustrated in Figure 66A.

Type locality and horizon. Sebkha de Timimoun, locality TIM-C8 (13.3 km west of Timimoun, Algeria); Upper *Bollandoceras-Bollandites* Assemblage.

Material. 19 specimens, conch diameter between 8 and 15 mm.

Diagnosis. Nomismoceras with thinly pachyconic and evolute conch in early juveniles, rapidly becoming extremely discoidal and evolute at 12–15 mm dm; aperture low, whorl expansion rate slowly increasing from 1.50 in early juveniles to 1.60–1.70 at 12–15 mm dm; adult stage with flattened flanks, ventrolateral groove and tabulate venter. Steinkern with constrictions, course biconvex with high ventral projection.

Discussion. The two species of *Nomismoceras* from the Timimoun section differ in a number of characters. The most striking of these is the deep steinkern constrictions in *N. waltoni*, whereas the steinkern in *N. salim* is practically smooth. Furthermore, the juvenile conch is wider in *N. waltoni* (ww/dm = 0.70 at 2 mm dm in *N. waltoni* and only 0.50 in *N. salim*).

N. vittiger (Phillips, 1836) is even more compressed, and this species possesses biconvex steinkern constrictions in the adult stage. The presence of riblets is another distinguishing character of *N. vittiger*.

Table 79. Conch ontogeny (Figs 67A, B, E, F) of *Nomismoceras waltoni* n. sp.

dm	conch shape	whorl cross section shape	aperture
2 mm	thinly pachyconic; evolute (ww/dm = 0.65–0.70; uw/dm = 0.48–0.53)	strongly to very strongly depressed; moderately to strongly embracing (ww/wh = 2.40–2.60; IZR = 0.27–0.35)	low (WER = 1.50–1.60)
8 mm	extremely discoidal; evolute (ww/dm = 0.30–0.35; uw/dm = 0.53–0.58)	weakly depressed; moderately embracing (ww/wh = 1.15–1.30; IZR = 0.15–0.20)	low (WER = 1.50–1.55)
15 mm	extremely discoidal; evolute (ww/dm = 0.18–0.20; uw/dm = 0.50–0.55)	weakly compressed; moderately embracing (ww/wh = 0.65–0.75; IZR = 0.15–0.22)	low (WER = 1.50–1.55)

Table 80. Conch dimensions (in mm) and proportions for reference specimens of *Nomismoceras waltoni* n. sp.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
paratype MB.C.18706.7	12.5	2.4	3.2	7.0	2.5	0.19	0.77	0.56	1.56	0.21
paratype MB.C.18706.6	11.5	2.5	2.8	6.6	2.4	0.21	0.87	0.57	1.59	0.16
holotype MB.C.18706.1	10.4	2.5	2.7	5.5	2.0	0.24	0.93	0.53	1.54	0.24
paratype MB.C.18706.2	9.3	2.6	2.3	5.2	1.9	0.28	1.12	0.55	1.59	0.18

Table 81. Suture line proportions (Figs 67C, D) for *Nomismoceras waltoni* n. sp.

specimen	at dm	EL w/d	EL/VLS	EL/AL	MS h	VLS w/h	remarks
paratype MB.C.18706.2	9.1 mm	0.91	1.35	1.60	0.37	0.67	A lobe very shallow
holotype MB.C.18706.5	4.0 mm	0.61	1.04	1.02	0.19	0.59	

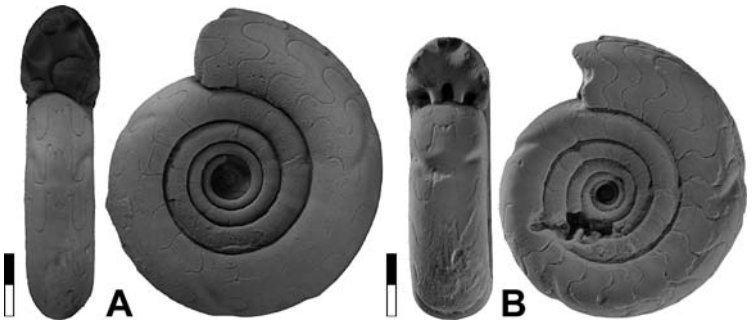


Figure 66. *Nomismoceras waltoni* n. sp. from locality TIM-C8; all ×4.0. **A.** Holotype MB.C.18706.1. **B.** Paratype MB.C.18706.2.

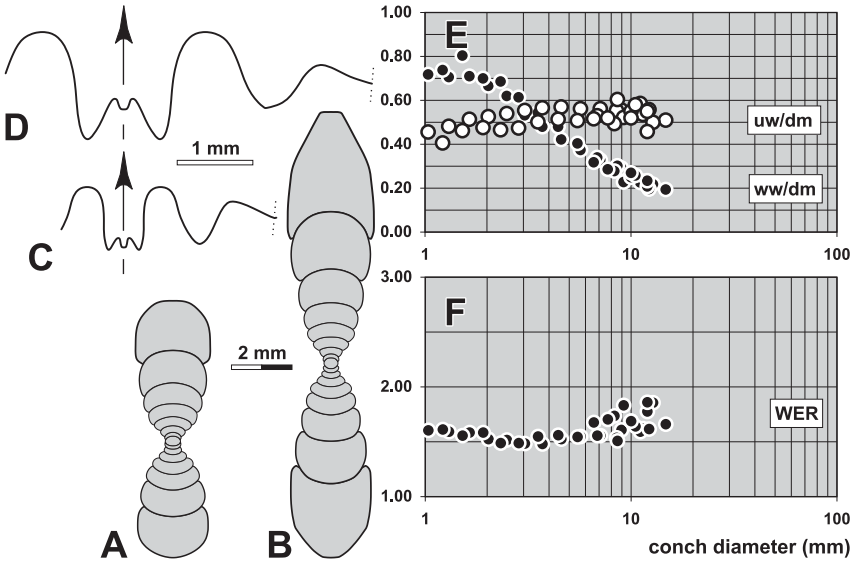


Figure 67. *Nomismoceras waltoni* n. sp. from locality TIM-C8. **A.** Cross section of paratype MB.C.18706.3; ×4.0. **B.** Cross section of paratype MB.C.18706.4; ×4.0. **C.** Suture line of paratype MB.C.18706.5, at 4.0 mm dm, 2.0 mm ww; ×10.0. **D.** Suture line of holotype MB.C.18706.2, at 9.1 mm dm, 2.6 mm ww, 2.2 mm wh; ×10.0. **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.

Order **Prolecanitida** Miller & Furnish, 1954
Suborder **Prolecanitina** Miller & Furnish, 1954
Superfamily **Prolecanitaceae** Hyatt, 1884
Family **Prolecanitidae** Hyatt, 1884
Subfamily **Prolecanitinae** Hyatt, 1884

Michiganites Ruzhencev, 1962

Type species. Goniatites marshallensis Winchell, 1862 (OD).

Michiganites sp.

Figure 68

Material. One fragment of the phragmocone (MB.C.18707) with a whorl height of approximately 4 mm. It shows the suture line typical for the genus but cannot be determined in greater detail.

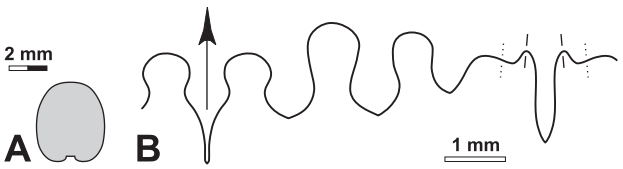


Figure 68. *Michiganites* sp. from locality TIM-C8. **A.** Cross section of specimen MB.C.18707; ×2.5. **B.** Suture line of the same specimen, at 3.1 mm ww, 3.4 mm wh; ×8.0.

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