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1 **Famennian (Late Devonian) ammonoids from the Ouarourout**  
2 **section (Saoura Valley, Algeria)**

3 *Ammonoïdes du Famennien (Dévonien supérieur) de la coupe de Ouarourout*  
4 *(Vallée de la Saoura, Algérie)*

5  
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15  
16  
17 **ABSTRACT**

18 In North Africa, the ammonoids constitute an important part of the Devonian marine macro-  
19 invertebrates. New material has been recently collected in the ‘Argiles de Marhouma’ Formation  
20 from several sections located near Béni-Abbès in the Saoura Valley (Ougarta Mountains, Algerian  
21 Sahara). Red nodular limestones (i.e., ‘griotte’ facies) characterize this formation rich in ammonoids.  
22 The assemblages from the Ouarourout section are composed of Goniaticlymenia and Clymeniida  
23 constituting 30 species and 19 genera belonging to 11 families, with *Cyrtoclymenia*, *Erfoudites*,  
24 *Kosmoclymenia*, *Planitornoceras*, *Platyglymenia*, and *Prionoceras*, as the most abundant genera. The  
25 taxonomic comparison and the biostratigraphic correlations are made by considering the  
26 assemblages recorded in the Anti-Atlas of Morocco, which are very close to those observed in  
27 Algeria. In the Ouarourout area, the ‘Argiles de Marhouma’ Formation contains middle and late  
28 Famennian ammonoid assemblages and three biostratigraphic intervals can be identified:  
29 *Planitornoceras*, *Platyglymenia* and *Medioclymenia*.

30 *Keywords:* Algeria, Devonian, Ammonoidea, systematics, biostratigraphy.

31  
32 **RESUME**

33 En Afrique du Nord, les ammonoïdes constituent une part importante des macro-invertébrés marins

34 du Dévonien. Du nouveau matériel a été récemment collecté au sein de la Formation des 'Argiles de  
35 Marhouma' dans plusieurs secteurs situés près de Béni-Abbès dans la vallée de la Saoura (Monts  
36 d'Ougarta, Sahara algérien). Des calcaires nodulaires rouges (faciès de type 'griotte') caractérisent  
37 cette formation riche en ammonoïdes. Les assemblages de la section de Ouarourout sont composés  
38 de Goniatitida et de Clymeniida constituant 30 espèces et 19 genres appartenant à 11 familles ; les  
39 genres les plus abondants sont *Cyrtoclymenia*, *Erfoudites*, *Kosmoclymenia*, *Planitornoceras*,  
40 *Platyclymenia* et *Prionoceras*. Les comparaisons taxonomiques et les corrélations biostratigraphiques  
41 sont établies en considérant les faunes décrites au Maroc, qui sont très proches de celles observées  
42 en Algérie. Dans les environs de Ouarourout, la Formation des 'Argiles de Marhouma' contient des  
43 assemblages d'ammonoïdes datant du Famennien moyen et supérieur, et trois intervalles  
44 biostratigraphiques peuvent être identifiés : *Planitornoceras*, *Platyclymenia* et *Medioclymenia*.  
45 *Mots clés:* Algérie, Dévonien, Ammonoidea, systématique, biostratigraphie.

46

47

## 48 **1. Introduction**

49

50 Ammonoids (Mollusca, Cephalopoda) appeared in the Early Devonian and rapidly became  
51 abundant and diverse in marine habitats (House, 1985; Becker and House, 1994; Klug et al., 2008;  
52 Klug et al., 2015a, b). They diversified in the context of the 'Devonian Nekton Revolution'  
53 characterized by the development of many active swimming marine organisms and important  
54 morphological innovations (Klug et al., 2010). In addition to their classical biostratigraphic ability and  
55 application, the knowledge of Devonian ammonoids can provide important insights regarding the  
56 understanding of this ecosystem revolution and the early diversification patterns in general (Klug et  
57 al., 2010). The Famennian (Late Devonian) corresponds to an important time interval for the  
58 ammonoid evolution: it is characterized by particularly high levels of taxonomic richness and  
59 morphological disparity and marked by the appearance of the order Clymeniida. Through the  
60 Famennian, the ammonoids also suffered several global extinction and were particularly impacted by  
61 the Kellwasser (Frasnian/Famennian boundary) and Hangenberg (Devonian/Carboniferous) crises  
62 (House, 1970, 1985, 1989; Becker, 1993b; Becker and House, 1994; see reviews of Korn and Klug,  
63 2012; Korn et al., 2015c).

64 The North Gondwana platform is considered to be one of the best regions to study the  
65 Devonian ammonoids. In the Anti-Atlas of Morocco, the middle and late Famennian ammonoids are  
66 particularly well documented, thanks to the numerous articles which have been published over the  
67 last 25 years (Korn 1994, 1999, 2004; Becker 1995, 2000, 2002; Becker and House 2000; Becker et al.  
68 2002; Korn and Klug 2002; Korn et al. 2000, 2014, 2015a, 2015b, 2016a, 2016b; Ebbighausen and

69 Korn 2007; Klug et al. 2016). However, they remain scarcely known in Algeria (Fig. 1; see reviews of  
70 Korn and Klug, 2015; and Korn and De Baets, 2015).

71

72 FIGURE 1 AROUND HERE

73

74 In Algeria (north Gondwana), Late Devonian deposits were first recognized in the Saoura Valley  
75 (Ougarta Mountains) by Haug (1903) based on ammonoids. Gautier (1906) realized the first  
76 comprehensive study regarding the geology of this area, and Alimen et al. (1952) refined it and  
77 described several important sections. More details were also given by Menchikoff (1930) who listed  
78 rich ammonoid assemblages in the Famennian succession of the Saoura Valley. The richness in  
79 ammonoids enabled Petter (1959, 1960) to discriminate the rough standard zonation established by  
80 Wedekind (1908, 1926) in Germany and subsequently modified by several authors (see the review of  
81 Korn and Klug, 2015). Göddertz (1987) published a monographic study describing ammonoids from  
82 the Saoura Valley (the so-called 'km 30' locality near Marhouma) but the Famennian ammonoids  
83 were not revised. Since the study of Göddertz (1987), Devonian ammonoids from Algeria have been  
84 only documented in few publications; sporadic information have been included in recent papers  
85 (Korn, 2004; Ebbighausen and Korn, 2007; Korn et al., 2014) and only one study entirely focusing on  
86 Algerian assemblages have been published (Korn et al. 2017). Korn et al. (2017) studied late  
87 Famennian sections from several localities in the vicinity of Béni Abbès (Saoura Valley, Algeria). They  
88 recognized several taxa already observed in Morocco, and they also described seven new species.  
89 Furthermore, according to Korn et al. (2017), the late Famennian succession in the Saoura Valley of  
90 Algeria is constituted of four distinct ammonoid assemblages: by stratigraphic order, the  
91 *Goniclymenia*, *Medioclymenia*, *Cymaclymenia lambidia* and *Wocklumeria* assemblages. However  
92 their stratigraphic range is not clearly defined and the correlations of these assemblages with the  
93 Moroccan biozonations have not been precisely established. Although since several years, the  
94 systematic and biostratigraphic revision of Devonian invertebrates from the Saoura Valley of Algeria  
95 have received a renewed interest (e.g., for brachiopods: Mottequin et al., 2015; for trilobites: Crônier  
96 et al., 2013, Feist et al., 2016; for ammonoids: Korn et al., 2017), the ammonoids still remained  
97 scarcely described and not precisely sampled.

98 The recent intensive sampling of new material from several sections in this area gives us the  
99 opportunity to better document the diversity of the Devonian ammonoid from the North  
100 Gondwanian platform. In this article we first focus on the ammonoid assemblages from one section  
101 located near Béni-Abbès: the Ouarourout section. Therefore, the aim of this paper is to describe the  
102 Late Devonian ammonoid assemblages collected in this section and to correlate them with the  
103 ammonoid assemblages from Morocco (same paleogeographic area, North Gondwana).

104 The ammonoids from the Ouarourout section correspond to middle and basal late Famennian  
105 assemblages. In this respect, our work complements the study of Korn et al. (2017) who focused on  
106 late Famennian assemblages from the same area.

107

108

## 109 **2. Geological setting**

110

111 All the material described in this paper comes from the Ouarourout section (labelled 'On') which is  
112 located in the eastern part of the Ougarta Mountains (Saoura Valley, Algerian Sahara), north-west of  
113 Béni Abbès (Fig. 2). For a description of the section and its palaeoenvironmental interpretation, see  
114 Menchikoff (1930), Petter (1959), Elmi and Ameur (1984), Benhamou et al. (2004), Ouali Mehadji et  
115 al. (2012), and Abbache et al. (2019).

116

117 FIGURE 2 AROUND HERE

118

119 This area belongs to a major structural unit corresponding to the Saharan Platform. It  
120 comprises a Precambrian basement unconformably overlain by thick sediments occurring in several  
121 Palaeozoic basins, which include the Ougarta Range (western Algeria). The Ougarta Mountains  
122 extend over 400 km in length and 200 km in width, and form an elongated structure with a NW/SE  
123 orientation. It is a folded domain which links the Moroccan Anti-Atlas (NW) with the hills of Bled El  
124 Mass and Tanezrouft (SE). The Ougarta Mountains encompasses a northern unit ('Saoura'), which is  
125 constituted by anticlines corresponding to Cambrian–Ordovician deposits and by synclines  
126 corresponding to Silurian–Devonian deposits (Menchikoff, 1930; Donzeau, 1983; Boumendjel et al.,  
127 1997a; Fabre et al., 2005).

128 Our material originates from the 'Argiles de Marhouma' Formation (Fig. 3), which is primarily  
129 characterized by fine-grained turbidite successions, interspersed with 'griotte' limestones bearing a  
130 pelagic fauna and showing a wide variety of fossil traces (Bendella and Ouali Mehadji, 2015).  
131 According to ammonoid, brachiopod, trilobite, conodont, and ostracod assemblages (Petter, 1959,  
132 1960; Casier, 1983; Malti, 2012; Crônier et al., 2013; Mottequin et al., 2015; Abbache et al., 2019),  
133 this formation contains Frasnian to Famennian (Late Devonian) deposits. This succession is overlaid  
134 by the sandstones of the uppermost Famennian Ouarourout Formation (Fabre et al., 2005). The  
135 'Argiles de Marhouma' Formation (260 m thick; Ouali Mehadji et al., 2012) corresponds to calcareous  
136 red nodular limestones rich in ammonoids, called 'griotte' limestones, which suggests an  
137 epicontinental platform (Benhamou et al., 2004; Abbache et al. 2019). These facies are linked to  
138 slope deposits of deepening basins along their transition toward the platform. These red nodular

139 limestones is observed in the Tafilalt and Maider basins in Morocco and as far as in the Ougarta  
140 Mountains (Saoura Valley) in Algeria. A Hercynian distension phase controlled this spatial extension  
141 as understood by modelling the physical geography of basins with 'griotte' facies in an insular  
142 palaeogeography (Benhamou et al., 2004).

143 The 'Argiles de Marhouma' Formation has been subdivided in four successive members (Malti,  
144 2012; Crônier et al., 2013). Member 1 consists of calcareous shales which correspond to late Frasnian  
145 deposits according to ammonoids (*Manticoceras*) and entomozocean ostracods (Casier, 1983).  
146 Member 2 includes silty shales with 'griotte' nodules and is divided in two sub-members: 1) the unit  
147 'M2a' comprises silty shales with numerous rhynchonellids (*Evanidisinurostrum saouraense*,  
148 *Sphaeridiorhynchus*; possibly from the early Famennian, see Mottequin et al., 2015) in thin  
149 calcareous lenses rich in horizontal burrows; and 2) the unit 'M2b' consists of alternating shales and  
150 'griotte' limestones containing the Famennian conodont *Palmatolepis minuta*, as well as the middle  
151 Famennian trilobite *Trimerocephalus caecus* and rhynchonellid *Leptoterorhynchus*. Member 3  
152 consists of 'griotte' limestones divided into three sub-members (M3a, b, c) corresponding to late  
153 Famennian levels according to conodonts (*Palmatolepis expansa*), trilobites (*Dianops*),  
154 rhynchonellids, and ammonoids. Member 4 consists of shales including 'griotte' levels associated to  
155 sandy and silty deposits. The succession outcropping in Ouarourout corresponds to the middle and  
156 upper parts of the Member 3 (sub-members M3b and M3c), and to the lower part of the Member 4  
157 (sub-member M4a).

158

159 FIGURE 3 AROUND HERE

160

161

### 162 3. Biostratigraphy

163

164 The ammonoids described here are distributed among 15 levels in the Ouarourout section. Their  
165 stratigraphic distribution is summarized in Figure 4. Three major informal ammonoid assemblages  
166 (groups of beds with roughly the same taxonomic composition) can be identified: in stratigraphic  
167 order, a *Planitornoceras* interval, a *Platyclymenia* interval, and a *Medioclymenia* interval. 1) The  
168 *Planitornoceras* interval is poorly diversified and mainly characterized by relatively abundant *P.*  
169 *euryomphalum*. 2) The *Platyclymenia* interval is the most diversified and mainly contains  
170 *Platyclymenia*, *Protactoclymenia*, *Trigonoclymenia*, *Erfoudites*, and *Prionoceras*. 3) The  
171 *Medioclymenia* interval is mainly characterized by *Medioclymenia saourensis*, *Muessenbiaergia*,  
172 *Kosmoclymenia inaequistriata*, *Cymaclymenia subvexa*, and *Mimimitoceras*. The *Platyclymenia*  
173 interval can be subdivided in two parts: a lower part with *Erfoudites zizensis* and *Prionoceras*

174 *lamellosum*, and an upper part with *Erfoudites rherisensis*, *Sporadoceras muensteri* and  
175 *Procyamclymenia ebbighauseni*, among others. Furthermore, two distinct but poorly represented  
176 levels can be identified between the *Platyclymenia* and *Medioclymenia* intervals: the lower one  
177 contains *Costaclymenia ornata*, and the upper one *Gonioclymenia cf. ali*.

178

179 FIGURE 4 AROUND HERE

180

181 Based on material from several localities in the Saoura Valley, Menchikoff (1930) and Petter  
182 (1959, 1960) established a rough biozonation reflecting the German standard biozonation. They  
183 recognized five zones within the Famennian succession in Algeria and correlated them to the major  
184 subdivisions established by Wedekind (1908) in Germany: by stratigraphic order, the *Cheiloceras*  
185 Zone, the *P. planidorsatum/P. sandbergeri* Zone, the *Platyclymenia* Zone, the *Gonioclymenia* Zone,  
186 and the *Kalloclymenia* Zone. The stratigraphic distribution of the material described in this study  
187 corroborates this biostratigraphic division, and three biozones can be recognized: the *P.*  
188 *planidorsatum/P. sandbergeri* Zone (*Planitornoceras* interval), the *Platyclymenia* Zone (*Platyclymenia*  
189 interval) and the *Gonioclymenia* Zone (*Medioclymenia* interval). Therefore, the sedimentary  
190 succession studied herein (Ouarourout section, Fig.4) corresponds to middle and late Famennian  
191 (basal part) deposits. Interestingly, in Algeria the transitions between the three zones are  
192 characterized by sudden changes in ammonoid assemblages. These faunal changes respectively  
193 correspond to the global *Annulata* and Dasberg bioevents (see the reviews of Hartenfels and Becker  
194 (2016a) for the *Annulata* Event and Hartenfels and Becker (2009) for the Dasberg Crisis).

195 Our newly collected material also enables identifying a finer biostratigraphic sequence for the  
196 Famennian deposits of Algeria. Indeed, finer subdivisions can be recognized for some part of the  
197 sequence, especially the *Platyclymenia* and *Gonioclymenia* intervals (see above), that can be  
198 tentatively correlated with the high-resolution of the Moroccan biozonation (see below). Note that  
199 Korn et al. (2017) identified two distinct ammonoid assemblages in Algeria for the *Gonioclymenia*  
200 zone of Petter (1959, 1960) based on a new collection: a lower one characterized by *Gonioclymenia*,  
201 and an upper one with *Medioclymenia* as the most conspicuous index genus. In the Ouarourout  
202 section, the identification of *Gonioclymenia* below the *Medioclymenia* interval (level On8f, Fig. 4)  
203 allows to confirm this subdivision. Interestingly, an additional subdivision can be also documented  
204 with the identification of *Costaclymenia ornata* at the base of the late Famennian succession. This  
205 species has been previously recognized in Morocco (Becker et al., 2002; Korn et al., 2018c) but not in  
206 Algeria.

207 As mentioned by Korn et al. (2017), the Algerian ammonoids show close relationship with time  
208 equivalent occurrences of the Anti-Atlas of Morocco (same paleogeographic area, Fig. 1);

209 furthermore, the Famennian ammonoids assemblages from Morocco are well documented and  
210 recent taxonomic and biostratigraphic descriptions and revisions have been made (see the reviews of  
211 Korn and De Baets, 2015; Korn and Klug, 2015). Thus the ammonoid assemblages from Algeria  
212 described in this study are here tentatively correlated to the Moroccan assemblages considering the  
213 biozonations of Becker et al. (2002, 2013), Klein and Korn (2014), Korn et al. (2014, 2015a, b) and  
214 Hartenfels and Becker (2016a, b). The correlations with these Moroccan biozonations are reported in  
215 Figure 5. For a general review of the Devonian ammonoid biostratigraphy, see Korn and Klug (2015).

216 The most comprehensive and precise ammonoid zonation has been proposed by Becker et al.  
217 (2002, 2013); it was subsequently updated for the middle and late Famennian by Hartenfels and  
218 Becker 2016a and b. This biozonation is composed of interval zones defined by the appearance of an  
219 index species. In addition, Klein and Korn (2014) and Korn et al. (2014, 2015a, b) created restricted  
220 biozones based on the occurrences of the successive species of different families or genera in  
221 Morocco (e.g., *Cymaclymeniidae*, *Prionoceras*, *Mimimitoceras*, *Sporadoceratidae*). Overall, the  
222 correlation among the Moroccan biozonations and the described Algerian material is complicated by  
223 the absence of several index species. The proposed correlation relies more on the coexistence of  
224 several taxa, rather than single index species. On the one hand, the genozones of Wedekind (1908)  
225 are clearly recognized as already noted by Menchikoff (1930) and Petter (1959, 1960). On the other  
226 hand, the species zones of Becker et al. (2002, 2013) are less straightforward to correlate. The poorly  
227 diversified *Planitornoceras* interval of Ouarourout does not contain the index species of the  
228 *Sulcoclymenia sulcata* and *Afrolobites* sp. Zones, and thus, can only be roughly correlated to the *P.*  
229 *euryomphalum* Zone according to the presence of *P. euryomphalum* (*Planitornoceras* genozone of  
230 Klein and Korn 2014). The *Platyclymenia* interval contains two distinct assemblages which can be  
231 tentatively correlated to the *Protoxyclymenia dunkeri* and *Procymaclymenia ebbighauseni* Zones,  
232 respectively, based on the presence of *E. zizensis* with *P. lamellosum*, and of *P. ebbighauseni* with *E.*  
233 *rherisensis* and *P. ouarouroutense* (*Platyclymenia* genozone of Klein and Korn 2014). The uppermost  
234 part with *Prionoceras* cf. *subtum* may correspond to the *Sporadoceras muensteri -orbiculare* Zone,  
235 however some *Prionoceras* species show different ranges compared to the Moroccan record. For  
236 example, in Ouarourout, *P. lentis* is associated with *P. ouarouroutense* and not with *P. lamellosum* as  
237 in the Anti-Atlas.

238 The *Medioclymenia* assemblage coupled with the *Costaclymenia* and *Gonioclymenia* levels can  
239 be correlated with the UD V interval of Becker (2002, 2013) which corresponds to the *Costaclymenia*  
240 and *Gonioclymenia* genozones of Klein and Korn (2014) (= *Gonioclymenia* Zone of Petter, 1960). The  
241 presence of *Cymaclymenia subvexa* in the *Medioclymenia* interval confirms the correlation with the  
242 *Gonioclymenia* genozone (Klein and Korn, 2014) and excludes the correlation with the *Kalloclymenia*  
243 genozone. The *Costaclymenia* level, although poorly represented in Ouarourout, is nevertheless in a



244 congruent position with the *Costacyclomenia ornata* Zone (Becker et al., 2002, 2013; Korn et al., 2018c)  
245 (= *Costacyclomenia* genozone of Klein and Korn 2014). As documented and discussed by Korn et al.  
246 (2017), the genera *Gonioclymenia* and *Medioclymenia* do not coexist and constitute two distinct  
247 successive zones in Algeria. These authors already discussed the correlation of these zones with the  
248 Moroccan biozonation: 1) the different species of *Gonioclymenia* co-occur in Algeria (Korn, 2017;  
249 Korn and Bockwinkel, 2017) and thus, do not constitute distinct biozones as in Morocco (Becker et  
250 al., 2002; Hartenfels and Becker, 2016b); 2) the “*Gonioclymenia hoevelensis*” Zone (= *G. spiniger*)  
251 containing “*Sphenoclymenia intermedia*” (= *Medioclymenia saouensis*), and the *Linguaclymenia*  
252 *similis-Kalloclymenia subarmata* Zone are separated by the *Medioclymenia aguelmousensis* Zone  
253 (Hartenfels and Becker, 2016b). This separation is confirmed in Algeria by the non-coexistence of  
254 both genera *Gonioclymenia* and *Kalloclymenia* (Korn et al., 2017; this study). In conclusion, despite  
255 slight differences, the Algerian and Moroccan assemblages are very close and most of the common  
256 species show similar biostratigraphic ranges which facilitate correlations.

257

258 FIGURE 5 AROUND HERE

259

260

#### 261 **4. Systematic palaeontology**

262

263 The material described and figured here is based on around 250 irregularly preserved and  
264 relatively small-sized specimens. Almost 200 of them have been identified at the species rank. They  
265 often correspond to internal moulds; most of them preserved the ornamentation, but the shell is  
266 rarely present. The preservation is in three dimensions and the deformation is minor. The suture  
267 lines are often visible and they were drawn with a light chamber microscope. The described and  
268 figured specimens were analysed at the University of Lille and are stored at the University of Mascara  
269 in Algeria. All the material was collected by one of us (A. Abbache).

270 The systematic nomenclature follows Korn and Klug (2002). The terminology used to describe  
271 the conch geometry, the ornamentation and the suture line follows Arkell et al. (1957), Korn (2010),  
272 Klug et al. (2015c) and Klug and Hoffmann (2015). The morphological abbreviations used for the  
273 biometric measurements are (Fig. 6; all dimensions are given in millimetres): **D**: shell diameter; **W**:  
274 whorl width; **H**: whorl height; **U**: umbilical diameter; **CWI**: conch width index =  $W/D$ ; **WWI**: whorl  
275 width index =  $W/H$ ; **UWI**: umbilical width index =  $U/D$ ; **WER**: whorl expansion rate =  $(D/d)^2$ . The  
276 abbreviations used for the suture line terminology are (Fig. 6): E lobe: external lobe; M saddle (M  
277 saddle); A lobe: adventive lobe; A<sub>2</sub>/A<sub>1</sub> saddle (between the first and the second A lobe); E/A saddle  
278 (between E lobe and A<sub>2</sub> lobe); L lobe: lateral lobe; U lobe: umbilical lobe; I lobe: internal lobe.

279 The ammonoids collected in the Ouarourout section (Famennian part of the 'Argiles de  
280 Marhouma' Formation) include 122 specimens of Clymeniida (suborders Clymeniina and  
281 Cyrtoclymeniina) and 74 specimens of Goniatiitida (suborder Tornoceratina). The Clymeniida are  
282 represented by four superfamilies (Cyrtoclymenioidea, 46 specimens; Platyclymenioidea, 37  
283 specimens; Clymenioidea, 24 specimens; Gonioclymenioidea, 15 specimens), and the Goniatiitida by  
284 two superfamilies (Tornoceratoidea, 24 specimens; Prionoceratoidea, 50 specimens). Overall, the  
285 identified ammonoids include 11 families, 19 genera, and 30 species. These ammonoid assemblages  
286 from Ouarourout are thus dominated by Clymeniida.

287

288 FIGURE 6 AROUND HERE

289

290 Phylum Mollusca Linnaeus, 1758

291 Class Cephalopoda Cuvier, 1797

292 Subclass Ammonoidea Zittel, 1884

293 Order Goniatiitida Hyatt, 1884

294 Suborder Tornoceratina Wedekind, 1914

295 Superfamily Tornoceratoidea Arthaber, 1911

296 Family Tornoceratidae Arthaber, 1911

297 Subfamily Falcitornoceratinae Becker, 1993a

298 Genus *Gundolficeras* Becker, 1995

299 **Type-species:** *Lobotornoceras bicaniculatum* Petter, 1959, p. 208; by original designation.

300 **Remarks:** Becker (1995) and Korn et al. (2016a, b) discussed in details the genus  
301 *Gundolficeras* and its species, especially those from the Anti-Atlas of Morocco.

302

303 ***Gundolficeras fezzouense*** (Becker, 1995)

304 (Figure 7A–D)

305 ? 1959 *Lobotornoceras delepinei* – Petter, p. 209, pl. 15, fig. 15

306 1995 *Exotornoceras fezzouense* – Becker, p. 618, pl. 2, figs 10–13, text-fig. 5a–f

307 1995 ?*Exotornoceras sylviae* – Becker, p. 619, pl. 2, figs 4–9, text-fig. 6

308 2016a *Gundolficeras fezzouense* – Korn et al., p. 206, figs 4–5

309 2017 *Gundolficeras fezzouense* – Korn et al., p. 128, figs 4–5

310 **Material:** Two poorly preserved specimens from samples On9 (*Planitornoceras* interval) and  
311 On14 (*Medioclymenia* interval).

312 **Description:** Specimen On14.16 (Fig. 7A, C) has a diameter of 32 mm; its conch is thinly  
313 discoidal (CWI = 0.45) and involute (UWI = 0.01), with a weakly compressed whorl cross section (WWI

314 = 0.87) and a high whorl expansion rate (WER = 2.08). The whorl section is oval; the venter is  
315 rounded and the flanks are converging (conch widest near the umbilicus); the umbilical margin is  
316 subangular and the umbilical wall is oblique. The shell is not preserved (growth lines not visible). The  
317 suture line (Fig. 7C) shows a narrow E lobe; a large and broadly rounded E/A saddle; a deep, rounded  
318 and asymmetric A lobe; a wide and broadly rounded A/L<sub>2</sub> saddle; and two shallow lateral lobes (L<sub>2</sub>,  
319 L<sub>1</sub>). Specimen On9.2 (Fig. 7B, D) has a smaller diameter (D = 13 mm) and a stouter conch) it is thickly  
320 discoidal (CWI = 0.52) and involute (UWI = 0.01), with a weakly compressed whorl cross section (WWI  
321 = 0.88) and an extremely high whorl expansion rate (WER = 2.64). Except the E/A ventrolateral saddle  
322 which is weakly flattened in On9.2 (Fig. 7D), there is no shape difference when comparing the suture  
323 line of both specimens.

324 **Discussion:** The suture line of both studied specimens is characteristic of the genus  
325 *Gundolficeras* (narrow E lobe; deep, rounded weakly asymmetric A lobe; large broadly rounded E/A  
326 saddle; shallow lateral lobes). Among the Moroccan species of *Gundolficeras*, *G. fezzouense* differs by  
327 its discoidal conch, by its rounded A lobe, and by the absence of ventrolateral grooves.

328 **Occurrence:** In the Ouarourout area (Algeria), *Gundolficeras fezzouense* is relatively rare and  
329 occurs in the *Planitornoceras* and *Medioclymenia* intervals (middle and late Famennian; Fig. 4). Korn  
330 et al. (2017) documented *G. fezzouense* in two localities in Algeria (Ouarourout and Cheffar Ahmar)  
331 and recorded it in the *Gonioclymenia* and *Medioclymenia* assemblages (late Famennian). In Morocco,  
332 the genus displays a long range within the Famennian, from the *Planitornoceras euryomphalum* Zone  
333 to the *Effenbergia falx* Zone (middle and late Famennian; Becker, 1995; Becker et al., 2002, 2013).

334  
335 Subfamily Aulatornoceratinae Becker, 1993a

336 Genus *Planitornoceras* Becker, 1995

337 **Type-species:** *Planitornoceras pugnax* Becker, 1995, p. 611; by original designation.

338  
339 ***Planitornoceras euryomphalum*** (Wedekind, 1918)

340 (Figure 7E–L)

341 1918 *Pseudoclymenia planidorsata* var. *euryomphala* – Wedekind, p. 138

342 1959 *Tornoceras (Protornoceras) planidorsatum* var. *euryomphala* – Petter, p. 203, pl. 15, figs

343 4–5

344 2002 *Planitornoceras euryomphalum* – Becker et al., pl. 4, fig. 1

345 2002 *Planitornoceras euryomphalum* – Korn and Klug, p. 162, text-fig. 148e

346 **Material:** 21 specimens from samples On4, On6, On7, On8p and On9 (*Planitornoceras*  
347 interval).

348 **Description:** The diameter of the specimens assigned to *P. euryomphalum* varies from 10.8 to

349 30.5 mm. They exhibit an extremely discoidal conch (CWI = 0.25–0.34; decreasing through ontogeny)  
350 with a weakly compressed whorl cross section (WWI = 0.60–0.78; decreasing through ontogeny). The  
351 umbilicus is relatively narrow; most of the specimens have a subinvolute conch (UWI = 0.18–0.34).  
352 The whorl expansion rate decreases considerably during the ontogeny, from very high (WER = 2.41 at  
353 D = 10.8 mm) to low (WER = 1.73 at D = 30.5 mm). The whorl section is subtrapezoidal; the venter is  
354 flat (subangular ventrolateral margins) and the flanks are slightly converging; the umbilical margin is  
355 subangular and the umbilical wall is oblique (Fig. 7 E–H). The ornamentation is composed of weak,  
356 slightly prorsiradiate, moderately spaced, sinuous ribs, which are thicker on the upper flanks. Growth  
357 lines are rectiradiate, biconvex, and projected backward on the venter (well visible in On9.12, Fig.  
358 7F). The suture line shows a shallow V-shaped E lobe; a strongly asymmetric, shallow and rounded A  
359 lobe which is elongated toward the venter; and an asymmetric, shallow and rounded L lobe (Fig. 7I–  
360 L).

361 **Discussion:** The very wide and asymmetric A lobe, the absence of ventrolateral grooves and  
362 constrictions, and the compressed subtrapezoidal whorl section (slightly converging flanks and  
363 angular venter), are characteristic of the genus *Planitornoceras*. *P. euryomphalum* shows a wide  
364 intraspecific variation regarding the thickness of the ornamentation, the conch width and the degree  
365 of involution. In Ouarourout, the genus is only represented by the species *P. euryomphalum* (the  
366 most evolute species of the genus); the species *P. pugnax* Becker, 1995 described in the Maider  
367 region (Morocco) has not been recognized.

368 **Occurrence:** In the Ouarourout area (Algeria), *Planitornoceras euryomphalum* is relatively  
369 abundant and occurs through the *Planitornoceras* interval (middle Famennian; Fig. 4). In Morocco, *P.*  
370 *euryomphalum* ranges from the *Planitornoceras euryomphalum* Zone to the *Sulcoclymenia sulcata*  
371 Zone (middle Famennian; Becker, 1995; Becker et al., 2002, 2013; Fig. 5).

372

373 FIGURE 7 AROUND HERE

374

375 Family Posttornoceratidae Bogoslovsky, 1971

376 Subfamily Discoclymeniinae Korn and Klug, 2002

377 Genus *Discoclymenia* Hyatt, 1884

378 **Type-species:** *Goniatites Haueri* Münster, 1840, p. 109; by monotypy.

379

380 *Discoclymenia atlantea* Korn et al., 2016a

381 (Figure 8A–B)

382 1950 *Discoclymenia cucullata* – Termier and Termier, p. 60, pl. 53, figs 38–45, pl. 54, figs 1–3

383 1959 *Discoclymenia cucullata* – Petter, p. 210, pl. 15, figs 8–10

- 384 ? 1959 *Discoclymenia cucullata* n. var.? – Petter, p. 211, pl. 15, fig. 16  
385 1983 *Discoclymenia cucullata* – Gupta and Erben, p. 94, text-figs 1a–d, 6.1  
386 1995 *Discoclymenia cucullata* – Becker, p. 622, pl. 3, figs 3–7, text-fig. 8b–d  
387 1999 *Discoclymenia cucullata* – Korn, p. 164, pl. 1, figs 7, 8  
388 2002 *Discoclymenia cucullata* – Becker, p. 66  
389 ? 2002 *Discoclymenia cucullata*– Becker et al., p.171–173  
390 2002 *Discoclymenia cucullata* – Korn and Klug, p. 170, text-figs 153a, d–f, 154c–e  
391 2016a *Discoclymenia atlantea* – Korn et al., p. 214, figs 13–15  
392 2017 *Discoclymenia atlantea* – Korn et al., p. 130, figs 8–9

393 **Material:** One fragmented specimen from sample On13 (*Medioclymenia* interval).

394 **Description:** Specimen On13.12 (Fig. 8A–B) is a fragment of conch with an estimated  
395 diameter of 40 mm. The proportions of this fragment indicate a thinly discoidal conch, with a weakly  
396 compressed whorl cross section. The whorl section is oval; the venter is narrowly rounded and the  
397 flanks are converging. The suture line shows a narrow and subparallel-sided E lobe; a shallow and  
398 rounded second adventive lobe (A<sub>2</sub> lobe) bordered by small rounded saddles; a deep, and nearly  
399 symmetric V-shaped first adventive lobe (A<sub>1</sub> lobe); and a skewed V-shaped L lobe which is shallower  
400 than the A<sub>1</sub> lobe. The shell is not preserved.

401 **Discussion:** The shallow, very short and rounded A<sub>2</sub>lobe is characteristic of the genus  
402 *Discoclymenia*. Among the Moroccan species of *Discoclymenia*, the single specimen described here,  
403 although fragmented, fits with *D. atlantea*, and therefore it is tentatively assigned to this taxa. The  
404 older *D. pola* differs by its subangular and flattened venter (ventrolateral shoulder often pronounced)  
405 and by its deeper E lobe, (Korn et al., 2016a, b).

406 **Occurrence:** In the Ouarourout area (Algeria), *Discoclymenia atlantea* seems extremely rare  
407 and occurs in the *Medioclymenia* interval (late Famennian; Fig. 4). Korn et al. (2016a, 2017) also  
408 documented *D. atlantea* in the Ouarourout area and recorded it in the *Medioclymenia* assemblage  
409 (late Famennian). In Morocco, the stratigraphic range of *D. atlantea* is unclear. Becker et al. (2002)  
410 documented it (“*D. cucullata*”) from the “*Endosiphonites muensteri*” Zone (= *Costaclymenia muensteri*  
411 Zone, UD V.A1) to the “*Mayneoceras nucleus*” Subzone (= *Parawocklumeria paradoxa* Zone, UD VI.C2,  
412 see Becker et al. 2013). Korn et al. (2016a) considered that in Morocco, *D. atlantea* is probably  
413 restricted to a shorter stratigraphic interval, corresponding to the time equivalent of the Algerian  
414 *Medioclymenia* assemblage (Korn et al., 2017). This assemblage constitutes a distinct interval mostly  
415 characterized by the presence of *Medioclymenia* coupled to the absence of *Gonioclymenia* and  
416 *Kalloclymenia* (Korn et al., 2016a, 2017); thus, it can be considered as time equivalent of the  
417 Moroccan *Medioclymenia aguelmousensis* Zone of Becker et al. (2013; see Fig. 5).

418

419 FIGURE 8 AROUND HERE

420

421 Superfamily Prionoceratoidea Miller and Furnish, 1957

422 Family Sporadoceratidae Miller and Furnish, 1957

423 Subfamily Sporadoceratinae Miller and Furnish, 1957

424 Genus *Sporadoceras* Hyatt, 1884

425 **Type species:** *Goniatites bidens* Sandberger and Sandberger, 1851, pl. 8; by original  
426 designation.

427 **Remarks:** Two sporadoceratid genera occurred in the Ouarourout section: *Sporadoceras* and  
428 *Erfoudites*. Korn et al. (2015b) revised and discussed in detail these genera and other  
429 Sporadoceratidae from the Anti-Atlas of Morocco. *Sporadoceras* differs from *Erfoudites* by its convex  
430 growth lines, by the absence of spiral ornament, and by its characteristic suture line which shows a  
431 very deep  $A_2$  lobe.

432

433 ***Sporadoceras cf. muensteri*** (von Buch, 1832)

434 (Figure 9A–C)

435 For the synonymy list of *S. muensteri*, see Korn et al., 2015b.

436 **Material:** Four specimens from sample On12 (*Platyclymenia* interval).

437 **Description:** Specimen On12.19 (Fig. 9A, C) has a diameter of 19.3 mm; its conch is thickly  
438 pachyconic (CWI = 0.80) and involute (UWI = 0.01), with a weakly depressed whorl cross section  
439 (WWI = 1.34) and a high whorl expansion rate (WER = 2.01). The whorl section is oval; the venter is  
440 broadly rounded and the flanks are converging; the umbilical margin is rounded and the umbilical  
441 wall is oblique. The shell shows convex growth lines, otherwise smooth. The suture line shows a  
442 narrow V-shaped E lobe; a deep and asymmetric V-shaped  $A_2$  lobe; a deep, relatively wide and  
443 asymmetric  $A_1$  lobe; wide and rounded E/ $A_2$  and  $A_2$ / $A_1$  saddles; and an asymmetric, wide and broadly  
444 rounded dorsolateral saddle. Specimen On12.26 (Fig. 9 B), with an estimated diameter of 40 mm,  
445 shows a very similar suture line. Specimen On12.23' (not illustrated), with a diameter of 23.1 mm,  
446 has a similar morphology; its conch is pachyconic (CWI = 0.72) and involute (UWI = 0.01), with a  
447 weakly depressed whorl cross section (WWI = 1.26) and a high whorl expansion rate (WER = 2.08).  
448 The whorl section is oval; the venter is broadly rounded and the flanks are converging. The surface of  
449 the shell is smooth. The suture line is partly visible and shows a narrow V-shaped E lobe and a deep  
450 V-shaped  $A_2$  lobe.

451 **Discussion:** The convex growth lines, the absence of spiral ornament on the shell, and the  
452 suture line shape, enable the attribution of this material to the genus *Sporadoceras*. The conch  
453 proportions and the deep  $A_2$  lobe showed by these Algerian specimens are characteristic of *S.*

454 *muensteri*, and differentiate this taxon from the other Moroccan species of *Sporadoceras*; however,  
455 they does not show constrictions on the internal mould (steinkern).

456 **Occurrence:** In the Ouarourout area (Algeria), *Sporadoceras* cf. *muensteri* occurs in the  
457 *Platyclymenia* interval (late Famennian, Fig. 4). In Morocco, *S. muensteri* ranges from the *Prionoceras*  
458 *ouarouroutense* Zone to the *Prionoceras jeranense* Zone (late Famennian; Korn et al., 2015b), but the  
459 most frequent occurrences is in the *Prionoceras subtum* Zone (= time equivalent of the *S. muensteri*-  
460 *orbiculare* Zone; see Fig. 5).

461

462 ***Sporadoceras* aff. *conforme*** Korn et al., 2015b

463 For the synonymy list of *S. conforme*, see Korn et al., 2015b.

464 (Figure 9D–F)

465 **Material:** Two specimens from samples On3 (before the *Planitornoceras* interval) and On4  
466 (*Planitornoceras* interval).

467 **Description:** Specimens On4.6 (D = 17.6 mm; Fig. 9D, F) and On3.7 (D = 18.0 mm; Fig. 9E)  
468 have similar conch proportions. Their conch is thickly discoidal (CWI = 0.56 and 0.50) and involute  
469 (UWI = 0.02), with a weakly compressed whorl cross section (WWI = 1.00 and 0.82) and a moderate  
470 whorl expansion rate (WER = 1.92 and 1.98). The whorl section is oval; the venter is rounded and the  
471 flanks are converging; the umbilicus is almost closed and the umbilical wall is oblique. The shell is not  
472 preserved (growth lines not visible). Both specimens show three steinkern constrictions on the last  
473 whorl. These constrictions are convex with a shallow ventral sinus, and they are more pronounced on  
474 the venter and on the upper part of the flanks. The suture lines are visible on both specimens, and  
475 they show a similar shape; however the surface of the fossils is altered and some sutural elements  
476 (as the adventive lobes) may appear more rounded than they were. At H = 7 mm, the suture line of  
477 specimen On4.6 (Fig. 9D) shows a narrow V-shaped E lobe; a narrow, deep and rounded U-shaped A<sub>2</sub>  
478 lobe; a deep, relatively wide and slightly asymmetric V-shaped A<sub>1</sub> lobe; a rounded and slightly  
479 asymmetric E/A<sub>2</sub> saddle; a relatively wide, rounded and symmetric A<sub>2</sub>/A<sub>1</sub> saddle; and a very wide and  
480 rounded dorsolateral saddle.

481 **Discussion:** The conch proportions, the presence of steinkern constrictions, and the suture  
482 line with a slightly asymmetric V-shaped A<sub>1</sub> lobe showed by the studied specimens are characteristic  
483 of *S. conforme*. However, in Morocco *S. conforme* has been recorded in younger levels (late  
484 Famennian, *Prionoceras vetus* and *Prionoceras lamellosum* zones; Korn et al., 2015b); and among the  
485 middle Famennian species of *Sporadoceras* documented in Morocco, *S. bidens* does not possess  
486 constrictions and has a very asymmetric A<sub>2</sub> lobe (Korn et al., 2015b), and *S. equale* also does not  
487 possess constrictions and has narrower adventive lobes (Becker et al., 2002). The state of  
488 preservation of both specimens (absence of preserved shell, poorly preserved suture) prevents to

489 reach a better assignment.

490       **Occurrence:** In the Ouarourout area (Algeria), *Sporadoceras* aff. *conforme* occurs in the  
491 *Planitornoceras* interval (middle Famennian, Fig. 4). In Morocco, *S. conforme* has been documented  
492 in younger deposits (late Famennian, *Prionoceras vetus* and *Prionoceras lamellosum* zones; Korn et  
493 al., 2015b; time equivalent of the *Platyclymenia annulata* and *Protoxyclymenia dunkeri* zones; see  
494 Fig. 5).

495

496       Subfamily Xenosporadoceratinae Korn, 2002

497       Genus *Erfoudites* Korn, 1999

498       **Type species:** *Erfoudites zizensis* Korn, 1999, p. 158; by original designation.

499       **Remarks:** The genus *Erfoudites* and its species, especially those from the Anti-Atlas of  
500 Morocco, have been recently discussed in detail (Korn et al., 2015b).

501

502       *Erfoudites rherisensis* Korn, 1999

503       (Figure 9G–M)

504       1959 *Sporadoceras biferum* – Petter, p. 260, pl. 20, figs 1, 3, pl. 21, figs 3, 4 (only)

505       1959 *Sporadoceras rotundolobatum* – Petter, p. 267, pl. 21, figs 1, 2

506       1999 *Erfoudites rherisensis* – Korn, p. 158, pl. 2, figs 4–6

507       2000 “*Maeneceras*” *ungeri ungeri* – Becker et al., p. 80, 81

508       2000 “*Maeneceras*” *ungeri rotundolobatum* – Becker et al., p. 80, 81

509       2002 *Erfoudites ungeri* – Becker et al., p. 171.

510       2002 *Erfoudites ungeri rotundolobatus* – Bockwinkel et al., p. 283, text-fig. 4d

511       2002 *Erfoudites rherisensis* – Korn and Klug, p. 189, textfig. 167A, B

512       2013 *Erfoudites ungeri* – Becker et al., p. 70, text-fig. 12.4

513       2015b *Erfoudites rherisensis* – Korn et al., p. 70, figs 23–31

514       **Material:** 12 specimens from samples On10, On11 and On12 (*Platyclymenia* interval).

515       **Description:** Specimens On12.47 (D = 41.8 mm), On12.48 (D = 44.0 mm) and On10.41 (= 36.0  
516 mm; Fig. 9G) show similar conch proportions. Their conch is thickly discoidal (CWI = 0.46–0.53) and  
517 involute (UWI = 0.01), with a weakly compressed whorl cross section (WWI = 0.83–0.91) and a high  
518 whorl expansion rate (WER = 2.30 and 2.01). The whorl section is oval; the venter is rounded and the  
519 flanks are converging; the umbilical margin is rounded and the umbilical wall is oblique. The shell is  
520 not preserved, but the internal mould shows steinkern constrictions (seven on the last whorl for the  
521 three specimens); these constrictions are more prominent on the venter and on the upper part of  
522 the flanks, and fade toward the umbilicus; they are concavo-convex and projected backward on the  
523 venter (these constrictions are well visible in specimen On 10.41, see Fig. 9G). Suture lines are visible



524 in specimens On 10.41 and On12.47; they show a wide V-shaped  $A_1$  lobe, and a shallow and rounded  
525  $A_2$  lobe. Specimen On12.25 (Fig. 9H) has a diameter of 30.6 mm; its conch is thickly discoidal (CWI =  
526 0.59) and involute (UWI = 0.01), with a weakly compressed whorl cross section (WWI = 0.97) and a  
527 very high whorl expansion rate (WER = 2.34). The whorl section is oval; the venter is rounded and the  
528 flanks are converging; the umbilical margin is rounded and the umbilical wall is oblique. The shell is  
529 partly preserved and four concavo -convex constrictions can be seen on the internal mould. The shell  
530 is covered by a very fine and dense spiral ornament; the spiral lines are narrower than the spaces  
531 between them. The growth lines are slightly biconvex and projected backward on the venter. Suture  
532 lines are well visible in specimens On 10.43 and On10.42 (Fig. 9J, K); they show a narrow V-shaped  $E$   
533 lobe; a shallow and rounded  $A_2$  lobe; and a deep and pointed V-shaped  $A_1$  lobe. Specimen On12.20  
534 (Fig. 9L, M) has a diameter of 20.3 mm; its conch is thickly discoidal (CWI = 0.62) and involute (UWI =  
535 0.02), with a weakly depressed whorl cross section (WWI = 1.15) and a high whorl expansion rate  
536 (WER = 2.10). The whorl section is oval; the venter is rounded and the flanks are converging. The  
537 shell is preserved and shows biconvex growth lines forming a thin spiral ornament (Fig. 9L, M). The  
538 suture line is partly visible, and shows a rounded and shallow  $A_2$  lobe, and a deep V-shaped  $A_1$  lobe.  
539 Specimen On12.18 (Fig. 9I) has a diameter of 14.7 mm; its conch is thickly discoidal (CWI = 0.60) and  
540 involute (UWI = 0.01), with a weakly depressed whorl cross section (WWI = 1.02) and a very high  
541 whorl expansion rate (WER = 2.39). The whorl section is oval; the venter is rounded and the flanks  
542 are converging. The spiral ornament formed by the thin biconvex growth lines is visible, but is less  
543 pronounced than in larger specimens. The series of specimens described herein illustrate the  
544 decrease of CWI and WWI through the ontogeny (more discoidal and compressed conch at the adult  
545 stage).

546 **Discussion:** The suture line with a shallow and rounded  $A_2$  lobe and a deep V-shaped  $A_1$  lobe,  
547 the steinkern constrictions, and the spiral ornament, are characteristic of the genus *Erfoudites*.  
548 Among the Moroccan species of *Erfoudites*, the high whorl expansion rate and the thin and dense  
549 spiral ornament are characteristic of *E. rherisensis*, and differentiate it from the older *E. zizensis*.

550 **Occurrence:** In the Ouarourout area (Algeria), *Erfoudites rherisensis* occurs in the upper part  
551 of the *Platyclymenia* interval (late Famennian; Fig. 4). According to Becker et al. (2002), in Morocco,  
552 *E. rherisensis* ("*E. ungeri*") ranges from the *Platyclymenia annulata* Zone to the *Kalloclymenia*  
553 *subarmata* Zone (late Famennian; Fig. 5). Korn et al. (2015b) documented a shorter range; they  
554 indicated that *E. rherisensis* occurs from the *Prionoceras mrakibense* Zone to the *Prionoceras*  
555 *jeranense* Zone (Fig. 5), and that the most frequent occurrence of the species is in the *P. jeranense*  
556 Zone (time equivalent of the *Costaclymenia muensteri* Zone; see Fig. 5).

557

558 ***Erfoudites cf. zizensis* Korn, 1999**

559 For the synonymy list of *E. zizensis*, see Korn et al., 2015b.

560 **Material:** Two poorly preserved specimens from sample On8 (*Platyclymenia* interval).

561 **Description:** Specimens On8.60 (D = 28.6 mm) and On8.61 (D = 24.5 mm) have similar conch  
562 proportions. Their conch is thickly discoidal (CWI = 0.57 and 0.64) and involute (UWI = 0.01), with a  
563 weakly depressed whorl cross section (WWI = 0.98 and 1.12) and a low whorl expansion rate (WER ≈  
564 1.7). The whorl section is oval; the venter is rounded and the flanks are converging; the umbilical wall  
565 is oblique. The internal mould shows several constrictions (five on the last whorl); they are more  
566 prominent on the venter and on the upper part of the flanks

567 **Discussion:** The state of preservation of the material prevents to reach a firm identification,  
568 both at the genus and at the species ranks. The conch morphology (thickly discoidal, involute, weakly  
569 depressed, with an oval whorl section) and the few convex constrictions projected backward on the  
570 venter are suggestive of *Erfoudites*, but the absence of preserved shell and suture line prevent to  
571 corroborate this hypothesis. These two specimens are tentatively assigned to *Erfoudites* cf. *zizensis*,  
572 based on the low whorl expansion rate (WER < 2.00).

573 **Occurrence:** In the Ouarourout area (Algeria), *Erfoudites* cf. *zizensis* occurs in the lower part  
574 of the *Platyclymenia* interval (late Famennian; Fig. 4). In Morocco, *E. zizensis* occurs in the  
575 *Prionoceras lamellosum* Zone (Korn et al., 2015b; time equivalent of the *Protoxyclymenia dunkeri*  
576 Zone, see Fig. 5).

577

578 ***Erfoudites* aff. *spirifer*** (Lange, 1929)

579 (Figure 9N–Q)

580 **Material:** Three poorly preserved specimens from samples On2 and On3 (levels below the  
581 *Planitornoceras* interval).

582 **Description:** Specimen On3.2 (Fig. 9N, O) has a diameter of 23.0 mm; its conch is thinly  
583 pachyconic (CWI = 0.63) and involute (UWI = 0.06), with a weakly depressed whorl cross section  
584 (WWI = 1.10) and a moderate whorl expansion rate (WER = 1.98). The whorl section is oval; the  
585 venter is broadly rounded and the flanks are converging; the umbilical margin and the umbilical wall  
586 are rounded. The suture line shows a V-shaped E lobe; a shallow and asymmetric A<sub>2</sub> lobe; a deep and  
587 lanceolate A<sub>1</sub> lobe; and a large and broadly rounded dorsolateral saddle. Specimens On2.4 (D = 14  
588 mm) and On2.5 (D = 19.7 mm; Fig. 9P, Q) have very similar conch proportions (UWI ≈ 0.09; CWI ≈  
589 0.66; WWI ≈ 1.29; WER = 1.56 and 1.77). Their internal moulds show few slightly convex  
590 constrictions. The suture line of these specimens shows an A<sub>2</sub> lobe less asymmetric than this of  
591 specimen On3.2 (see Fig. 9O, P).

592 **Discussion:** The poorly preserved material prevents to reach a firm identification both at the genus  
593 and species ranks. The conch geometry (involute, weakly depressed, thickly discoidal, oval whorl

594 section) and the few convex constrictions are suggestive of *Erfoudites* and *Maenoceras*. The spirally  
595 ornamented shell surface is not preserved but the suture line shape resembles to this of the  
596 Moroccan species of *Erfoudites* (*E. zizensis* and *E. rherisensis*). These specimens are tentatively  
597 assigned to *Erfoudites* aff. *spirifer* (for illustrations of the species *E. spirifer*, see Korn and Klug, 2002;  
598 and Becker et al., 2002) because they differ from *E. zizensis* and *E. rherisensis* by a more depressed  
599 conch and a highly asymmetric A<sub>2</sub> lobe. This type of suture line resembles those of *Felisporadoceras*,  
600 but this genus has a more depressed conch and a much higher whorl expansion rate (Korn et al.,  
601 2015b). The genus *Erfoudites* can also be confused with the genus *Ungusporadoceras*; they have  
602 similar conch proportions and they both possess spiral ornament, but in *Ungusporadoceras* the A<sub>2</sub>  
603 lobe is clearly deeper (Korn et al., 2015b).

604 **Occurrence:** In the Ouarourout area (Algeria), *Erfoudites* aff. *spirifer* occurs in the  
605 *Planitornoceras* interval (middle Famennian; Fig. 4). In Morocco, *E. spirifer* occurs from the  
606 *Planitornoceras euryomphalum* Zone to the *Sulcoclymenia sulcata* Zone (middle Famennian; Becker  
607 et al., 2002).

608

609 FIGURE 9 AROUND HERE

610

611 Family Prionoceratidae Hyatt, 1884

612 Subfamily Prionoceratinae Hyatt, 1884

613 Genus *Prionoceras* Hyatt, 1884

614 **Type species:** *Goniatites divisus* Münster, 1832, p. 24; by original designation.

615 **Remarks:** The genus *Prionoceras* and its species, especially those from the Anti-Atlas of  
616 Morocco, have been recently discussed in detail (Korn et al., 2014).

617

618 ***Prionoceras ouarouroutense*** Korn et al., 2014

619 (Figure 10A–B)

620 1959 *Prionoceras frechi* – Petter, p. 243, pl. 18, figs 1–3, 17–18

621 2014 *Prionoceras ouarouroutense* – Korn et al., p. 193, figs 25–27

622 **Material:** Three specimens (internal moulds) from samples On10 and On11 (*Platyclymenia*  
623 interval).

624 **Description:** The three specimens assigned to *Prionoceras ouarouroutense* (On11.24, D =  
625 25.4 mm, Fig. 10A; On10.31, D = 19.6 mm, Fig. 10B; On11.25, D = 20.4 mm) have similar proportions.  
626 Their conch is thinly discoidal (CWI = 0.45–0.54) and involute (UWI = 0.01), with a weakly compressed  
627 whorl cross section (WWI = 0.80–0.91) and a low whorl expansion rate (WER = 1.48–1.69). The whorl  
628 section is oval; the venter is rounded and the flanks are slightly converging; the umbilicus is almost

629 closed. They show five steinkern constrictions standing in distances of 70°; most of them are linear  
630 with a relatively deep ventral sinus, but interestingly the last constriction of specimen On 11.24 has a  
631 slightly convex course (Fig. 10A), and the last constriction of specimen On10.31 seems to have an  
632 irregularity in its course (Fig. 10B). In all specimens, the shell is not preserved, and the suture lines  
633 are not visible.

634 **Discussion:** The conch geometry (thickly discoidal, involute, oval whorl section) and the  
635 steinkern constrictions are characteristic of the genus *Prionoceras*. These specimens are assigned to  
636 *Prionoceras ouarouroutense* based on the number of constrictions (five at a diameter of 15 mm) and  
637 on their shape (deep ventral sinus), and on the conch width (compressed conch). Among the species  
638 having also five constrictions at similar sizes (Korn et al., 2014), *P. lamellosum* has constrictions  
639 without ventral sinus, a higher CWI (> 0.6) and a higher WWI (> 1.20); *P. subtum* has constrictions  
640 with shallow ventral sinus, a higher CWI (0.58) and a higher WWI (> 1.10); and *P. jeranense* has  
641 constrictions without ventral sinus, a higher CWI (> 0.65) and a higher WWI (> 1.15).

642 **Occurrence:** In the Ouarourout area (Algeria), *Prionoceras ouarouroutense* occurs in the  
643 middle part of the *Platyclymenia* interval (late Famennian; Fig. 4). In Morocco, this species marks the  
644 *P. ouarouroutense* Zone (late Famennian; Korn et al., 2014; see Fig. 5).

645

646 ***Prionoceras lamellosum*** Korn et al., 2014

647 (Figure 10C–D)

648 ? 1959 *Prionoceras substriatum* – Petter, p. 247, pl. 18, fig. 10 (pars)

649 1994 *Prionoceras divisum* – Korn, text-figs 29B, 30E (only)

650 2002 *Prionoceras divisum* – Korn and Klug, text-fig. 171A

651 2014 *Prionoceras lamellosum* – Korn et al., p. 183, figs 15–18

652 **Material:** Five specimens from sample On8 (*Platyclymenia* interval).

653 **Description:** Specimen On8.58 (Fig. 10D) has a diameter of 20.1 mm; its conch is thinly  
654 pachyconic (CWI = 0.70) and involute (UWI = 0.01), with a weakly depressed whorl cross section  
655 (WWI = 1.24) and a low whorl expansion rate (WER = 1.58). The whorl section is oval; the venter is  
656 rounded and the flanks are converging; the umbilical margin is rounded and the umbilical wall is  
657 convex. The internal mould shows three constrictions; they extend linearly on the flanks and on the  
658 venter, and they stand in distances of around 120°. Specimens On8.51–8.54 (around 10 mm conch  
659 diameter) have similar conch proportions (thinly pachyconic, CWI = 0.58–0.80; involute, UWI = 0.02;  
660 weakly depressed, WWI = 1.05–1.57; low whorl expansion rate, WER = 1.65). The whorl section is  
661 oval; the venter is broadly rounded and the flanks are converging; the umbilical margin is rounded  
662 and the umbilical wall is convex. The internal mould shows three or four constrictions, which have a  
663 slightly sinuous course. Specimen 8.51 (Fig. 10C) shows four steinkern constrictions; they are slightly

664 concave on the flanks, with a low ventral projection, and stand in distances of around 90°. In all  
665 specimens, the shell is not preserved, and the suture lines are not visible.

666 **Discussion:** The conch shape (thinly pachyconic, involute, weakly depressed, oval whorl  
667 section) and the steinkern constrictions are characteristic of the genus *Prionoceras*. These specimens  
668 are assigned to *Prionoceras lamellosum* based on the number of constrictions (three at a diameter of  
669 20 mm) and on their shape (linear), and on the conch width (depressed conch). *Prionoceras*  
670 *lamellosum* has a typical ornamentation (lamellose and wide-standing growth lines with convex  
671 course), but it cannot be observed in our Algerian material because none of the studied specimens  
672 have preserved their shell surface. As noted by Korn et al. (2014), the CWI and the WWI of this  
673 species show a large variability, but not the WER. Among the Moroccan species of *Prionoceras*, *P.*  
674 *divisum* also has three linear constrictions at similar size (Korn et al., 2014), but it has a slightly higher  
675 WWI (> 1.30) and a lower WER (< 1.55). *P. lentis*, *P. mrakibense* and *P. triens*, also have three  
676 constrictions, but all these species have a more compressed conch (WWI < 1.00).

677 **Occurrence:** In the Ouarourout area (Algeria), *Prionoceras lamellosum* occurs in the lower  
678 part of the *Platyclymenia* interval (late Famennian; Fig. 4). In Morocco, this species marks the *P.*  
679 *lamellosum* Zone (late Famennian; Korn et al., 2014; see Fig. 5).

680

681 ***Prionoceras* aff. *frechi*** (Wedekind, 1913)

682 (Figure 10E–G)

683 For the synonymy list of *P. frechi*, see Korn et al. 2014.

684 **Material:** Three specimens from samples On8 and On10 (*Platyclymenia* interval).

685 **Description:** Specimen On10.34 (Fig. 10F) has a diameter of 32.4 mm; its conch is thinly  
686 discoidal (CWI = 0.38) and involute (UWI = 0.01), with a weakly compressed whorl cross section (WWI  
687 = 0.72) and a low whorl expansion rate (WER = 1.63). The whorl section is oval; the venter is narrowly  
688 rounded and the flanks are subparallel (conch widest at the midflank area); the umbilical margin is  
689 rounded and the umbilical wall is convex. The internal mould shows four constrictions, which are  
690 linear on the flanks and slightly convex on the venter; they are irregularly-spaced and stand in  
691 distances of 120° and 90°. Specimen On10.33 (D = 26.1 mm; Fig.10E, G) has similar conch proportions  
692 (thinly discoidal, CWI = 0.39; involute, UWI = 0.04; weakly compressed, WWI = 0.67; low whorl  
693 expansion rate, WER = 1.57). The whorl section is oval; the venter is narrowly rounded and the flanks  
694 are subparallel; the umbilical margin is rounded and the umbilical wall is convex. The internal mould  
695 shows three constrictions, which are relatively linear on the flanks and slightly convex on the venter;  
696 they stand in distances of around 110°. The suture line shows a deep, narrow and parallel-sided E  
697 lobe; a narrow and relatively deep V-shaped L lobe; a wide, rounded and asymmetric ventrolateral  
698 saddle; and a very wide and broadly rounded dorsolateral saddle.

699           **Discussion:** The conch geometry (thinly discoidal, involute, weakly compressed, oval whorl  
700 section) and the steinkern constrictions are characteristic of the genus *Prionoceras*. These specimens  
701 are tentatively assigned to *Prionoceras* aff. *frechi* based on the number of constrictions (four at 20–  
702 30 mm diameter) and on their shape (linear with a shallow ventral sinus), on the conch proportions  
703 (weakly compressed conch), and on the shape of the flanks (subparallel) Two species of *Prionoceras*,  
704 which resemble to the European species *P. frechi*, are known from Morocco: *P. mrakibense* and *P.*  
705 *lentis* (see Korn et al., 2014). *P. mrakibense* differs by having a stouter conch (WWI > 0.90); *P. lentis*  
706 has similar conch proportions but differs by having converging flanks (they are subparallel in *P.*  
707 *lentis*).

708           **Occurrence:** In the Ouarourout area (Algeria), *Prionoceras* aff. *frechi* occurs in the  
709 *Platyclymenia* interval (late Famennian; Fig. 4). Becker et al. (2002) recognized *P. frechi* in the Anti-  
710 Atlas of Morocco, and documented it from the *Platyclymenia annulata* Zone to the *Sporadoceras*  
711 *muensteri- orbiculare* Zone ; however according to Korn et al. (2014) this species only occurs in  
712 Europe where it is restricted to the *Platyclymenia annulata* Zone.

713

714           ***Prionoceras lentis*** Korn et al., 2014

715           (Figure 10H–I)

716           1994 *Prionoceras frechi* – Korn, text-figs 29A, 30D (only)

717           1999 *Prionoceras frechi* – Korn, pl. 2, fig. 7

718           2002 *Prionoceras frechi* – Korn and Klug, text-fig. 171B

719           2014 *Prionoceras lentis* – Korn et al., p. 189, figs 21–22

720           **Material:** Three specimens from sample On11 (*Platyclymenia* interval).

721           **Description:** Specimens On11.20 (D = 15.8 mm; Fig. 10H) and On11.22 (D = 18.5 mm; Fig. 10I)  
722 have a similar conch geometry; their conch is thinly discoidal (CWI = 0.45 and 0.47) and involute (UWI  
723 = 0.01 and 0.03), with a weakly compressed whorl cross section (WWI = 0.79 and 0.80) and a low  
724 whorl expansion rate (WER = 1.56 and 1.61). The whorl section is oval; the venter is narrowly rounded  
725 and the flanks are converging; the umbilical margin is rounded and the umbilical wall is convex. The  
726 internal mould shows three constrictions standing in distance of 120°; they are linear with a shallow  
727 ventral sinus. In all specimens, the shell is not preserved, and the suture lines are not visible.

728           **Discussion:** These specimens are assigned to *Prionoceras lentis* based on the number of  
729 constrictions (three) and on their shape (linear with a shallow ventral sinus), and on the conch  
730 proportions (weakly compressed conch). In Morocco, two species of *Prionoceras* resemble *P. lentis*:  
731 *P. mrakibense* and *P. ouarouroutense* (see Korn et al., 2014); but these both species have a stouter  
732 conch at comparable diameter (in *P. mrakibense* and *P. ouarouroutense* WWI = 0.50–0.60 at D = 20  
733 mm, but 0.35–0.40 in *P. lentis*). In Algeria, *P. lentis* and *P. aff. frechi* have a very close morphology;

734 they differs only by the shape of their flanks (converging in *P. lentis* and subparallel in *P. aff. frechi*).  
735 Intermediary shapes (from converging to subparallel flanks) may exist between these two  
736 morphotypes and that would indicate that these species could be actually considered as synonym.  
737 However, more material is needed to evaluate this morphological variability and confirm or not this  
738 hypothesis.

739 **Occurrence:** In the Ouarourout area (Algeria), *Prionoceras lentis* occurs in the middle part of  
740 the *Platyclymenia* interval (late Famennian; Fig. 4). In Morocco, *P. lentis* is restricted to the  
741 *Prionoceras lamellosum* Zone (Korn et al., 2014; see Fig. 5).

742

743

744 ***Prionoceras cf. subtum*** Korn et al., 2014

745 (Figure 10J–K)

746 **Material:** Two specimens from sample On12 (*Platyclymenia* interval).

747 **Description:** Specimen On12.22 (Fig. 10J) has a diameter of 21.7 mm; its conch is thinly  
748 pachyconic (CWI = 0.67) and involute (UWI = 0.01), with a weakly depressed whorl cross section  
749 (WWI = 1.14) and a moderate whorl expansion rate (WER = 1.92). The whorl section is subglobular;  
750 the venter is broadly rounded and the flanks are converging. The internal mould shows three  
751 irregularly-spaced constrictions, which are convex with a shallow ventral sinus. Specimen On12.13  
752 (Fig. 10K) has a diameter of 19.7 mm; its conch is thinly pachyconic (CWI = 0.60) and involute (UWI =  
753 0.01), with a weakly depressed whorl cross section (WWI = 1.04) and a low whorl expansion rate  
754 (WER = 1.62). The whorl section is subglobular; the venter is rounded and the flanks are converging;  
755 the umbilical margin is rounded. The internal mould shows three prominent constrictions, irregularly  
756 spaced, and standing in distances of around 90° or 110°; they show a slightly convex course on the  
757 flanks with a very shallow ventral sinus. The shell is partly preserved; the growth lines are sinuous,  
758 very fine, and densely arranged. The suture lines are not visible.

759 **Discussion:** These specimens are tentatively assigned to *Prionoceras cf. subtum* based on the  
760 conch proportions (at D ≈ 20 mm: CWI = 0.60–0.70; WWI = 1.05–1.15) and on the constriction shape  
761 (slightly convex with a shallow ventral sinus). However, this Algerian material shows only three  
762 constrictions, while *P. subtum* is supposed to have four constrictions at a diameter of 20 mm.  
763 Specimen On12.22 has a higher whorl expansion rate than the type material from the Anti-Atlas  
764 described by Korn et al. (2014; in *P. subtum* WER ≈ 1.60 at 20 mm). In Morocco, the *Prionoceras*  
765 species having close conch proportions are *P. mrakibense*, *P. ouarouroutense*, *P. jeranense*, and *P.*  
766 *takhbtitense* (see Korn et al., 2014). *P. ouarouroutense* and *P. mrakibense* differ by having a slender  
767 conch (CWI < 0.55; WWI < 1.05); *P. ouarouroutense* differs also by having five constrictions. *P.*  
768 *jeranense* has a slightly more depressed whorl section (WWI > 1.15) and up to six constrictions. *P.*

769 *takhtitense* differs by having linear constrictions.

770 **Occurrence:** In the Ouarourout area (Algeria), *Prionoceras* cf. *subtum* occurs in the upper  
771 part of the *Platyclymenia* interval (late Famennian; Fig. 4). In Morocco, this species marks the  
772 *Prionoceras subtum* Zone (Korn et al., 2014; see Fig. 5).

773

774 ***Prionoceras* cf. *triens*** Korn et al., 2014

775 (Figure 10L)

776 **Material:** One specimens from sample On12 (*Platyclymenia* interval).

777 **Description:** Specimen On12.46 (Fig. 10L) has a diameter of 27.7 mm; its conch is thinly  
778 pachyconic (CWI = 0.60) and involute (UWI = 0.01), with a weakly depressed whorl cross section  
779 (WWI = 1.04) and a low whorl expansion rate (WER = 1.72). The whorl section is subglobular; the  
780 venter is rounded and the flanks are converging; the umbilicus is almost closed. The internal mould  
781 shows three irregularly-spaced constrictions (standing in distances of around 140° and 180°), which  
782 are concave on flanks and relatively linear on the venter.

783 **Discussion:** This specimen is tentatively assigned to *Prionoceras* cf. *triens* based on the conch  
784 proportions and on the constriction shape (concave on flanks, with a shallow ventral sinus) and  
785 number (only 3). However, this Algerian specimen has a lower WER and a higher shell diameter than  
786 the typical material from Morocco (see Korn et al., 2014).

787 **Occurrence:** In the Ouarourout area (Algeria), *Prionoceras* cf. *triens* occurs in the upper part  
788 of the *Platyclymenia* interval (late Famennian; Fig. 4). In Morocco, *P. triens* occurs in the slightly  
789 younger *Prionoceras jeranense* Zone (Korn et al., 2014; see Fig. 5).

790

791

792 Genus ***Mimimitoceras*** Korn, 1988

793 **Type species:** *Mimimitoceras trizonatum* Korn, 1988, p. 607; by original designation.

794 **Remarks:** The genus *Mimimitoceras* and its species from the Anti-Atlas (Morocco) and from  
795 the Saoura Valley (Algeria) have been recently discussed in detail (Korn et al., 2015a, 2017).

796

797 ***Mimimitoceras* cf. *caratum*** Korn et al., 2015a

798 (Figure 10M–N)

799 For the synonymy list of *M. caratum*, see Korn et al. 2015a.

800 **Material:** Two specimens from samples On13 and On14 (*Medioclymenia* interval).

801 **Description:** Specimens On13.1 (D = 10.1 mm; Fig. 10N) and On14.13 (D = 17.9 mm; Fig.  
802 10M) have similar conch proportions; their conch is thinly pachyconic (CWI = 0.72–0.82) and involute  
803 (UWI = 0.01), with a weakly depressed whorl cross section (WWI = 1.30–1.37). Specimen On13.1 has



804 a low whorl expansion rate (WER = 1.59); and specimen On14.13 has a very low whorl expansion rate  
805 (WER = 1.45). The whorl section is globular; the venter is broadly rounded and the flanks are  
806 subparallel; the umbilical margin is rounded and the umbilicus is almost closed. The both specimens  
807 show three steinkern constrictions standing in distance of around 120°; their course is almost linear  
808 on the flanks and on the venter. In both specimens, the shell is not preserved, and the suture lines  
809 are not visible.

810 **Discussion:** The globular and involute conch is typical of the genus *Mimimitoceras*. These  
811 specimens are assigned to *Mimimitoceras* cf. *caratum* based on the conch proportions (at a  
812 diameter of 15 mm: CWI = 0.75–0.85; WWI = 1.30–1.40; WER = 1.45–1.50). Among the Moroccan  
813 species of *Mimimitoceras* revised by Korn et al. (2015a), *M. caratum* has the stoutest conch (CWI >  
814 0.70; WWI > 1.30). *M. endocuboide* differs by having a lower whorl expansion rate (WER < 1.40) and  
815 by the course of its constrictions which are often interrupted for a short interval on the midventer  
816 (Korn et al., 2015a); but the both species have a very similar conch morphology and can be easily  
817 confused. According to Korn et al. (2015a), specimens cannot be attributed with confidence to *M.*  
818 *caratum* and *M. endocuboide* if the whorl section shape of the juvenile stage (circular in *M.*  
819 *caratum* and cuboid with a wider umbilicus in *M. endocuboide*) is unknown. Therefore, it seems  
820 reasonable to identify these Algerian specimens as *Mimimitoceras* cf. *caratum*. The Algerian species  
821 *M. callumbilicum* differs by its concave umbilical wall due to a shell thickening near the umbilicus  
822 (Korn et al., 2017).

823 **Occurrence:** In the Ouarourout area (Algeria), *Mimimitoceras* cf. *caratum* occurs in the  
824 *Medioclymenia* interval (late Famennian; Fig. 4). Korn et al. (2017) documented the occurrence of  
825 *M. caratum* in Ouarourout (*Medioclymenia* assemblage, see Fig. 5). In Morocco, the stratigraphic  
826 range of this species is not well constrained, but it probably occurs in the *Gonioclymenia* beds (Korn  
827 et al., 2015a; see Fig. 5).

828

829 ***Mimimitoceras* cf. *comtum*** Korn et al., 2015b

830 (Figure 100–P)

831 For the synonymy list of *M. comtum*, see Korn et al. 2015a.

832 **Material:** Seven specimens from samples On13 and On14 (*Medioclymenia* interval).

833 **Description:** Specimen On14.17 (Fig. 100) is an internal mould with a diameter of 36 mm. Its  
834 conch is thinly pachyconic (CWI = 0.60) and involute (UWI = 0.04), with a weakly depressed whorl  
835 cross section (WWI = 1.09) and a low whorl expansion rate (WER = 1.62). The whorl section is  
836 subglobular; the venter is rounded and the flanks are converging; the umbilical margin is rounded  
837 and the umbilicus is almost closed. The conch shows four steinkern constrictions irregularly-spaced;  
838 they are slightly convex with a shallow ventral sinus. Specimen On13.3 (Fig. 10P) is also an internal

839 mould, with a diameter of 28.5 mm. Its conch is thinly pachyconic (CWI = 0.62) and involute (UWI =  
840 0.03), with a weakly depressed whorl cross section (WWI = 1.11) and a low whorl expansion rate  
841 (WER = 1.65). The whorl section is globular; the venter is rounded and the flanks are converging; the  
842 umbilical margin is rounded and the umbilicus is almost closed. The conch shows four steinkern  
843 constrictions standing in distance of 90°; their course is slightly convex with a shallow ventral sinus.  
844 In all specimens, the shell is not preserved, and the suture lines are not visible.

845 **Discussion:** The globular and involute conch is characteristic of the genus *Mimimitoceras*.  
846 These specimens are tentatively assigned to *Mimimitoceras* cf. *comtum* based on the conch  
847 proportions (at a diameter of 30 mm: CWI = 0.60–0.65; WWI = 1.05–1.15; WER = 1.60–1.80).  
848 However, these Algerian specimens slightly differs from the Moroccan type material by having a  
849 higher whorl expansion rate (WER = 1.60–1.80 at D = 30 mm, but 1.55–1.65 in *M. comtum*). Among  
850 the Moroccan and Algerian species of *Mimimitoceras* (see Korn et al., 2015b, 2017), *M. taourirtense*  
851 is the closest species in conch proportions, but it differs by having a significantly higher whorl  
852 expansion rate (WER > 1.80).

853 **Occurrence:** In the Ouarourout area (Algeria), *Mimimitoceras* cf. *comtum* occurs in the  
854 *Medioclymenia* interval (late Famennian; Fig. 4). Korn et al. (2017) also reported the occurrence of  
855 *M. comtum* in Ouarourout (*Medioclymenia* assemblage, see Fig. 5). In Morocco, this species probably  
856 occurs in the *Gonioclymenia* beds (Korn et al., 2015a; see Fig. 5).

857

858 FIGURE 10 AROUND HERE

859

860 Order Clymeniida Hyatt, 1884

861 Suborder Cyrtoclymeniina Korn and Klug, 2002

862 Superfamily Cyrtoclymenioidea Hyatt, 1884

863 Family Cyrtoclymeniidae Hyatt, 1884

864 Subfamily Cyrtoclymeniinae Hyatt, 1884

865 Genus *Protactoclymenia* Wedekind, 1908

866 **Type species:** *Clymenia pulcherrima* Wedekind, 1908, p. 608; by subsequent designation  
867 (Price and Korn, 1989).

868

869 ***Protactoclymenia* sp. indet. A**

870 **Material:** Six poorly preserved specimens from samples On8, On10 and On11 (*Platyclymenia*  
871 interval).

872 **Description:** These poorly preserved specimens (not illustrated) have a diameter of around  
873 22 mm; their conch is thinly discoidal (CWI ≈ 0.40) and subinvolute (UWI ≈ 0.29), with a weakly

874 compressed whorl cross section ( $WWI \approx 0.98$ ). The whorl section is oval; the venter is rounded and  
875 the flanks are converging; the umbilical margin is rounded. The suture lines have a rounded and  
876 shallow ventral saddle; and a broadly rounded, shallow and symmetric L lobe. The ornamentation of  
877 the inner whorls is composed of weak and prorsiradiate ribs, rapidly fading on the flanks. Specimen  
878 On10.21 shows widely spaced and sinuous growth lines projected backward on the venter.

879 **Discussion:** Based on the suture line shape (shallow ventral saddle, shallow and symmetric L  
880 lobe) and on the conch proportions (weakly compressed, subinvolute and thinly discoidal conch),  
881 these specimens are attributed to the genus *Protactoclymenia*. However, the poorly preserved  
882 material prevents to reach a specific comparison and identification. Petter (1960) described a species  
883 from Algeria (*Cyrtoclymenia tenuicostata*) considered as *Protactoclymenia* by Korn and Klug (2002);  
884 however, our specimens differ by having a narrower umbilicus, a more depressed conch, and a  
885 smooth shell.

886 **Occurrence:** In the Ouarourout area (Algeria), *Protactoclymenia* sp. indet. A occurs in the  
887 *Platyclymenia* interval (late Famennian; Fig. 4). In Morocco, the genus *Protactoclymenia* ranges from  
888 the *Platyclymenia annulata* Zone to the *Sporadoceras orbiculare* Zone (Becker et al., 2002; see Fig. 5).

890 ***Protactoclymenia* sp. indet. B**

891 (Figure 11F)

892 **Material:** Three specimens from samples On8 and On10 (*Platyclymenia* interval).

893 **Description:** Specimen On8.3 (Fig. 11F) has a diameter of 18.55 mm; its conch is thinly  
894 discoidal and subinvolute ( $CWI = 0.36$ ;  $UWI = 0.27$ ), with a whorl cross section weakly compressed  
895 ( $WWI = 0.82$ ), and a moderate whorl expansion rate ( $WER = 1.87$ ). The whorl section is oval; the  
896 venter is narrowly rounded and the flanks are converging; the umbilical margin is rounded. The  
897 ornamentation is composed of very weak and prorsiradiate ribs, rapidly fading on the flanks. The last  
898 part of the conch shows two constrictions; they are convex with a deep V-shaped ventral sinus, and  
899 they fade on the flanks toward the umbilicus. The suture line shows a rounded and shallow ventral  
900 saddle followed by a broadly rounded, shallow and symmetric L lobe. Interestingly the last sutures of  
901 the phragmocone are crowded. Specimen On8.1, at  $D = 14.3$  mm, has the following conch  
902 proportions: thinly discoidal ( $CWI = 0.37$ ) and subinvolute ( $UWI = 0.26$ ), with a weakly compressed  
903 whorl cross section ( $WWI = 0.83$ ) and a high whorl expansion rate ( $WER = 2.04$ ). The whorl section is  
904 oval; the venter is rounded and the flanks are converging; the umbilical margin is rounded. The conch  
905 exhibits two steinkern constrictions which are prominent on the venter where they form a deep and  
906 V-shaped ventral sinus. The suture line shows a rounded and shallow ventral saddle; and a wide,  
907 shallow, rounded and symmetric L lobe.

908 **Discussion:** The suture line shape (shallow and symmetric L lobe) and the conch proportions

909 (thinly discoidal, subinvolute and weakly compressed) are characteristic of the genus  
910 *Protactoclymenia*. However, the state of preservation of the material prevents to reach a detailed  
911 specific comparison and a firm identification. The presence of ventral constrictions clearly  
912 distinguished these specimens from *Protactoclymenia* sp. indet. A.

913 **Occurrence:** In the Ouarourout area (Algeria), *Protactoclymenia* sp. indet. B occurs in the  
914 *Platyclymenia* interval (late Famennian, Fig. 4). In Morocco, the genus *Protactoclymenia* ranges from  
915 the *Platyclymenia annulata* Zone to the *Sporadoceras orbiculare* Zone (Becker et al., 2002; see Fig. 5).

916

917

918 Genus *Cyrtoclymenia* Hyatt, 1884

919 **Type species:** *Planulites angustiseptatus* Münster, 1832, p. 7; by original designation.

920

921 *Cyrtoclymenia* cf. *frechi* (Tokarenko, 1903)

922 (Figure 11A–E)

923 For the synonyms of *C. frechi*, see Korn and Klug, 2002.

924 **Material:** 15 specimens from samples On8, On10, On11 and On12 (*Platyclymenia* interval).

925 **Description:** Specimen On12.37 has a diameter of 27.5 mm; its conch is thinly discoidal (CWI  
926 = 0.45) and subinvolute (UWI = 0.27), with a weakly depressed whorl cross section (WWI = 1.05) and  
927 a very high whorl expansion rate (WER = 2.23). The whorl section is oval; the venter is rounded and  
928 the flanks are converging; the umbilical margin is rounded. The ornamentation is composed of weak,  
929 slightly concave, prorsiradiate ribs (eight ribs per half whorl), fading on the flanks; the ribs are thicker  
930 on the inner whorls. The suture line shows a rounded, shallow and wide ventral saddle, followed by a  
931 broadly rounded, deep and symmetric L lobe. Specimen On12.33 (Fig. 11A) has a diameter of 22.8  
932 mm; its conch is thinly discoidal (CWI = 0.47) and subevolute (UWI = 0.31) with a weakly depressed  
933 whorl cross section (WWI = 1.11) and a very high whorl expansion rate (WER = 2.54). The whorl  
934 section is oval; the venter is rounded and the flanks are converging; the umbilical margin is rounded.  
935 The conch bears moderately spaced (12 ribs per half whorl), prorsiradiate and slightly concave ribs,  
936 rapidly fading on the flanks. The suture lines are partly eroded, but clearly show a rounded ventral  
937 saddle, and a symmetric and rounded L lobe. Specimen On10.19 (D = 18.9 mm; Fig. 11E) has a thinly  
938 discoidal (CWI = 0.51) and subevolute conch (UWI = 0.31), with a weakly compressed whorl cross  
939 section (WWI = 1.21) and a very high whorl expansion rate (WER = 2.08). The whorl section is  
940 subtrapezoidal; the venter is rounded and the flanks are strongly converging; the umbilical margin is  
941 rounded. The conch shows relatively wide ribs which are relatively prominent near the umbilicus and  
942 fading toward the venter. Specimen On10.18 (D = 17.2 mm; Fig. 11D) shows very thick and  
943 prominent ribs on its inner whorls, but they suddenly disappear on the last whorl. The suture lines

944 show a rounded ventral saddle, and a slightly asymmetric, wide and rounded L lobe (Fig. 11C).  
945 Specimen On10.17 (D = 15.7 mm; Fig. 11B) has a thinly discoidal (CWI = 0.45) and subevolute (UWI =  
946 0.32) conch, with a weakly depressed whorl cross section (WWI = 1.15) and very high whorl  
947 expansion rate (WER = 2.28). The whorl section is oval; the venter is rounded and the flanks are  
948 converging; the umbilical margin is rounded. The conch bears moderately-spaced (12 ribs per half  
949 whorl), prorsiradiate and slightly concave ribs, fading on the flanks. The suture lines show a rounded  
950 ventral saddle and a wide, symmetric and rounded L lobe.

951 **Discussion:** The suture line shape (rounded ventral saddle, moderately deep and relatively  
952 symmetric L lobe) and the conch proportions (thinly discoidal conch with a weakly depressed whorl  
953 cross section, and a narrow umbilicus) are characteristic of the genus *Cyrtoclymenia*. There are many  
954 species of *Cyrtoclymenia* (see synthesis of Korn and Klug, 2002), and the rounded and slightly curved  
955 umbilical ribs fading on the flanks displayed by the studied specimens, remind the species *C. frechi*;  
956 therefore, they are tentatively attributed to this species. These specimens differ from the Algerian *C.*  
957 *nodifera* (Korn et al., 2017) mainly by having a much higher whorl expansion rate (WER = 2.2).

958 **Occurrence:** In the Ouarourout area (Algeria), *Cyrtoclymenia* cf. *frechi* occurs in the  
959 *Platyclymenia* interval (late Famennian; Fig. 4). *C. frechi* has not been reported in Morocco, but the  
960 genus has a very long range in the Famennian (Korn, 1999; Becker et al., 2002; Korn et al., 2017).

961  
962 FIGURE 11 AROUND HERE

963

964 Family Cymaclymeniidae Hyatt, 1884

965 Subfamily Genuclymeniinae Korn and Klug, 2002

966 Genus ***Genuclymenia*** Wedekind, 1908

967 **Type-species:** *Clymenia frechi* Wedekind, 1908, p. 617; by subsequent designation  
968 (Schindewolf, 1957).

969

970 ***Genuclymenia* sp. indet.**

971 (Figure 12O–P)

972 **Material:** One specimen from sample On9 (*Planitornoceras* interval).

973 **Description:** Specimen On9.17 (Fig. 12O) has a diameter of 16.1 mm; its conch is thinly  
974 discoidal (CWI = 0.37) and subevolute (UWI = 0.35), with a weakly compressed whorl cross section  
975 (WWI = 0.97) and a high whorl expansion rate (WER = 2.11). The whorl section is oval; the venter is  
976 narrowly rounded and the flanks are converging; the umbilical margin is rounded. The suture lines  
977 show a rounded, shallow and very wide ventral saddle; followed by a broadly rounded, relatively  
978 deep and slightly asymmetric L lobe (Fig. 12P).

979           **Discussion:** Based on the conch geometry and on the suture line shape, the single specimen  
980 from Ouarourout clearly belongs to the genus *Genuclymenia*. However, without additional material,  
981 the specific attribution remains uncertain.

982           **Occurrence:** In the Ouarourout area (Algeria), *Genuclymenia* sp. indet. occurs in the upper  
983 part of the *Planitornoceras* interval (middle Famennian; Fig. 4). *Genuclymenia* is unknown in  
984 Morocco, but in Germany this genus occurs in the *Platyclymenia delphinus* and *Platyclymenia*  
985 *annulata* zones (see House, 1970; Korn, 2004).

986  
987

988           Subfamily Cymaclymeniinae Hyatt, 1884

989           Genus ***Procymaclymenia*** Korn and Klug, 2002

990           **Type-species:** *Cymaclymenia inflata* Czarnocki, 1989, p. 67; by original designation.

991           **Remarks:** Klein and Korn (2014) revised the Cymaclymeniinae from the Anti-Atlas of  
992 Morocco, and erected new species of *Cymaclymenia* and related genera (*Procymaclymenia* and  
993 *Postclymenia*). The morphology of both genera *Procymaclymenia* and *Cymaclymenia* are very close.  
994 In *Procymaclymenia*, the lateral lobe is more rounded and less asymmetric, and the venter is slightly  
995 flattened (in *Cymaclymenia*, the venter is rounded). Only one species of *Procymaclymenia* is known  
996 from Morocco (*P. ebbighauseni*).

997

998           ***Procymaclymenia ebbighauseni*** Klein and Korn, 2014

999           (Figure 12A–I)

1000           1960 *Cymaclymenia striata* – Petter, p. 45, pl. 8, figs 3, 5, 11, 14 (only)

1001           1999 *Cymaclymenia* sp. – Korn, p. 170, pl. 4, fig. 6

1002           2002 *Cymaclymenia pudica* – Becker et al., p. 171, pl. 4, figs 4, 5

1003           2002 *Procymaclymenia* sp. – Korn and Klug, p. 220, fig. 193d

1004           2014 *Procymaclymenia ebbighauseni* – Klein and Korn, p. 11, figs 4a, 11, 12

1005           **Material:** Seven specimens from samples On10 and On12 (*Platyclymenia* interval).

1006           **Description:** Specimen On12.44 (Fig. 12A) has a diameter of 34.4 mm; its conch is extremely  
1007 discoidal (CWI = 0.28), with a weakly compressed whorl cross section (WWI = 0.68) and a high whorl  
1008 expansion rate (WER = 2.05); the umbilicus is not visible. The whorl section is subrectangular; the  
1009 venter is slightly flattened and separated from the flanks by a subangular margin; the flanks are  
1010 subparallel. The shell exhibits very faint riblets on the upper part of the flanks. The suture line shows  
1011 a very wide and relatively flat ventral saddle, followed by a rounded, shallow and slightly asymmetric  
1012 L lobe. Specimen On12.40 (Fig. 12C, H) has a diameter of 22.85 mm; its conch is extremely discoidal  
1013 (CWI = 0.28) and subinvolute (UWI = 0.30), with a weakly compressed whorl cross section (WWI =

1014 0.65) and a very high whorl expansion rate (WER = 2.32). The whorl section is subrectangular; the  
1015 venter is flattened and separated from the flanks by a subangular margin; the flanks are subparallel;  
1016 the umbilical margin is rounded. The shell exhibits faint, rectiradiate and slightly concave riblets,  
1017 which are more prominent toward the ventrolateral and umbilical margins. The suture line shows a  
1018 very wide and flat ventral saddle, and a rounded, shallow and slightly asymmetric L lobe. Specimens  
1019 On12.38 (D = 16.4 mm; Fig. 12B, G), On12.39 (D = 19.9 mm; Fig.12D, F) and On10.25 (D = 20.0 mm;  
1020 Fig. 12E, I) have a smaller diameter, but are very similar to On12.40 in conch proportions and suture  
1021 line shape (CWI = 0.29–0.34; UWI = 0.24–0.27; WWI = 0.65–0.79; WER = 2.21–2.44). . Their suture  
1022 lines show a blunt and slightly asymmetric L lobe, which is characteristic of the genus  
1023 *Procymaclymenia*.

1024 **Discussion:** The conch proportions (extremely discoidal, subinvolute, weakly compressed,  
1025 subrectangular whorl section) and the suture line shape (small, blunt and slightly asymmetric L lobe)  
1026 of these specimens are characteristic of the genus *Procymaclymenia*. Only the species *P.*  
1027 *ebbighauseni* is clearly established for Morocco (see Klein and Korn, 2014). Although eroded, the  
1028 described specimens from Algeria are very similar to those from Morocco and can be assigned to *P.*  
1029 *ebbighauseni*. As noted by Klein and Korn (2014), *P. ebbighauseni* differs from *P. inflata* (Czarnocki,  
1030 1989) and *P. pudica* (Czarnocki, 1989) from the Holy Cross Mountains, by the smooth internal mould  
1031 without constrictions, and the nearly absence of umbilical riblets.

1032 **Occurrence:** In the Ouarourout area (Algeria), *P. ebbighauseni* occurs in the upper part of the  
1033 *Platyclymenia* interval (late Famennian; Fig. 4). In Morocco, *P. ebbighauseni* occurs above the  
1034 *Platyclymenia annulata* Zone and ranges until the *Costaclymenia* genozone (Klein and Korn, 2014;  
1035 see Fig. 5).

1036

1037

1038 Genus *Cymaclymenia* Hyatt, 1884

1039 **Type-species:** *Cymaclymenia striata* Münster, 1843, p. 11; by original designation.

1040 **Remarks:** Based on large new collections, Klein and Korn (2014) revised the species of  
1041 *Cymaclymenia* from the Anti-Atlas of Morocco; these are endemic and differ from the European  
1042 species (for their review, see Korn, 1981). *Cymaclymenia* is characterized by a suture line showing a  
1043 pointed and asymmetric L lobe, and by a rounded venter.

1044

1045 *Cymaclymenia subvexa* Klein and Korn, 2014

1046 (Figure 12J–N)

1047 1960 *Cymaclymenia striata* – Petter, p. 45, pl. 8, figs 1, 4, 13 (only)

1048 ? 1960 *Cymaclymenia striata* – Petter, p. 45, pl. 7, figs 16, 17, 19 (only)

- 1049 1999 *Cymaclymenia cordata* – Korn, p. 170, pl. 4, fig. 5  
1050 2002 *Procyamclymenia* sp. – Korn and Klug, p. 220, fig. 193d  
1051 2014 *Cymaclymenia subvexa* – Klein and Korn, p. 13, figs 4b, 13, 14  
1052 2017 *Cymaclymenia subvexa* – Korn et al., p. 152, figs 37, 38, table 11

1053 **Material:** 14 specimens from samples On13 and On14 (*Medioclymenia* interval).

1054 **Description:** Specimen On13.27 (not illustrated) has a diameter of 40.25 mm; its conch is  
1055 extremely discoidal (CWI = 0.30) and subinvolute (UWI = 0.21), with a weakly compressed whorl  
1056 cross section (WWI = 0.63) and a high whorl expansion rate (WER = 2.10). The whorl section is oval;  
1057 the venter is rounded and the flanks are slightly converging; the umbilical margin is slightly oblique.  
1058 The growth lines are poorly preserved, but they show a biconvex course. The suture line shows a  
1059 shallow and rounded M saddle; a faint A lobe; and a pointed and asymmetric L lobe. Specimen  
1060 On13.28 (not illustrated) is very similar to On13.27 in conch proportion, ornamentation, and suture  
1061 line shape (D = 39.2 mm; CWI = 0.33; UWI = 0.22; WWI = 0.69). It slightly differs by the presence on  
1062 the body chamber of two backward-projected U-shaped ventral constrictions. Specimen On13.26 (D  
1063 = 35.4 mm; Fig. 12K) has similar conch proportions (CWI = 0.27 and WWI = 0.64). Its suture line  
1064 shows a shallow, wide and rounded M saddle; a very shallow and rounded A lobe; and a very pointed  
1065 and very asymmetric L lobe (Fig. 12L). Specimen On13.24 (Fig. 12J) has a diameter of 33.4 mm; its  
1066 conch is extremely discoidal (CWI = 0.34) and subinvolute (UWI = 0.19), with a weakly compressed  
1067 whorl cross section (WWI = 0.70) and very high whorl expansion rate (WER = 2.30). The whorl section  
1068 is oval; the venter is narrowly rounded and the flanks are slightly converging; the umbilical margin is  
1069 slightly oblique. The growth lines are poorly preserved, but they show a biconvex course. The suture  
1070 line shows a shallow and rounded M saddle; a faint A lobe; and a pointed, but slightly blunt, and very  
1071 asymmetric L lobe (Fig. 12N). Specimen On13.22 has a diameter of 29.0 mm; its conch is extremely  
1072 discoidal (CWI = 0.28) and subinvolute (UWI = 0.27), with a whorl cross section weakly compressed  
1073 (WWI = 0.64). The whorl section is oval and similar to the previously described specimens. The suture  
1074 line shows a shallow and rounded M saddle; a very shallow and rounded A lobe; and a pointed and  
1075 very asymmetric L lobe (Fig. 12M).

1076 **Discussion:** The suture line shape (pointed and strongly asymmetric L lobe) and the conch  
1077 proportions (extremely discoidal and subinvolute conch with a weakly compressed whorl cross  
1078 section) of these specimens are characteristic of the genus *Cymaclymenia*. The specimens closely  
1079 resemble, in conch shape, ornament and suture line, the material described by Klein and Korn (2014)  
1080 in Morocco and by Korn et al. (2017) in Algeria, and can be unambiguously assigned to the species *C.*  
1081 *subvexa*. One specimen (On13.28) slightly differs by the presence of ventral constrictions at the end  
1082 of the growth; this characteristic remind the morphology of some European species such as *C.*  
1083 *silesiaca* (Renz, 1914); but without additional material a firm identification is compromised and this



1084 specimen is here attributed to *C. subvexa*.

1085         **Occurrence:** In the Ouarourout area (Algeria), *Cymaclymenia subvexa* occurs in the  
1086 *Medioclymenia* interval (late Famennian; Fig. 4). Korn et al. (2017) documented *C. subvexa* in two  
1087 localities in Algeria (Ouarourout and Cheffar Ahmar) and recorded it in the *Gonioclymenia*  
1088 assemblage (late Famennian; see Fig. 5). In Morocco, *C. subvexa* occurs in the *Gonioclymenia*  
1089 genozone (Klein and Korn, 2014; see Fig. 5).

1090

1091 FIGURE 12 AROUND HERE

1092

1093         Suborder Clymeniina Edwards, 1849

1094         Superfamily Platyclymenioidea Wedekind, 1914

1095         Family Platyclymeniidae Wedekind, 1914

1096         Subfamily Platyclymeniinae Wedekind, 1914

1097         Genus ***Platyclymenia*** Hyatt, 1884

1098         **Type-species:** *Goniatites annulatus* Münster, 1832, p. 3; by original designation.

1099         **Remarks:** Price and Korn (1989) discussed in details this genus and its German species.  
1100 Interestingly, they pointed out that all named species of the subgenus *Platyclymenia* (*Platyclymenia*)  
1101 could be placed in a continuous range of variation in strength and density of ribs, and shape of the  
1102 whorl section.

1103

1104         ***Platyclymenia annulata*** (Münster, 1832)

1105         (Figure 13A–D)

1106         1832 *Goniatites annulatus* – Münster, p. 3, pl. 6, fig. 6

1107         1914 *Platyclymenia richteri* – Wedekind, p. 34, pl. 3, fig. 1

1108         1960 *Platyclymenia annulata* – Petter, p. 23, pl. 4, figs 4–4a, 7–7a, 9, 10–10a

1109         1960 *Platyclymenia annulata* var. *densicosta* – Petter, p. 24, pl. 4, fig. 5, pl. 5, figs 13–13a, 23

1110         1960 *Platyclymenia richteri* – Petter, p. 25, pl. 4, figs 13–13a

1111         1960 *Platyclymenia richteri* var. *semperornata* – Petter, p. 25, pl. 4, figs 6–6a, 11–11a

1112         1960 *Platyclymenia ruedemanni* var. *semiornata* – Petter, p. 27, pl. 5, figs 12–12a

1113         ? 1960 *Platyclymenia geminicosata* – Petter, p. 26, pl. 5, figs 6–6a

1114         1999 *Platyclymenia annulata* – Korn, pl. 5, figs 2, 3, 10

1115         **Material:** 18 specimens from samples On8 and On10 (*Platyclymenia* interval).

1116         **Description:** Specimen On8.23 (not illustrated) has a diameter of 27.2 mm; its conch is  
1117 extremely discoidal (CWI = 0.26) and evolute (UWI = 0.46), with a weakly compressed whorl cross  
1118 section (WWI = 0.86) and a moderate whorl expansion rate (WER = 1.83). The whorl section is

1119 subrectangular; the venter is slightly tabulate, the ventrolateral margins are narrow and slightly  
1120 angular, and the flanks are subparallel; the umbilical margin is subangular. The ornamentation  
1121 consists of weak, widely spaced (10 ribs per half whorl), prorsiradiate and concave ribs, fading  
1122 toward the ventrolateral margins. The suture line shows a flattened M saddle; and a wide,  
1123 moderately deep and rounded L lobe. Specimen On10.13 (Fig. 13A) has a diameter of 21.7 mm; its  
1124 conch is extremely discoidal (CWI = 0.27) and evolute (UWI = 0.51), with a weakly compressed whorl  
1125 cross section (WWI = 0.97) and a high whorl expansion rate (WER = 1.96). The whorl section is oval to  
1126 subrectangular; the venter is narrowly rounded and the flanks are subparallel; the umbilical margin is  
1127 subangular. The conch shows widely spaced (14 ribs per half whorl), prorsiradiate and concave ribs  
1128 fading toward the venter. The suture line is characterized by a very large, rounded and moderately  
1129 deep L lobe. Specimen On8.16 (not illustrated) has a diameter of 20 mm; its conch is extremely  
1130 discoidal (CWI = 0.31) and subevolute (UWI = 0.40), with a weakly compressed whorl cross section  
1131 (WWI = 0.87) and a moderate whorl expansion rate (WER = 1.93). The whorl section is oval; the  
1132 venter is narrowly rounded, but shows slightly subangular ventrolateral margins, and the flanks are  
1133 subparallel; the umbilical margin is subangular. The conch bears thin, moderately spaced (17 ribs per  
1134 half whorl), prorsiradiate and concave ribs, fading toward the venter. Specimen On10.8 (D = 14.7  
1135 mm; Fig. 13B) has a similar conch geometry (extremely discoidal, CWI = 0.32; subevolute, UWI = 0.43;  
1136 weakly compressed, WWI = 0.98; moderate whorl expansion rate, WER = 1.98; oval whorl section).  
1137 The ribs are characteristically concave, prorsiradiate, and fading toward the venter; but they are  
1138 closely spaced (23 ribs per half whorl). The suture shows a flattened M saddle; and a wide,  
1139 moderately deep L lobe. Specimens On8.31 (Fig. 13C) and On8.35 (Fig. 13D) have a diameter of 17.5  
1140 mm; their conch is extremely discoidal (CWI = 0.27 and 0.28) and evolute (UWI = 0.45 and 0.53), with  
1141 a weakly compressed whorl cross section (WWI = 0.82) and a moderate whorl expansion rate (WER =  
1142 1.98). The whorl section of specimen On8.31 is oval (Fig. 13C); the venter is narrowly rounded and the  
1143 flanks are subparallel; the umbilical margin is rounded and slightly oblique. The conch bears thin,  
1144 moderately spaced (15 ribs per half whorl), prorsiradiate and concave ribs, fading toward the venter.  
1145 The shell is partly preserved and shows thin concave growth lines which are projected backward on  
1146 the venter. The whorl section of specimen On8.35 is subquadrate; the venter is flattened and the  
1147 flanks are subparallel; the umbilical margin is rounded. The conch is smooth and does not show any  
1148 ribs.

1149 **Discussion:** As pointed out by Price and Korn (1989), the genus *Platyclymenia* contains  
1150 numerous species, which differ by very minor differences in ornament, and most of them probably  
1151 should be synonymised. The material studied here cannot enable this revision. This Algerian material  
1152 shows a wide range of morphologies, notably in the thickness and density of ribbing and in the shape  
1153 of whorl sections (circular to subquadrate). Two groups can be distinguished: the first one has a WER

1154 ranging from 1.81 to 2.06 and a UWI ranging from 0.39 to 0.51, and is assigned to *P. annulata*; the  
1155 second one has a WER ranging from 2.04 to 2.26 and a UWI ranging from 0.34 to 0.43, and is  
1156 tentatively assigned to *P. cf. ibnsinai*, which is also characterized by a high whorl expansion rate and  
1157 a narrow umbilicus according to Korn (1999).

1158 **Occurrence:** In the Ouarourout area (Algeria), *Platyclymenia annulata* occurs in the lower  
1159 and middle parts of the *Platyclymenia* interval (late Famennian; Fig. 4). In Morocco, *Platyclymenia*  
1160 *annulata* ranges from its zone to the *Sporadoceras orbiculare* zone (Becker et al., 2002; see Fig. 5).

1161

1162 ***Platyclymenia cf. ibnsinai*** Korn, 1999

1163 (Figure 13E–J)

1164 **Material:** 12 specimens from samples On8, On10, On11 and On12 (*Platyclymenia* interval).

1165 **Description:** Specimen On12.29 has a diameter of 24.6 mm; its conch is extremely discoidal  
1166 (CWI = 0.31) and subevolute (UWI = 0.39), with a weakly compressed whorl cross section (WWI =  
1167 0.84) and a high whorl expansion rate (WER = 2.05). The suture line shows a flat M saddle; and a  
1168 wide, relatively shallow and rounded L lobe (Fig. 13J). Specimen On10.14 (Fig. 13E) has a diameter of  
1169 22.7 mm; its conch is extremely discoidal (CWI = 0.31) and subevolute (UWI = 0.42), with a weakly  
1170 compressed whorl cross section (WWI = 0.94) and a high whorl expansion rate (WER = 2.12). The  
1171 whorl section is oval; the venter is narrowly rounded and the flanks are subparallel; the umbilical  
1172 margin is rounded but slightly subangular. The conch shows widely spaced (13 ribs per half whorl),  
1173 thin, prorsiradiate and concave ribs, fading toward the venter. Specimen On8.38 (Fig. 13H–I) has a  
1174 diameter of 21.8 mm; its conch is extremely discoidal (CWI = 0.27) and subevolute (UWI = 0.40), with  
1175 a weakly compressed whorl cross section (WWI = 0.74) and a high whorl expansion rate (WER =  
1176 2.11). The whorl section is subrectangular; the venter is slightly tabulate (subangular ventrolateral  
1177 margins) and the flanks are subparallel; the umbilical margin is rounded. The ornamentation consists  
1178 of weak, widely spaced, prorsiradiate and concave ribs, fading toward the venter. The suture line  
1179 shows a flattened M saddle; and a wide, moderately deep and rounded L lobe (Fig. 13I). Specimens  
1180 On10.11 (Fig. 13G) and On10.12 (Fig. 13F) have a similar conch geometry (extremely discoidal, CWI =  
1181 0.34; subevolute, UWI = 0.40; weakly compressed, WWI = 0.98; high whorl expansion rate, WER =  
1182 2.12; oval whorl section). These specimens bear thin, prorsiradiate and concave ribs fading toward  
1183 the ventrolateral margins; one has a dense ribbing (On10.12, 22 ribs per half whorl; Fig. 13F), and the  
1184 other one a widely-spaced ribbing (On10.11, 11 ribs per half whorl; Fig. 13G).

1185 **Discussion:** As discussed previously, this group of *Platyclymenia* specimens from Ouarourout  
1186 is tentatively assigned to *Platyclymenia cf. ibnsinai* based on their high whorl expansion rate and  
1187 their narrow umbilicus. However, our material prevents to reach a firm identification, because it is  
1188 restricted to small specimens showing a wide variation in conch proportions, partly overlapping the

1189 range of values of *P. annulata*.

1190         **Occurrence:** In the Ouarourout area (Algeria), *Platyclymenia* cf. *ibnsinai* occurs in the  
1191 *Platyclymenia* interval (late Famennian; Fig. 4). In Morocco, *P. ibnsinai* ranges from the *Platyclymenia*  
1192 *annulata* Zone to the *Cymaclymenia pudica* Zone (Becker et al., 2002; *C. pudica* Zone = time  
1193 equivalent of the *P. ebbighauseni* and *P. dunkeri* zones; see Fig. 5).

1194

1195

1196         Genus ***Trigonoclymenia*** Schindewolf, 1934

1197         **Type-species:** *Clymenia spinosa* Münster, 1842, p. 122; by original designation.

1198

1199         *Trigonoclymenia* cf. *spinosa* (Münster, 1842)

1200         (Figure 13K–M)

1201         **Material:** Seven specimens from samples On8, On10 and On11 (*Platyclymenia* interval).

1202         **Description:** Specimen On10.40 (Fig. 13K) has a diameter of 31.7 mm; its conch is extremely  
1203 discoidal (CWI = 0.31) and evolute (UWI = 0.51), with a weakly depressed whorl cross section (WWI =  
1204 1.23) and a moderate whorl expansion rate (WER = 1.94). The whorl section is subquadrate; the  
1205 venter is slightly flattened (subangular ventrolateral margins) and the flanks are subparallel; the  
1206 umbilical margin is slightly subangular. The ornamentation consists of widely spaced, rectiradiate and  
1207 concave ribs, enlarged on mid-flanks and without crossing the venter; these ribs are projected  
1208 forward on the ventrolateral shoulder, irregularly leading to parabolic nodes. The suture line shows a  
1209 flat M saddle; and a shallow and very large L lobe going forward near the umbilicus (Fig. 13M).  
1210 Specimen On8.22 (Fig. 13L) has a diameter of 19.7 mm; its conch is extremely discoidal (CWI = 0.29);  
1211 and evolute (UWI = 0.49), with a weakly depressed whorl cross section (WWI = 1.04) and a moderate  
1212 whorl expansion rate (WER = 1.82). The whorl section is subquadrate; the venter is flat (subangular  
1213 ventrolateral margins) and the flanks are subparallel; the umbilical margin is subangular. The conch  
1214 bears widely spaced, thin, rectiradiate and concave ribs, projected forward on the ventrolateral  
1215 shoulder, without crossing the venter; some ribs show weak, ventrolateral, parabolic nodes.  
1216 Specimen On10.3 (not illustrated) has a diameter of 14.9 mm; its conch is extremely discoidal (CWI =  
1217 0.34) and evolute (UWI = 0.48), with a weakly depressed whorl cross section (WWI = 1.19) and a  
1218 moderate whorl expansion rate (WER = 1.87). The whorl section is subquadrate; the venter is  
1219 narrowly and the flanks are subparallel; the umbilical margin is oblique. The ornamentation is  
1220 characterized by weak, rectiradiate and concave ribs bearing weak, ventrolateral and parabolic  
1221 nodes.

1222         **Discussion:** Based on the widely-spaced concave ribs bearing ventrolateral parabolic nodes,  
1223 the studied specimens from Ouarourout can be assigned to *Trigonoclymenia*. Many species of

1224 *Trigonoclymenia* have been described; they differ by very minor subtle differences and they may  
1225 constitute transitional forms (see Petter, 1960). The parabolic ribs bearing weak nodes near the  
1226 ventrolateral shoulders are distinctive of *T. spinosa*, but our limited material prevents to reach a  
1227 confident species identification.

1228         **Occurrence:** In the Ouarourout area (Algeria), *Trigonoclymenia* cf. *spinosa* occurs in the lower  
1229 and middle parts of the *Platyclymenia* interval (late Famennian; Fig. 4). In Morocco, *T. spinosa* ranges  
1230 from the *Platyclymenia annulata* Zone to the *Cymaclymenia pudica* Zone (Becker et al., 2002; *C.*  
1231 *pudica* Zone = time equivalent of the *P. ebbighauseni* and *P. dunkeri* zones; see Fig. 5).

1232

1233 FIGURE 13 AROUND HERE

1234

1235         Superfamily Clymenioidea Edwards, 1849

1236         Family Kosmoclymeniidae Korn and Price, 1987

1237         Subfamily Kosmoclymeniinae Korn and Price, 1987

1238         Genus ***Kosmoclymenia*** Schindewolf, 1949

1239         **Type species:** *Planulites undulatus* Münster, 1832, p. 9; by original designation.

1240

1241         ***Kosmoclymenia inaequistriata*** (Münster, 1832)

1242         (Figure 14A–K)

1243         1832 *Planulites inaequistriatus* – Münster, p. 10, pl. 2, fig. 4

1244         ? 1960 *Kosmoclymenia sedgwickii* – Petter, p. 36, pl. 6, figs 1, 3, 6 (only)

1245         1987 *Kosmoclymenia (Kosmoclymenia) inaequistriata inaequistriata* – Korn and Price, p. 29,  
1246 pl. 3, figs 18–21, pl. 4, figs 22–28, text-fig. 13F, G

1247         1999 *Kosmoclymenia inaequistriata* – Korn, pl. 6, fig. 7

1248         ? 2017 *Kosmoclymenia* sp. – Korn et al., p. 137, fig. 17

1249         **Material:** 19 specimens from samples On13 and On14 (*Medioclymenia* interval).

1250         **Description:** Specimen On13.18 (Fig. 14A) has a diameter of 51.1 mm; its conch is extremely  
1251 discoidal (CWI = 0.25) and subevolute (UWI = 0.41), with a weakly compressed whorl cross section  
1252 (WWI = 0.75) and a high whorl expansion rate (WER = 2.12). The whorl section is oval; the venter is  
1253 tabulate and bounded by slight ventrolateral furrows forming a ventral band; the flanks are slightly  
1254 converging; the umbilical margin is rounded and slightly oblique. At a diameter of 40 mm, the venter  
1255 is rounded without ventral band. The last half of the conch shows faint biconvex ribs projected  
1256 backward on the venter. Specimen On14.32 (Fig. 14B) has a diameter of 36 mm; its conch is  
1257 extremely discoidal (CWI = 0.23) and evolute (UWI = 0.46), with a weakly compressed whorl cross  
1258 section (WWI = 0.75) and a high whorl expansion rate (WER = 2.12). At a diameter of 26 mm, the

1259 venter is rounded without ventrolateral furrows. The shell geometry is therefore similar to the  
1260 previous specimen On13.18, but in On14.32 the slight ventrolateral furrows appears earlier. The shell  
1261 shows dense, closely spaced, biconvex growth lines projected backward on the venter. The suture is  
1262 partly visible and shows a typical Z-shaped L lobe. Specimen On13.9 (Fig. 14H) has a diameter of 34.4  
1263 mm; its conch is extremely discoidal (CWI = 0.27) and evolute (UWI = 0.46), with a weakly  
1264 compressed whorl cross section (WWI = 0.86) and a high whorl expansion rate (WER = 2.05). The  
1265 whorl section is oval without slight ventrolateral furrows; the flanks are slightly converging; the  
1266 umbilical margin is rounded and slightly oblique. The shell is characterized by dense, closely spaced,  
1267 biconvex growth lines projected backward on the venter; this ventral projection forms a relatively  
1268 wide ventral band; the growth lines are bunched into groups of approximately six, forming faint ribs.  
1269 Specimen On13.8 (not illustrated) has a diameter of 27.1 mm; its conch is extremely discoidal (CWI =  
1270 0.28) and subevolute (UWI = 0.43), with a weakly compressed whorl cross section (WWI = 0.86) and a  
1271 high whorl expansion rate (WER = 2.23). The whorl section is oval without ventrolateral grooves; the  
1272 flanks are slightly converging; the umbilical margin is rounded and slightly oblique. The shell shows  
1273 dense, biconvex growth lines projected backward on the venter and forming a relatively large ventral  
1274 band; this ventral band shows periodic U-shaped lines corresponding to the growth lines bunched  
1275 into groups of approximately six (for a similar example, see Korn and Price, 1987, pl. 3, fig. 20b).  
1276 Specimen On13.6 (Fig. 14G) has a diameter of 19.5 mm; its conch is extremely discoidal (CWI = 0.30)  
1277 and evolute (UWI = 0.47), with a weakly compressed whorl cross section (WWI = 0.98) and a  
1278 moderate whorl expansion rate (WER = 1.91). The whorl section is oval; the venter is rounded and  
1279 the flanks are subparallel; the umbilical margin is rounded and slightly oblique. The suture line is well  
1280 exposed and shows the typical asymmetric, relatively deep and pointed L lobe, associated to a rather  
1281 flat M saddle. Specimens On13.10 (Fig. 14E, J), On13.7 (Fig. 14F, K), On14.10 (Fig. 14D, I), and On14.7  
1282 (Fig. 14C) show the suture line at various size (from H = 3 to 8.5 mm); it is characterized by a  
1283 relatively flat M saddle, followed by an asymmetric, pointed, Z-shaped L lobe; at the largest size, an  
1284 additional rounded, shallow A lobe is visible.

1285 **Discussion:** The specimens from Ouarourout closely resemble, in conch shape, ornament and  
1286 suture line, the material from Germany and Morocco (see Korn and Price, 1987; Korn, 1999); they  
1287 display the ventral band typical of the genus. *Kosmoclymenia inaequistriata* differ from the closely  
1288 allied *K. lamellosa* by more biconvex and more closely spaced growth lines appearing at a diameter  
1289 of about 15 mm. It differs from other species of *Kosmoclymenia* by a more compressed whorl section  
1290 and by a wider ventral band.

1291 **Occurrence:** In the Ouarourout area (Algeria), *Kosmoclymenia inaequistriata* occurs in the  
1292 *Medioclymenia* interval (late Famennian; Fig. 4). In Morocco, *K. inaequistriata* occurs in the  
1293 *Goniclymenia hoevelensis* and *Kallocalymenia subarmata* zones; the closely related *K. lamellosa* is

1294 older and occurs in the *Costaclymenia muensteri* and *Gonioclymenia subcarinata* zones (Becker et al.,  
1295 2002; see Fig. 5).

1296

1297

1298 Genus ***Muessenbiaergia*** Korn and Price, 1987

1299 **Type species:** *Planulites sublaevis* Münster, 1832, p. 10; by original designation.

1300

1301 ***Muessenbiaergia* cf. *ouarouroutensis*** Korn et al., 2017

1302 (Figure 14L)

1303 **Material:** One incomplete specimen from sample On14 (*Medioclymenia* interval).

1304 **Description:** Specimen On14.36 (Fig. 14L) has a diameter of 47.1 mm; its conch is extremely  
1305 discoidal (CWI = 0.26) and subevolute (UWI = 0.42), with a weakly compressed whorl cross section  
1306 (WWI = 0.71) and a very high whorl expansion rate (WER = 2.28). The whorl section is oval; the  
1307 venter exhibits weak, but distinct ventral grooves, forming a broad ventral keel; the flanks are  
1308 subparallel; the umbilical margin is rounded. At a diameter of 33 mm, the venter is rounded without  
1309 ventral band. The shell is poorly preserved, but partly shows fine, widely spaced and slightly biconvex  
1310 growth lines.

1311 **Discussion:** This specimen from Ouarourout shows a broad ventral keel (only visible in the  
1312 outer whorls) associated to a slightly flattened venter. Its morphology is close to the European  
1313 species *M. sublaevis* (Münster, 1832) and *M. diversa* (Korn and Price, 1987), but the formers have  
1314 more closely spaced growth lines, and a less pronounced ventral band. Nevertheless, specimens  
1315 characterized by this late appearance of a wide ventral keel accompanied with weak ventrolateral  
1316 grooves have been assigned to a new species, *M. ouarouroutensis*, by Korn et al. (2017) based on  
1317 Algerian material from Ouarourout.

1318 **Occurrence:** In the Ouarourout area (Algeria), *Muessenbiaergia* cf. *ouarouroutensis* occurs in  
1319 the *Medioclymenia* interval (late Famennian; Fig. 4). Korn et al. (2017) identified this species in  
1320 Ouarourout within the *Medioclymenia* assemblage (see Fig. 5). In Morocco, *M. diversa* occurs from  
1321 the *Gonioclymenia hoevelensis* to the *Kalloclymenia subarmata* zone, while *M. sublaevis* ranges  
1322 above, up to the *Parawocklumeria patens* zone (Becker et al., 2002).

1323

1324 ***Muessenbiaergia beniabbesensis*** Korn et al., 2017

1325 (Figure 14M–N)

1326 ? 1960 *Kosmoclymenia bisulcata* – Petter, p. 38, pl. 6, figs 2, 7, 8

1327 2017 *Muessenbiaergia beniabbesensis* – Korn et al., p. 139, figs 20, 21, table 7

1328 **Material:** Two specimens from samples On13 and On14 (*Medioclymenia* interval).

1329           **Description:** Specimen On14.35 (Fig. 14M–N) has a diameter of 36.8 mm; its conch is  
1330 extremely discoidal (CWI = 0.24) and moderately evolute (UWI = 0.45), with a weakly compressed  
1331 whorl cross section (WWI = 0.80) and a high whorl expansion rate (WER = 2.17). The venter is  
1332 tabulate with a relatively high and narrow keel, which is bounded by two shallow grooves; the flanks  
1333 are slightly converging; the umbilical margin is rounded and the umbilical wall is slightly oblique. The  
1334 shell is poorly preserved, and partly shows fine, biconvex, rursiradiate growth lines, and faint ribs  
1335 parallel to the growth lines which are fading toward the umbilicus. The suture line (partly visible) is  
1336 characterized by a deep, asymmetric and pointed L lobe (Fig. 14N). The fragmentary specimen  
1337 On13.19 (not illustrated) has a diameter of 33.2 mm; its conch geometry and ornamentation are  
1338 similar to specimen On14.35 (tabulate venter bounded by sharp grooves forming a narrow keel). At a  
1339 diameter of 25 mm, the venter is already keeled, but the ventrolateral furrows are only weakly  
1340 developed leading to a more rounded venter.

1341           **Discussion:** The specimens characterized by the early appearance of a sharp tabulate venter  
1342 bordered by ventrolateral grooves forming a narrow keel are assigned to *Muesseniaergia*  
1343 *beniabbesensis*. Our specimens slightly differ from those figured by Korn et al. (2017) by their higher  
1344 WER (> 2). This species is close to the European group of *M. bisulcata* (see Korn and Price, 1987)  
1345 based on the tabulate venter with sharp ventral furrows; but it differs by the biconvex growth lines  
1346 not projected forward near the umbilicus, and by the absence of a lateral groove at the adult stage  
1347 (Korn et al. 2017).

1348           **Occurrence:** In the Ouarourout area (Algeria), *Muesseniaergia beniabbesensis* occurs in the  
1349 *Medioclymenia* interval (late Famennian; Fig. 4). Korn et al. (2017) also identified this species in  
1350 Ouarourout within the *Medioclymenia* assemblage (see Fig. 5). *M. beniabbesensis* have not been  
1351 reported in Morocco.

1352

1353 FIGURE 14 AROUND HERE

1354

1355           Superfamily Gonioclymenioidea Hyatt, 1884

1356           Family Gonioclymeniidae Hyatt, 1884

1357           Genus ***Gonioclymenia*** Hyatt, 1884

1358           **Type species:** *Goniatites speciosus* Münster, 1831, p. 177; by original designation.

1359           **Remarks:** This genus has been recently revised by Korn (2017) and Korn and Bockwinkel  
1360 (2017) for the European and Moroccan occurrences, respectively. They gave a full discussion about  
1361 this genus, which seems to have different species among these regions. In the Anti-Atlas of Morocco,  
1362 Korn and Bockwinkel (2017) discussed and distinguished six species; three of them have been also  
1363 recognized in Algeria by Korn et al. (2017; *G. wendti*, *G. ali* and *G. spiniger*).



1364

1365 ***Gonioclymenia cf. ali*** Korn and Bockwinkel, 2017

1366 (Figure 15A–B)

1367 **Material:** Eight incomplete specimens from sample On8f (*Gonioclymenia* level).

1368 **Description:** Specimen On8.49 (Fig. 15A) has a diameter of 41.1 mm; its conch is extremely  
1369 discoidal (CWI = 0.23) and subevolute (UWI = 0.41), with a weakly compressed whorl cross section  
1370 (WWI = 0.59) and a relatively high whorl expansion rate (WER = 2.15). At this diameter, the venter is  
1371 sharply concave. The ornamentation consists of weak, dense, prorsiradiate ribs, without  
1372 ventrolateral nodes. Specimen On8.48 (not illustrated) has an estimated diameter of 65 mm and still  
1373 shows weak ribs and a sharp concave venter. At a diameter of 16 mm, the suture lines of specimens  
1374 On8.44 and On8.45 (poorly visible, not illustrated) show a deep V-shaped L lobe; a shallow A lobe;  
1375 and a wide and asymmetric L/U saddle with a curved left-flank. Specimen On8.46 (Fig. 15B) has a  
1376 diameter of 21.7 mm and a stouter conch; it is extremely discoidal (CWI = 0.25) and subevolute (UWI  
1377 = 0.41), with a weakly compressed whorl cross section (WWI = 0.65) and a high whorl expansion rate  
1378 (WER = 2.27). The whorl section is subrectangular; the venter is concave (typical ventral groove) and  
1379 the flanks are slightly converging; the umbilical margin is rounded. The ornamentation consists of  
1380 dense, straight to sinuous, prorsiradiate ribs (16 per half-whorl) extending from the umbilicus to the  
1381 ventrolateral margins where they fade without crossing the venter. The inner whorls are badly  
1382 preserved but show several ventrolateral nodes, which disappear around a diameter of 15 mm.

1383 **Discussion:** The concave venter with a ventral groove in juvenile and intermediate stages,  
1384 and the early disappearance of the ventrolateral nodes are typical of the genus *Gonioclymenia*. The  
1385 specimens from Ouarourout are close to the species *G. ali*, identified in Morocco and in Algeria (Korn  
1386 and Bockwinkel, 2017; Korn et al., 2017). The absence of adult specimens and the poor preservation  
1387 of the sutures within our material prevent to reach a firm conclusion, but the sculpture (coarse ribs;  
1388 small ventrolateral nodes only in juvenile stage) suggests an affinity with *G. ali*. It differs from other  
1389 revised species of *Gonioclymenia* from Morocco by the absence of prominent ventrolateral nodes (in  
1390 contrast to *G. wendti*, *G. spiniger* and *G. ebbighauseni*) and by the development of coarse ribs during  
1391 the middle stage of the growth (in contrast to *G. inornata*); it differs from *G. subcostulata* (Petter,  
1392 1960) by a coarser and a more widely spaced ribbing.

1393 **Occurrence:** In the Ouarourout area (Algeria), *Gonioclymenia cf. ali* occurs in the  
1394 *Gonioclymenia* level (late Famennian; Fig. 4). Korn et al. (2017) identified *Gonioclymenia ali* in  
1395 Ouarourout within the *Medioclymenia* assemblage (see Fig. 5). In Morocco, it occurs in the  
1396 ‘*Gonioclymenia* Limestone’ (Hartenfels and Becker, 2016b; Korn and Bockwinkel 2017); this interval is  
1397 not precisely dated, and can belong to the *Gonioclymenia subcarinata* and/or to the *Gonioclymenia*  
1398 *hoevelensis* zones (see Becker et al., 2002; Korn and Bockwinkel, 2017; Fig. 5).

1399  
1400 Family Costaclymeniidae Ruzhencev, 1957  
1401 Genus *Costaclymenia* Schindewolf, 1920  
1402 **Type species:** *Goniatites binodosus* Münster, 1832, p. 31; by original designation.  
1403 **Remarks:** This genus and the taxonomic problems related to its type species have been  
1404 recently revised by Korn et al. (2018a, b). It appears that most Moroccan occurrences attributed to  
1405 *Endosiphonites muensteri* and its homonym zone (see Becker et al., 2002) belong to the species  
1406 *Costaclymenia ornata* (see Korn et al., 2018c).  
1407  
1408 ***Costaclymenia ornata*** (Petter, 1960)  
1409 (Figure 15G)  
1410 1950 *Costaclymenia binodosa* – Termier and Termier, p. 77, pl. 160, fig. 28.10  
1411 1960 *Trochoclymenia ornata* – Petter, p. 34, pl. 3, figs 1, 2, 4, 7, 8  
1412 1999 *Endosiphonites muensteri* – Korn, p. 161, text-fig. 8A–E, pl. 7, figs 1–3  
1413 2002 *Endosiphonites muensteri* – Becker et al., pl. 5, figs 7, 8  
1414 2018c *Costaclymenia ornata* – Korn et al., p. 36, figs 1–3 [with additional synonymy]  
1415 **Material:** One specimen from a loose block collected just above the sample On12  
1416 (*Costaclymenia* level, sample On12f).  
1417 **Description:** Specimen On12.31 (Fig. 15G) has a diameter of 49.3 mm; its conch is extremely  
1418 discoidal (CWI = 0.20) and evolute (UWI = 0.47), with a weakly compressed whorl cross section (WWI  
1419 = 0.64) and a high whorl expansion rate (WER = 2.10). The whorl section is subrectangular; the venter  
1420 is flat and slightly arched, and the flanks are very slightly converging toward subangular ventrolateral  
1421 margins; the umbilical margin is rounded and slightly oblique. The ornamentation shows moderately  
1422 spaced, weak, ventrolateral riblets (around 20 on the last half whorl, which in the meantime shows  
1423 nine sutures). The suture line shows a very shallow E lobe; a large asymmetric and broadly rounded L  
1424 lobe; and a shallow U lobe.  
1425 **Discussion:** Although a single specimen from Ouarourout is assigned to *Costaclymenia*  
1426 *ornata*, it perfectly fits with the description and the illustrated Moroccan material of Korn et al.  
1427 (2018c), as well as the Algerian material of Petter (1960). Our specimen has a weak ornamentation,  
1428 but the whorl shape and the suture line are clearly characteristic of *C. ornata*; thus, it constitutes a  
1429 slender variant of the species.  
1430 **Occurrence:** In the Ouarourout area (Algeria), *Costaclymenia ornata* seems rare and usually  
1431 found in loose blocks. Nevertheless, it probably occurs in a stratigraphic position equivalent to the  
1432 Moroccan specimens (*Endosiphonites* (= *Costaclymenia*) *muensteri* Zone of Becker et al., 2002),  
1433 between the *Platyclymenia* interval and the *Gonioclymenia* level (late Famennian; see Figs 4–5).

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Family Sphenoclymeniidae Korn, 1992

Genus *Medioclymenia* Korn in Korn and Klug, 2002

**Type species:** *Goniatites intermedius* Münster, 1839, p. 53; by original designation.

***Medioclymenia saourensis*** Korn et al., 2017

(Figure 15C–F)

1960 *Sphenoclymenia intermedia* – Petter, p. 18, fig. 2A, pl. 2, figs 15, 15a, 16

2002 *Sphenoclymenia intermedia* – Becker et al., pl. 5, figs 5, 6

2017 *Medioclymenia saourensis* – Korn et al., p. 146, figs 29, 30, table 9

**Material:** Six specimens from sample On14 (*Medioclymenia* interval).

**Description:** Specimen On14.1 (Fig. 15D, F) has a diameter of 16.7 mm; its conch is extremely discoidal (CWI = 0.22) and subevolute (UWI = 0.41), with a weakly compressed whorl cross section (WWI = 0.62) and a very high whorl expansion rate (WER = 2.39). The whorl section is subtrapezoidal; the venter is flat and the flanks are slightly converging toward subangular ventrolateral margins; the umbilical margin is oblique and rounded. The inner whorls show coarse, distant, spiny ventrolateral nodes (seven per whorl at a diameter of 8 mm), which disappear at a diameter of 10 mm; these nodes influence the shape of the subsequent whorl by preventing embracement of the outer flank, thus leading to a polygonal outline of the umbilicus. At a diameter of 12.8 mm, the suture line shows: a shallow and rounded E lobe; a shallow, rounded and symmetric A lobe; a wide, relatively deep, slightly acute and asymmetric L lobe; and a rounded and shallow U lobe (Fig. 15F). Similarly, specimen On14.40 (Fig. 15C), at an estimated diameter of 45 mm, exhibits a smooth conch with a subtrapezoidal whorl section, and a polygonal umbilicus resulting from spiny ventrolateral tubercles present until a diameter of 13 mm. Specimen On14.39 has a diameter of 43.1 mm; its conch is extremely discoidal (CWI = 0.20) and subevolute (UWI = 0.39), with a weakly compressed whorl cross section (WWI = 0.53) and a very high whorl expansion rate (WER = 2.33). The whorl section is subrectangular; the venter is concave and the flanks are slightly converging toward subangular ventrolateral margins; the umbilical margin is rounded. The concave venter is clearly visible at a diameter of 28 mm, but it progressively flattens toward a diameter of 40 mm. The ornamentation shows only weak prorsiradiate, straight to sinuous folds fading toward the umbilicus and venter. At H = 11.0 mm, the suture line shows a relatively shallow, rounded and symmetric E lobe; a moderately deep, rounded and symmetric A lobe; a deep, rounded and slightly asymmetric L lobe; and a rounded and asymmetric U lobe (Fig. 15E). Specimen On14.41 (not illustrated) has an estimated diameter of about 62 mm. The conch geometry and the ornamentation are similar to the specimen On14.39, but the ventral groove has disappeared and consequently the venter is rounded and slightly convex.

1469 Specimen On14.43 (not illustrated) also shows this rounded and convex venter at an estimated  
1470 diameter of 120 mm. This specimen shows an eroded suture line with a zigzag course constituted of:  
1471 a narrow and deep E lobe; a deep, acute, and narrow A lobe; and an asymmetric and lanceolate L  
1472 lobe.

1473 **Discussion:** These specimens from Ouarourout are close to the European species  
1474 *Sphenoclymenia intermedia*. However, recent material from Algeria showing the typical polygonal  
1475 umbilicus and ventrolateral spines in the inner whorls, as well as a subrectangular whorl section,  
1476 have been assigned to a new species, *Medioclymenia saouensis*, by Korn et al. (2017). The A<sub>2</sub> lobe  
1477 characterizing *S. intermedia* (Petter, 1960; Price and Korn, 1989) cannot be observed in our  
1478 specimens because of their small size. Nevertheless, our material clearly matched the specimens  
1479 figured by Becker et al. (2002) and Korn et al. (2017).

1480 **Occurrence:** In the Ouarourout area (Algeria), *Medioclymenia saouensis* occurs in the  
1481 *Medioclymenia* interval (late Famennian; Fig. 4). Korn et al. (2017) identified this species in  
1482 Ouarourout within the *Medioclymenia* assemblage (see Fig. 5). In Morocco, *M. saouensis* ("*S.*  
1483 *intermedia*") is restricted to the *Gonioclymenia hoevelensis* Zone (Becker et al., 2002; see Fig. 5).

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1485 FIGURE 15 AROUND HERE

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1489

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1759  
1760

1761 Figures

1762

1763 **Fig. 1.** Palaeogeographic map of the Famennian for the North Atlantic region (modified after Korn  
1764 and De Baets, 2015, and based on an image from Ron Blakey, <http://jan.ucc.nau.edu/rcb7/>), with the  
1765 position of major ammonoid localities (MT Montana, OK Oklahoma; DC Devon and Cornwall; RM  
1766 Rhenish Mountains; SU Sudetes; FT Franconia and Thuringia; HC Holy Cross Mountains; SU South  
1767 Urals; CM Cantabrian Mountains; MN Montagne Noire; CA Carnic Alps; AA Anti-Atlas; SV Saoura  
1768 Valley). The map shows the close affinity of Morocco and Algeria during the Devonian, both located  
1769 on the northern Gondwana margin.

1770 *Carte paléogéographique de l'Atlantique Nord au Famennien (modifiée d'après Korn et De Baets,*  
1771 *2015, et basée sur une image de Ron Blakey, <http://jan.ucc.nau.edu/rcb7/>) indiquant la position des*  
1772 *principales localités caractérisées par la présence d'ammonoïdes. La carte montre les affinités étroites*  
1773 *entre le Maroc et l'Algérie, situés sur la marge nord du Gondwana.*

1774

1775 **Fig. 2.** Location of the studied area. The outcrop of Ouarourout (gray star) is located north-west of  
1776 Béni-Abbès (C), in the Saoura Valley (B; background from Google Earth) in Algeria (A; simplified  
1777 geological context modified after Fabre et al., 1978).

1778 *Localisation de la zone d'étude. L'affleurement de Ouarourout (étoile grise) est situé au nord-ouest de*  
1779 *Béni-Abbès (C), dans la vallée de la Saoura (B ; fond d'après Google Earth) en Algérie (A ; contexte*  
1780 *géologique simplifié d'après Fabre et al., 1978).*

1781

1782 **Fig. 3.** Stratigraphic log and views of the Ouarourout section near Béni-Abbès (Saoura Valley, Algeria).  
1783 The numbers On1–On14 refer to the fossiliferous samples containing ammonoids. A, Late Devonian  
1784 strata outcropping as an anticline fold unconformably overlain by Neogene sediments. B, The 'griotte  
1785 limestones' unit. C–D, The 'griotte shaly limestones' unit.

1786 *Colonne stratigraphique et vues de la section de Ouarourout près de Béni-Abbès (vallée de la Saoura,*  
1787 *Algérie). Les numéros On1–On14 font référence aux échantillons fossilifères contenant des*  
1788 *ammonoïdes. A, Dépôts du Dévonien supérieur formant un pli anticlinal recouvert de manière*  
1789 *discordante par des sédiments néogènes. B, Unité des 'calcaires griottes'. C–D, Unité des 'calcaires-*  
1790 *argileux à griottes'.*

1791

1792 **Fig. 4.** Stratigraphic ranges of the ammonoids identified in the Ouarourout section near Béni-Abbès  
1793 (Saoura Valley, Algeria).

1794 *Distributions stratigraphiques des ammonoïdes identifiés au sein de la coupe de Ouarourout près de*  
1795 *Béni-Abbès (vallée de la Saoura, Algérie).*

1796

1797 **Fig. 5.** Correlation of the Moroccan biozonations (Famennian) with the intervals and levels identified  
1798 in the Ouarourout section near Béni-Abbès (Algeria).

1799 *Corrélation des biozonations marocaines (Famennien) avec les intervalles et niveaux identifiés au sein*  
1800 *de la coupe de Ouarourout près de Béni-Abbès (Algérie).*

1801

1802 **Fig. 6.** Explanatory diagram of the classical shell parameters measured for the present study (for  
1803 details see text).

1804 *Schéma explicatif des paramètres classiques de la coquille mesurés pour cette étude (pour plus de*  
1805 *détails, voir le texte).*

1806

1807 **Fig. 7.** Tornoceratidae from Ouarourout (Algeria). Scale bar = 5 mm. **A–D**, *Gundolficeras fezzouense*  
1808 (Becker, 1995); **A**, Specimen On14.16; **B**, Specimen On9.2; **C**, Suture line of On14.16 at H = 16.0 mm;  
1809 **D**, Suture lines of On9.2 at H = 7.5 mm and H = 5.5 mm. **E–L**, *Planitornoceras euryomphalum*  
1810 (Wedekind, 1918); **E**, Specimen On9.9; **F**, Specimen On9.12; **G**, Specimen On9.15; **H**, Specimen  
1811 On8.41; **I**, Suture line of On9.9 at H = 7.3 mm; **J**, Suture lines of On9.15 at H = 5.7 mm and H = 4.5  
1812 mm; **K**, Suture line of On9.12 at H = 4.5 mm; **L**, Suture line of On8.41 at H = 3.0 mm.

1813 *Tornoceratidae provenant de Ouarourout (Algérie). Barre d'échelle = 5 mm. A–D*, *Gundolficeras*  
1814 *fezzouense (Becker, 1995) ; A, Spécimen On14.16 ; B, Spécimen On9.2 ; C, Ligne de suture de On14.16*  
1815 *à H = 16,0 mm ; D, Lignes de suture de On9.2 à H = 7,5 mm et H = 5,5 mm. E–L*, *Planitornoceras*  
1816 *euryomphalum (Wedekind, 1918) ; E, Spécimen On9.9 ; F, Spécimen On9.12 ; G, Spécimen On9.15 ; H,*  
1817 *Spécimen On8.41 ; I, Ligne de suture de On9.9 à H = 7,3 mm ; J, Lignes de suture de On9.15 à H = 5,7*  
1818 *mm et H = 4,5 mm ; K, Ligne de suture de On9.12 à H = 4,5 mm ; L, Ligne de suture de On8.41 à H =*  
1819 *3,0 mm.*

1820

1821 **Fig. 8.** Posttornoceratidae from Ouarourout (Algeria). Scale bar = 5 mm. **A–B**, *Discoclymenia atlantea*  
1822 Korn et al., 2016a; **A**, Specimen On13.12; **B**, Suture line of On13.12 at H = 17.5 mm.

1823 *Posttornoceratidae provenant de Ouarourout (Algérie). Barre d'échelle = 5 mm. A–B*, *Discoclymenia*  
1824 *atlantea Korn et al., 2016a ; A, Spécimen On13.12 ; B, Ligne de suture de On13.12 à H = 17,5 mm.*

1825

1826 **Fig. 9.** Sporadoceratidae from Ouarourout (Algeria). Scale bar = 5 mm. **A–C**, *Sporadoceras* cf.  
1827 *muensteri* (von Buch, 1832); **A**, Specimen On12.19; **B**, Specimen On12.26; **C**, Suture lines of On12.19  
1828 at H = 10.2 mm and at H = 8.4 mm. **D–F**, *Sporadoceras* aff. *conforme* Korn et al., 2015a; **D**, Suture line  
1829 of On4.6 at H = 7 mm; **E**, Specimen On3.7; **F**, Specimen On4.6. **G–M**, *Erfoudites rherisensis* Korn,  
1830 1999; **G**, Specimen On10.41; **H**, Specimen On12.25; **I**, Specimen On12.18; **J**, Suture line of On10.43 at

1831 H = 12 mm; **K**, Suture line of On10.42 at H = 7.3 mm; **L**, Specimen On12.20; **M**, Zoom on the upper  
1832 flank of On12.20 showing the spiral ornament. **N–Q**, *Erfoudites* aff. *spirifer* (Lange, 1929); **N**,  
1833 Specimen On3.2; **O**, Suture line of On3.2 at H = 10 mm; **P**, Suture line of On2.5 at H = 7 mm; **Q**,  
1834 Specimen On2.5.

1835 *Sporadoceratidae* provenant de Ouarourout (Algérie). Barre d'échelle = 5 mm. **A–C**, *Sporadoceras* cf.  
1836 *muensteri* (von Buch, 1832) ; **A**, Spécimen On12.19 ; **B**, Spécimen On12.26 ; **C**, Lignes de suture de  
1837 On12.19 à H = 10,2 mm et à H = 8,4 mm. **D–F**, *Sporadoceras* aff. conforme Korn et al., 2015a ; **D**,  
1838 Ligne de suture de On4.6 à H = 7 mm ; **E**, Spécimen On3.7 ; **F**, Spécimen On4.6. **G–M**, *Erfoudites*  
1839 *rherisensis* Korn, 1999 ; **G**, Spécimen On10.41 ; **H**, Spécimen On12.25 ; **I**, Spécimen On12.18 ; **J**, Ligne  
1840 de suture de On10.43 à H = 12 mm ; **K**, Ligne de suture de On10.42 à H = 7,3 mm ; **L**, Spécimen  
1841 On12.20 ; **M**, Zoom sur le flanc supérieur de On12.20 montrant l'ornementation spirale. **N–Q**,  
1842 *Erfoudites* aff. *spirifer* (Lange, 1929) ; **N**, Spécimen On3.2 ; **O**, Ligne de suture de On3.2 à H = 10 mm ;  
1843 **P**, Ligne de suture de On2.5 à H = 7 mm ; **Q**, Spécimen On2.5.

1844

1845 **Fig. 10.** *Prionoceratidae* from Ouarourout (Algeria). Scale bar = 5 mm. **A–B**, *Prionoceras*  
1846 *ouarouroutense* Korn et al., 2014; **A**, Specimen On11.24; **B**, Specimen On10.31. **C–D**, *Prionoceras*  
1847 *lamellosum* Korn et al., 2014; **C**, Specimen On8.51; **D**, Specimen On8.58. **E–G**, *Prionoceras* aff. *frechi*  
1848 (Wedekind, 1913); **E**, Specimen On10.33; **F**, Specimen On10.34; **G**, Suture line of On10.33 at H = 8.3  
1849 mm. **H–I**, *Prionoceras lentis* Korn et al., 2014; **H**, Specimen On11.20; **I**, Specimen On11.22. **J–K**,  
1850 *Prionoceras* cf. *subtum* Korn et al., 2014; **J**, Specimen On12.13; **K**, Specimen On12.22. **L**, *Prionoceras*  
1851 cf. *triens* Korn et al., 2014, specimen On12.46. **M–N**, *Mimimitoceras* cf. *carnatum* Korn et al., 2015b;  
1852 **M**, Specimen On14.13; **N**, Specimen On13.1. **O–P**, *Mimimitoceras* cf. *comtum* Korn et al., 2015b; **O**,  
1853 Specimen On14.17; **P**, Specimen On13.3.

1854 *Prionoceratidae* provenant de Ouarourout (Algérie). Barre d'échelle = 5 mm. **A–B**, *Prionoceras*  
1855 *ouarouroutense* Korn et al., 2014 ; **A**, Spécimen On11.24 ; **B**, Spécimen On10.31. **C–D**, *Prionoceras*  
1856 *lamellosum* Korn et al., 2014 ; **C**, Spécimen On8.58 ; **D**, Spécimen On8.51. **E–G**, *Prionoceras* aff. *frechi*  
1857 (Wedekind, 1913) ; **E**, Spécimen On10.33 ; **F**, Spécimen On10.34 ; **G**, Ligne de suture de On10.33 à H =  
1858 8,3 mm. **H–I**, *Prionoceras lentis* Korn et al., 2014 ; **H**, Spécimen On11.20 ; **I**, Spécimen On11.22. **J–K**,  
1859 *Prionoceras* cf. *subtum* Korn et al., 2014 ; **J**, Spécimen On12.13 ; **K**, Spécimen On12.22. **L**, *Prionoceras*  
1860 cf. *triens* Korn et al., 2014, Spécimen On12.46. **M–N**, *Mimimitoceras* cf. *carnatum* Korn et al., 2015b ;  
1861 **M**, Spécimen On14.13 ; **N**, Spécimen On13.1. **O–P**, *Mimimitoceras* cf. *comtum* Korn et al., 2015b ; **O**,  
1862 Spécimen On14.17 ; **P**, Spécimen On13.3.

1863

1864 **Fig. 11.** *Cyrtoclymeniidae* from Ouarourout (Algeria). Scale bar = 5 mm. **A–E**, *Cyrtoclymenia* cf. *frechi*  
1865 (Tokarenko, 1903); **A**, Specimen On12.33; **B**, Specimen On10.17; **C**, Suture lines of On10.18 at H = 5

1866 mm and at H = 4 mm; **D**, Specimen On10.18; **E**, Specimen On10.19. **F**, *Protactoclymenia* sp. indet. **B**;  
1867 Specimen On8.3.

1868 *Cyrtoclymeniidae* provenant de Ouarourout (Algérie). Barre d'échelle = 5 mm. **A–E**, *Cyrtoclymenia* cf.  
1869 *frechi* (Tokarenko, 1903) ; **A**, Spécimen On12.33 ; **B**, Spécimen On10.17 ; **C**, Lignes de suture de  
1870 On10.18 à H = 5 mm et à H = 4 mm ; **D**, Spécimen On10.18 ; **E**, Spécimen On10.19. **F**,  
1871 *Protactoclymenia* sp. indet. **B** ; Spécimen On8.3.

1872

1873 **Fig. 12.** *Cymaclymeniidae* from Ouarourout (Algeria). Scale bar = 5 mm. **A–I**, *Procymaclymenia*  
1874 *ebbighauseni* Klein and Korn, 2014; **A**, Specimen On12.44; **B**, Specimen On12.38; **C**, Specimen  
1875 On12.40; **D**, Specimen On12.39; **E**, Suture line of On10.25 at H = 6.5 mm; **F**, Suture line of On12.39 at  
1876 H = 6.5 mm; **G**, Suture line of On12.38 at H = 6.8 mm; **H**, Suture line of On12.40 at H = 6.2 mm; **I**,  
1877 Specimen On10.25. **J–N**, *Cymaclymenia subvexa* Klein and Korn, 2014; **J**, Specimen On13.24; **K**,  
1878 Specimen On13.26; **L**, Suture line of On13.26 at H = 14 mm; **M**, Suture line of On13.22 at H = 15 mm;  
1879 **N**, Suture line of On13.24 at H = 9.8 mm. **O–P**, *Genuclymenia* sp. indet.; **O**, Specimen On9.17; **P**,  
1880 Suture lines of On9.17 at H = 5.5 mm and at H = 3 mm.

1881 *Cymaclymeniidae* provenant de Ouarourout (Algérie). Barre d'échelle = 5 mm. **A–I**, *Procymaclymenia*  
1882 *ebbighauseni* Klein and Korn, 2014 ; **A**, Spécimen On12.44 ; **B**, Spécimen On12.38 ; **C**, Spécimen  
1883 On12.40 ; **D**, Spécimen On12.39 ; **E**, Ligne de suture de On10.25 à H = 6,5 mm ; **F**, Ligne de suture de  
1884 On12.39 à H = 6,5 mm ; **G**, Ligne de suture de On12.38 à H = 6,8 mm ; **H**, Ligne de suture de On12.40 à  
1885 H = 6,2 mm ; **I**, Spécimen On10.25. **J–N**, *Cymaclymenia subvexa* Klein et Korn, 2014 ; **J**, Spécimen  
1886 On13.24 ; **K**, Spécimen On13.26 ; **L**, Ligne de suture de On13.26 à H = 14 mm ; **M**, Ligne de suture de  
1887 On13.22 à H = 15 mm ; **N**, Ligne de suture de On13.24 à H = 9,8 mm. **O–P**, *Genuclymenia* sp. indet. ;  
1888 **O**, Spécimen On9.17 ; **P**, Lignes de suture de On9.17 à H = 5,5 mm et à H = 3 mm.

1889

1890 **Fig. 13.** *Platyclymeniidae* from Ouarourout (Algeria). Scale bar = 5 mm. **A–D**, *Platyclymenia annulata*  
1891 (Münster, 1832); **A**, Specimen On10.13; **B**, Specimen On10.8; **C**, Specimen On8.31; **D**, Specimen  
1892 On8.35. **E–J**, *Platyclymenia* cf. *ibnsinai* Korn, 1999; **E**, Specimen On10.14; **F**, Specimen On10.12; **G**,  
1893 Specimen On10.11; **H**, Specimen On8.38; **I**, Suture line of On8.38 at H = 6.8 mm; **J**, Suture line of  
1894 On12.29 at H = 7 mm. **K–M**, *Trigonoclymenia* cf. *spinosa* (Münster, 1842); **K**, Specimen On10.40; **L**,  
1895 Specimen On8.22; **M**, Suture line of On10.40 at H = 6.5 mm.

1896 *Platyclymeniidae* provenant de Ouarourout (Algérie). Barre d'échelle = 5 mm. **A–D**, *Platyclymenia*  
1897 *annulata* (Münster, 1832) ; **A**, Spécimen On10.13 ; **B**, Spécimen On10.8 ; **C**, Spécimen On8.31 ; **D**,  
1898 Spécimen On8.35. **E–J**, *Platyclymenia* cf. *ibnsinai* Korn, 1999 ; **E**, Spécimen On10.14 ; **F**, Spécimen  
1899 On10.12 ; **G**, Spécimen On10.11 ; **H**, Spécimen On8.38 ; **I**, Ligne de suture de On8.38 à H = 6,8 mm ; **J**,  
1900 Ligne de suture de On12.29 à H = 7 mm. **K–M**, *Trigonoclymenia* cf. *spinosa* (Münster, 1842) ; **K**,



1901 *Spécimen On10.40 ; L, Spécimen On8.22 ; M, Ligne de suture de On10.40 à H = 6,5 mm.*

1902

1903 **Fig. 14.** *Kosmoclymeniidae* from Ouarourout (Algeria). Scale bar = 5 mm. **A–K**, *Kosmoclymenia*  
1904 *inaequistriata* (Münster, 1832); **A**, Specimen On13.18; **B**, Specimen On14.32; **C**, Specimen On14.7; **D**,  
1905 Specimen On14.10; **E**, Specimen On13.10; **F**, Specimen On13.7; **G**, Specimen On13.6; **H**, Growth line  
1906 of On13.9 at H = 10.4 mm; **I**, Suture line of On14.10 at H = 8.5 mm; **J**, Suture line of On13.10 at H =  
1907 8.4 mm; **K**, Suture line of On13.7 at H = 4.5 mm. **L**, *Muessenbiaergia* cf. *ouarouroutensis* Korn et al.,  
1908 2017, specimen On14.36. **M–N**, *Muessenbiaergia beniabbesensis* Korn et al., 2017; **M**, Specimen  
1909 On14.35; **N**, Suture line of On14.35 at H = 8.2 mm.

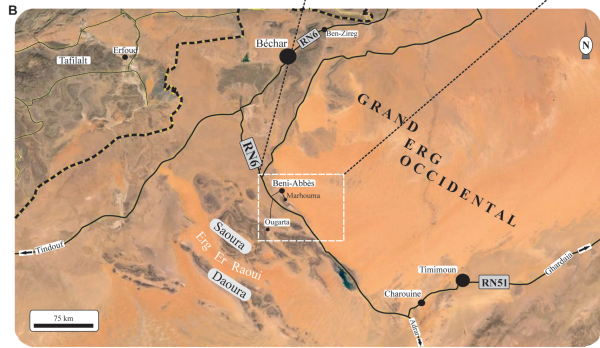
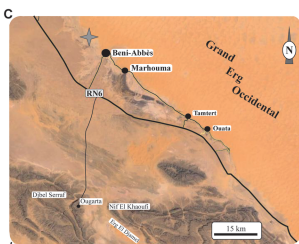
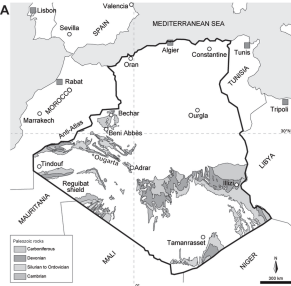
1910 *Kosmoclymeniidae* provenant de Ouarourout (Algérie). Barre d'échelle = 5 mm. **A–K**, *Kosmoclymenia*  
1911 *inaequistriata* (Münster, 1832) ; **A**, Spécimen On13.18 ; **B**, Spécimen On14.32 ; **C**, Spécimen On14.7 ;  
1912 **D**, Spécimen On14.10 ; **E**, Spécimen On13.10 ; **F**, Spécimen On13.7 ; **G**, Spécimen On13.6 ; **H**, Ligne de  
1913 croissance de On13.9 à H = 10,4 mm ; **I**, Ligne de suture de On14.10 à H = 8,5 mm ; **J**, Ligne de suture  
1914 de On13.10 à H = 8,4 mm ; **K**, Ligne de suture de On13.7 à H = 4,5 mm. **L**, *Muessenbiaergia* cf.  
1915 *ouarouroutensis* Korn et al., 2017, spécimen On14.36. **M–N**, *Muessenbiaergia beniabbesensis* Korn et  
1916 al., 2017 ; **M**, Spécimen On14.35 ; **N**, Ligne de suture de On14.35 à H = 8,2 mm.

1917

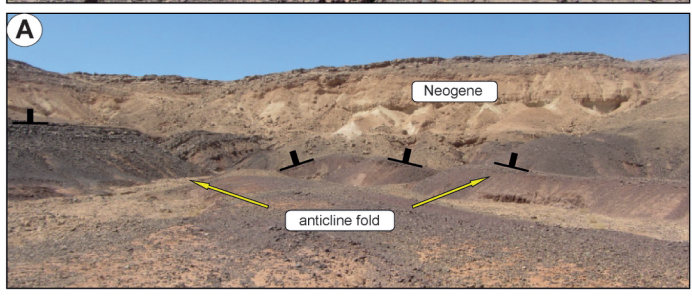
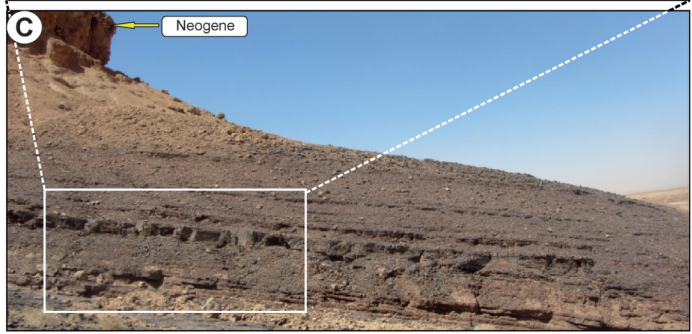
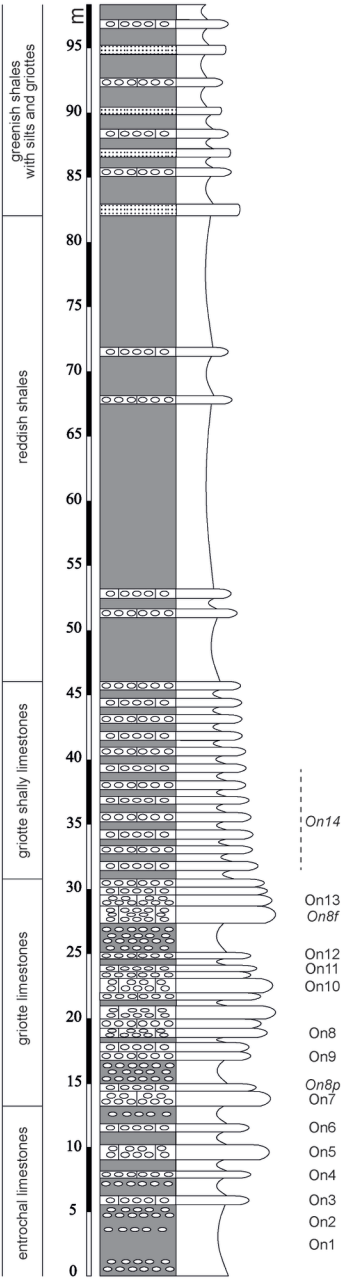
1918 **Fig. 15.** *Gonioclymeniidae*, *Sphenoclymeniidae* and *Costaclymenidae* from Ouarourout (Algeria).  
1919 Scale bar = 5 mm. **A–B**, *Gonioclymenia* cf. *ali* Korn and Bockwinkel, 2017; **A**, Specimen On8.49; **B**,  
1920 Specimen On8.46. **C–F**, *Medioclymenia saourensis* Korn et al., 2017; **C**, Specimen On14.40; **D**,  
1921 Specimen On14.1; **E**, Suture line of On14.39 at H = 11.0 mm. **F**, Suture line of On14.1 at H = 4 mm. **G**,  
1922 *Costaclymenia ornata* (Petter 1960), specimen On12.31.

1923 *Gonioclymeniidae*, *Sphenoclymeniidae* et *Costaclymenidae* provenant de Ouarourout (Algérie). Barre  
1924 d'échelle = 5 mm. **A–B**, *Gonioclymenia* cf. *ali* Korn et Bockwinkel, 2017 ; **A**, Spécimen On8.49 ; **B**,  
1925 Spécimen On8.46. **C–F**, *Medioclymenia saourensis* Korn et al., 2017 ; **C**, Spécimen On14.40 ; **D**,  
1926 Spécimen On14.1 ; **E**, Ligne de suture de On14.39 à H = 11,0 mm ; **F**, Ligne de suture de On14.1 à H = 4  
1927 mm. **G**, *Costaclymenia ornata* (Petter 1960), spécimen On12.31.





# Argiles de Marhouma Formation



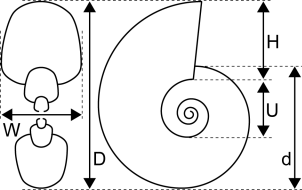
'Argiles de Marhouma' Formation

Formation	Facies	Thickness (m)	Synthetic log	Samples	Ammonoid intervals	
	red shales	50				
	grotite shally-limestones	45				
	grotite limestones	40				
	grotite limestones	35				
	grotite limestones	30				
	grotite limestones	25				
	grotite limestones	20				
	grotite limestones	15				
	grotite limestones	10				
	grotite limestones	5				
	crinoidal limestones	0				
					<p><i>Goniatites fezzouense</i></p> <p><i>Plantormoceras eurycephalum</i></p> <p><i>Disoclymenia atlantica</i></p> <p><i>Sporoboceras aff. conforme</i></p> <p><i>Sporoboceras cf. muelleri</i></p> <p><i>Erfoudites aff. spiniferus</i></p> <p><i>Erfoudites cf. zitensis</i></p> <p><i>Erfoudites rhenensis</i></p> <p><i>Prionoceras lamellosum</i></p> <p><i>Prionoceras aff. frechi</i></p> <p><i>Prionoceras levati</i></p> <p><i>Prionoceras ouaroufense</i></p> <p><i>Prionoceras cf. frens</i></p> <p><i>Mimiboceras cf. carnialium</i></p> <p><i>Mimiboceras cf. coarctum</i></p> <p><i>Proctoclymenia</i> sp. indet. A</p> <p><i>Proctoclymenia</i> sp. indet. B</p> <p><i>Cyrtoclymenia cf. frechi</i></p> <p><i>Gentoclymenia</i> sp. indet.</p> <p><i>Proclymenia ebbighauseni</i></p> <p><i>Cymaclymenia subveza</i></p> <p><i>Platyclymenia annulata</i></p> <p><i>Platyclymenia cf. fibrinosa</i></p> <p><i>Trigonoclymenia cf. spinosa</i></p> <p><i>Kosmoclymenia inaequidistria</i></p> <p><i>Muessembaergia henlibesensis</i></p> <p><i>Muessembaergia cf. ouaroufensis</i></p> <p><i>Gentoclymenia cf. aff.</i></p> <p><i>Medioclymenia saurensis</i></p> <p><i>Costaclymenia ornata</i></p>	
				On14		<i>Medioclymenia</i>
				On13		
				On8f		<i>Gonioclymenia</i>
				On12f		<i>Costaclymenia</i>
				On12		
				On11		
				On10		<i>Platyclymenia</i>
				On8		
			On9			
			On8p			
			On7		<i>Plantormoceras</i>	
			On6			
			On5			
			On4			
			On3			
			On2			
			On1			

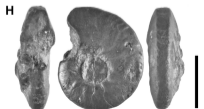
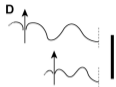
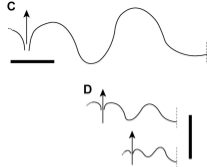
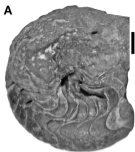
Ammonoid intervals Ouarourout, Algeria (this study)	Ammonoid keys and zones Anti-Atlas (Becker et al. 2013; Hartenfels & Becker 2016a,b)	Ammonoid genozones Anti-Atlas (Klein & Korn 2014)	Prionoceratid zones Anti-Atlas (Korn et al. 2014, 2015a)	Sporadoceratid zones Anti-Atlas (Korn et al. 2015b)	Cymaclymeniid zones Anti-Atlas (Klein & Korn 2014)	Ammonoid assemblages Algeria (Korn et al. 2017)
	UD VI A	<i>Kalliclymenia subarmata</i>	<i>Kalliclymenia</i>	<i>Mimimiceras endocuboide</i> <i>Mimimiceras taouritense</i>	<i>C. aular</i>   <i>C. formosa</i>	
<i>Medioclymenia</i> On14 On13	C	<i>Medioclymenia aguelmousensis</i>				<i>Medioclymenia</i>
	UD V B	<i>Gonioclymenia hoewelensis</i>	<i>Gonioclymenia</i>	<i>Mimimiceras camatum</i> <i>Mimimiceras confum</i>	<i>Cymaclymenia subvexa</i>	
<i>Gonioclymenia</i> On8f	A2	<i>Gonioclymenia subcarinata</i>				<i>Gonioclymenia</i>
<i>Costaclymenia</i> On12f	A1	<i>Costaclymenia muensteri</i>	<i>Endosiphonites</i>	<i>Prionoceras jeranense</i>		
	UD IV C	<i>Sporadoceras muensteri-orbiculare</i>		<i>Prionoceras subtum</i>	<i>Erfudites rheisensis</i>   <i>Sporadoceras muensteri</i>	<i>Procymaclymenia ebbighauseni</i>
<i>Platyclymenia</i> On12 On10 On11	B	<i>Procymaclymenia ebbighauseni</i>	<i>Platyclymenia</i>	<i>Prionoceras ouarouroutense</i> <i>Prionoceras irakibense</i>		
		<i>Protaxyclymenia dunkeri</i>		<i>Prionoceras lamellosum</i>	<i>E. zizensis</i>   <i>Ungosporid unguiforme</i>	
	A	<i>Platyclymenia annulata</i>		<i>Prionoceras vetus</i>		
	UD III C2	<i>Sulcoclymenia sulcata</i>	<i>Sulcoclymenia</i>			
<i>Planitomoceras</i> On4, 5,7,9	C1	<i>Afrolobites</i> sp.	<i>Planitomoceras</i>			
	B	<i>Planitomoceras euryomphalum</i>				
	A	<i>Sporadoceras equale</i>	<i>Maeneceras</i>			

↑ Daaberg Event

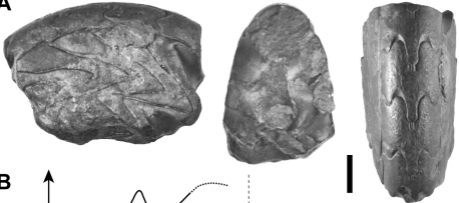
↑ Annulata Event

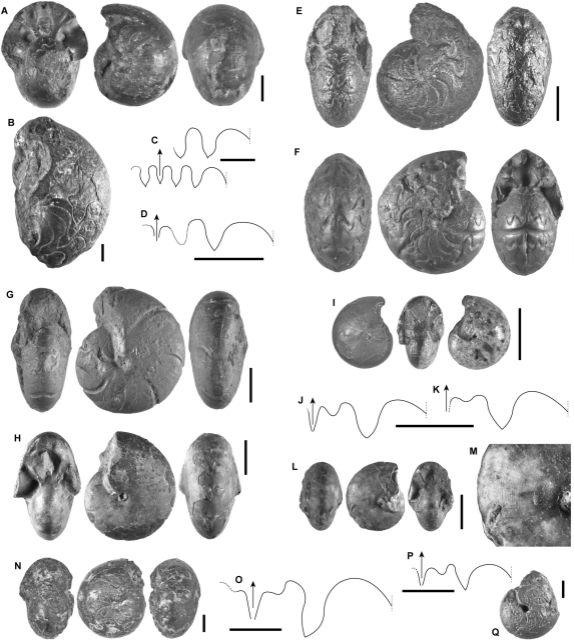


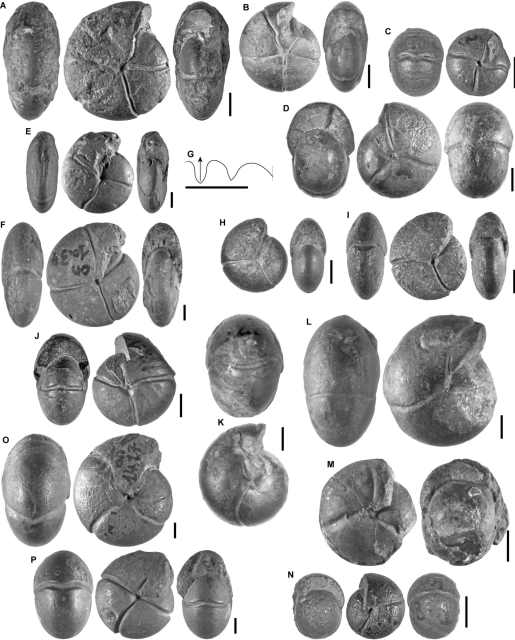
$$\begin{aligned} \text{CWI} &= W / D \\ \text{WWI} &= W / H \\ \text{UWI} &= U / D \\ \text{WER} &= (D / d)^2 \end{aligned}$$

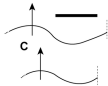
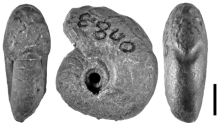


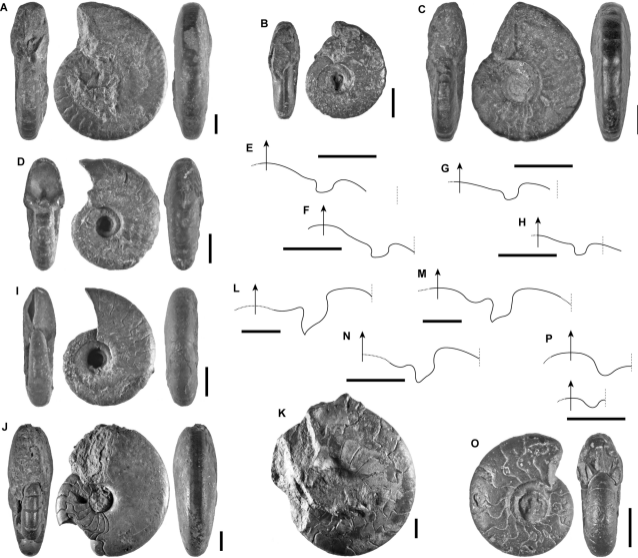


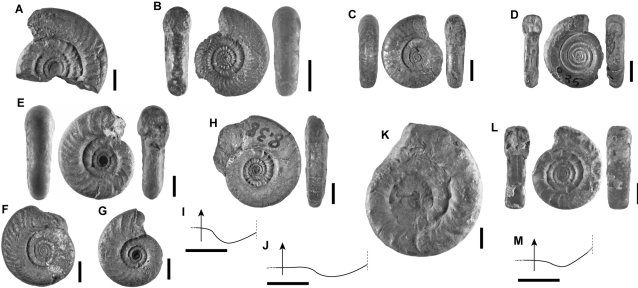
**A****B**

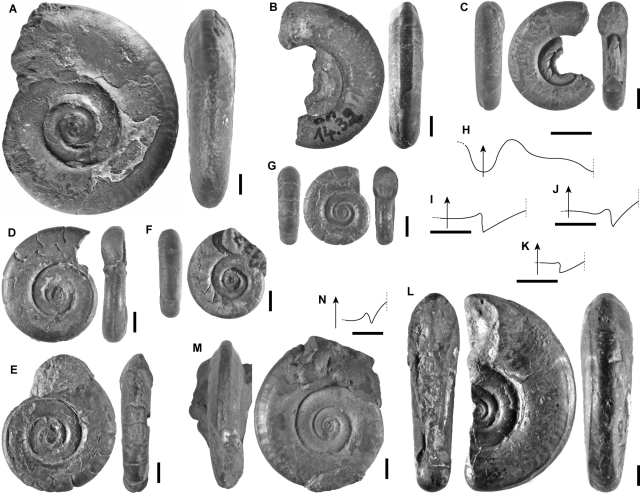




**A****E****B****D****F**







**A****B****C****D****E****F****G**