Taxonomy and taphonomy of Cenomanian (Upper Cretaceous) nautilids from Annopol, Poland

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ABSTRACT:


A nautilid faunule of seven specimens, comprising Eutrephoceras bouchardianum (d’Orbigny, 1840), Cymatoceras deslongchampianum (d’Orbigny, 1840), and Cymatoceras tourtiae (Schlüter, 1876) is described from a condensed middle Cenomanian interval at Annopol, Poland. C. tourtiae is recorded for the first time in Poland. The studied material consists of reworked phosphatised internal moulds of phragmocones, which may be of early or middle Cenomanian age, given the stratigraphic range of the associated ammonites. The nautilid moulds vary in inferred mode of infilling, and in intensity of abrasion, bioerosion and mineralisation. The sediment entered the phragmocones in two ways: 1) through punctures in the shell, the result of bioerosion or mechanical damage; 2) through siphonal openings by intracamerual currents. In contrast to the fossil moulds from the Albian phosphorites of Annopol, which originated via direct precipitation of apatite around and/or inside fossils, the present nautilid moulds seem to have originated through secondary phosphatisation of the initially calcareous moulds. Diversity of taphonomic signatures in nautilid material from the middle Cenomanian interval at Annopol is compatible with the complex, multi-event depositional scenario proposed for this level.

Key words: Nautilids; Condensed deposits; Taphonomy; Cenomanian; Cretaceous; Annopol; Poland.

INTRODUCTION

Cretaceous nautiloids are fairly conservative in terms of evolutionary development (bradytelic), morphologically rather poor in characters and commonly long-ranging in their stratigraphic distribution. Modern systematic and stratigraphic studies on mid-Cretaceous taxa in Europe are comparatively rare (e.g., Frank 2010; Frank et al. 2013) and there are no recent papers at all on the mid-Cretaceous nautilids from Poland. The latest contributions on this latter subject are those by Cieśliński (1959), who described several Albian and Cenomanian taxa from the northern border of the Holy Cross Mountains, Marcinowski (1970) and Marcinowski and Radwański (1983) who described and/or illustrated specimens of Eutrephoceras sublaevigatum (d’Orbigny, 1840) and Cymatoceras deslongchampianum (d’Orbigny, 1840) from the Polish Jura. Additionally, Dzik (1984) figured Pseudocenoceras archiciatom (d’Orbigny, 1840) from the lower Cenomanian of the classic Polish Fossil-Lagerstätte at Annopol.
Renewed interest and exploration of the Annopol site resulted recently in a series of papers on various aspects of the mid-Cretaceous palaeontology (Machalski and Kennedy 2013; Machalski and Martill 2013; Popov and Machalski 2014; Machalski and Ol-szewksa-Nejbert 2015; Bardet et al. 2015; Fraaije et al. 2015; Kapuścińska and Machalski 2015; Kennedy and Machalski 2015). Other studies are in progress. The present note on the taxonomy and taphonomy of a nautilid faunule from a middle Cenomanian at Annopol is another contribution to this project.

GEOLOGIC BACKGROUND

The nautilids studied come from the middle Cenomanian interval of the mid-Cretaceous (uppermost lower Albian–lower Turonian) condensed, phosphorite-bearing succession exposed along the limbs of the Annopol anticline, central Poland (Text-fig. 1A–C). The reader is referred to Machalski and Kennedy (2013) for a more detailed summary of the lithologic development, biostratigraphy and palaeontology of the Annopol succession.
The nautilid-bearing interval (unit 5 in Text-fig. 1A) is very thin and residual in nature, being restricted to the glauconitic marls infilling large burrows and cavities in the underlying lower Cenomanian limestone (unit 4 in Text-fig. 1A). Both burrow infillings and intervening hummocks of the lower Cenomanian limestone are truncated by a complex nodular hardground with strong phosphate and glauconite impregnation (Text-fig. 1C). This is a highly fossiliferous level, yielding numerous phosphatised sponge fragments and phosphatic moulds, more or less incomplete, of diverse gastropods, bivalves, echinoids, nautilids, and ammonites (Samsonowicz 1925, 1934; Marcinowski 1980, Marcinowski and Walaszczyk 1985; Walaszczyk 1987).

According to Marcinowski and Walaszczyk (1985), the ammonite assemblage from this level is composed of numerous lower Cenomanian taxa plus those characteristic of the middle Cenomanian Acanthoceras rhotomagense Zone (with mixed elements of both the Turritilites costatus and T. acutus subzones). Foraminiferal assemblages include the planktonic Rotalipora cushmani, which is a middle to early late Cenomanian form and is compatible with the ammonite-based dating of this unit (Walaszczyk 1987). Given the age-range of the associated ammonites, which are preserved as mineralised moulds, the studied nautilid material is best considered as early to/or middle Cenomanian in age. In general, unit 5 with its mixed remanié phosphatic fossils may be regarded as a local reflection of the so-called mid-Cenomanian eustatic low, distinguished worldwide by Hancock (1990, 2004). The classic regressive Rouen Fossil Bed replete with phosphatised ammonite moulds (Juignet and Kennedy 1976) may be a close analogue. Also, a glauconite-stained “Hg grün” in the Hannover area, for which Ernst et al. (1983) coined the term “Mid-Cenomanian Event”, seems to represent a comparable horizon (see also Wilmsen 2003 and Wilmsen et al. 2005).

### Systematic Palaeontology

Significant contributions to the taxonomy and systematics of post-Triassic nautiloids were presented by Kummel (1956, 1964), Wiedmann (1960), and to some extent by Dzik (1984), while Shimansky (1975) focused mainly on Cretaceous species and their phylogenetic relationships. A series of papers on Upper Cretaceous nautilids of Japan is also important in this respect (Matsumoto 1983; Matsumoto and Miyachi 1983; Matsumoto and Muramoto 1983; Matsumoto et al. 1984a, b). Despite these efforts, classification at the familiar and generic levels is still under debate, especially with respect to the family Cymatoceratidae Spath, 1927 (see discussion in Wilmsen 2000; Wilmsen and Yazykova 2003; Wilmsen and Esser 2004; Frank 2010; and Frank et al. 2013). Herein, we follow Shimansky (1975), placing most of the ‘cymatoceratid’ genera within the family Nautilidae Blainville, 1825 (e.g., Wilmsen 2000; Cichowolski 2003; Frank et al. 2013). Because the present paper is only a short communication, synonymies are kept to a minimum (first reference, regional records, important revisions). Morphological features and terms are used according to Teichert (1964) and measurements, obtained using a Vernier Caliper, of maximum diameter (D), whorl breadth (Wb), whorl height (Wh), and size of umbilicus (U) are given in mm and % of maximum diameter (in brackets; Text-fig. 2). The material is stored in the collections of the Institutte of Paleobiology of the Polish Academy of Sciences, Warszawa (abbreviated ZPAL N.III).

**Order Nautilida Agassiz, 1847**

**Family Nautilidae Blainville, 1825**

**Genus Eutrephoceras Hyatt, 1894**

*TYPE SPECIES: Nautilus dekayi* Morton, 1834 (p. 33, pl. 8, fig. 4).

**Eutrephoceras bouchardianum** (d’Orbigny, 1840)  
(Text-figs 3A–D, 4A, B)

*1840. Nautilus bouchardianus* d’Orbigny, p. 75, pl. 13, figs 1–3.

1891. *Nautilus bouchardianus*, d’Orbigny; Foord, p. 261. [see for pre-1890 synonymies]

1956. Eutrephoceras bouchardianus* (d’Orbigny); Kummel, p. 380.
1960. *Eutrephoceras bouchardianum* (d’Orbigny); Wiedmann, p. 161, pl. 19, figs H, I; pl. 23, fig. J; pl. 24, figs 6–9; text-fig. 6. [see for synonymy]

1975. *Eutrephoceras bouchardianum* (d’Orbigny); Shimansky, p. 60, pl. 5, figs 2–3; text-figs 16–17.

2000. *Eutrephoceras bouchardianum* (d’Orbigny); Wilmsen, p. 38, pl. 4, figs 1a–b, pl. 5, figs 9, 22.

2006a. *Eutrephoceras bouchardianum* (d’Orbigny); Tintant and Gauthier, p. 20, pl. 3, figs 1a–b, 2a–c.

2010. *Eutrephoceras bouchardianum* (d’Orbigny); Fricot, p. 197, fig. 135B.

**TYPE:** Lectotype is specimen LPMP-R4251 (d’Orbigny collection no 5747 A-1, Laboratoire de Paléontologie du Muséum, Paris) from the Albian of Wissant, France (Tintant and Gauthier 2006a).

**MATERIAL:** Two wholly septate internal moulds with parts of the shell preserved (ZPAL N.III/60 and /64).

**Dimensions**

<table>
<thead>
<tr>
<th>Specimen</th>
<th>D</th>
<th>Wb (%)</th>
<th>Wh (%)</th>
<th>Wh/Wb</th>
<th>U (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZPAL N.III/60</td>
<td>76.4</td>
<td>66.5 (87)</td>
<td>50.0 (65)</td>
<td>1.33</td>
<td>occluded</td>
</tr>
<tr>
<td>ZPAL N.III/64</td>
<td>79.2</td>
<td>68.8 (87)</td>
<td>52.2 (66)</td>
<td>1.32</td>
<td>occluded</td>
</tr>
</tbody>
</table>

**DESCRIPTION.** Depressed (Wb/Wh ~ 1.3) nautilid with occluded umbilicus. Greatest whorl breadth is at the umbilical margin from where the flanks converge towards the venter without any ventrolateral shoulder, forming a semi-circular whorl cross-section. The suture is nearly straight and the septa widely separated (there are ca. eight septa in the last half whorl). The position of the siphuncle cannot be established due to matrix covering the last preserved septum. An iron-stained spot in the centre of the septum in ZPAL N.III/60 may indicate its sub-central position.

**REMARKS:** The present specimens correspond well in shell proportions and closed umbilicus as well as simple suture and distant septa to *Eutrephoceras bouchardianum* (d’Orbigny, 1840) as described and illustrated in the literature (e.g., Wiedmann 1960, Shimansky 1975). This is also true when compared to the lectotype of the species from the Albian of Wissant (Pas de Calais, France) as designated and illustrated by Tintant and Gauthier in 2006a (pl. 3, figs 1a, b; Wb = 87%, Wb/Wh = 1.39).

*E. sublaevigatum* (d’Orbigny, 1850) is a similar and also contemporaneous species that already has been reported from the Cenomanian of Poland (Cieśliński 1959; Marciniowski 1970; Marciniowski and Radwański 1983). However, it is less strongly inflated, more evolute and has a reniform whorl cross-section. *E. indicum* (d’Orbigny, 1850) is also more compressed and has a more sinuous suture. *E. sphaericum* (Forbes, 1845), on the other hand, is much more inflated (Wb = 100%, Wb/Wh ~ 1.5) and the latter two species are typically occurring in higher stages of the Upper Cretaceous.

**OCCURRENCE:** *Eutrephoceras bouchardianum* is known from the upper Lower Cretaceous (Albian) of France, Switzerland, and Spain, and the Upper Cretaceous of Spain, Poland, Russia, India and Madagascar (Wiedmann 1960; Cieśliński 1959; Marciniowski 1970; Shimansky 1975; Wilmsen 2000; Fricot 2010).

**Genus Cymatoceras** Hyatt, 1884

**TYPE SPECIES:** *Nautilus pseudoelegans* d’Orbigny, 1840 (p. 70, pl. 8, by original designation).

*Cymatoceras deslongchampsianum* (d’Orbigny, 1840) (Text-figs 3E–H, 4C–E)

*1840. Nautilus deslongchampsianus* d’Orbigny, p. 90, pl. 20, figs 1–4.

*1853. Nautilus deslongchampsianus*, d’Orbigny; Sharpe, p. 12, pl. 3, figs 1a, b, 2.

*1876. Nautilus delongchampsianus*, d’Orbigny; Schlüter, p. 172, pl. 47, figs 7–8.

*1891. Nautilus delongchampsianus*, d’Orbigny; Foord, p. 252. [see for pre-1890 synonymies]

*1956. Cymatoceras deslongchampsianum* (d’Orbigny); Kummel, p. 424, text-fig. 23K.

*1959. Cymatoceras deslongchampsianum* (d’Orbigny); Cieśliński, p. 30, text-fig. 11.

*1970. Cymatoceras deslongchampsianum* (d’Orbigny, 1840). Marciniowski, p. 427, pl. 2, fig. 3a, b.

*2002. Cymatoceras deslongchampsianum* (d’Orbigny); Kennedy, p. 225, text-fig. 10.2a.

*2006b. Pseudocenoceras? deslongchampsianum* (d’Orbigny); Tintant and Gauthier, p. 23, pl. 6, figs 4a–b, 5a–c.

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Text-fig. 3. Nautilids from the middle Cenomanian of Annopol; all figures in natural size. A–D – *Eutrephoceras bouchardianum* (d’Orbigny, 1840), specimen ZPAL N.III/60 in lateral (A, C), apertural (B) and ventral (D) views. E–H – *Cymatoceras deslongchampsianum* (d’Orbigny, 1840), specimen ZPAL N.III/61 in lateral (E, F), apertural (G) and ventral (H) views. I–K – *Cymatoceras tourtiae* (Schlüter, 1876), specimen ZPAL N.III/62 in ventral (I), lateral (J) and apertural (K) views. Unphosphatised interior of the mould is arrowed in A and D.
CRETACEOUS NAUTILOIDS FROM POLAND
TYPE: Lectotype and paralectotype are the specimens LPMP-B46142 and B46143, respectively (d’Orbigny collection no 6104-1 and -2, Laboratoire de Paléontologie du Muséum, Paris), from the Cenomanian of Rouen (Seine-Maritime), France (Tintant and Gauthier 2000b).

MATERIAL: Two wholly septate internal moulds of the inner whorls with some parts of the shell remaining in ZPAL N.III/61 and /65.

Dimensions

<table>
<thead>
<tr>
<th>Specimen</th>
<th>D</th>
<th>Wb (%)</th>
<th>Wh (%)</th>
<th>Wb/Wh</th>
<th>U (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N.III/61</td>
<td>37.5</td>
<td>26.3 (70)</td>
<td>21.6 (58)</td>
<td>1.22</td>
<td>3.8 (10)</td>
</tr>
<tr>
<td>N.III/65</td>
<td>41.7</td>
<td>31.9 (76)</td>
<td>26.3 (63)</td>
<td>1.21</td>
<td>4.1 (10)</td>
</tr>
</tbody>
</table>

DESCRIPTION: Depressed (Wb/Wh ~ 1.2) nautilids with subglobose, involute shell (U = 10%). The deep umbilicus has an oblique, outward-inclined umbilical wall and a sharp umbilical shoulder, which is the point of the greatest whorl breadth. The flanks are slightly flattened and converge towards broadly rounded ventrolateral shoulders. The venter is broad and weakly convex. Strong and sharp ribs arise at the umbilical margin, increase in strength and are prorsiradiate and convex on the flanks and curve backwards across the ventrolateral shoulder, forming a conspicuous ventral concavity. The ribs are feebly broadened at the venter. The suture has a distinct saddle at the umbilical shoulder, a broad lateral lobe, a low saddle at the ventrolateral shoulder and a broad shallow ventral lobe. The siphuncle is not visible.

REMARKS: The ornament, shape of suture and the conspicuous, sharp-rimmed conical umbilicus show the Annopol specimens to be Cymatoceras deslongchampsianum (d’Orbigny, 1840). Tintant and Gauthier (2006b) placed the species with doubt in Pseudocenoceras Spath, 1927 and designated a lectotype (specimen LPMP-B46142 from the Cenomanian of Rouen, Seine-Maritime, France, illustrated on pl. 6, fig. 4a, b). However, we do not follow this generic assignment because Spath’s genus comprises compressed forms without ornament. Matsumoto in Matsumoto and Muramoto (1983) erected a new genus Eurocymatoceras nov. gen. with Nautilus deslongchampsianus d’Orbigny, 1840 as type species. However, the minor differences to Cymatoceras in the shell form and suture are not sufficient for the establishment of a new genus in our view. Nautilus archiacianus d’Orbigny, 1840 (p. 91, pl. 21, figs 1–4), also from the Cenomanian of Rouen [Pseudocenoceras? archiacianum (d’Orbigny, 1840) in Tintant and Gauthier 2006c] differs from C. deslongchampsianum only in the absence of ornament but shares the same shell proportions, suture shape and position of the siphuncle as well as the conspicuous conical umbilicus. The presence/absence of ornament in (Cretaceous) nautilids may strongly depend on taphonomic processes (e.g., Frank et al. 2013), and Tintant and Gauthier (2006c, p. 23) already indicated the possibility that the two taxa are conspecific. Both taxa have now also been reported from Annopol because Dzik (1984, pl. 47, fig. 9a, b, 10a, b) illustrated Pseudocenoceras archiacianum (d’Orbigny, 1840) from the lower Cenomanian of Annopol. C. deslongchampsianum has also been reported from the Cenomanian of the northern border of the Holy Cross Mountains, including the Annopol area, by Cieśliński (1959) and Marcinowski (1970).
**OCCURRENCE:** Cenomanian of England, France, Switzerland, Germany and Poland (e.g., Foord 1891; Cieśliński 1959; Kennedy 2002).

_Cymatoceras tourtiae_ (Schlüter, 1876) (Text-figs 3I–K, 4F, G)

1876. _Nautilus tourtiae_, sp. n. Schlüter, p. 170, pl. 46, figs 1–4.

1956. _Cymatoceras tourtiae_ (Schlüter); Kummel, p. 426, text-fig. 23C.

1975. _Cymatoceras tourtiae_ (Schlüter); Shimanski, p. 90, 91.

?1999. _Cymatoceras tourtiae_ (Schlüter); Wittler et al., p. 10, text-figs 8–12.

2002. _Cymatoceras tourtiae_ (Schlüter); Kennedy, p. 228, text-fig. 10.2D.

**TYPE:** The specimen STIPB-Schlüter-94, illustrated by Schlüter (1876) on pl. 46, figs 1 and 2, hosted in the Goldfuss-Museum, University of Bonn, is designated as lectotype herein.

**MATERIAL:** Three fully septate internal moulds (ZPAL N.III/62, /66 and /67).

<table>
<thead>
<tr>
<th>Specimen</th>
<th>D</th>
<th>Wb (%)</th>
<th>Wh (%)</th>
<th>Wb/Wh</th>
<th>U (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N.III/62</td>
<td>86.9</td>
<td>~52 (60)</td>
<td>48.0 (55)</td>
<td>1.08</td>
<td>12.5 (14)</td>
</tr>
<tr>
<td>N.III/66</td>
<td>80.8</td>
<td>51.7 (64)</td>
<td>47.7 (59)</td>
<td>1.08</td>
<td>8.2 (10)</td>
</tr>
<tr>
<td>N.III/67</td>
<td>33.5</td>
<td>21.8 (65)</td>
<td>20.1 (60)</td>
<td>1.08</td>
<td>3.8 (11)</td>
</tr>
</tbody>
</table>

**DESCRIPTION:** Slightly depressed (Wb/Wh = 1.08) nautilids with open, deep and relatively large umbilicus (U = 10–14%). The umbilical wall is overhanging and the umbilical shoulder narrowly rounded. The whorl cross-section is trapezoidal, with greatest breadth on the lower flanks, just outside the umbilical shoulder. The flanks are flat to feebly concave and converging towards the rounded ventrolateral shoulder. The venter is broad and weakly convex. There are weak ribs on the outer flanks and the venter. They are convex across the ventrolateral shoulder and form a concave arc across the venter. On the last preserved half whorl, every third or fourth rib is slightly strengthened, producing weak folds on the ventrolateral shoulder and venter. The suture shows a weak saddle at the umbilical shoulder and the lower flank, followed by a broad lateral lobe. It is nearly straight across the venter. The siphuncle is close to the dorsal margin of the septum.

**REMARKS:** The trapezoidal, slightly depressed whorl cross-section, the ribbing pattern and the dorsal position of the siphuncle indicate the Annopol specimens to be _Cymatoceras tourtiae_ (Schlüter, 1876). The specimens described and illustrated by Wittler et al. (1999) from the Cenomanian Essen Grünsand Formation of the Münsterland Cretaceous Basin (Germany), a unit of glauconitic nearshore sediments, are placed in _C. tourtiae_ only with doubt because they are very inflated, subglobose and have nearly closed umbilici. The lower Cenomanian specimen from the “Chalk with siliceous grains” of Chardstock (England) illustrated by Sharpe (1853, pl. 5, fig. 1a, b) as “Nautilus radiatus Sow.” and referred to _Cymatoceras deslongchampsianum_ (d’Orbigny) by Wright and Wright (1951, p. 33) is close to Schlüter’s species based on its relatively fine and dense ribbing and general shell form but may differ slightly in more involute coiling and position of the siphuncle (Schlüter 1876, p. 171).

**OCCURRENCE:** _Cymatoceras tourtiae_ is known from the Cenomanian of England, France, and Poland (first record herein).

**TAPHONOMY**

The nautilid specimens studied are preserved as internal moulds, occasionally with phosphatised shell remnants still adhering to their surface. Seven better preserved specimens, which form a basis of the taxonomic part of this study (Text-fig. 3A–K) are more or less intact phragmocones without body chambers. These specimens display phosphatic and glauconite mineralisation, corroded and abraded surfaces, occasional borings and encrusters (not figured here), and signs of physical damage. These are taphonomic signatures typical for phosphatic _remanié_ fossil assemblages described e.g., from the basal Cenomanian Glauconite Marl of south-east England (Kennedy and Garrison 1975), testifying to their formation through repeated cycles of cementation, mineralisation, burial and re-exposure (_op. cit._). In view of the stratigraphic range of the associated
amonites in phosphate preservation (see above), these cycles may represent an extended time interval from early to middle Cenomanian. On the other hand, it should be noted that similar taphonomic alterations including epizoan encrustation, shell damage, traces of boring organisms and sediment filling of the phragmocones have been observed in varying degrees in modern Nautilus shells from New Cale-
donia with resting times on the sea-floor of only between 14–42 years (Mapes et al. 2010).

One specimen (Text-fig. 3A–D) displays an internal, white limestone infilling of chambers under a phosphatic crust covering its surface. This suggests secondary phosphatisation of an originally calcareous mould, compatible with the classic replacement model proposed for the Glauconitic Marl specimens by Kennedy and Garrison (1985). There is thus a difference between the present material and the phosphatic moulds of fossils recovered from the upper Albian unit 3 at Annopol (Machalski and Olszewska-Nejbert 2015; see Text-fig. 1A for position of this level in the section). These latter formed through direct precipitation of apatite around and/or inside fossils (Machalski and Olszewska-Nejbert 2015).

Two moulds of indeterminate nautilids from unit 5 have been sectioned in order to study their internal structure and the fabric of the infill. These specimens illustrate different taphonomic histories. Specimen ZPAL N.III/58 (Text-fig. 5 A, B) is more complete, retaining part of the body chamber. It has been filled by two generations of internal sediment which is patchy in distribution and lacks internal lamination. This suggests that the sediment entered this shell via the aperture and punctures in the shell. These holes could be caused by physical damage or bioerosion, as documented for the ammonite and nautilid moulds from the Maastrichtian of Western Australia (Henderson and McNamara 1985; see also Mapes et al. 2010, p. 607, for data on infilling of modern Nautilus shells).

Specimen ZPAL N.III/59 (Text-fig. 5C, D) is a strongly phosphatised fragment of a single whorl of a phragmocone. Zones of phosphatised matrix with incorporated older phosphatic intraclasts adhere to the phragmocone. Boundaries between the phragmocone and surrounding phosphatic matrix are marked by distinct zones of glauconite impregnation (arrowed in Text-fig. 5C). Borings filled with white, unphosphatised sediment are clearly visible, both on the external surface of the specimen and in the cross-section (arrowed in Text-fig. 5C, D). The specimen thus bears evidence for multiphase growth and reworking, representing a typical "Hiatus-Konkretion" (hiatus concretion) in the sense of Voigt (1968).

Information about the infilling scenario of ZPAL N.III/59 is provided by internal lamination visible in several chambers, which is picked up by differences in size and density of glauconite grains (pellets) (arrowed in Text-fig. 5D). These suggest a different mode of sediment entry into the shell than that for the ZPAL N.III/58, namely by intracameral currents introducing the sediment through siphonal openings into successive chambers (see discussion and references in Kennedy and Garrison 1975).

SUMMARY

Phosphatised internal moulds of *Eutrephoceras bouchardianum* (d'Orbigny, 1840), *Cymatoceras deslongchampsianum* (d'Orbigny, 1840) and *Cymatoceras tourtiae* (Schlüter, 1876) are described here from a highly condensed middle Cenomanian interval at Annopol. The last-named species is recorded from Poland for the first time. Given the age-range of the associated ammonites, the studied nautilid material is early to/middle Cenomanian in age.

Previous workers proposed a multi-event depositional scenario for this unit, which involved several episodes of reworking, phosphatisation and burial of fossils (Marcinowski and Walaszczyk 1985, fig. 2). The taphonomical analysis of the nautilid material generally supports these conclusions. Observed variation of the taphonomic signatures in the present material is compatible with heterogeneity of the fossil assemblages from unit 5 and its multi-event history proposed by Marcinowski and Walaszczyk (1985).

Acknowledgements

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