A small faunule of nautiloids is described from the upper Campanian Bahiya Coquina Member of the Al-Hisa Phosphorite Formation of north-western Jordan. It consists of *Eutrephoceras sphaericum* (Forbes, 1845), *Cimomia desertora* (Quaas, 1902) and a specimen assigned to Hercoglossidae indet. in open nomenclature. *E. sphaericum* and *C. desertora* are reported for the first time from Jordan. The present records further complement the information on the temporal and spatial distribution of nautiloids at the southern margin of the Neotethyan Ocean during the late part of the Cretaceous Period.

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1. Introduction

Cretaceous nautiloids are commonly long-ranging in their stratigraphic distribution, morphologically rather limited in external shell characters and often poorly preserved. Furthermore, they tend to be fairly conservative in terms of evolutionary development (bradytelic) compared to the contemporaneous, fast-evolving ammonites (e.g., Ward and Signor, 1983). It is also due to these shortcomings that comprehensive modern systematic accounts on Cretaceous taxa are very rare.

Up to now, there are very few records of nautiloids from Jordan. Bender (1963) and Wolfart (1968) mentioned Lower Silurian nautiloids from southern Jordan, east of the Hejaz railroad. In an unpublished report, LeBlanc (2019) reported the occurrence of some nautiloid fragments and a cephalopod jaw from the Middle Eocene (Lutetian) Wadi Shallalah Formation at Wadi Al-Rijla Al-Bayda, Eastern Desert of Jordan. Cretaceous taxa have, to the best of our knowledge, only marginally been mentioned in papers dealing with other aspects (e.g., Wiese and Schulze, 2005, p. 944). Therefore, we document herein a small faunule of rather well-preserved nautiloids that has been collected from the lower part of the upper Campanian to lower Maastrichtian Al-Hisa Phosphorite Formation that crops out at Deir Abu Said, north-western Jordan (Fig. 1). The scope of the present short contribution is to enhance the knowledge on the stratigraphic and palaeogeographic distribution of nautiloids at the southern margin of the Neotethyan Ocean during the late phase of the Cretaceous Period.

2. Geological setting and stratigraphy

The study area was located at the southeastern margin of the Neotethyan Ocean at tropical palaeolatitudes (Fig. 1A). Several compressional features formed during the Campanian–Maastrichtian (Bowen and Jux, 1987; Guiraud and Bosworth, 1997; Walley, 2001; Abed, 2013). There is general agreement that the major tectonic pulse of this Syrian Arc system took place during the Campanian–Maastrichtian (Bowen and Jux, 1987; Guiraud and Bosworth, 1997; Walley, 2001; Abed, 2013). Campanian–Maastrichtian strata are widely distributed in central, southern and northern Jordan (Blankenhorn, 1903; Masri, 1963; Bender, 1974; Hiyari, 1985; Abed, 2013; Khrewesh et al., 2014; Ahmed et al., 2014).

Blankenhorn (1903) was the first to describe phosphate deposits in Jordan, 16 km northwest of Amman. The Al-Hisa
Fig. 1. Geologic and stratigraphic framework. A, Campanian palaeogeographic and plate tectonic situation (modified after Barrier and Vrielynck, 2008). The map area of Fig. 1B is outlined and the nautiloid occurrences according to the records cited in the taxonomic descriptions are indicated. B, Location map of the studied section, north-western Jordan. C, Stratigraphic section of the upper Campanian–Maastrichtian sequence at Deir Abu Said, north-western Jordan.
Phosphorite Formation, named after the type area of Al-Hisa in Central Jordan (Hiyari, 1985), is equivalent to the upper part of Calcaires silex (Wetzel and Morton, 1959), the upper part of the Amman Formation (Masri, 1963; Parker, 1970) as well as the upper part (unit B2b) of the B2 Silicified Limestone and Phosphorite Formation, and the phosphorite member of Bender (1974). Isolated outcrops of this formation are also known from the area of Deir Abu Said which is located north of Amman (Fig. 1B). The Al-Hisa Phosphorite Formation includes three formal members which are, in ascending order, the Sultani Phosphorite, the Bahiya Coquina, and Qatrana Phosphorite members (Fig. 1C). Lithologically, the Al-Hisa Phosphorite Formation is composed of alternating beds of phosphatic chert, phosphatic limestone, phosphate, chalky limestone, micritic limestone, marl, and cross-bedded oyster beds (coquinas). The facies suite was interpreted to be deposited in shallow marine subtidal to intertidal environments (Moumani, 2002). The collected and described nautiloids come from the Bahiya Coquina Member, which is approximately 6 m thick in the study area (Fig. 1C).

The Bahiya Coquina Member is characterized by large-scale cross-bedded, graded beds of shelly limestone with abundant well-preserved oysters along with abundant phosphatic layers containing the studied nautiloids. The member also contains well-preserved bivalves (mainly oysters), gastropods and ammonoids (Libycoceras spp. and Baculites sp.) as well as fish teeth and poorly preserved fish fragments. The ranges of the ammonoid taxa provide the basis for a twofold division of the upper Campanian Bahiya Coquina Member with the biozones of Libycoceras spp. (below) and Baculites sp. (above, Fig. 1C). The specimens of Libycoceras from northern Jordan, originally assigned to *L. ismaelis* (Zittel) by Galmed et al. (2013), have been re-determined as *L. crosensis* Zaborski and *L. afikpoense* Reynet based on their sutures and shell morphologies by Ifrim (2017), supporting a late Campanian age. Well-dated *L. ismaelis*, however, are inferred to be always derived from Maastrichtian strata (Ifrim, 2017). The stratigraphic interpretation of the nautiloid find layer as upper Campanian is supported by an early Maastrichtian age assignment of the overlying Muwaqqar Formation (Farouk et al., 2014; Ahmad et al., 2015).

The age of the phosphorite deposits of Jordan has been controversially discussed in the past. Authors such as Burdon (1959), Hamam (1977), Abed and Ashour (1987), and Capetta et al. (1996) assigned an early Maastrichtian age whereas others suggested a late Campanian age (Bender, 1974; Pufahl et al., 2003; Powell and Moh’d, 2011; Galmed al., 2013; Abed, 2013). The Al-Hisa Phosphorite Formation was assigned a Campanian age by Wetzel and Morton (1959), and Campanian–Maastrichtian by Bender (1974). Reiss et al. (1985) allocated the reported ammonites *Libycoceras* sp. and *Anaklinoceras reflexum* Stephenson to the late Campanian (see also Lewy, 1986).

### 3. Systematic palaeontology

Cretaceous nautiloids are morphologically fairly poor in diagnostic external shell features, bradytelic in their macroweometry, and commonly long-ranging. Furthermore, they are often poorly preserved, especially in carbonate facies, where their fossil record is mostly restricted to internal moulds of very variable preservational quality (Malchyk et al., 2017). Consequently, the group is rather poorly known and only a few synoptic modern works on their systematics and taxonomy exist (e.g., Baudouin et al., 2016). Important contributions to post-Triassic nautiloids were presented by Kummel (1956, 1964), Wiedmann (1960) and Dzik (1984), Shimansky (1975) and Matsumoto et al. (1984) focused on Cretaceous species and their phylogenetic relations. However, in spite of these important groundworks, classification at the family and genus levels is still controversially discussed, especially with respect to ribbed representatives of the family Cymatoceratidae Spath, 1927 (e.g., see Wilmsen, 2000; Chichowolski, 2003; Wilmsen and Zaborski, 2003; Wilmsen and Esser, 2004; Frank, 2010; Frank et al., 2013; Machalski and Wilmsen, 2015; Lehmann et al., 2017). Herein, we follow the classification of Shimansky (1975) with the exception that we regard the genus *Deltoidonautilus* Spath, 1927 as a synonym of *Angulites* de Montfort, 1808.

The present paper is only a short communication, thus, the synonymies are limited to a minimum (first reference, regional records, important revisions). Morphological features and terms are used according to Teichert (1964), Biometric measurements of maximum diameter (D), whorl breadth (Wb), whorl height (Wh), and size of umbilicus (U) were obtained using a Vernier Caliper and are given in mm and % of maximum diameter (in brackets; Fig. 2). The material is stored in the collections of the Geological Museum, Cairo University (repository CUGM/JCAM).

**Order Nautilida Agassiz, 1847**

**Superfamily Nautilioidea** Blairville, 1825

**Family Nautilidae** Blairville, 1825

**Genus Eutrephoceras Hyatt, 1894.**

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

*Eutrephoceras sphæricum* (Forbes, 1845)

**Figs. 3A, 4A**

Fig. 2. Taxonomically important features and biometric parameters of the planispiral nautiloid shell.

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*1845* *Nautilus sphæricus* sp. nov., Forbes, p. 98.

1891 *Nautilus sphæricus* Forbes — Foord, p. 298.

1956 *Eutrephoceras sphæricum* (Forbes) 1846 — Kummel, p. 383.

1960 *Eutrephoceras sphæricum* (Forbes) — Wiedmann, p. 170, pl. 18, figs. D–G, pl. 23, figs. G, M, N.

1960 *Eutrephoceras sphæricum* geinitzi n. ssp. — Wiedmann, p. 171.

1985 *Eutrephoceras sphæricum* geinitzi Wiedmann, 1960 — Klingcr, p. 3, text-fig. 3A–E.

2016 *Eutrephoceras sphæricum* (Forbes, 1845) — Wilmsen, p. 62, pls 4c, 5, text-fig. 2a.
**Material.** One fully septate internal mould (CUGM/JCAM 49).

<table>
<thead>
<tr>
<th>Specimen</th>
<th>D</th>
<th>Wb (%)</th>
<th>Wh (%)</th>
<th>Wb/Wh</th>
<th>U (%)</th>
</tr>
</thead>
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<tr>
<td>CUGM/JCAM 49</td>
<td>69</td>
<td>69 (100)</td>
<td>48 (70)</td>
<td>1.44</td>
<td>Occluded</td>
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</table>

**Dimensions.**

Description. Globular, strongly depressed (Wb/Wh = 1.44) nautilid with occluded umbilicus. During ontogeny, whorl breadth increases rapidly, forming a globular conch in which Wb is approximating D. The whorl cross-section is transverse elliptical and the venter broadly rounded. The suture is nearly straight with only weak undulations while the distance of septa is rather low. The position of the siphuncle cannot be seen.

Remarks. *Eutrephoceras sphaericum* is a very inflated nautilid species with Wb/D = 1 (e.g., Forbes, 1845; Wiedmann, 1960). In association with the simple suture it can thus be well separated from contemporaneous less inflated nautilids. Our specimen is very close in sagittal section to the holotype in Forbes (1845, p. 98, see Fig. 4A). Also the Wb/D ratio of 0.7 is very close to data given for this species in the literature (Wiedmann, 1960, p. 170). However, it should be noted that *E. dekayi* (Morton) is a fairly similar and contemporaneous nautilid species in which Wb/D can approach a ratio of 1, too. Mainly known from the upper Campanian–Maastrichtian of the Cretaceous of the Western Interior Seaway in North America (e.g., Sohl and Koch, 1983), the species has also been reported from northern Africa by Wanner (1902, p. 142) from strata contemporaneous to the find layers in Jordan, unfortunately without illustration. As we did not trace Wanner’s specimens, we cannot finally conclude on the taxonomic affinity of his material, and an examination of a potential specific concordance of *E. dekayi* and *E. sphaericum* is beyond the scope of the paper.

On the basis of a single specimen from the Turonian of Saxony (Germany), Wiedmann (1960, p. 171) introduced a new subspecies, *Eutrephoceras sphaericum* geinitzi n. ssp. However, the differences to the nominate subspecies, *E. sphaericum* sphaericum, are very subtle (shallow external lobe vs. shallow external saddle) and prone to be influenced by taphonomic processes (Wilmersen, 2016). Furthermore, we feel that the separation of subspecies in morphologically poorly differentiated and long-ranging Cretaceous nautiloids is pointless in general. Thus, we refrain from separating any subspecies in *E. sphaericum*.

**Occurrence.** The species ranges from the Cenomanian to the Maastrichtian (Wiedmann, 1960, fig. 26) and has so far been reported from India, Europe, South Africa and possibly Madagascar (Fig. 1A). The present study is the first documentation of *Eutrephoceras sphaericum* (Forbes) from the upper Campanian of Jordan.

Family Hercoglossidae Spath, 1927
Genus *Cimomia* Conrad, 1866

Type species: *Nautilus burtini* Galeotti, 1837, p. 140. *Cimomia desertora* (Quaas, 1902)
Figs. 3B, 4B

1902 *Nautilus desertorum* Zitt. (in manu.), Quaas, p. 299, pl. 29, fig. 1; pl. 33, figs. 29, 30.

1915 *Nautilus desertorum* Zitt. – Greco, p. 229, pl. 22, figs. 5, 6.

1956 *Eutrephoceras desertorum* (Quaas) – Kummel, p. 381.

1960 *Angulithes* (*Cimomia*) *desertorum* (Zittel) in Quaas 1902 – Wiedmann, p. 179, pl. 19, figs. J, K, M, N; pl. 23, fig. I; pl. 24, fig. 5. (with synonymy of *Cimomia ?desertorina* Zittel in Quaas, 1902) – Shimansky, p. 135, pl. 30, fig. 1.


1984 *Eutrephoceras desertorum* (Quaas) – Dzik, p. 180, figs. 71/5.

1995 *Cimomia* aff. *sowerbyana* (d’Orbigny, 1840) – Morris, p. 252, pl. 1, fig. 4, pl. 2.

2002 *Eutrephoceras desertorum* (Quaas) – Hewaidy and Azab, p. 213, pl. 4, figs. 1–4.

2019 *Eutrephoceras desertorum* (Quaas, 1902) – Hewaidy et al., p. 50, text-figs. 4A, B.

**Material.** One fully septate internal mould (CUGM/JCAM 50).

<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>CUGM/JCAM 50</td>
<td>100</td>
<td>75 (75)</td>
<td>66 (66)</td>
<td>1.14</td>
<td>occluded</td>
</tr>
</tbody>
</table>

**Dimensions.**

Description. Slightly depressed (Wb/Wh = 1.14) nautiloid with occluded umbilicus. Greatest whorl breadth is just above the umbilical margin from where the flanks converge towards the broadly rounded venter without any ventrolateral shoulder, forming a semi-circular whorl cross-section (Fig. 4B). The suture rises from an umbilical lobe towards a narrow and shallow saddle across the umbilical margin followed by a wide, shallow lobe on the flanks. On the venter, a very shallow, narrow saddle and a somewhat broader lobe are present. Individual septa are rather closely spaced (ca. 18 septa in the last whorl). The siphuncle has a dorso-central position (Fig. 4B).

Remarks. The present specimen corresponds well in shell proportions, shape of suture, position of siphuncle and closely spaced septa to *Cimomia desertora* (Quaas, 1902) as described and illustrated in the literature (e.g., Wiedmann, 1960). In several papers, the species has also been assigned to the genus *Eutrephoceras* (starting with Kummel, 1956) but the rather sinuous suture, the numerous (i.e., densely spaced) septa and the rather dorsal position of the siphuncle suggest a closer affinity with *Cimomia* (see also Wiedmann, 1960; Shimansky, 1975). According to Kummel (1956, 1964), *Cimomia* is transitional between *Eutrephoceras* and *Hercoglossa*. A fairly similar and broadly contemporaneous taxon has been described as *Cimomia* aff. *sowerbyana* (d’Orbigny, 1840) by Morris (1995, p. 252, pl. 1, fig. 4, pl. 2) from the lower Maastrichtian Sinsima Formation of the United Arab Emirates–Oman border region. It mainly differs from *C. desertora* as described herein by means of the more central position of the siphuncle. However, the position of the siphuncle in *C. desertora* changes ontogenetically from dorso-central to ventro-central (e.g., Quaas, 1902, p. 300) and the specimen from the Sinsima Formation is larger (D ca. 150 mm). Thus, we regard it as conspecific to *C. desertora*. Furthermore, *Angulithes sowerbyanus* (d’Orbigny, 1840) is a Turonian species that is much more compressed and has an open umbilicus (Tintant and Gauthier, 2006, pl. 4, fig. 2a, b). *Cimomia imperialis* (Sowerby, 1812), mainly known from the Eocene of Europe, has more sinuous suture but is otherwise very similar shell proportions. Furthermore, a number of *Eutrephoceras* species such as *E. bouchantianum* (d’Orbigny, 1840) and *E. dorbigynanum* (Forbes, 1846) share similarities to *C. desertora* as described herein. However, their sutures are simpler and the distance of the septa is larger (e.g., Wilmensen, 2000, 2016; Nielsen and Salazar, 2011; Machalski and Wilmensen, 2015).

Occurrence. *Cimomia desertora* has so far been reported from the Santonian of Spain (Wiedmann, 1960), the Maastrichtian to Paleocene of Egypt (Western Desert: Quaas, 1902; Barthel and Herrmann-Degen, 1981; Hewaidy et al., 2019; Eastern Desert: Greco, 1915; southwest Aswan: Hewaidy and Azab, 2002), and, as *Cimomia* aff. *sowerbyana*, from the lower Maastrichtian of the United Arab
Fig. 3. Nautiloids from the upper Campanian of Jordan; all figures in natural size. 

A, Eutrephoceras sphaericum (Forbes, 1845), specimen CUGM/JCAM 49 in lateral (A1), apertural (A2) and ventral (A3) views. 

B, Cimomia desertori (Quaas, 1902), specimen CUGM/JCAM 50 in lateral (B1, B3), and apertural (B2) views. 

C, Hercoglossidae indet., specimen CUGM/JCAM 51 in lateral (C1), apertural (C2) and ventral (C3) views.
Emirates (Morris, 1995) (see Fig. 1A). A questionable record is from the uppermost Cretaceous of Crimea (Shimansky, 1975). Herein, Cimomia desertora is first recorded from the upper Campanian of Jordan.

Hercoglossidae indet.

Material. One internal mould (CUGM/JCAM 51).

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>CUGM/JCAM 51</td>
<td>55</td>
<td>35 (64)</td>
<td>35 (64)</td>
<td>1.00</td>
<td>occluded</td>
</tr>
</tbody>
</table>

Description. The small specimen (D = 55 mm) is convolute. Greatest whorl breadth is directly at the umbilical margin from where the flat flanks converge to a slender, rounded venter, resulting in a triangular whorl cross-section with Wb = Wh. Due to the poor state of preservation of the studied specimen, the suture lines along with the position of the siphuncle cannot be seen. However, faint growth lines at the venter (see Fig. 3C3) show the presence of a rather deep hyponomic sinus.

Remarks. The imperfect preservation impedes a specific and even a safe generic identification of specimen CUGM/JCAM 51. The characteristic triangular whorl shape suggests that it may be a representative of the widespread genus Angulithes which ranges from the Upper Cretaceous into the Eocene. However, Wanner (1902, p. 143, pl. 19, figs. 12, 21a) introduced a new species, Nautilus jordani, from the Maastrichtian of western Egypt that has later been placed in Cimomia by Kummel (1956) and Shimansky (1975), and in Angulithes (Cimomia) by Wiedmann (1960). It has a flexed suture and the siphuncle is close to the dorsum, and the triangular whorl section is very similar to specimen CUGM/JCAM 51, albeit somewhat more broadly rounded (Fig. 4D). Another similar and broadly contemporaneous taxon with triangular whorl section has been described as Deltoidonautilus salisius sp. nov. by Morris (1995, p. 251, pl. 1, figs. 1–3) from the base of the Simsima Formation (probably lower Maastrichtian) of the United Arab Emirates–Oman border region. It shares the flexed suture and dorsal position of the siphuncle with C. jordani but seems to be more compressed. However, our specimen cannot be safely identified and the exact taxonomic relationship between C. jordani and (sic) Angulithes salisius (Morris) needs to be evaluated elsewhere. We thus keep specimen CUGM/JCAM 51 in open nomenclature.

Occurrence. The specimen is from the Al-Hisa Phosphorite Formation, Bahiya Coquina Member, upper Campanian.

4. Discussion and concluding remarks

Cretaceous nautiloids from Jordan have not been dealt with in any detail so far. In order to minimize this dark spot in this palaeobiogeographically important region of the Middle East, we report and describe a small faunule of nautiloids from the upper Campanian Bahiya Coquina Member of the upper Campanian to lower Maastrichtian Al-Hisa Phosphorite Formation of northwestern Jordan.

The Bahiya Coquina Member at Deir Abu Said, north-northwest of Amman, is composed of large-scale cross-bedded bioclastic limestone with abundant well-preserved oysters and layers of phosphatic clasts. It contained the studied nautiloids and was deposited in an agitated, shallow-marine environment as shown by
the coarse-grain size and fabric of the strata as well as the large-scale cross-bedding. Despite the unfavorable taphonomic conditions prone to physical destruction of organic remains, the preservation of the nautiloid specimens is moderate to good. The small faunule (three specimens) consists of 

Angulithes

representative of the widespread Late Cretaceous to Eocene genus

certus, known from Cretaceous ammonites (e.g., Kennedy and Cobban, 1964; Fig. 4D) and


References


