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The First Record of an Ammonite in the Upper Cenomanian (Upper Cretaceous) of the Crimea

E. Yu. Baraboshkin* (ORCID: 0000-0003-4373-1543)

Moscow State University, Moscow, 119991 Russia

**e-mail: EJBaraboshkin@mail.ru*

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Abstract—A Cenomanian ammonite, *Calycoceras (Calycoceras) naviculare* (Mantell, 1822) (Acanthoceratidae, Ammonoidea) has been found in the well-known section of the Selbukhra Mountain in the vicinity of the village of Nauchnyi in southwestern Crimea. This is the first find of the ammonite in the upper Cenomanian deposits in the Crimea and in Russia.

Keywords: ammonite, *Calycoceras (Calycoceras) naviculare*, Upper Cretaceous, upper Cenomanian, biostratigraphy, southwestern Crimea

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INTRODUCTION

As is known, ammonite finds in the Cenomanian deposits of Crimea are distributed extremely unevenly. They are most common in deposits of the Lower Cenomanian, as well as in a narrow interval of the Middle Cenomanian, immediately above the surface of the break at its base (Marcinowski, 1980; Naidin and Alekseev, 1980; Alekseev, 1989). Finds of *Calycoceras* sp., mentioned from the lower Cenomanian of Crimea, are either not depicted (Alekseev, 1989) or very poorly preserved (*Atlas*..., 1997) and raise doubts about their correct identification.

Until now, ammonites were not found in the upper Cenomanian deposits of Crimea. Therefore, the specimen of *Calycoceras* (*Calycoceras*) *naviculare* (Mantell) that we found is of undoubted interest, especially since it belongs to the index species of the zone of the same name. This ammonite was found by the author in 2023 during the study of the well-known section of Cenomanian deposits on the southern slope of the Selbukhra Mountain, about 40 m east of the gulley in which the section is usually described, below a large single tree clearly visible on the slope (Figs. 1, 2). This is the first find of an upper Cenomanian ammonite in Crimea and it confirms the age of the lower part of member VI (Alekseev, 1989), although it does not clarify the position of the boundary between the middle Cenomanian and upper Cenomanian.

SYSTEMATIC PALEONTOLOGY

The description used standard terminology and measurements of shells from (*Atlas*..., 1997). The collection is deposited at the Earth Science Museum, Moscow State University (MZ MGU), no. 158.

Order Ammonoidea Zittel, 1884
Suborder Ammonitina Hyatt, 1889
Superfamily Acanthoceratoidea de Grossouvre, 1894
Family Acanthoceratinae de Grossouvre, 1894
Subfamily Acanthoceratinae de Grossouvre, 1894
Genus and subgenus *Calycoceras* Hyatt, 1900
***Calycoceras (Calycoceras) naviculare* (Mantell, 1822)**

Figs. 3a, 3b

1822. *Ammonites navicularis*: Mantell, p. 198, Pl. 22, fig. 5 (erroneously indicated as *Ammonites catinus*).

1971. *Calycoceras* (*Calycoceras*) *naviculare* (Mantell): Kennedy, p. 71, Pl. 33, figs. 1A–1B; Pl. 34, figs. 1A–1B; Pl. 35, figs. 1–2; Pl. 36, figs. 1–4; Pl. 37, figs. 1–3; Pl. 47, figs. 1, 3, 5 (with synonymy).

1981. *Calycoceras* (*Calycoceras*) *naviculare* (Mantell): Wright and Kennedy, p. 34, Pl. 4, Pl. 5, figs. 1–3, text-fig. 13, 14c–14e (with synonymy until 1981).

1989. *Calycoceras* (*Calycoceras*) *naviculare* (Mantell): Fischer, Pl. 140, figs. 1, 2.

1990. *Calycoceras* (*Calycoceras*) *naviculare* (Mantell): Wright and Kennedy, p. 236, Pl. 61, fig. 1, Pl. 62, figs. 1–6, Pl. 63, figs. 1–3, text-fig. 88e, I, 89d, 110c (with additional synonymy until 1990).

1996. *Calycoceras naviculare* (Mantell): Kirkland, p. 79, Pl. 10, figs. L, M.

1996. *Calycoceras* (*Calycoceras*) *naviculare* (Mantell): Wright, Calloman, and Howarth, p. 164, figs. 125a–125f.

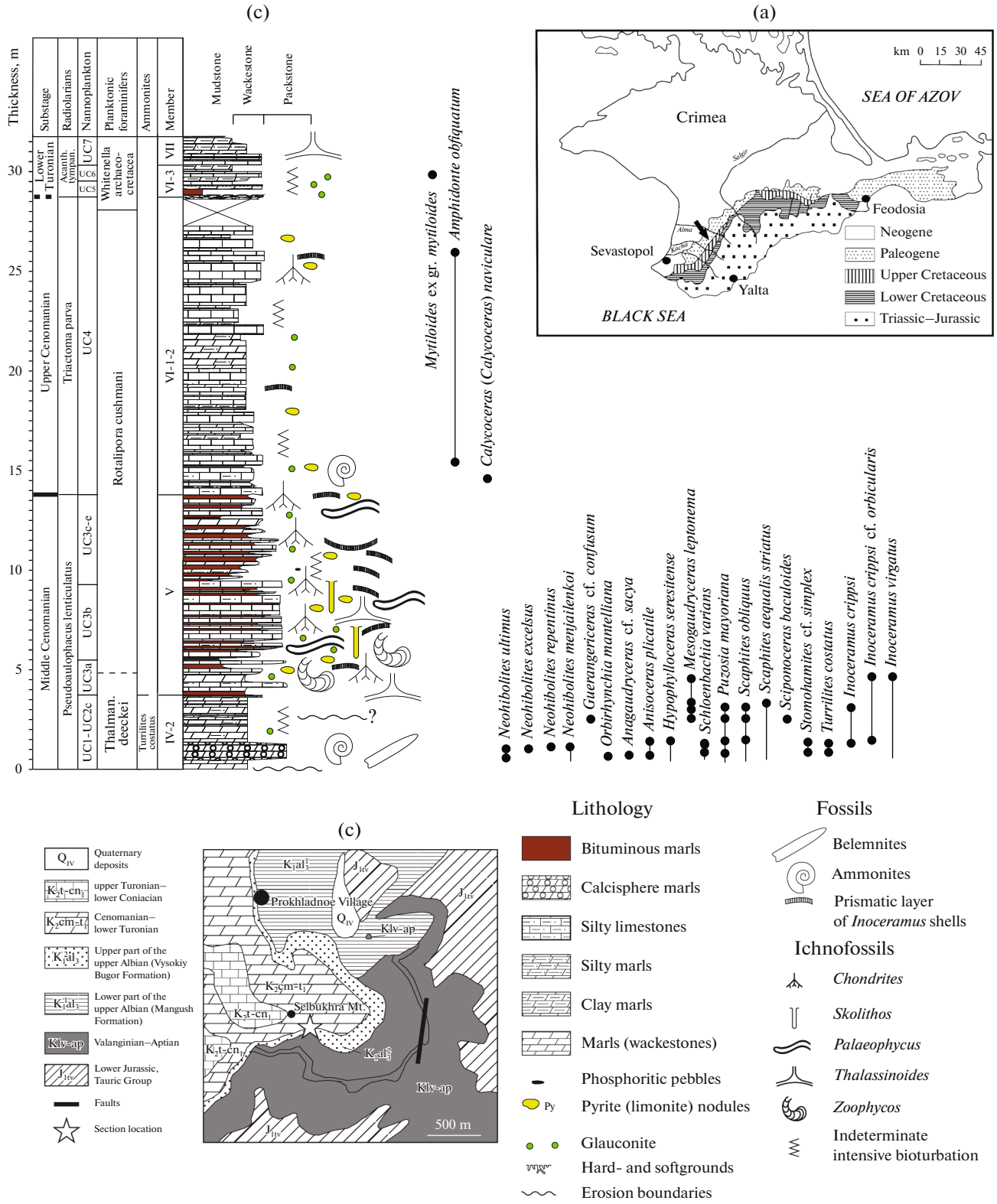

Fig. 1. (a), (b) Location of the section; (b) section of the middle–upper Cenomanian on the southern slope of the Selbukhra Mountain and locality of the ammonite *Calycoceras (Calycoceras) naviculare* (Mant). Distribution of the Cenomanian fauna according to (Naidin and Alekseev, 1980) with redeterminations according to (Marcinowski, 1980; Wright et al., 2017). Boundaries of micropaleontological zones: based on nannoplankton (Shcherbinina and Gavrilov, 2016), radiolarians (Bragina and Bragin, 2023), and planktonic foraminifers (Alekseev, 1989; Avenirova et al., 2023).

Fig. 2. Locality of the ammonite (arrow) on the southern slope of the Selbukhra Mountain in the vicinity of the village of Nauchnyi (photograph by M.Yu. Tomatkin, Moscow State University).

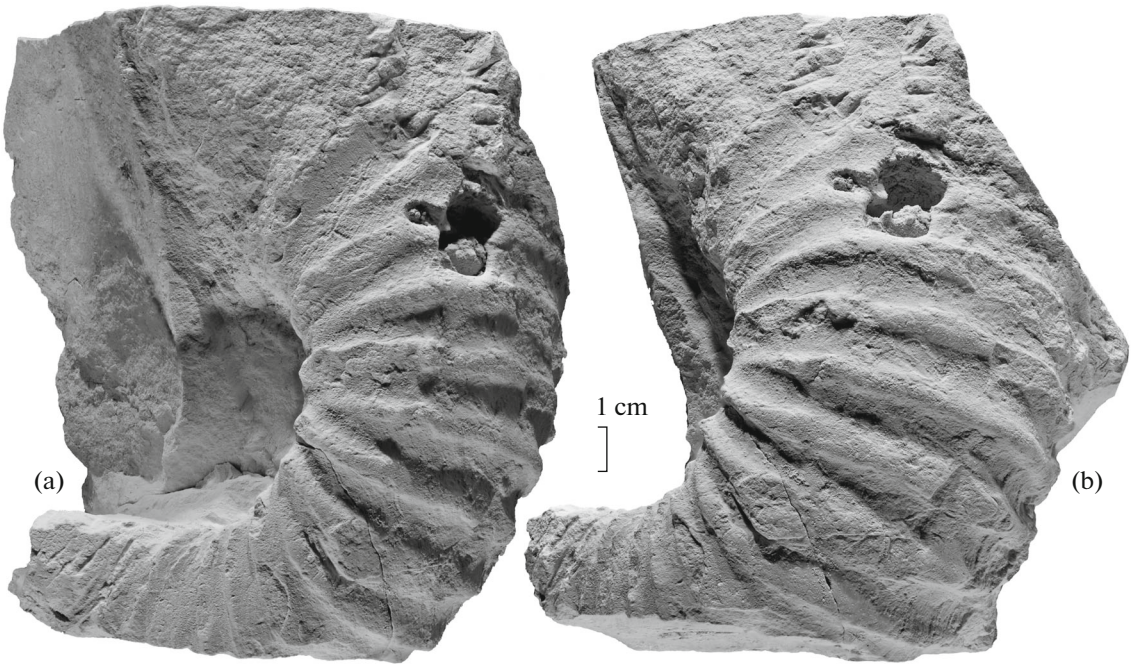

Fig. 3. *Calycoceras (Calycoceras) naviculare* (Mantell), specimen no. 158/2: (a) lateral view, (b) ventral view; upper Cenomanian, southern slope of the Selbukhra Mountain in the vicinity of the village of Nauchnyi, Bakhchisarai district, Republic of Crimea.

?2008. *Calycoceras naviculare* (Mantell): Abdel-Gawad, p. 211, pl. 1, figs. 1a–1c, 2.

2009. *Calycoceras naviculare* (Mantell): Barroso-Barcenilla et al., fig. 8B.

2015. *Calycoceras* (*Calycoceras*) *naviculare* (Mantell): Kennedy and Gale, p. 292, Pl. 22, fig. 6 (with additional synonymy).

2016. *Calycoceras* (*Calycoceras*) *naviculare* (Mantell): Zaoui et al., Pl. 1, figs. 5a–5b.

2017. *Calycoceras* (*Calycoceras*) *naviculare* (Mantell): Wright et al., text-figs. 203G, 203H.

2018. *Calycoceras* (*Calycoceras*) *naviculare* (Mantell): Zaoui et al., p. 345, fig. 7B.

2018. *Calycoceras* (*Calycoceras*) *naviculare* (Mantell): Košťák et al., p. 156, figs. 5A–5L (with additional synonymy).

?2019. *Calycoceras* (*Calycoceras*) *naviculare* (Mantell): Mendir et al., p. 244, pl. 3, figs. 2a–2b.

2020. *Calycoceras* (*Calycoceras*) *naviculare* (Mantell): Hoyez et al., pl. 16, figs. 7a–7b.

2023. *Calycoceras naviculare* (Mantell): Benyoucef et al., figs. 11D, 11E.

Holotype by monotypy, specimen BMNH 5681, Mantell's original specimen (Mantell, 1822, Pl. 22, fig. 5), from the middle part of the upper Cenomanian "Plenus marls" of "Offham," Sussex, England. The holotype is re-illustrated in (Crick, 1919, p. 154, Pl. 4; Kennedy, 1971, p. 71, Pl. 33, figs. 1a, 1b; Wright and Kennedy, 1981, p. 35, Pl. 4; Wright et al., 1996, p. 164, figs. 125a–125b).

Description. The specimen is represented by half a body whorl. The specimen is strongly and somewhat asymmetrically flattened in the dorsoventral direction. Shell is semi-involute, not less than 100 mm in diameter. Although it is difficult to establish the true shape of the cross section, it is undoubtedly quite wide and slightly angular at the boundary between the lateral and ventral sides. Ribs are straight, bifurcated, intercalating, and single. They originate on the umbilical wall and branch at the umbilical bend with the formation of a swelling or, less often, a small tubercle. There are 11 main ribs per half whorl. On the flattened ventral side, the number of ribs reaches 16 per half whorl; they cross the ventrum without weakening. On the ventral bend, ribs are slightly thicker, which gives them a somewhat angular shape, albeit without the formation of tubercles.

Comparison. This specimen was previously erroneously identified as *C.* (*C.*) cf. *boulei* (Avenirova et al., 2023). This is not surprising, since the species *C.* (*C.*) *boulei* Collignon, 1957 is closest to the species *C.* (*C.*) *naviculare* and is presumably its ancestor (Kennedy, 1971). In *C.* (*C.*) *boulei*, ribbing is finer and more frequent, with distinct lateral tubercles; the cross section is less swollen and slightly angular and the umbilicus is narrower than those in *C.* (*C.*) *naviculare*.

Remarks. The list of literature sources with descriptions or images of *Calycoceras* (*Calycoceras*) *naviculare* (Mant.) or synonymous forms is enormous. This species was revised in detail in the monographs (Kennedy, 1971; Wright and Kennedy, 1981, 1990). The author follows the understanding of the species *C.* (*C.*) *naviculare* as given in these works. An additional revision is provided in the article (Košťák et al., 2018).

Other finds that were not recorded by previous researchers or published later are given in the synonymy list. Specimens that can be assigned to the species *C.* (*C.*) *naviculare*, even though they are not always well preserved, are not commented on here; other forms are discussed below.

In (Mendir et al., 2019), the small fragment of "*C.* (*C.*) *naviculare*," despite its very poor preservation, have visible straightened, frequent thin ribs, which are nontypical for this species. The same concerns the ammonite fragment in (Abdel-Gawad, 2008).

Occurrence. *C.* (*C.*) *naviculare* is a widespread species in the upper Cenomanian and is its index species. It is recorded from the Calycoceras (Proeucalycoceras) guerangeri Zone to the lower part of the Metoicoceras geslinianum Zone in sections of North America (Kansas, New Mexico, Texas, Colorado, Oregon, and California), North Africa (Algeria, Tunisia, and Libya), South Africa (Angola), Madagascar, Middle East, southern India, Japan, Europe (England, France, Spain, Portugal, Germany, and Czech Republic), and Crimea (Fig. 4).

Material. One specimen, MZ MGU no. 158/2.

DISCUSSION

The species *C.* (*C.*) *naviculare* served as the traditional and main index species of the upper Cenomanian for a long time (Hancock, 1960); however, at the Cretaceous Symposium in Brussels in 1995, it was fundamentally decided to divide the upper Cenomanian into three part and search for another marker species of the base of the upper Cenomanian (Tröger et al., 1996). A brief summary of the stratigraphy of the Cenomanian Stage is given in (Kennedy and Gale, 2006), where it is proposed to mark the base of the upper Cenomanian for the European sections by the disappearance of *Acanthoceras rhotomagense* (Brongn.), the index species of the middle Cenomanian; it disappears almost simultaneously with the appearance of *Calycoceras* (*Proeucalycoceras*) *guerangeri* (Spath), the index species of the upper Cenomanian. This determination of the boundary makes the use of *C.* (*C.*) *naviculare* as an index species less suitable, since it appears above the level of disappearance of *Acanthoceras rhotomagense*. The establishment of the base of the upper Cenomanian at the base of the Calycoceras (Proeucalycoceras) guerangeri Zone is

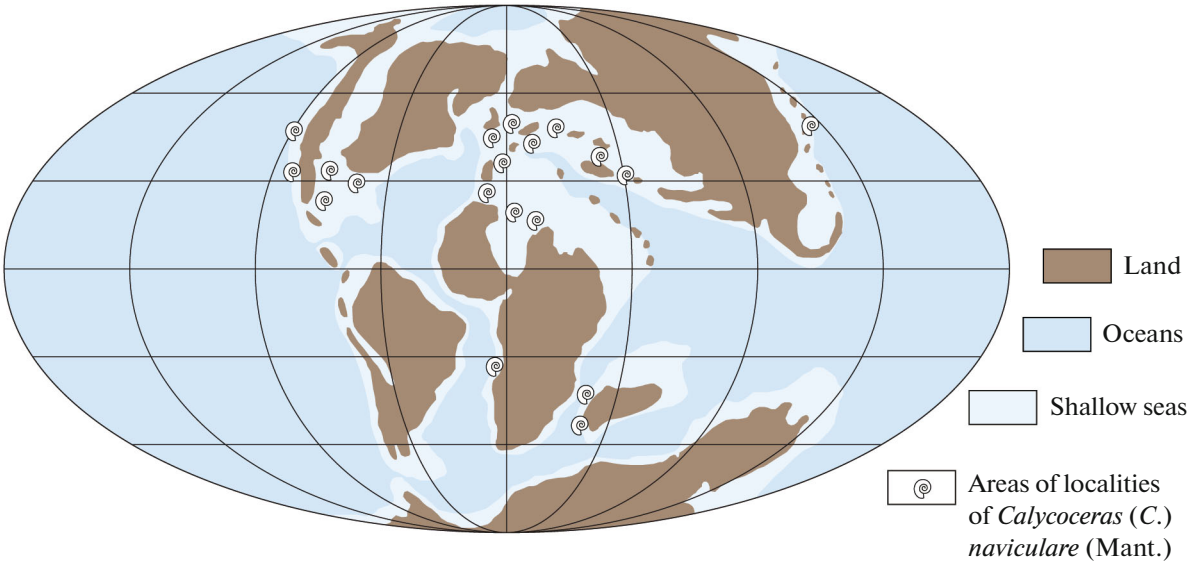

Fig. 4. Scheme of the geographical distribution of *Calycoceras (Calycoceras) naviculare* (Mantell) on a paleotectonic basis (according to R. Blakey, with changes).

accepted (albeit internationally not approved) in most stratigraphic works, including the general scale of the Upper Cretaceous of Russia (Olfer'ev and Alekseev, 2002).

Until now, the base of the upper Cenomanian in the sections of the southwestern Crimea was established along the lower boundary of member VI based on the microfauna (Alekseev, 1989); however, there were no clear criteria for its marking. Based on finds of oysters (*Amphidonte obfiquatum* (Pulteney)) and by analogy with sections in northern Germany, E. Gale et al. (1999) established the base of the upper Cenomanian approximately 1 m above the base of member VI. An important feature of the base of the upper Cenomanian is the $\delta^{13}C$ isotope excursion of "Jukes-Browne" event, which has been recently identified in the same section in the upper 1.1 m layer of member V (Avenirova et al., 2023). In Great Britain, this excursion occurs at the base of the Calycoceras guerangeri Zone (Jarvis et al., 2006), where it marks the lower boundary of the upper Cenomanian. In the Selbukhra section, the Jukes-Brown level is identified at about 1–1.5 m below the find of *C.* (*C.*) *naviculare* (Mant.), which corresponds to the hypothesis of W. Kennedy about the appearance of this species slightly above the level of the boundary between the lower Cenomanian and upper Cenomanian (Tröger et al., 1996). The ammonite find itself is about 0.5 m above the base of member VI and 1.5 m below the characteristic greenish tuffaceous interlayer recorded by all geologists.

CONCLUSIONS

Thus, the unique find of *Calycoceras* (*Calycoceras*) *naviculare* (Mant.) in the Cenomanian section of the Selbukhra Mountain confirms the validity of marking the base of the upper Cenomanian at the base of member VI (Alekseev, 1989) and expands the understanding of the geographical distribution of this important biostratigraphic marker.

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CONFLICT OF INTEREST

The author of this work declares that he has no conflicts of interest.

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