Inoceramid bivalves from the Maastrichtian of the Western Fore-Balkan Mts (Bulgaria)

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Abstract. Taxonomic descriptions of newly recorded inoceramid species from the Maastrichtian of the Western Fore-Balkan Mountains (Bulgaria) are presented. The following taxa have been determined: *Cataceramus subcircularis* (Meek, 1876); *Cataceramus palliseri* (Douglas, 1942); *Cataceramus barabini* (Morton, 1834); *Cataceramus?* *glendivensis* Walaszczyk, Cobban and Harries, 2001; *Cataceramus?* cf. *bebahoensis* (Sornay, 1973); *Cataceramus* aff. *goldfussianus* (d’Orbigny, 1847); *Trochoceramus tenuiplicatus* (Tzankov, 1981); *Endocostea typica* Whitfield, 1880; *Endocostea jolkicevi* Walaszczyk, Odin and Dhondt, 2002; *Endocostea* sp. aff. *E. coxi* (Reyment, 1955); and “*Inoceramus*” *howletti* Walaszczyk, Kennedy and Klinger, 2009. The present record allowed two lower Maastrichtian inoceramid zones, namely the *Endocostea typica* and *Trochoceramus radiosus* zones, to be indicated. The material allows for correlation with the Northwestern and Boreal areas of Europe and elsewhere.

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INTRODUCTION

Inoceramid bivalves have traditionally been an important fossil group for the age assessment and biostratigraphy of Upper Cretaceous strata in Bulgaria. This is due to the rapid vertical change of the inoceramid associations and their relatively common occurrence in sediments of diverse faunal context, which usually outweighs that of the ammonites in Bulgarian Upper Cretaceous sequences. Significant progress has been made over the past decades and a number of inoceramid taxa have been reported and illustrated from different stratigraphic intervals of the Upper Cretaceous (e.g., Jolkičev, 1962, 1984, 1989; Tzankov, 1968, 1981). In this respect, the epicontinental sedimentary successions of the Upper Cretaceous in the Fore-Balkan Mts region are particularly favorable. Many localities have been studied and published over the years and, although much of the

previously published data needs to be revised, it is clear that inoceramid associations are rich enough to build a stable zonal succession. This is especially true for the Campanian–Maastrichtian interval, in which a number of characteristic elements found in Northwestern and Boreal Europe seem to be commonly obtainable. The aim of the present work is to describe and illustrate a newly collected inoceramid material from the mid-upper lower Maastrichtian of the Western Fore-Balkan Mts. Ten species of the genera *Cataceramus* Heinz, 1932, *Trochoceramus* Heinz, 1932, *Endocostea* Whitfield, 1877 and “*Inoceramus*” s. l. were studied. Three forms were left in open nomenclature. Despite being represented by a small number of specimens, these taxa have high stratigraphical value, being both an addition to the previously obtained inoceramid evidence from Bulgaria and new indications of inoceramid species that have poorly been identified to date.

STRATIGRAPHIC BACKGROUND AND MATERIAL OF THIS STUDY

The Western Fore-Balkan Mts, in the upper and middle reaches of the Skat River (Vratsa District, W Bulgaria), is a foothill region, which consists of gently folded Cretaceous sedimentary rocks that are covered unconformably by thick Pliocene–Miocene and Quaternary sediments (Filipov *et al.*, 1995; Tz. Tzankov *et al.*, 2005). From a structural point of view, this region is considered to form the most elevated western segment of the Markova Anticline, which is a positive fault-bend structure with NW–SE trend that extends southeast of the Skat River between the villages of Ohoden (Vratsa District) and Rakita (Pleven District) (Bončev, 1971). Regionally, this structure belongs to the northwestern outer part of the Central Balkan–Fore-Balkan Zone (*sensu* Ivanov, 1998, 2017) and is located near the

southern edge of the Moesian Platform (Fig. 1a). According to Bončev (1971) and Filipov *et al.* (1995), the Markova Anticline contains a core and uplifted center composed of Lower Cretaceous (Aptian–Albian) siliciclastic sediments and asymmetrical flanks comprising Upper Cretaceous (Santonian–Maastrichtian) carbonates. The northern flank of the anticline is longitudinally disrupted by the Nivianin Fault, and the Cretaceous rocks are overlain by diverse terrigenous-carbonate Pliocene–Miocene formations, as well as by fluvial and eolian Quaternary sediments (see Fig. 1b).

The area containing the localities of this study corresponds to the western pericline of the Markova Anticline, which can be traced in the vicinity of the villages of Bukovets, Tlachene and Virovsko (Vratsa District). The Upper Cretaceous strata of this area conform to a wedge-shaped band of exposures of Santonian–Maastrichtian carbonate rocks,

Fig. 1. Location maps of the fields yielding the inoceramids of this study: *a*) tectonic sketch map of Bulgaria, showing the position of the area containing the inoceramid-bearing localities (after Ivanov, 1998, 2017); *b*) geological sketch map of the Western Fore-Balkan Mts in the area of Bukovets and Virovsko villages (after Filipov *et al.*, 1995, and Tzankov *et al.*, 1995; simplified).

into which six formal lithostratigraphic units have been recognized in superposition: the Kalena, Novachene, Darmantsi, Kunino, Mezdra and Kaylaka formations (Jolkičev, 1986). These rocks transgressively overlie different levels of siliciclastic sediments of the Lower Cretaceous Malopeshtene Formation. Of these, the former three units compose the lower, thinner and poorly exposed, part of the Upper Cretaceous succession, whereas the latter three formations are of greater total thickness and have sufficiently good, traceable exposures. Two fossil fields, called Bukovets and Virovsko, supplied material for this study. The former field, located near Bukovets Village (43°19'14.55"N; 23°49'0.76"E), is a part of a previously studied section (~7.5 m thick), from which Jolkitshev and Vapzarova (1967) described the sediments of the Darmantsi and Kunino formations and referred these rocks to the Campanian. We were unable to follow the sequence as given by the earlier authors, since at the present no good exposures of either the Darmantsi Formation or the lower levels of the Kunino Formation exist there. From the upper parts of the Kunino Formation, comprising a few meters thick, thin-bedded, sandy to clayey limestones, we collected new inoceramid material that indicates the middle part of the lower Maastrichtian, a stratigraphic level that has not been recorded before. The second locality included in this study is a newly discovered fossil-bearing field, located 4 km NNE of Virovsko Village (43°21'14.85"N; 23°48'38.25"E), which corresponds to a 2-m thick interval of micritic limestones, probably from the middle of the Mezdra Formation. The inoceramids collected from this locality indicated uppermost lower Maastrichtian.

A total of 31 inoceramid specimens (15 from Bukovets and 16 from Virovsko) were studied. The specimens from Bukovets are internal molds of single valves, without shell fragments attached. The inoceramids from Virovsko are well-preserved internal molds of single valves, with shell fragments attached to some specimens. Inoceramid specimens included herein were covered with ammonium chloride and the fossil figures have been prepared with 1.0× magnification. The terminology used herein is after Harries *et al.* (1996). The abbreviations and terminology are as follows: h – length measured along growth axis; l – length measured perpendicularly to the growth axis; H – height of the valve; L – length of the valve; AM – length of the anterior margin; s – length of the hinge line; α – angle between anterior margin and hinge line; δ – angle between growth axis and hinge line. The studied specimens are housed at the Museum of Paleontology and Historical Geology at the University of Sofia.

BIOSTRATIGRAPHIC NOTES

The inoceramid material is both vertically and laterally isolated and separated by non-sequences at both localities. Therefore, it was not possible to follow the inoceramid assemblages in superposition. Nevertheless, both localities yielded stratigraphically significant taxa that allowed their stratigraphic position to be defined. The taxonomic determination and age assessment of the inoceramid taxa described below are based on published genera and species with better documented stratigraphical distribution (typically in NW Europe, but also in the U.S. Western Interior Basin, South Africa or Euroboreal areas) from outside Bulgaria (Walaszczyk *et al.*, 2001, 2002; cf. Walaszczyk *et al.*, 2004, 2009) (see Fig. 2).

The inoceramids from Bukovets are represented by small- to medium-sized specimens that compose moderately rich assemblage dominated by representatives of the genus *Cataceramus*. Several small-sized specimens of the genus *Endocostea* were also found. From this locality, the following taxa were identified: *Cataceramus palliseri* (Douglas, 1942), *C. subcircularis* (Meek, 1876), *C. barabini* (Morton, 1834), *C. glendivensis* Walaszczyk, Cobban and Harries, 2001, *Endocostea typica* (Whitfield, 1880) and *E. jolkicevi* Walaszczyk, Odin and Dhondt, 2002. This assemblage is very characteristic and, mostly based on the presence of *C. glendivensis*, we indicate the upper part of the lower Maastrichtian *Endocostea typica* Zone (Walaszczyk *et al.*, 2001, 2009).

The inoceramid assemblage from Virovsko is richer in species than that of the Bukovets locality. The collected material comprises medium- to large-sized specimens, of which *Cataceramus* is the dominant genus and the genera *Endocostea*, *Trochoceramus* and “*Inoceramus*” occur as single specimens. The following taxa were determined: *Cataceramus subcircularis* (Meek, 1876), *C. palliseri* (Douglas, 1942), *C. barabini* (Morton, 1834), *Cataceramus* cf. *bebahoensis* (Sornay, 1973), *Cataceramus* aff. *goldfussianus* (d’Orbigny, 1847), *Endocostea jolkicevi* Walaszczyk, Odin and Dhondt, 2002, *Trochoceramus tenuiplicatus* (Tzankov, 1981), “*Inoceramus*” cf. *howletti* Walaszczyk, Kennedy and Klinger, 2009 and *Endocostea* sp. aff. *E. coxi* (Reyment, 1955). Of these taxa, *Trochoceramus tenuiplicatus* and “*Inoceramus*” *howletti* Walaszczyk, Kennedy and Klinger, 2009 are characteristic elements of the lower Maastrichtian *Trochoceramus radiosus* Zone (Walaszczyk *et al.*, 2001, 2009, 2010). The presence of these valuable taxa among the *Cataceramus*-dominated inoceramid association, including *Cataceramus* aff. *goldfussianus* and *Cataceramus* cf. *bebahoensis*, allowed us to recog-

Tercis		U. S. Western Interior (Walaszczyk <i>et al.</i> , 2001)	Tercis section (France) (Walaszczyk <i>et al.</i> , 2002)	KwaZulu (South Africa) (Walaszczyk <i>et al.</i> , 2009) (pars)	Boreal		Vistula section (Walaszczyk, 2004) (pars)	
Stage	Substage				Stage	Substage		
MAASTRICHTIAN	UPPER			<i>Inoceramus ianjonaensis</i>	MAASTRICHTIAN			
	LOWER	<i>Inoceramus balchi</i>	Virovsko locality	<i>Trochoceras radiosus</i>			Endocostea typica	
		<i>Trochoceras radiosus</i>						
		<i>Inoceramus incurvus</i>	Bukovets locality	STRAIGRAPHIC GAP				Inoceramus redbirdensis
		<i>Endocostea typica</i>	<i>Endocostea typica</i>					
CAMPANIAN	UPPER (PARS)	<i>Inoceramus redbirdensis</i>	<i>Inoceramus redbirdensis</i>			<i>Inoceramus redbirdensis</i>		
	<i>Inoceramus oblongus</i>	<i>Trochoceras costaeus</i> <i>Inoceramus oblongus</i>				<i>Trochoceras costaeus</i>		
					CAMPANIAN	UPPER	<i>Inoceramus inkermanensis</i>	

Fig. 2. Correlation chart of the inoceramid biostratigraphy for the upper Campanian–lower Maastrichtian interval of the U.S. Western Interior Basin, Tercis section (France), KwaZulu (South Africa) and Middle Vistula section (Central Poland). The Campanian/Maastrichtian boundary and substage subdivisions according to “Tercis” and “Boreal” subdivisions are shown. The approximate positions and extents of the localities Bukovets and Virovsko, from the Western Fore-Balkan Mts, are shown as gray shaded areas.

nize the *Trochoceras radiosus* Zone in the Virovsko locality (Fig. 2).

Based on the inoceramid record from both localities, we found that the inoceramid association of Bukovets is older than that of Virovsko, and the two localities indicate, respectively, the uppermost part of the *Endocostea typica* Zone and the *Trochoceras radiosus* Zone, as defined by Walaszczyk *et al.* (2002) in the GSSP for the Campanian/Maastrichtian boundary at Tercis (SW France) (Fig. 2).

SYSTEMATIC PART

Genus *Cataceramus* Heinz, 1932

Type species. *Inoceramus balticus* Böhm (1909, pl. 11, fig. 2), from the lower Campanian at Dülmen (northern Germany), by the original designation of Heinz (1932).

Description. This genus includes inoceramids with shell outline and ornamentation style that are typical for the *balticus*-group: small- to large-sized inoceramids with variable elongation, obliquity and inflation of the disc. In some species, variable geniculation may occur. The ornamentation com-

prises commarginal rugae that are varied in strength and outline.

Discussion. For the emended use of the genus *Cataceramus*, see the extensive discussions in Dhondt (1993) and Walaszczyk *et al.* (2001, 2009).

Occurrence. Middle Santonian to early late Maastrichtian; worldwide.

Cataceramus subcircularis (Meek, 1876) (Fig. 3a–c)

pars 1834. *Inoceramus barabini* Morton, p. 62, Pl. 13, Fig. 11; non Pl. 17, Fig. 3 (= *Inoceramus barabini* Morton, 1834).

1876. *Inoceramus proximus*? var. *subcircularis* Meek, p. 55, Pl. 12, Fig. 2.

pars 1880. *Inoceramus vanuxemi* Meek and Hayden: Whitfield, p. 396, Pl. 7, Fig. 9 (non Pl. 7, Figs 8, 10).

1913. *Inoceramus proximus* Toumey var. *subcircularis* Meek: Böse, p. 32, Pl. 2, Fig. 7.

pars 1947. *Inoceramus regularis* d’Orbigny: Tzankov, p. 199, Pl. 1, Fig. 4 (only).

pars 1958. *Inoceramus regularis* Orb: Kociubynskij, p. 19, Pl. 9, Figs 34, 35 (only).

1959. *Inoceramus buguntaensis* Dobrov and Pavlova, p. 140, Pl. 22, Fig. 1.

1962. *Inoceramus regularis* d’Orb: Jolkičev, p. 137, Pl. 3, Fig. 1 (only).

1968. *Inoceramus regularis* d'Orbigny: Kociubynskij, p. 143, Pl. 29, Figs 1–2.
1973. *Inoceramus mandembataensis* n. sp.: Sornay, p. 90, Pl. 4, Fig. 4.
1974. *Inoceramus regularis* d'Orbigny: Kociubynskij, p. 85, Pl. 21, Fig. 2; Pl. 23, Fig. 1.
- V pars 1981. *Inoceramus* (*Cataceramus*) *regularis* d'Orb: Tzankov, p. 94, Pl. 36, Fig. 1 (only).
1993. *Trochoceramus nahoriaensis* (Kociubynskij): Dhondt, p. 238, Pl. 7, Fig. 4.
1995. *Endocostea* (*Selenoceramus*) *semaili* Morris, p. 260, Pl. 1, Figs 5, 6.
1996. “*Inoceramus*” sp. cf. *planus* (of authors) Münster: Walaszczyk *et al.*, Pl. 5, Fig. 4.
1997. *Inoceramus buguntaensis* Dobrov and Pavlova: Atabekian, p. 68, Pl. 27, Fig. 1.
2001. *Cataceramus*? *subcircularis* (Meek, 1876a): Walaszczyk *et al.*, pp. 160–162, Pl. 31, Fig. 3; Pl. 36, Fig. 8 (refigured holotype); Pl. 37, Figs 1 (?), 2; Pl. 39, Figs 3, 6; Pl. 41, Fig. 1, 2 (?); Pl. 42, Fig. 1; Pl. 43, Fig. 6; Pl. 44, Fig. 5.
2001. *Selenoceramus sornayi*: Odin, Pl. 2, Fig. 17.
2001. *Trochoceramus* sp.: Odin, Pl. 3, Figs 28–29.
2002. *Cataceramus subcircularis* (Meek, 1876a): Walaszczyk *et al.*, Pl. 13, Figs 6, 10; Pl. 14 Figs 1–3, 6, 8–9.
2004. *Cataceramus subcircularis* (Meek, 1876): Walaszczyk, Text-fig. 16A–C, E–H.
2009. *Cataceramus subcircularis* (Meek, 1876): Walaszczyk *et al.*, Fig. 28B.
2016. *Cataceramus subcircularis* (Meek, 1876): Jurkowska, Text-fig. 9d, 9e.
2017. *Cataceramus subcircularis* (Meek, 1876): Jurkowska and Barski, Fig. 3a.

Holotype. The holotype, USNM 479, was figured by Meek (1876, p. 12, fig. 2), and is a specimen from “the Yellowstone River, 150 miles above its mouth” (upper part of Pierre Shale near Glendive, Montana), probably from the lower Maastrichtian. The holotype was refigured by Walaszczyk *et al.* (2001, pl. 36, fig. 8).

Material and record. Three specimens preserved as internal molds, without shell fragments attached: two specimens from Bukovets (Inv.-Nrs U.S., K₂ 1734 and U.S., K₂ 1738, uppermost part of the *E. typica* Zone); one specimen from Virovsko (Inv.-Nr U.S., K₂ 1728, *T. radiosus* Zone).

Dimensions:

Inventory Nr	Valve	h	l	H	L	AM	s	α°	δ°
U.S., K ₂ 1728	left	137.4	115	115	125.5	64	57.2	115	60
U. S., K ₂ 1734	left	–	–	–	–	–	–	–	–
U.S., K ₂ 1738	left	38.5	36	35	37	18.6	23.5	120	55

Description. Small- to large-sized and weakly inflated inoceramids. The valves are subcircular in outline, moderately oblique, with δ around 55°. The anterior, posterior and ventral margins are rounded. The hinge line is moderately long to long and straight. The beak is small and slightly projecting above the hinge line. The posterior auricle is small, not separated from the disc. The valves are ornamented with regularly spaced subcircular com-marginal rugae, with increasing interspaces ventral-ward.

Remarks. As stated by Walaszczyk *et al.* (2001), the shell outline and ornamentation of *C. subcircularis* are very common amongst the inoceramids and, due to this ordinarieness, it is one of the most difficult species to be interpreted. For instance, *C. palliseri* (Douglas, 1942) displays similar shell outline and ornamentation, but the inoceramids of this species have higher shell obliquity (δ oscillating around 40°), less circular ornamentation and shorter anterior margin than those of *C. subcircularis*.

Our examples show shell outline and ornamentation that are typical for the species to which they were referred. Specimen U.S., K₂ 1734 (Fig. 3b) is an incompletely preserved left valve, but both the rounded anterior and the anteroventral margins, as well as the regular circular disc ornamentation, are typical features of *C. subcircularis*. Specimen U.S., K₂ 1728 (Fig. 3a) is large and moderately oblique ($\delta = 60^\circ$), with moderately long anterior margin and rounded anteroventral margin. The posterior and posteroventral margins are not preserved. The ornamentation in the umbonal part is not well visible, but in other portions of the disc it is composed of subcircular and regularly spaced rugae.

Careful study of previously published Bulgarian inoceramids has revealed that *C. subcircularis* can be recognized in a few specimens collected from the lower Maastrichtian. We believe that the available material, which has previously been published or labeled as either “*Inoceramus regularis* d’Orb.” or “*I. (Cataceramus) regularis* d’Orb.”, includes both *C. subcircularis* and *Cataceramus palliseri* (Douglas, 1942). For instance, we identify as *C. subcircularis* the small-sized specimen with rounded ventral margin, long hinge line and beak projected above it, and regular subcircular ornamentation that was defined by Tzankov (1947, pl. 1, fig. 4) as “*Inoceramus regularis* d’Orb.” Of the two specimens defined as “*Inoceramus regularis* d’Orb.” by Jolkičev (1962), we interpret one as *C. subcircularis* (Jolkičev, 1962, pl. 3, fig. 1), while the other we consider *Cataceramus palliseri* (Douglas, 1942) (Jolkičev, 1962, pl. 3, fig. 2). The same holds true for the specimens identified as “*I. (Cataceramus) regularis* d’Orb.”

Fig. 3. Inoceramids of the genus *Cataceramus*: a–c) *Cataceramus subcircularis* (Meek, 1876); a – Inv.-Nr U.S., K₂ 1728 (Virovsko locality, *Trochoceramus radiosus* Zone); b – Inv.-Nr U.S., K₂ 1734 (Bukovets locality, uppermost part of the *Endocostea typica* Zone); c – Inv.-Nr U.S., K₂ 1738 (Bukovets locality, uppermost part of *E. typica* Zone); d) *Cataceramus barabini* (Morton, 1834), Inv.-Nr U.S., K₂ 1745 (Bukovets locality, uppermost part of *E. typica* Zone); e, f) *Cataceramus palliseri* (Douglas, 1942); e – Inv.-Nr U.S., K₂ 1737; f – Inv.-Nr U.S., K₂ 1740 (Bukovets locality, uppermost part of *E. typica* Zone). All figures are in natural size.

by Tzankov (1981, pl. 36, figs 1, 2). One of them is *C. subcircularis* (Tzankov, 1981, Pl. 36, fig. 1), while the other is *C. palliseri* (Tzankov, 1981, pl. 36, fig. 2).

Occurrence. This species ranges from the base of the Maastrichtian to the upper Maastrichtian in Europe (Poland, Belgium, SW France, Ukraine, Russia, Caucasus and Bulgaria), the U.S. Western Interior Basin, Arabian Peninsula, Africa, and Madagascar.

Cataceramus palliseri (Douglas, 1942)

(Fig. 3e, f; Fig. 4a–c, f; Fig. 8g)

1847. *Inoceramus regularis* d'Orbigny, p. 516, Pl. 410, Figs 1–2.
 pars 1880. *Inoceramus vanuxemi* Meek and Hayden: Whitfield, p. 396, Pl. 7, Figs 8, 9(?).
 ? 1934. *Inoceramus regularis* d'Orbigny: Stefanov and Tzankov, p. 150, Pl. 1, Fig. 6.
 1942. *Inoceramus palliseri* Douglas, p. 62, Pl. 1, Fig. 2.
 pars 1947. *Inoceramus regularis* d'Orbigny: Tzankov, 1947, p. 199, Pl. 2, Fig. 4 (only).
 1958. *Inoceramus balticus* Böhm: Kociubynskij, p. 18, Pl. 8, Fig. 33.
 pars 1958. *Inoceramus impressus* d'Orbigny: Kociubynskij, p. 20, Pl. 9, Fig. 36 (only).
 pars 1962. *Inoceramus regularis* d'Orb: Jolkičev, Pl. 3, Fig. 2 (only).
 1962. *Inoceramus regularis* d'Orbigny: Sornay, p. 120, Fig. 1C; Pl. 7, Fig. 3.
 1964. *Inoceramus* cf. *regularis* d'Orbigny: Gires, p. 247, Pl. 3, Figs 3, 4.
 pars 1968. *Inoceramus impressus* d'Orbigny: Kociubynskij, p. 144, Pl. 28, Fig. 1.
 1974. *Inoceramus impressus* d'Orbigny: Kociubynskij, p. 84, Pl. 21, Fig. 1.
 1976. *Inoceramus regularis* d'Orbigny: Sornay, p. 7, Pl. 2, Fig. 3; Pl. 3, Figs 3, 4.
 pars 1976. *Inoceramus artigesii* n. sp.: Sornay, p. 3, Pl. 1, Fig. 2.
 V pars 1981. *Inoceramus* (*Cataceramus*) *regularis* d'Orbigny: Tzankov, p. 94, Pl. 36, Fig. 2 (only).
 1993. *Selenoceramus sornayi* n. sp.: Dhondt, p. 236, Pl. 6, Fig. 3; Pl. 7, Fig. 5.
 1995. *Endocostea?* (*Cataceramus*) sp. indet: Morris, p. 261, Fig. 2.
 1997. *Cataceramus sornayi* (Dhondt): Walaszczyk, p. 26, Pl. 32, Figs 1–3.

1997. *Inoceramus artigesii* Sornay: Walaszczyk, Pl. 32, Figs 4, 5.
 2001. *Cataceramus?* *palliseri* (Douglas, 1942): Walaszczyk *et al.*, p. 162, Pl. 27, Fig. 2; Pl. 33, Fig. 2 (refigured holotype); Pl. 37, Fig. 1.
 2002. *Cataceramus?* *palliseri* (Douglas, 1942): Walaszczyk *et al.*, p. 283, Pl. 8, Figs 1–2; Pl. 10, Fig. 4.
 2004. *Cataceramus palliseri* (Douglas, 1942): Walaszczyk, p. 119, Text-fig. 14.
 2005. *Cataceramus palliseri* (Douglas): Walaszczyk and Dhondt, p. 173, Pl. 2, Fig. E; Pl. 3, Figs B, C.
 2009. *Cataceramus palliseri* (Douglas, 1942): Walaszczyk *et al.*, p. 66, Fig. 38B.

Holotype. The holotype, GSC 8928, was figured by Douglas (1942, pl. 1, fig. 2), and is a specimen from Boxelder Creek (Canada), about 180 m below the top of the Bearpaw Formation. The holotype was refigured by Walaszczyk *et al.* (2001, pl. 33, fig. 2).
Material and record. Two specimens preserved as internal molds from Bukovets (Inv.-Nrs U.S., K₂ 1737 and U.S., K₂ 1740, uppermost part of the *E. typica* Zone), and three specimens preserved as internal molds, with shell fragments attached, from Virovsko (Inv.-Nrs U.S., K₂ 1727, U.S., K₂ 1726 and U.S., K₂ 1731, *T. radiosus* Zone).

Dimensions:

Inventory Nr	Valve	h	l	H	L	AM	s	α°	δ°
U.S., K ₂ 1726	left	–	88.1	66.5	90.5	–	–	–	–
U.S., K ₂ 1727	right (juvenile)	60.5	45.5	40.5	60	13.5	32	125	35
U.S., K ₂ 1731	left	58.1	51	40	60	19	37.1	90	35
U.S., K ₂ 1737	left	70	61	58	73.5	28	42	130	50
U.S., K ₂ 1740	right	76	56	55	74	21	45	115	50

Description. Inoceramids of medium size, inequilateral, equivalved, with weakly inflated juvenile part. Specimen U.S., K₂ 1727 (Fig. 4a–c) displays both juvenile and adult stages that contact with

positive geniculation, with very high angle (90°), while in the other specimens juvenile stages are preserved only. The beak is small and indistinct, projecting slightly above the hinge line. The anterior margin is short, relatively rounded, passing into a broadly rounded ventral margin and then into a rounded posterior margin. The hinge line is long and straight. The posterior auricle is small and indistinct, not separated from the disc. In specimen U.S., K₂ 1737, the ornament consists of closely and regularly spaced concentric rugae. Specimens U.S., K₂ 1740 (Fig 3f), U.S., K₂ 1731 (Fig. 4f) and U.S., K₂ 1726 (Fig. 8g) possess regular, commarginal rugae, but with wider interspaces. In specimen U.S., K₂ 1727, the sculpture in the juvenile part is not well visible, but it seems to consist of low and irregularly spaced concentric rugae. The adult stage is ornamented with low, sub- to irregularly and widely spaced rugae.

Remarks. This species was thoroughly discussed by Walaszczyk *et al.* (2001), who emphasized that *C. palliseri* (Douglas, 1942) is the correct name for the European forms previously referred to *C. sornayi* by Dhondt (1993) as *nomen novum* for *Inoceramus regularis* d’Orbigny (1847). *Cataceramus palliseri* is very similar to *C. balticus* (Böhm, 1909), from which it differs in having higher obliquity, finer disc ornamentation and different stratigraphical range (Walaszczyk *et al.*, 2001, 2002). *Cataceramus palliseri* closely resembles *C. subcircularis*, but it differs in having more postero-ventral elongation and different type of geniculation.

Specimen U.S., K₂ 1727 (Fig. 4a–c) closely resembles *C. palliseri* as described and illustrated by Walaszczyk (2004, p. 120, fig. 14). It has high *balticus*-type geniculation, with very high angle (90°), which is a typical feature of *C. palliseri*, but we only tentatively refer it to this species, because the ornamentation style in the juvenile part is atypical for *C. palliseri* (i.e., asymmetrical, commarginal, low rugae).

The presence of *C. palliseri* in Bulgaria, as seen from earlier records, remains problematic. We believe that the available material, which has previously been published as “*Inoceramus regularis* d’Orbigny” (cf. Stefanov and Tzankov, 1934; Tzankov, 1947, 1981), contains both *palliseri* examples and inoceramids of other, different species. Stefanov and Tzankov (1934, p. 150, pl. 1, fig. 6), for instance, described and figured a poorly preserved internal mold of a right valve, which we conditionally assign to *C. palliseri*. One of the specimens figured by Tzankov (1947, pl. 2, fig. 4) displays shell outline and ornament that give us reason to refer it to *C. palliseri*, but the remaining specimens we place in *C. barabini* (Morton, 1834

sensu Meek, 1876) (Tzankov, 1947, pl. 2, fig. 3), *C. oviformis* Walaszczyk, Cobban and Harries, 2001 (Tzankov, 1947, pl. 1, fig. 3) and *C. subcircularis* (Meek, 1876) (Tzankov, 1947, pl. 1, fig. 4). Tzankov (1981) figured two specimens, of which one has the characteristics of *C. palliseri* (Tzankov, 1981, pl. 36, fig. 2), while the other we consider *C. subcircularis* (Tzankov, 1981, pl. 36, fig. 1).

Occurrence. This species is described from the uppermost Campanian and the lower Maastrichtian in Europe and the U.S. Western Interior Basin, as well as from the lower upper Maastrichtian in Africa.

***Cataceramus barabini* (Morton, 1834)
(Fig. 3d)**

1834. *Inoceramus Barabini* Morton, 1834, p. 62, Pl. 13, Fig. 11; Pl. 17, Fig. 3.
1876. *Inoceramus cripsii* var. *Barabini* Morton: Meek, p. 49, Pl. 12, Fig. 3; Pl. 13, Fig. 1(?); Text-figs 1–4.
pars 1880. *Inoceramus barabini* Morton: Whitfield, p. 398, Pl. 7, Fig. 7(?); Pl. 9, Fig. 8.
1898. *Inoceramus cripsii* var. *barabini* (sic) Morton: Logan, p. 504, Pl. 109, Fig. 2.
pars 1913. *Inoceramus Barabini* Morton: Böse, p. 35, Pl. 4, Fig. 1 (only).
pars 1970. *Inoceramus barabini* Morton: Kauffman, p. 217, Pl. 1, Fig. 8 (only).
V 1981. *Inoceramus* (*Inoceramus*) *barabini* Morton: Tzankov, p. 86, Pl. 31, Fig. 1.
pars 1974. *Inoceramus barabini* Morton: Kociubynskij, p. 83, Pl. 23, Fig. 2 (only).
2001. *Cataceramus?* *barabini* (Morton, 1834): Walaszczyk *et al.*, p. 156, Pl. 33, Figs 1, 3, 4 (refigured lectotype); Pl. 35, Fig. 1; Pl. 36, Figs 2, 4, 6–7; Pl. 39, Figs 4, 5; Pl. 40, Fig. 5.
2001. *Platyceramus alaiformis*: Odin, Pl. 2, Fig. 14.
2001. *Inoceramus* sp. indet.: Odin, Pl. 3, Fig. 26.
2002. *Cataceramus?* *barabini* (Morton, 1834): Walaszczyk *et al.*, Pl. 14, Figs. 4, 11, 14.
2009. *Cataceramus barabini* (Morton, 1834, *sensu* Meek, 1876): Walaszczyk *et al.*, Figs 16E; 38C–E; 39C; 40A–I; 41B, 41C, 41K; 42C; 43H, 43I, 43K(?).

Lectotype. The original of Morton (1834, pl. 17, fig. 3), ANSP 1549, from the Upper Cretaceous strata of Greene County, Alabama (U.S.A.), was designated lectotype by Meek (1876, p. 55). The lectotype was refigured by Walaszczyk *et al.* (2001, pl. 33, fig. 4).

Material. One specimen from Bukovets (Inv.-Nr U.S., K₂ 1745, uppermost part of the *E. typica* Zone).

Dimensions:

Inventory Nr	Valve	h	l	H	L	AM	s	α°	δ°
U.S., K ₂ 1745	right	–	–	25	–	13	26.5	90	28

Description. The specimen is a small-sized, partially preserved internal mold, prosocline and markedly oblique. The valve is inequilateral, probably equivalved, and characterized by small to moderate inflation. The anterior margin is relatively short, slightly convex, passing into broadly rounded ventral and postero-ventral margins. The umbo is small, projecting slightly above the hinge line. The posterior auricle is not visible. The hinge line is very long and straight. The valve ornamentation is poorly preserved but visible, and is composed of regular to subregular and widely spaced commarginal rugae with interspaces increasing ventralward.

Remarks. Following the original interpretation of Morton (1834), Walaszczyk *et al.* (2001) emended this species, based on rich inoceramid material from the *Baculites eliasi*–*Baculites baculus* ammonite zones of the Western Interior Basin. They assigned to *C. barabini* medium-sized, moderately inflated, and posteriorly elongated forms with regularly spaced rugae in the juvenile stage and increasing irregularly in the adult stage. Later on, Walaszczyk *et al.* (2009) illustrated a number of *Cataceramus barabini* (Morton, 1834 *sensu* Meek, 1876) specimens from different localities in KwaZulu, South Africa. They followed Meek’s opinion on the species, based on specimen Nr. 477A of the collections of the U.S. National Museum of Natural History in Washington D.C., U.S.A. (Walaszczyk *et al.*, 2009, p. 60). In *C. barabini* (Morton, 1834 *sensu* Meek, 1876), they included strongly posteriorly elongated, *balticus*-like morphotypes, with moderate inflation of the umbonal and the anterior parts that, in lateral view, give a massive appearance to the valves. Although the specimens included in Meek’s variety come from a distinctly younger interval (the *Baculites grandis* ammonite Zone), identical forms can be found with specimens typical for Morton’s species. Furthermore, the relationship between Morton’s species and Meek’s variety requires further study (Walaszczyk *et al.* 2001, p. 158).

Our specimen comes from the lower Maastrichtian *Endocostea typica* Zone, and here we follow Morton’s interpretation for the species (*i.e.*, posteriorly elongated and slightly inflated forms with small umbonal region and valves, ornamented with widely spaced and regular concentric rugae). Specimen U.S., K₂ 1745 (Fig. 3d) is a small and poorly preserved right valve with erased sculpture in the umbonal and posterior parts of the disc. Based on the main shape outline, the short and slightly convex anterior margin and the high posterior elongation, we include the latter specimen in Morton’s species.

Occurrence. Lower and lower upper Maastrichtian. France, Belgium, Germany, Bulgaria, the U.S. Western Interior Basin and South Africa.

***Cataceramus? glendivensis* Walaszczyk, Cobban and Harries, 2001**

(Fig. 4d, e, g; Fig. 5a; Fig. 8e)

1958. *Inoceramus planus* Münster: Kociubynskij, p. 22, Pl. 7, Fig. 30.
1968. *Inoceramus planus* Münster: Kociubynskij, p. 147, Pl. 29, Fig. 7.
pars 1973. *Inoceramus bebahoensis* n. sp.: Sornay, p. 89, Pl 3, Fig. 2 (only).
2001. *Cataceramus? glendivensis* sp. nov.: Walaszczyk *et al.*, p. 170, Pl. 42, Figs 2, 11; Pl. 44, Figs 2, 4.
2001. *Inoceramus* sp. indet.: Odin, Pl. 3, Fig. 27.
2001. *Cataceramus? glendivensis* Walaszczyk, Cobban & Harries, 2001: Tröger *et al.*, p. 151, Pl. 1, Fig. 1; Text-fig. 7.
2002. *Cataceramus? glendivensis* Walaszczyk, Cobban & Harries, 2001: Walaszczyk *et al.*, p. 281, Pl. 14, Figs 5, 7, 12.
2009. *Cataceramus? glendivensis* Walaszczyk, Cobban & Harries, 2001: Walaszczyk *et al.*, p. 62, Figs 13A, 13B, 14A, 16A–C, 19A, 21B(?), 23B, 23E(?), 24A, 24C, 24D, 24F.
2010. *Cataceramus? glendivensis* Walaszczyk, Cobban & Harries, 2001: Walaszczyk *et al.*, p. 155, Figs 3/4, 4/2, 4/3, 4/7.
2011. *Cataceramus glendivensis* Walaszczyk, Cobban & Harries: Walaszczyk and Kennedy, p. 105, Fig. 2.1.
2016. *Cataceramus glendivensis* Walaszczyk, Cobban & Harries, 2001: Jurkowska, Text-fig. 9c.
2017. *Cataceramus glendivensis* Walaszczyk, Cobban & Harries, 2001: Jurkowska and Barski, Fig. 3b.

Holotype. The holotype, YPM 191001, was described and figured by Walaszczyk *et al.* (2001, p. 170 pl. 42, fig. 2), and is a specimen from the upper part of the *Baculites baculus* ammonite Zone, Glendive section, Montana (U.S.A.). Specimens YPM 191002 (Walaszczyk *et al.*, 2001, pl. 42, fig. 11), USNM 507649 (Walaszczyk *et al.*, 2001, pl. 42, fig. 2) and USNM 507650 (Walaszczyk *et al.*, 2001, pl. 42, fig. 4) are paratypes.

Material. Four specimens preserved as internal molds, with shell fragments attached (Inv.-Nrs U.S., K₂ 1733; U.S., K₂ 1739; U.S., K₂ 1742 and U.S., K₂ 1744), from Bukovets (uppermost part of the *E. typica* Zone), and one specimen, preserved as an internal mold, from Virovsko (Inv.-Nr U.S., K₂ 1729; *Trochoceramus radiosus* Zone).

Dimensions:

Inventory Nr	Valve	h	l	H	L	AM	s	α°	δ°
U.S., K ₂ 1733	right	66	57.1	59	–	37.5	34.1	100	55
U.S., K ₂ 1739	right	–	–	–	–	18	–	100	38
U.S., K ₂ 1744	left	–	–	58.5	–	28	–	115	55
U.S., K ₂ 1742	right	–	–	–	–	18	–	100	38
U.S. K ₂ 1729	right	–	–	–	–	–	–	–	–

Description. Small- to medium-sized and weakly inflated inoceramids. The obliquity of the valves is moderate, with δ around 50° . The anterior margin is short and slightly convex, passing into a broadly rounded anteroventral margin. The ventral, posterior and posteroventral margins are not preserved. The hinge line is moderately long and straight. The umbo is pointed and projecting slightly above the hinge line. The ornamentation consists of regularly to subregularly spaced concentric rugae, with interspaces slightly increasing ventralward.

Specimen U.S., K₂ 1742 is a poorly preserved internal mold of a right valve. The valve is slightly to moderately oblique, with a moderately long and straight anterior margin. In the umbonal part, the ornamentation cannot be observed, while, in the other preserved portion of the disc, it consists of irregularly spaced commarginal rugae.

Remarks. Walaszczyk *et al.* (2001, 2009) emphasized that *Cataceramus? glendivensis* closely resembles *Inoceramus bebahoensis* described by Sornay (1973, Pl. 3, fig. 2 only). Moreover, Walaszczyk *et al.* (2009, p. 61) referred Sornay's species to the genus *Cataceramus* and interpreted *C. bebahoensis* as an evolutionary successor of *Cataceramus? glendivensis*. However, Sornay's species is more inflated and possesses more regular ornamentation.

Although U.S., K₂ 1744 (Fig. 4g) is a partially preserved internal mold of a single left valve (the ventral and the posteroventral part of the disc are missing), we include it in *Cataceramus? glendivensis*, based on the general shell outline, the pointed umbo that is projecting slightly above the hinge line, and the sculpture, which is typical for this species. Specimen U.S., K₂ 1742 (Fig. 5a) is described in open nomenclature due to its poor preservation. Perhaps, it may be a poorly preserved *Cataceramus? bebahoensis* (Sornay, 1973), which is thought to be an evolutionary successor of *C.? glendivensis* (Walaszczyk *et al.*, 2009, p. 61). Specimen U.S., K₂ 1729 (Fig. 8e) is poorly preserved internal mold of a single right valve ornamented with regularly spaced commarginal rugae. The margins of the valve are not preserved, but according to the general valve outline and the type of sculpture, we ten-

tatively interpret this specimen as a juvenile part of *Cataceramus glendivensis*.

Occurrence. Lower Maastrichtian to upper lower and lower upper Maastrichtian. In France (Tercis), this species is limited to the upper part of the lower Maastrichtian *Endocostea typica* Zone. In Austria, Ukraine, Belgium and the U.S. Western Interior, the species is known from the lower Maastrichtian (*E. typica* and *T. radiosus* zones). In KwaZulu (South Africa), it occurs in the upper lower and the lower upper Maastrichtian.

***Cataceramus? cf. bebahoensis* (Sornay, 1973)**
(Fig. 5 b–d)

- pars 1973. *Inoceramus bebahoensis* n. sp.: Sornay, p. 89, Pl. 3, Fig. 1; Pl. 4, Fig. 5.
1995. '*Endocostea*' *bebahoensis* (Sornay, 1973): Morris, p. 262, Pl. 2, Figs 1, 2.
2009. *Cataceramus? bebahoensis* (Sornay, 1973): Walaszczyk *et al.*, pp. 60–61, Figs 21D, 23F, 43C, 43D, 43J, 43K (?), 44B, 44F, 45.
2011. *Cataceramus cf. bebahoensis* (Sornay, 1973): Walaszczyk and Kennedy, p. 107, Figs 3.1, 3.2.

Holotype. The holotype is the original of Sornay (1973, pl. 3, fig. 1), from the Maastrichtian of the Bebaho Basin, southwest Madagascar.

Material. One specimen preserved as internal mold of a single right valve (Inv.-Nr U.S., K₂ 1720) from Virovsko (*T. radiosus* Zone).

Dimensions:

Inventory Nr	Valve	h	l	H	L	AM	s	α°	δ°
U.S., K ₂ 1720	right	–	–	–	–	23.1	39	115	50

Description. Medium-sized and inequilateral specimen, with triangular outline and missing posteroventral part. The valve is distinctly inflated, with moderate obliquity. The anterior margin is moderately long and slightly convex. The umbonal region is massive. The other margins and the posterior auricle could not be observed. The ornamentation consists of regularly to subregularly spaced com-

Fig. 4. Inoceramids of the genus *Cataceramus*: a–c) *Cataceramus palliseri* (Douglas, 1942), Inv.-Nr U.S., K₂ 1727 (Virovsko locality, *Trochoceras radiosus* Zone); a – juvenile view; b – adult view; c – general view of the valve with almost 90° geniculation; d, e, g) *Cataceramus? glendivensis* Walaszczyk, Cobban and Harries, 2001; d – Inv.-Nr U.S., K₂ 1733; e – Inv.-Nr U.S., K₂ 1739; g – Inv.-Nr U.S., K₂ 1744 (Bukovets locality, uppermost part of the *Endocostea typica* Zone); f) *Cataceramus palliseri* (Douglas, 1942), Inv.-Nr U.S., K₂ 1731 (Virovsko locality, *T. radiosus* Zone). All figures are in natural size.

marginal rugae, with slightly increasing interspaces ventralward.

Remarks. *Cataceramus bebahoensis* (Sornay, 1973) is morphologically very similar to *Cataceramus? glendivensis* Walaszczyk, Cobban and Harries, 2001, and these taxa are thought to be phylogenetically related (see Walaszczyk *et al.*, 2009). However, they have different ornamentation styles and inflation of the valves: *Cataceramus? glendivensis* is weakly inflated, while *C. bebahoensis* is much more inflated.

Despite being incomplete, the Bulgarian specimen has a general outline that closely resembles the holotype. Both the style and the direction of the rugae, however, are different in these specimens, and therefore our definition is conditional. Our specimen is similar in sculpture to the one figured by Walaszczyk *et al.* (2009, fig. 44 F).

Occurrence. Upper lower Maastrichtian to lower upper Maastrichtian. France, Bulgaria, Arabian Peninsula, Madagascar and KwaZulu (South Africa).

***Cataceramus* aff. *goldfussianus* (d’Orbigny, 1847)**

(Fig. 5e; Fig. 6a)

Material. Two specimens preserved as internal molds, without shell fragments attached (Inv.-Nrs U.S., K₂ 1719 and U.S., K₂ 1723), from Virovsko (*T. radiosus* Zone).

Dimensions:

Inventory Nr	Valve	h	l	H	L	AM	s	α°	δ°
U.S., K ₂ 1729	left	95.8	98.5	86.7	111.1	38.1	62	115	48
U.S., K ₂ 1719	left	68	66	60.5	73	26.6	51.9	125	50

Description. Specimen U.S., K₂ 1723 is an incompletely preserved left valve of moderate size, which is moderately inflated, with maximum inflation in the dorsocentral part of the disc. The anterior margin is relatively short, passing into rounded anteroventral and anterior margins. The posterior auricle is not separated from the disc. The hinge line is relatively long and straight. The beak is projecting slightly above the hinge line. The ornament is composed of subregular and widely spaced concentric rugae, with interspaces increasing ventralward.

Specimen U.S., K₂ 1719 is an internal mold of a single left valve. The valve is inequilateral and moderately oblique (δ=48°), with subrectangular outline, which is slightly inflated in the juvenile part. The anterior margin is short and very slightly

concave, passing into a broadly rounded and convex anteroventral margin. The ventral margin is rounded, while the posterior is straight. The hinge line is straight, with moderate length. The posterior auricle is elongated and slightly separated from the disc. A geniculation, with relatively high angle, between the juvenile and the adult parts is visible. The juvenile part is ornamented with strong and widely spaced commarginal rugae, with increasing interspaces ventralward. The adult stage is almost smooth. Slightly radial ornamentation is visible in the adult portion of the disc, probably as a result of deformation.

Discussion. Taking into account the valve outline and the sculpture pattern of specimen U.S., K₂ 1723 (Fig. 6a), we believe that it could be referred to *Cataceramus goldfussianus*, although it shows more widely spaced rugae and was recorded in a higher stratigraphic level than that of the typical representatives of this species. The second specimen, U.S., K₂ 1719 (Fig. 5e), differs from *Cataceramus* aff. *goldfussianus* (d’Orbigny) described by Walaszczyk *et al.* (2009, Fig. 15) in the general valve outline and the ornamentation style. It is more posteriorly elongated and more oblique, and possesses more closely spaced and regular rugae, with oval outline, while the specimens figured by Walaszczyk *et al.* (2009) display slightly subpentagonal rugae outline. It is worth noting that specimen U.S., K₂ 1719 closely resembles *Inoceramus* (?) *goldfussianus* (d’Orbigny) figured by McLeod (1994, fig. 11.4). The latter example, however, was subsequently included into synonymy with the newly defined “*Inoceramus*” *howletti* by Walaszczyk *et al.* (2009). This gives rise to the possibility of defining the Bulgarian specimen as “*I.*” *howletti*, but it differs by having a more oblique valve, different shape of the umbonal region and the rugae outline. It is possible that this specimen falls within the range of variability of the species as defined by Walaszczyk *et al.* (2009), but there is not supporting material that can be evaluated.

Occurrence. *Cataceramus goldfussianus* is widely recorded in the upper Campanian, and the record presented herein is from the lower Maastrichtian.

Genus *Trochoceramus* Heinz, 1932

Type species: *Inoceramus helveticus* Heinz (1932, p. 19), by original designation.

Description. Inoceramids with subcircular, oval subquadrate to ellipsoidal shell outline, with different elongation and obliquity of the valves ranging from 40° to 90°. The hinge line is straight and long, with beak weakly or strongly projecting above the

Fig. 5. Inoceramids of the genus *Cataceramus*: a) *Cataceramus* cf. *glendivensis* Walaszczyk, Cobban and Harries, 2001, Inv.-Nr U.S., K₂ 1742 (Bukovets locality, uppermost part of the *Endocostea typica* Zone); b–d) *Cataceramus*? cf. *bebahoensis* (Sornay, 1973), Inv.-Nr U.S., K₂ 1720 (Virovsko locality, *Trochoceras radiosus* Zone); e) *Cataceramus* aff. *goldfussianus* (d’Orbigny, 1847), Inv.-Nr U.S., K₂ 1719 (Virovsko locality, *T. radiosus* Zone). All figures are in natural size.

Fig. 6. Inoceramids of the genera *Cataceramus* and “*Inoceramus*”: a) *Cataceramus* aff. *goldfussianus* (d’Orbigny, 1847), Inv.-Nr U.S., K₂ 1723 (Virovsko locality, *Trochoceramus radiosus* Zone); b) “*Inoceramus*” cf. *howletti* Walaszczyk, Kennedy and Klinger, 2009, Inv.-Nr U.S., K₂ 1717 (Virovsko locality, *T. radiosus* Zone). All figures are in natural size.

hinge line. The type of the concentric ornamentation varies in strength, outline and rugae interspaces. The radial ribbing is typical for the genus, and it is well developed on the entire disc, usually the concentric ornamentation dominating. The radial ornament can vary between weak and slightly visible in rugae interspaces in the adult portion of the disc only.

Discussion. For discussion, see Seitz (1970) and Walaszczyk *et al.* (2001, 2009).

Occurrence. The genus ranges from the uppermost Campanian to probably the lower part of the upper Maastrichtian in the U.S. Western Interior, Bulgaria, Biscay region of France and Spain, France, Austria, Switzerland, Poland, Western Ukraine, Caucasus, Egypt and South Africa (KwaZulu).

***Trochoceramus tenuiplicatus* (Tzankov, 1981)** (Fig. 7a, b)

1906. *Inoceramus salisburgensis* Fugger and Kastner: Petraschek, p. 164, Text-fig. 3.
1941. *Inoceramus vanuxemi* Meek and Hayden?: Stephenson, p. 99, Pl. 13, Fig. 3.
1970. *Inoceramus* (*Trochoceramus*) aff. *monticuli* Fugger and Kastner: Seitz, p. 119, Pl. 18, Fig. 2.
V pars 1981. *Inoceramus* (*Inoceramus*) *tenuiplicatus* sp. nov.: Tzankov, p. 85.
1996. *Trochoceramus tenuiplicatus* (Tzankov, 1981): Walaszczyk *et al.*, p. 160, Pl. 2, Fig. 9; Pl. 5, Fig. 2.
2001. *Trochoceramus tenuiplicatus* (Tzankov, 1981): Walaszczyk *et al.*, p. 188, Pl. 43, Figs 1, 2.
2009. *Trochoceramus tenuiplicatus* (Tzankov, 1981): Walaszczyk *et al.*, p. 71, Fig. 18.

Holotype. The holotype is the original of Petraschek (1906, text-fig. 3), from the Maastrichtian of Leopoldsberge near Vienna (Austria).

Material. Two specimens (Inv.-Nrs U.S., K₂ 1721 and U.S., K₂ 1725) from Virovsko (*T. radiosus* Zone).

Dimensions:

Inventory Nr	Valve	h	l	H	L	AM	s	α°	δ°
U.S., K ₂ 1721	left	111	–	100.5	–	55	54	124	50
U.S., K ₂ 1725	right	110.9	99	92.2	111	51	58.5	110	55

Description. Specimen U.S., K₂ 1721 (Fig. 7a) is an incompletely preserved internal mold of a left valve, with missing anteroventral and ventral parts. The valve is subrectangular, moderately oblique and weakly inflated. The anterior margin is straight and long. The beak is projecting above the long and straight hinge line. The posterior auricle is not visible on the disc. The ornamentation is composed of relatively closed and regularly spaced concentric rugae. Rugae interspaces gradually increase ventralward. Radial ribs are not visible.

Specimen U.S., K₂ 1725 (Fig. 7b) is a completely preserved internal mold of a large-sized single right valve. The valve is subrectangular, weakly inflated and moderately oblique. The anterior margin is slightly rounded and relatively long, passing into rounded anteroventral, ventral and posteroventral margins. The hinge line is long and straight. The beak is small and projecting above the hinge line. The posterior auricle is not separated from the disc. The valve is ornamented with regularly spaced concentric rugae, with interspaces increasing ventralward. The radial ornamentation is quite distinct in both the anteroventral and ventral portions of the disc, mostly on the rugae interspaces.

Remarks. As noted by Walaszczyk *et al.* (2001), the specimen illustrated by Tzankov (1981, pl. 30, fig. 1) does not have radial ribbing, and the visible radial ornamentation is a result of deformation. Therefore, this form should be excluded from the synonymy of *T. tenuiplicatus*. Our material is the first authentic record of *T. tenuiplicatus* in Bulgaria, especially specimen U.S., K₂ 1725 (Fig. 7b), which very closely resembles the holotype (see Petraschek, 1906, text-fig. 3). *Trochoceramus tenuiplicatus* is very similar to *T. radiosus* (Quaas, 1902), but the latter species possesses less oblique valves, more widely spaced concentric rugae and a different outline. Although specimen U.S., K₂ 1721 (Fig. 7a) has a long and straight anterior margin, which is not typical for *T. tenuiplicatus*, it closely resembles the specimen referred to this species and illustrated by Stephenson (1941, pl. 13, fig. 3) and refigured by Walaszczyk *et al.* (2001, pl. 43, fig. 2).

Occurrence. The upper part of the lower Maastrichtian. Poland, Austria, Ukraine, Bulgaria, the U.S. Western Interior Basin and South Africa.

Fig. 7. Inoceramids of the genus *Trochoceramus*: a, b) *Trochoceramus tenuiplicatus* (Tzankov, 1981); a – Inv.-Nr U.S., K₂ 1721 (Virovsko locality, *Trochoceramus radiosus* Zone); b – Inv.-Nr U.S., K₂ 1725 (Virovsko locality, *T. radiosus* Zone). All figures are in natural size.

Genus *Endocostea* Whitfield, 1877

Type species: *Endocostea typica* (Whitfield, 1880, p. 32, by original designation) from the lower Maastrichtian the *Baculites baculus* ammonite Zone, the Old Woman Fork (Cheyenne River, Black Hills area, easternmost Wyoming, U.S.A.).

Description. The genus encompasses small- to medium-sized forms, which are strongly inequilateral and probably equivalved. The valves are posteriorly elongated, weakly to strongly inflated, subrectangular or trapezoidal in outline. The ornamentation consists of regular to subregular commarginal rugae. In the adult stage, the rugation retains the style from the juvenile part but becomes less regular. In most of the species, both slightly visible and well-developed internal ribs are observed. The latter morphological feature is not unique to *Endocostea* and may be developed in other genera.

Discussion. Walaszczyk *et al.* (2001, pp. 138, 178) discussed in detail the systematics and taxonomic problems concerning the genus *Endocostea*.

Occurrence. Uppermost Campanian to the lower upper Maastrichtian in Europe, Western Asia, North America, South America and Africa.

Endocostea typica Whitfield, 1880 (Fig. 8a, b)

- pars 1880. *Endocostea typica* Whitfield: Whitfield, p. 403, Pl. 9, Figs 1–3.
 1913. *Inoceramus barabini* Morton: Böse, p. 35, Pl 3, Fig. 1.
 1967. *Inoceramus (Endocostea) typicus* Whitfield, 1880: Seitz, pp. 55–60, Pl. 2, Figs 3, 4.
 1967. *Inoceramus (Cordiceramus ?)* juv. sp.: Seitz, p. 51, Pl. 2, Fig. 1.
 1967. *Inoceramus (Endocostea)* cf. *cymba* Böhm: Seitz, p. 52, Pl. 2, Fig. 2.
 pars 1968. *Inoceramus impressus* Orbigny: Kociubynskij, Pl. 29, Fig. 4–5.
 non 1968. *Inoceramus impressus* Orbigny Kociubynskij, Pl. 28, Fig. 1.
 1970. *Inoceramus (Endocostea) typicus* Whitfield: Kauffman, Pl.1, Figs 2, 7.
 2001. *Endocostea typica* Whitfield, 1880: Walaszczyk *et al.*, p. 178, Pl. 40, Figs 1–4, 7–8 (Fig. 3 = refigured lectotype).

2001. *Inoceramus* sp. indet.: Odin, Figs. 10, 11; Pl. 3, Fig. 24.
 2001. *Trochoceramus* sp.: Odin, Pl. 3, Fig. 22.
 2002. *Endocostea typica* Whitfield, 1877: Walaszczyk *et al.*, p. 287, Pl. 13, Figs 1–5, 7–8, 11.
 2004. *Endocostea typica* Whitfield, 1877: Walaszczyk, p. 128, Text-fig. 16J, 16K.
 2015. *Endocostea typica* Whitfield: Dochev and Metodiev, p. 107, Fig. 1D, 1F.
 2017. *Endocostea typica* Whitfield, 1877: Jurkowska, Text-fig. 7d.

Lectotype. The lectotype is a specimen of Whitfield (1880, pl. 9, fig. 3; USNM 12261), designated by Seitz, (1967, p. 55), from the lower Maastrichtian of the Old Woman Fork (Cheyenne River, the Black Hills, Wyoming, U.S.A). It was refigured by Walaszczyk *et al.* (2001, pl. 40, fig. 3).

Material. Two specimens preserved as internal molds (Inv.-Nrs U.S., K₂ 1736 and U.S., K₂ 1743) from Bukovets (uppermost part of the *E. typica* Zone).

Dimensions:

Inventory Nr	Valve	h	l	H	L	AM	s	α°	δ°
U.S., K ₂ 1743	right	41	30	28	44.5	9	32	105	38
U.S. K ₂ 1736	left	39	36	31	39.5	12.5	35.5	100	50

Description. The specimens are small-sized internal molds of single left and right valves. The valves are inequilateral, prosocline and slightly inflated. The anterior margin is short and slightly convex, passing into a broadly convex and rounded ventral margin. The hinge line is long and straight. The beak is small and slightly projecting above the hinge line. The posterior auricle is triangular, posteriorly elongated and well separated from the disc.

The ornamentation consists of regularly spaced concentric rugae, weakening when passing on the posteroventral part of the disc (Fig. 8a) and the posterior auricle (Figs 8a, b). In specimen U.S., K₂ 1736 (Fig. 8b), an internal rib is well visible in the posteroventral part of the disc, and is parallel to the growth axis.

Fig. 8. Inoceramids of the genus *Endocostea* and *Cataceramus*: a, b) *Endocostea typica* Whitfield, 1880; a – Inv.-Nr U.S., K₂ 1743; b – Inv.-Nr U.S., K₂ 1736 (Bukovets locality, uppermost part of the *Endocostea typica* Zone); c, f) *Endocostea jolkicevi* Walaszczyk, Odin and Dhondt, 2002; c – Inv.-Nr U.S., K₂ 1741 (Bukovets locality, uppermost part of *E. typica* Zone); f – Inv.-Nr U.S., K₂ 1735 (Bukovets locality, uppermost part of *E. typica* Zone); d) *Endocostea* sp. aff *E. coxi* (Reyment, 1955) – Inv.-Nr U.S., K₂ 1722, (Virovsko locality, *Trochoceramus radiosus* Zone); e) *Cataceramus? glendivensis* Walaszczyk, Cobban and Harries, 2001 Inv.-Nr U.S., K₂ 1729 (Virovsko locality, *T. radiosus* Zone); g) *Cataceramus palliseri* (Douglas, 1942), Inv.-Nr U.S., K₂ 1726 (Virovsko locality, *T. radiosus* Zone). All figures are in natural size.

Remarks. *Endocostea typica* Whitfield, 1880 was discussed in detail by Walaszczyk *et al.* (2001), who heeded that this species displays a relatively wide range of morphological variations. *Endocostea typica* is very similar to *E. coxi* (Reyment, 1955), but the latter species possesses more inflated valves, longer anterior margin and different ornamentation style. Usually, these species are clearly discernible in shape, length and strength of the internal rib.

Occurrence. Lower Maastrichtian. France, Poland, Bulgaria, the U.S. Western Interior Basin and South Africa.

***Endocostea jolkicevi* Walaszczyk, Odin and Dhondt, 2002**

(Fig. 8c, f)

1996. “*Inoceramus*” ex gr. *impressus* d’Orbigny: Walaszczyk *et al.*, pl. 4, fig. 1.

2001. *Endocostea* sp.: Walaszczyk *et al.*, Pl. 39, Fig. 9.

2001. *Inoceramus* sp. indet: Odin, Pl. 3, Fig. 25.

2002. *Endocostea jolkicevi* sp. nov: Walaszczyk *et al.*, Pl 13, Fig. 9.

Holotype: The holotype, is specimen IW-121 of Walaszczyk *et al.* (2002, Pl 13, fig. 9), from level E3.3 of the Tercis quarry; lowermost Maastrichtian, lowermost part of the *Endocostea typica* Zone.

Material. Two specimens preserved as internal molds (Inv.-Nrs U.S., K₂ 1735 and U.S., K₂ 1741) from Bukovets (uppermost part of the *E. typica* Zone).

Dimensions:

Inventory Nr	Valve	h	l	H	L	AM	s	α°	δ°
U.S., K ₂ 1735	right	–	–	–	–	–	–	–	–
U.S., K ₂ 1741	left	–	–	–	–	20	–	90	35

Description. Small- to medium-sized inequilateral, slightly inflated, and slightly oblique specimens. Specimen U.S., K₂ 1741 (Fig. 8c) is an internal mold of a single left valve with subquadrate outline, slightly oblique, represented by the umbonal part of the valve only. It possesses a straight anterior margin, slightly projected beak and well-visible radial internal rib (Hohlkehle). The posterior auricle is not visible. The ornamentation is composed of closely, regularly spaced sharp rugae.

Specimen U.S., K₂ 1735 (Fig. 8f) is a poorly preserved internal mold of the juvenile part of a single right valve with triangular shell outline, slightly oblique and slightly inflated. The anterior margin is long and straight; the other are not preserved. The sculpture is composed of closely, regularly spaced commarginal rugae.

Remarks. Walaszczyk *et al.* (2002) introduced *Endocostea jolkicevi* as a separate species based on its lower obliquity, the presence of a radial sulcus that affects the outline of strong and regular rugae. Walaszczyk *et al.* (2010) described one partially preserved specimen as *E. cf. jolkicevi* based on the valve’s outline and the character of the juvenile rugation. Our specimens are only partially preserved, but based on their weak inflation and obliquity, as well as on the regular and closely spaced rugae, we assume that they are conspecific with *E. jolkicevi*. The main difference with the latter species is the absence of radial sulcus, which can be a result of the poor preservation. Moreover, it should also be noted the unusual position of the internal rib in specimen U.S., K₂ 1741 (Fig. 8c), which is close to the posterior margin of the valve.

Occurrence. Lower Maastrichtian. France, Bulgaria, Dagestan, U.S. Western Interior; uppermost part of *E. typica* Zone in Bulgaria. Walaszczyk *et al.* (2010) reported one specimen, with open nomenclature, from the *Trochoceramus radiosus* Zone in the Vijlen Member of the Gulpen Formation in Belgium and Germany.

Endocostea sp. aff. *E. coxi* (Reyment, 1955)
(Fig. 8d)

Material. One specimen (U.S., K₂ 1722), from Virovsko (*T. radiosus* Zone).

Dimensions:

Inventory Nr	Valve	h	l	H	L	AM	s	α°	δ°
U.S., K ₂ 1722	right	–	–	–	–	44	–	90	28

Description. Specimen U.S., K₂ 1722 (Fig. 8d) is weakly oblique and very slightly inflated internal mold, with deformed and not well-visible juvenile portion of the disc. The adult stage has trapezoidal outline. The anterior margin is relatively long and straight; the other margins are not observed. The posterior auricle is not observed. The ornamentation is poorly preserved, but in the umbonal region it is composed of regular, closely spaced, round-topped commarginal rugae, while in the rest of the disc it seems to be less regular and composed of more widely spaced concentric rugae, with the direction and outline identical with the umbonal rugation.

Remarks. Our specimen has shell outline of the preserved adult part of the disc that resembles some specimens of *E. coxi* (Reyment, 1955) illustrated by Walaszczyk *et al.* (2009, fig. 46A–B, F; fig. 47B, D, F). Typical features of the latter specimens are the strongly inflated valves, with a maximum inflation between the juvenile and the adult transitions, and in some cases, the valves are almost geniculated. Although U.S., K₂ 1722 (Fig. 8d) has an adult valve outline typical for *E. coxi*, it is not possible to be attributed to Reyment’s species, as the juvenile part of the disc was not observed. Additionally, our specimen comes from older stratigraphic interval (lower Maastrichtian, *Trochoceras radiosus* Zone), while *E. coxi* is a characteristic element for the upper Maastrichtian “*Inoceramus*” *ianjonaensis* Zone.

Occurrence. The Bulgarian specimen comes from the lower Maastrichtian *Trochoceras radiosus* Zone.

Inoceramids with unknown generic affiliation

All of the collected inoceramid specimens that are of unknown generic affiliation are referred herein to the genus “*Inoceramus*” s. l.

“*Inoceramus*” cf. *howletti* Walaszczyk, Kennedy and Klinger, 2009
(Fig. 6b)

Material. One partially preserved internal mold of a right valve, with partially preserved shell in the ventral and posteroventral parts of the disc (Inv.-Nr U.S., K₂ 1717), Virovsko (*T. radiosus* Zone).

Dimensions:

Inventory Nr	Valve	h	l	H	L	AM	s	α°	δ°
U.S., K ₂ 1717	right	–	155	160	150	–	83	–	–

Description. Large-sized and incomplete single right valve. The valve is inequilateral, prosocline, moderately oblique and weakly inflated, with maximum inflation in the dorsocentral part of the disc. The anterior, anteroventral and ventral margins are not preserved. The posteroventral margin is rounded, and the hinge line is long and straight. Part of the beak and the umbonal region is missing, but the rest is raised and projecting clearly above the hinge line. The posterior auricle is not observed.

In the umbonal and central parts of the disc, the ornamentation consists of regularly to irregularly spaced commarginal rugae, with increasing interspaces ventralward. Where the shell is preserved, the sculpture is composed of low, round-topped and irregularly spaced, slightly lamellate commarginal rugae, with interspaces wider than the rugae. Interspaces’ growth lines are visible and parallel to the rugae.

Remarks. The strongly concave anterior margin, distinctly projecting umbo and simple ornamentation are the main features of “*I.*” *howletti*. Unfortunately, we cannot observe the characteristics of the anterior margin, but in general our specimen has a valve with raised umbonal region and a beak projecting above the hinge line, which is typical for this species. The posteroventral and posterior part of the disc are crushed and displaced, and the rugae in the posterior part are more closely spaced and even overlapped. Due to the missing anterior and anteroventral parts of the disc, the crushing, displacement and more inflated dorsocentral part of the disc, the studied specimen has been left in open nomenclature.

Occurrence. This species is known from the uppermost part of the lower Maastrichtian *Trochoceras radiosus* Zone in Austria, northeast Belgium, Germany, Poland, and South Africa.

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