Inoceramids from the Upper Campanian and Lower Maastrichtian of the Tercis section (SW France), the Global Stratotype Section and Point for the Campanian – Maastrichtian boundary; taxonomy, biostratigraphy and correlation potential

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ABSTRACT:


Thirty-three inoceramid species from the upper Upper Campanian and Lower Maastrichtian of the Tercis section (SW France), the Global Boundary Stratotype Section and Point for the Campanian – Maastrichtian boundary, are described, of which 8 are left in open nomenclature. Two species are described as new: *Endocostea jolkicevi* and "*Inoceramus*" cobbani. The described species represent four inoceramid genera *Cataceramus* HEINZ, 1932, *Sphaeroceramus*, HEINZ, 1932, *Enodcostea* WHITFIELD, 1877, *Trochoceramus* HEINZ, 1932, and thirteen species are referred to the genus "*Inoceramus*" sensu lato. The inoceramids allow the subdivision of the upper Campanian and of the Lower Maastrichtian into seven zones and their correlation with the ammonite scheme, as well as with the chronostratigraphic standard. The Campanian – Maastrichtian boundary falls in the topmost part of the "*Inoceramus*" redbirdensis Zone, and the base of the successive, *Endocostea typica* Zone is a good proxy for this stage boundary. Besides the *Trochoceramus costaecus* Zone all other zones are also distinguishable in the US Western Interior.

Key words: Tercis, SW France, Global Boundary Stratotype Section and Point, amnonnian, Maastrichtian, Upper Cretaceous, Inoceramid paleontology, Inoceramid stratigraphy,

INTRODUCTION

This paper provides the taxonomic description and biostratigraphy of the Upper Campanian and Lower Maastrichtian inoceramids from the Tercis section, SW France, the Global Standard stratotype Section and Point for the Campanian-Maastrichtian boundary. This section was proposed and positively voted during the second Symposium on Cretaceous Stage Boundaries in Brussels, 1995 (ODIN 1996a; see also KENNEDY & al. 1995, ODIN 1996b) and officially proposed a year later by GSO, voted on by the Subcommission on

Inoceramid material from Tercis represents a unique collection among Late Campanian – Early Maastrichtian European inoceramid collections. Firstly, it was collected bed-by-bed, secondly, it has a very precise stratigraphical control by other fossil groups, such as ammonites, echinoids, brachiopods, asteroids, and microfossil groups represented by calcareous nannofossils, dinoflagellates, and foraminifers, and thirdly, it is rich and represented by relatively well preserved specimens.

The very poor inoceramid material hitherto available from the European Campanian and Maastrichtian was the reason for numerous misconceptions concerning the inoceramid succession and the evolutionary history of the group in the late Late Cretaceous, as well as its supposed almost total uselessness in biostratigraphy. As recently demonstrated for the Campanian and Lower Maastrichtian inoceramids from the US Western Interior (WALASZCZYK & al. 2001), and shown herein by the record from Tercis, inoceramids retained high taxonomic diversity and high evolutionary rate up to their extinction at the Early/Late Maastriechtian boundary (excluding the representatives of the genus Tenuipteria), which places them, similarly to the early Late Cretaceous representatives of the group, among the most efficient biostratigraphical tools.

Fig. 1. Geographical location of the geological site at Tercis-les-Bains (compiled after ODIN 2001); A-B. Geographical location of Tercis; C. The sketch map of the Tercis Quarry; B, D, E, F, P – particular outcrops of the Tercis site, with P marking the main outcrop, and E the additional one used in the present paper; I, II, III, IV, and V – exploitation platforms within the main (P) outcrop (see figure 2 for the stratigraphical range of particular platforms).
Inoceramids in the Tercis section, studied here, were first collected in the 1980s, with their subsequent taxonomic description (DHONDT 1993). Most of that material came, however, from a part well below the Campanian-Maastrichtian boundary and numerous specimens were imprecisely located in the succession. New collecting between 1993 and 2001 brought markedly richer and more precisely horizoned material, with the number of determinable specimens raised to above 300, and good representation of almost the complete succession as available in the Tercis section. A small part of this new collection was recently commented on by ODIN (2001, chapter D3a; with determinations by A.V. DHONDT), but the greater part is treated herein for the first time.

THE TERCIS SECTION

The Geological Site at Tercis, SW France (Text-fig. 1), comprises several sections where Triassic to Palaeogene deposits can be observed. The Campanian-Maastrichtian succession is accessible in the Grande Carrière Moderne. The first detailed lithostratigraphic log and biostratigraphic interpretation of the Campanian-Maastrichtian succession was provided by HANCOCK & al. (1993), with further refinement by ODIN & ODIN (1994) and ODIN (1996a, b). HANCOCK & KENNEDY (1993) and WARD & ORR (1997) described the ammonite fauna and DHONDT (1993) the inoceramids available at that time. The comprehensive survey on the succession with detailed lithological and sedimentological studies, multistratigraphic investigations, as well as detailed history of researches appeared recently (ODIN 2001a) in a comprehensive volume collecting a series of papers of group of palaeontologists and geologists working on the Tercis section in the late 1990s.

The quarry is composed of two sections. The main section, composed of five exploitation platforms, located one above the other, and one independent section (the E section), 400 metres distant (Text-fig. 2). The successions of particular platforms of the main section, and of section E, have been compared and correlated using distinct sedimentological characters. The base of section E correlates with level 114 to the main quarry (Text-fig. 2). All five platforms of the main section are characterised by very similar succession with the same thickness relationships. Slightly different thicknesses were measured in section E.

The lithological succession of the Tercis section has been subdivided into two units: the d’Avezac Unit, composed of pithonellid bearing limestones, with 5 to 15% of clay, from level 0 to level 100, and the lithologically similar Les Vignes Unit, characterised by flint nodules (Text-fig. 2). The d’Avezac Unit has been subdivided further into 5 subunits, depending on the glaucony content. The Les Vignes Unit was subdivided into 2 subunits, based on the colour of the flint nodules (Text-fig. 2) (see ODIN 2001a, chapter B1a).

Precise correlation with the lithological log of HANCOCK & al. (1993) is rather difficult. The approximate correlation is shown in Fig. 2 and a more detailed discussion is provided by Odin (2001a, chapter B1a, fig. 11 and chapter D3a, figure 1). Among the most convincing correlation levels is the boundary between units J and K of HANCOCK & al. (1993) with level 98 of ODIN (2001a).

INOCERAMID SUCCESSION IN TERCIS

Inoceramid bivalves are the dominant macrofossil group in the Tercis succession. Intact shells or inoceramid shell debris have been observed sub-continuously from level 4.5 to level 171.0 (Text-figs 3-4; see ODIN 2001, chapter D3a). Very rich shell material occurs between levels 45.1 and 47.4 and between levels 66.5 and 67.3, referred to here as the lower and the upper interval with inoceramid concentration respectively. Both intervals give good opportunities for collecting. Although shell debris is present and sometimes abundant, the intact specimens are difficult to collect, and several other intervals (e.g. 11 to 21, 52 to 65, 68 to 80 and 114 to 117) are completely barren in respect of inoceramid remains. Taxonomic diversity is relatively high throughout the succession with a distinct peak around level 93 (Text-fig. 5).

The oldest finds come from levels 6.5 to 6.7, where inoceramids are represented by rare but relatively large specimens of Cataceramus paraheberti (SORNAY, 1968), C. subcompressus (MEEK & HAYDEN, 1856) and C. ex gr. balticus (BOHMI, 1907). Above, up to the lower interval with inoceramid concentration around level 47, the record is very scanty, with single finds of “Inoceramus” conflin Walaszczyk, Cobban & Harries, 2001, Cataceramus ex gr. balticus (BOHMI, 1907), C. goldfussianus (d’ORBIGNY, 1847), C. mortoni (MEEK & HAYDEN, 1860), Cordiceramus heberti (FALLOT, 1885), “Inoceramus” algieriensis HEINZ, 1932, and “Inoceramus” borilensis Jolkićev, 1962. A very characteristic form, representing most probably a new species, comes from level 42.4 (Pl. 2, fig. 6). Unfortunately it is represented by a single specimen and further material is needed to make a reasonable final decision.

All of these taxa are either known to span a relatively large interval ranging from the lower Middle to lower Upper Campanian, or their stratigraphical position is poorly known. Therefore, they do not allow a more precise stratigraphical classification of that part of the section.
Fig. 2. Composite section of the Campanian and Maastrichtian succession of the Tercis Quarry (compiled after Odin, 2001); the letter symbols to the left are lithological units of Hancock & al. (1993)
Around level 47 (more precisely between level 45.1 and 47.4) occurs the lower interval with frequent inoceramids. The assemblage here is very distinctive and diverse taxonomically. The most common taxa are *Cataceramus goldfussianus* (D'ORBIGNY, 1847), *Cataceramus palliseri* (Douglas, 1942), and *Sphaeroceramus pertenuiformis* WALASZCZYK, COBBAN & HARRIES, 2001. Also noted are *Cataceramus? aff. barabini* (MORTON, 1834), and "Inoceramus" bordiensis JOLKICˇEV, 1962.

Above this level, up to the next interval with abundant inoceramids located around level 67, there is an about 20 metre thick barren succession with almost no inoceramid record (this is also the case with the ammonites). To what extent this is a local phenomenon or a record of supra-regional Late Campanian events remains unclear and more detailed studies on other Upper Campanian sections are required to answer the question.

The barren interval finishes sharply at the base of the second interval with high inoceramid concentration, in the interval between levels 66.5 and 67.4. The dominant inoceramids of this interval differ markedly from those characterising the lower 'concentration' level. The main

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**Fig. 3. Quantitative distribution of inoceramids in the Tercis section**

<table>
<thead>
<tr>
<th>Level</th>
<th>E Outcrop</th>
<th>Collect. Shells</th>
<th>Studies</th>
</tr>
</thead>
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<tr>
<td>160</td>
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<td>140</td>
<td>20</td>
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<td>Dhondt, 98</td>
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<tr>
<td>80</td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>68.5</td>
<td>43</td>
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**Studies**

<table>
<thead>
<tr>
<th>V</th>
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<tbody>
<tr>
<td>O</td>
<td>37 (13)</td>
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<tr>
<td>N</td>
<td>38 (18)</td>
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<tr>
<td>M</td>
<td>39+59 (16+41)</td>
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<tr>
<td>L</td>
<td>100+75 (45+55)</td>
</tr>
<tr>
<td>K</td>
<td>4+0 (1+0)</td>
</tr>
<tr>
<td>J</td>
<td>1 (4)</td>
</tr>
<tr>
<td>H</td>
<td>22 (5)</td>
</tr>
<tr>
<td>G</td>
<td>43 (10)</td>
</tr>
<tr>
<td>F</td>
<td>30 (7)</td>
</tr>
<tr>
<td>E</td>
<td>1 (1)</td>
</tr>
</tbody>
</table>

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**LES VIGNES Unit**

- **Collect. Shells**
  - 140 collected
  - 155 collected
  - 390 collected

- **Identified**
  - 50 identified
  - 236 identified

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**D'AVEZAC Unit**

- **Sub Unit**
  - 50 identified
  - 74 identified
morphotypes are represented by moderate to moderately large, regularly ribbed, usually weakly oblique forms of the following species: "Inoceramus" altus MEEK, 1871, "Inoceramus" sagensis OWEN, 1852, Cataceramus goldfussianus (d’ORBIGNY, 1847), and "Inoceramus" vanuxemi MEEK & HAYDEN, 1869.

Above the second inoceramid concentration interval (around level 67.0) the group very quickly becomes rare. A few specimens of "I." vanuxemi and "I." sagensis, found at level 73.9 show, however, that the assemblage characteristic of the second inoceramid concentration continues distinctly higher. Its exact range is not recognised, but in the next level with frequent inoceramids, around level 84, the taxonomic composition of the inoceramid assemblage is very different, with most of the species characteristic of the interval below, disappearing.

The interval around level 84 is dominated by Cataceramus palliseri (DOUGLAS, 1942)(= Inoceramus regularis d’ORBIGNY). The number of associated species is, however, relatively high. Among the well-represented forms are: Cataceramus goldfussianus (d’ORBIGNY, 1847), “Inoceramus” aff. gandjaeformis WALASZCZYK, COBBAN & HARRIES, 2001, and Endocostea aff. typica (WHITFIELD). Two specimens were provisionally referred to Inoceramus oblongus White. From level 84 comes a single specimen of a large, strongly rugate form, which represents presumably the herein newly described “Inoceramus” cobbani.

A very similar assemblage is noted higher, in the next interval with numerous inoceramids around level 93. Besides “Inoceramus” oblongus MEEK, 1871, Cataceramus? palliseri (DOUGLAS, 1942), “Inoceramus” gandjaeformis WALASZCZYK, COBBAN & HARRIES, 2001, it also contains “Inoceramus” alaeformis ZEKELL, 1852, of authors, “Inoceramus” balchiformis WALASZCZYK, COBBAN & HARRIES, 2001, “Inoceramus” magniumbonatus DOUGLAS, 1942 and “Inoceramus” cobbani sp. nov.

Above level 93, but still in the topmost Campanian, appear two successive faunas, with distinctly lower taxonomic variability than in the assemblages below, but with very characteristic and easily identifiable species. The stratigraphically older fauna is dominated by forms belonging to the genus Trochoceramus occurring in the interval between levels 97.5 and 102, represented here by T. costaecus (KHALAFOVA, 1966) characterised by fine ornament, with closely spaced rugae, a weak inflation and a relatively small size. The non-trochoceramid taxa are rare and the collected material at hand is not specifically identifiable, but at least three non-trochoceramid species are present.

The younger assemblage, and actually the youngest Campanian inoceramid assemblage recognised so far in the Tercis section, occurs between levels 108 and 111. It contains two species described recently from the US Western Interior: “Inoceramus” redbirdensis WALASZCZYK, COBBAN & HARRIES, 2001, occurring fairly frequently and, more rarely, “Inoceramus” wyomingensis WALASZCZYK, COBBAN & HARRIES, 2001. The former is a very distinctive morphotype, which may easily be identi-
fied and thus appears to be a good taxon for recognition of the Campanian – Maastrichtian boundary interval.

Six metres higher, at level 117.1, the main change in inoceramid fauna takes place (see also Text-fig. 4). Here, in an interval about 1 metre thick, appears a fauna, composed almost exclusively of small-sized *Endocostea typica* (Whitefield, 1880), accompanied by very rare *Cataceramus subcircularis* (Meek, 1876). Although the collected material is rich, it must be emphasised that the level around 117 is very widely exposed for easy sampling and this may be the reason for the apparent inoceramid abundance there. [The change in the inoceramid fauna may actually take place below, somewhere in the interval between the last *Inoceramus wyomingensis* and the level with numerous *Endocostea typica*, but so far no data from that interval are available]. Higher up the section, almost at the top of the exposed part of the Tercis section, *Endocostea typica* disappears (two specimens are known from level around 145) and the assemblage is composed of dominant *Cataceramus subcircularis*, associated with rare *C.? barabini* (Morton, 1834) and, in the highest part of the section, at level 150-160, *C.? glendivensis* Walaszczyk, Cobban & Harries, 2001.

![Stratigraphical distribution of inoceramid species and inoceramid zonation of the upper Upper Campanian and of the Lower Maastrichtian in the Tercis section; inoceramid zones at the bottom are as follows: 1 – *Sphaerocermus pertenuiformis* Zone; 2 – *Inoceramus* altus Zone; 3 – *Inoceramus* oblongus Zone; 4 – *Trochoceramus costaeus* Zone; 5 – *Inoceramus* redbirdensis Zone; 6 – *Endocostea typica* Zone; 7 – *Trochoceramus radiatus* Zone](image)
Of importance is the single find of *Trochoceramus* well above the base of the Maastrichtian, and well above the level with common trochoceramids between 97.5 and 102 m. It is *Trochoceramus radiosus* (Quaas, 1902), found in unit V of Hancock & al. (1993; see Dhondt 1993), estimated to be about 50 m above the base of the *Endocostea typica* Zone.

**INOCERAMID BIOSTRATIGRAPHY AND ITS CORRELATION WITH THE US WESTERN INTERIOR SUCCESSION**

Besides the lowermost part of the succession at Tercis, which in inoceramid terms, does not reveal a clear stratigraphical pattern (Text-fig. 5), the inoceramid record enabled the establishing of the inoceramid zonal scheme. Seven zones are recognised, which with slight modification, correspond closely to the zonation proposed recently for the Campanian – Lower Maastrichtian of the US Western Interior (Walaszczyk & al. 2001), reflecting a high similarity of both areas in respect of their inoceramid faunas (Walaszczyk & al. 2002). From bottom upward, these are zones of (Text-fig. 5): *Sphaeroceramus pertenuiformis*, “*Inoceramus*” altus, “*Inoceramus*” oblongus, *Trochoceramus costaecus*, “*Inoceramus*” redbirdensis, *Endocostea typica*, and *Trochoceramus radiosus*. All of the zones are defined as interval range zones with the base of particular zones defined by the first occurrence of the eponymous species.

The applied zonation, its chronostratigraphic interpretation and correlation with the Western Interior inoceramid and *Baculites* zonation is as follows (from top downward):

**Sphaeroceramus pertenuiformis Zone**

The base of the *Sphaeroceramus pertenuiformis* Zone is placed at the base of the lower interval with inoceramid concentration, which corresponds to level 45.1. The actual position of this boundary may, however, be lower, due to the very incomplete inoceramid record below that interval. Similarly, there is a problem with the actual position of the upper boundary of the zone. Its present location at level 66.5, indicated by the FO of the index taxon of the successive zone of “*Inoceramus*” altus, may appear too high. The reason is the almost complete absence of inoceramids from between the lower and upper intervals with inoceramid concentration.

The *Sph. pertenuiformis* Zone is characterised by a very distinctive inoceramid assemblage. Besides the nominative species, common species are: “*Inoceramus*” borilensis Jolkicˇev, 1962, *C. goldfusianus* (D’Orbigny, 1847), *Cataceramus palliseri* (Douglas, 1942), and *Cataceramus* aff. barabini (Morton, 1834).

The inoceramid assemblage of the *Sph. pertenuiformis* Zone in Tercis corresponds well to the time-equivalent assemblage recognised in the US Western Interior. In the latter area the *Sph. pertenuiformis* Zone corresponds

<table>
<thead>
<tr>
<th>Chronostratigraphy</th>
<th>Inoceramid zones, Tercis</th>
<th>Western Interior <em>Baculites</em> and <em>Inoceramus</em> Zonations (after Cobb 1994, and references therein; and Walaszczyk &amp; al. 2001)</th>
</tr>
</thead>
<tbody>
<tr>
<td>L. Maastrichtian (pars)</td>
<td><em>Trochoceramus radiosus</em></td>
<td><em>T. radiosus</em></td>
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<tr>
<td>U. Campanian (pars)</td>
<td><em>Endocostea typica</em></td>
<td>“<em>I.</em>” incavis</td>
</tr>
<tr>
<td>U. Campanian (pars)</td>
<td>“<em>Inoceramus</em>” redbirdensis</td>
<td>“<em>Inoceramus</em>” redbirdensis</td>
</tr>
<tr>
<td>U. Campanian (pars)</td>
<td><em>Trochoceramus costaecus</em></td>
<td>“<em>Inoceramus</em>” oblongus</td>
</tr>
<tr>
<td>U. Campanian (pars)</td>
<td>“<em>Inoceramus</em>” oblongus</td>
<td></td>
</tr>
<tr>
<td>U. Campanian (pars)</td>
<td>“<em>Inoceramus</em>” altus</td>
<td>“<em>Inoceramus</em>” altus</td>
</tr>
<tr>
<td>U. Campanian (pars)</td>
<td><em>Sphaeroceramus</em> pertenuiformis</td>
<td><em>Sphaeroceramus</em> pertenuiformis</td>
</tr>
<tr>
<td>U. Campanian (pars)</td>
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</table>
roughly to the ammonite zones of Exiteloceras jenneyi and of Didymoceras stevensoni, which in the subdivision of the Campanian applied in the USA, places it in the lower Upper Campanian.

“Inoceramus” altus Zone

The base of the zone is placed at the base of the higher level with inoceramid concentration, which corresponds to level 66.5. As mentioned above, the actual position of this boundary may, however, be slightly lower, in view of the lack of inoceramid records in the interval below. The upper boundary of the zone is marked by the first occurrence of “Inoceramus” oblongus, somewhere between levels 80 and 88. The highest record of “I.” altus comes from level 93.6, although the highest record of the assemblage characterising the zone comes from level 73.9.

This zone contains a very characteristic assemblage, with numerous weakly oblique and regularly rugate species. The record is limited, however, mostly to the lowermost 2 metres of the zone. The most typical taxa are: “Inoceramus” altus MEEK, 1871, “Inoceramus” sagensis OWEN, 1852, Cataceramus? aff. barabini (MORTON, 1834), and “Inoceramus” aff. pseudoregularis SORNY, 1962; also well represented is C. goldfussianus (d’ORBIGNY, 1847) (see Pls 4-6). From the upper part of the zone come some other forms with unknown specific affinities (Pl. 7, figs 2, 5).

In the US Western Interior it is the assemblage that characterises above all, the Baculites compressus ammonite Zone, known from the famous material of the Sage Creek section, as well as from the mass occurrences in western Colorado. The stratigraphically oldest representatives of the assemblage come, however, from the underlying Didymoceras cheyenense Zone, whereas the youngest come from the basal part of the overlying Baculites cuneatus Zone. The precise correlation of the ammonite and inoceramid zonal boundaries at that interval has yet to be worked out.

“Inoceramus” oblongus Zone

The base of the zone, marked by the FO of the index taxon, lies somewhere between levels 80 and 88, and its precise location still needs further collecting. Its upper boundary lies at level 97.5, the level of the FO of representatives of the genus Trochoceras.

The inoceramid assemblage of this zone is inevitably the most diverse taxonomically within the whole Tercis succession. The most common species in the lower part (around level 85) of the zone is Cataceramus? palliseri (Douglas, 1942) (Pl. 8, Figs 1-2) accompanied by “Inoceramus” aff. gandjaeformis WALASZCZYK, COBBAN & Harries, 2001 (see Pl. 8, Figs 3,6), which is very characteristic of this level. The index species of the zone is more common higher up, around level 93, which is also the level with the highest taxonomic diversity of inoceramid fauna. Besides “I.” oblongus MEEK, 1871, Cataceramus goldfussianus (d’ORBIGNY, 1847), “Inoceramus” alaeformis ZEKELI, 1852 (of authors), “Inoceramus” aff. gandjaeformis WALASZCZYK, COBBAN & HARRIES, 2001, and C. palliseri (D’ORBIGNY, 1842) (see Pls 8-10), also encountered here are: “I.” magnumbonatus DOUGLAS, 1942, “I.” cobbani sp.nov., “I.” balchiformis WALASZCZYK, COBBAN & HARRIES, 2001, and “Inoceramus” sp., an elongated, regularly ornamented (not illustrated herein), which represents presumably a new species. From a level slightly below, around level 88, comes Endocostea sp. (Text-fig. 7), which seems to be the oldest member of the genus.

The details of the inoceramid succession within the “I.” oblongus Zone are still not sufficiently known to give a precise distribution of particular taxa, but it seems that further subdivision of the zone is possible.

In the US Western Interior, the “I.” oblongus Zone characterises roughly the ammonite zone of Baculites resediei. The precise correlation of its lower and upper boundaries is, however, unknown.

Trochoceras costaeacus Zone

The lowest specimen of the eponymous species was found at level 96.7, marking the base of the zone. The top of the zone is placed at level 108, the level of the FO of “Inoceramus” redbirdensis WALASZCZYK, COBBAN & HARRIES, 2001. The occurrence of Trochoceras (Pl. 11; Pl. 12, figs 1-3, 7) is limited to the lower part of the zone. The stratigraphically highest specimen was found at level 101.9. From higher levels of the zone the inoceramid fauna is practically unknown.

The inoceramid assemblage of the Trochoceras costaeacus Zone has not been recognised in the Western Interior succession, but this does not preclude its presence there. In terms of the Western Interior Baculites zonation the T. costaeacus Zone may correspond to the Baculites jenseni ammonite Zone or even higher, to the lower part of the Baculites eliasi ammonite Zone.

“Inoceramus” redbirdensis Zone

The base of the zone is located at level 108, the lowest occurrence level of the index taxon. As in the case of the preceding zone, the index taxon was found so far only in the lowermost part of the zone (the stratigraphically highest specimen was found at level 110.5). A relatively thick, 7 m interval of the zone has no inoceramid
record. A single species, “Inoceramus wyomingensis Walaszczyk, Cobban & Harries, 2001, was found associated with the index taxon.

Both species (Pl. 12, Figs 5-6; Pl. 13, Figs 12-16) were recognised originally in the US Western Interior (Walaszczyk et al. 2001) in the lower and middle parts of the Baculites eliasi ammonite Zone.

“I.” redbirdensis is a very characteristic species, and its occurrence may be used as a very practical proxy for the Campanian – Maastrichtian boundary. Using the mean rate of deposition calculated in that portion of the quarry (Odin 2001a, chap. B1c) the taxon would have lived about 0.2 Ma before the boundary.

Endocostea typica Zone

The base of the zone is placed at level 117.1 and marks a radical change in inoceramid faunas. At the base of the zone the inoceramid assemblage is an almost monospecific assemblage of the eponymous species (Pl. 13, Figs 1-5, 7-8, 11). The associated forms represented by Endocostea jolckeii sp.nov., Cataceramus subcircularis (Meeke, 1876), Cataceramus? oviformis Walaszczyk, Cobban & Harries 2001 and Cataceramus? barabini (Morton, 1834) are very rare (Pl. 13, Figs 6, 9-10; Pl. 14, Figs 1-4, 6, 8-9, 11-14). The middle and upper parts of the zone are poorly documented. However, the eponymous species does not dominate any more. In the upper part of the zone appears the very characteristic species Cataceramus? glendivensis Walaszczyk, Cobban & Harries, 2001 (Pl. 14, Figs 5, 7, 12). The species also appears in a similar stratigraphical position in the US Western Interior (Walaszczyk et al. 2001), where it ranges higher into the successive Trochoceramus radiosus Zone, and in Austria (Tröger & al. 2002), and it seems to be a potentially a very useful biostratigraphical marker. Its record in the Tercis section is, however, very limited and consequently we did not distinguish a separate C.? glendivensis Zone.

The zone is well represented in the US Western Interior, where the mass occurrence of E. typica at its base is a very good marker of the ammonite zone of Baculites baculus. The upper boundary of the zone lies in the topmost part of the B. baculus Zone.

Trochoceramus radiosus Zone

It is the highest inoceramid zone distinguished in the Tercis succession. The presence of this zone is documented by a single specimen of Trochoceramus radiosus (Quas, 1902) (see Pl. 14, Fig. 10), found in unit V of Hancock & al. (1993; see Dhondt 1993). It corresponds roughly to level 170 in the present scheme. This zone is well represented in the US Western Interior, where it corresponds to the uppermost part of the Baculites baculus ammonite Zone and the overlying Baculites grandis Zone.

INOCERAMIDS AT THE CAMPANIAN/MAASTRICHTIAN BOUNDARY

As recently discussed (Walaszczyk et al. 2002), the base of the Maastrichtian, in inoceramid terms, falls in an interval between the last occurrence of “Inoceramus” redbirdensis and the first appearance of Endocostea typica Whitfield. When the respective zones are defined as interval zones, the boundary is located in the topmost part of the former. In practice, the FO of E. typica is a very useful proxy of the boundary. In Tercis and also in the Western Interior, this species appears in abundance, in monospecific concentrations that are easily located in the section. It is accompanied by rare Cataceramus subcircularis (Meeke) and an unassigned specifically Cataceramus. The first appearance of E. typica also marks a significant size decrease of inoceramid faunas (see Text-fig. 4), what may be used as a very convenient practical tool for the boundary position.

Close to the boundary is also the FO of the genus Trochoceramus, used as one of the boundary events by Odin (2001). The very characteristic ornamentation of this species makes it easy to use. This occurrence characterises the deosists about 0.8 Ma older that the stage boundary.

In the US Western Interior, according to the inoceramid correlation, the Campanian/Maastrichtian falls in the topmost part of the Baculites eliasi ammonite Zone (above the highest record of “I.” redbirdensis and just below the first occurrence of E. typica) (see Walaszczyk et al. 2001, 2002).

REPOSITORIES AND CATALOGUING SYSTEM

The whole collection is housed at the Université P. & M. Curie and will be preserved in the Museum facilities planned to be realised in the future near the Geological site at Tercis.

The location of the specimens in the succession is referred to “levels”, distinguished in the quarry and not to a metre scale, although these two values are probably very close (see Odin 2001). It is because of the homogeneity of the succession and problems with the precise lateral correlation within the quarry with the original measurements made and marked in 1992.

The levels of the specimens collected from the E section are characterised by a level quoted later with “a” in
order to indicate that precise correspondence with the main section may possibly be slightly biased. Specimens collected loose, but which can be attributed to lithological units on lithological grounds are marked with the level shown in brackets.

SYSTEMATIC ACCOUNT

Genus *Cordiceramus* Heinz, 1932

**TYPE SPECIES:** *Inoceramus cordiformis* Sowerby (1823, p. 61, pl. 440), from Gravesand, England, *Micraster coranguinum* echinoid Zone, Santonian.

*Cordiceramus heberti* (Fallot, 1885)  
(Pl. 1, Fig. 6)

1885. *Inoceramus heberti* Fallot, p. 249, pl. 7, fig. 1.
2001. *Cordiceramus heberti* (Fallot); Walaszczyk & al., pl. 7, figs 4, 8, 11 (full synonymy therein).

**TYPE:** The holotype is the original of Fallot (1885, pl. 7, fig. 1) housed in the E. Fallot collection of the Laboratoire de Paléontologie, Muséum national d'Histoire naturelle de Paris. The specimen comes most probably from the Middle Campanian (see discussion in Walaszczyk & al. 2001).

**MATERIAL:** Single specimen IW-9 from level 25.5.

**DESCRIPTION:** The specimen is the internal mould of a single RV, with postero-ventral part missing, with h max = 69 mm. The umbonal part is indistinct, with the beak projecting only slightly above the hinge line. The hinge line is moderately long, straight. The growth axis is almost straight, slightly convex anteriorly. The broadly convex
anterior margin passes into the rather narrowly convex ventral margin. The postero-ventral margin is not preserved, but the postero-dorsal margin is straight, parallel to the growth axis.

The surface is ornamented with sharp-edged concentric rugae, with flat-floored interspaces increasing in size distinctly ventralward. The rugae are superimposed by distinct growth lines. Anteriorly of the growth axis the rugae display a narrow flexure zone, where they cross the growth lines obliquely.

REMARKS: The moderate obliquity, subquadrate outline, and the character of ornament (with a characteristic anteriorly located flexure zone) show the T ercis specimen to belong to *Cordiceramus heberti* (FALLOT, 1885). From *Cataceramus beckumensis* (GIERS, 1964), which is very similar in respect of general outline, it differs in its type of ornament. WALASZCZYK & al. (2001) recently discussed the species based on North American material.

OCCURRENCE: In the US Western Interior it is known from the *Baculites gregoryensis* ammonite Zone of the Middle Campanian. The holotype comes from SE France, most probably from an equivalent level.

Genus: *Cataceramus*, HEINZ, 1932

TYPE SPECIES: *Inoceramus balticus* BOHM (figured in BOHM, 1909, pl. 11, fig. 2) from Dülmen, Lower Campanian of Westphalia, northern Germany.

*Cataceramus* ex gr. *balticus* (BOHM, 1907)  
(Pl. 1, Fig. 5)

MATERIAL: IW-1, IW-3, IW-5, all from level 6.5, and IW-6 from level 7.0.

REMARKS: From the bottom part of the section comes a series of poorly preserved, moderately large single valve internal moulds, which may be called the "balticus" morphotype. All are characterised by the "balticus" outline, with moderate to weak inflation and a regular concentric ornament. The rugae are widely spaced. The character of the growth lines cannot be observed.

The "balticus" group, as understood here, comprises *C. balticus* (BOHM, 1907), *C. pteroides* (GIERS, 1964) and *C. marcki* (GIERS, 1964)(see also WALASZCZYK 1997). The Tercis specimens most closely resemble the latter species, which, in contrast to *C. balticus* (BOHM, 1907), possesses a more robust ornament and moderate inflation (see GIERS 1964). Having only a few specimens to hand it is rather difficult to make a more proper identification.

OCCURRENCE: In Tercis, *Cataceramus* ex gr. *balticus* is limited to the lowermost part of the section.

*Cataceramus? barabini* (MORTON, 1834)  
(Pl. 14, Figs 4, 11, 14)

1834. *Inoceramus Barabini* MORTON, p. 62, pl. 13, fig. 11; pl. 17, fig. 3.  
1876a. *Inoceramus Criptii?*, var. *Barabini*, MORTON; MEEK, p. 49, pl. 12, fig. 3; [?pl. 13, fig. 1]; text-figs 1-4.  
1880. *Inoceramus barabini* MORTON; WHITFIELD, p. 398 (?pars), [?pl. 7, fig. 7]; pl. 9, fig. 8.  
1898. *Inoceramus barabina* MORTON; LOGAN, p. 504, pl. 109, fig. 2.  
1913. *Inoceramus Barabini* MORTON; BOSE, p. 35 (pars), pl. 4, fig. 1; [non pl. 3, figs 1, 7; pl. 3, fig. 1 = *Endocostea typica Whitfield*].  
1942. *Inoceramus barabini* var. *inflatiformis* DOUGLAS, p. 63, pl. 2, fig. 3.  
?non 1959. *Inoceramus barabini* MORTON; DOBROV & PAVLOVA, p. 140, pl. 22, fig. 2. [=?*Cataceramus aff. barabini*]  
1970. *Inoceramus barabini* MORTON; KAUFFMAN, p. 217 (pars), pl. 1, fig. 8 [non pl. 1, fig. 3].  
?1974. *Inoceramus barabini* MORTON; KOCIUBYNSKI, p. 83 (?pars), [?pl. 23, fig. 2 [non pl. 20, fig. 1 = *Cataceramus subundatus* (MEEK)].  
2001. *Cataceramus? barabini* (MORTON); WALASZCZYK & al.; pl. 33, figs 1, 3; pl. 35: fig. 1; pl. 36, figs 2, 4, 6-7; pl. 39, figs 4-5; ?pl. 40, fig. 5  

TYPE: The lectotype, by subsequent designation of MEEK (1876a, p. 55) is ANSP 15469, the original of MORTON’s (1834, pl. 17, fig. 3) from Upper Cretaceous strata of Greene County, Alabama, USA.

MATERIAL: Three specimens IW-157 from level 155.6; IW-111 from level 143.8; IW-147 from level 161.1, IW-148 from 140.1.

DESCRIPTION: All of the specimens are internal moulds of single valves. IW-157 (Pl. 14, Fig. 11) is an incompletely preserved LV; its antero-dorsal part is missing. IW-111 (Pl. 14, Fig. 4) is a small-sized specimen. All of the specimens are markedly oblique, with $\delta = 20-25^\circ$, strongly elongated posteriorly. The umbo is indistinct, with the beak projecting very slightly above the hinge line.
The hinge line is long and straight. The anterior margin is short, convex, passing into long and broadly convex antero-ventral and ventral margins. The posterior margin is moderately short, convex. The valves are covered with subregular concentric rugae, usually narrowly spaced.

REMARKS: The specimens referred herein to \textit{C.? barabini} correspond well to the American material as recently illustrated and discussed by WALASZCZYK \& \textit{al.} (2001). IW-147 (Pl. 14, Fig. 14) differs slightly in respect of the surface ornament, possessing more widely spaced rugae. Its surface is, however, not particularly well preserved and thus its ornament may have been changed secondarily to some extent.

OCCURRENCE: All Tercis specimens are from the Lower Maastrichtian, as in the case of the American forms illustrated by MEEK (1876a, pl. 13, fig. 1) or recently by WALASZCZYK \& \textit{al.} (2001). The precise location of \textit{MORTON}’s type still has to be worked out.

\textit{Cataceramus} ? aff. \textit{barabini} (MORTON, 1834) (Pl. 3, Figs 4, 9; Pl. 4, Fig. 1)

\textit{Cataceramus} ? aff. \textit{barabini} (MORTON, 1834); WALASZCZYK \& \textit{al.}, p. 43, pl. 11, figs 1-4; pl. 15, fig. 3.

MATERIAL: Three specimens; IW-141 from level 148.2; IW-137 from level 157.0 and IW-124 from level 169.0.

DESCRIPTION: All three specimens are internal moulds of single valves. The valves are of rather small to moderate size, weakly inflated. The umbo is delicate, with the beak projecting clearly above the hinge line. The valves are moderately oblique and are characterised by a relatively long, broadly convex anterior margin, passing into a regularly rounded ventral margin, and with a rather short, almost straight posterior margin. The hinge line is long and straight. The posterior auricle is subtriangular and moderately well separated from the disc.

The valves are regularly ornamented with subevenly spaced concentric rugae, with interspaces increasing in size gradually ventralward and weakening slightly when passing onto the posterior auricle.

REMARKS: \textit{Cataceramus} ? aff. \textit{barabini} was recently described by WALASZCZYK \& \textit{al.} (2001) from the \textit{Didymoceras nebrascense} through \textit{Exiteloceras jenneyi} ammonite Zone of the US Western Interior. \textit{Baculites grandis} Zone), whereas \textit{C.? aff. barabini} occurs in the middle Upper Campanian.

OCCURRENCE: Known from the \textit{Sph. pertenuiformis} Zone and basal “\textit{I. altus} Zone of the Tercis section; described from the lowermost Upper Campanian (\textit{Didymoceras nebrascense} through \textit{Exiteloceras jenneyi} ammonite Zones) of the US Western Interior.

\textit{Cataceramus? glendivensis} WALASZCZYK, COBBAN \& HARRIES, 2001 (Pl. 14, Figs 5, 7, 12)

\textit{Cataceramus? glendivensis} WALASZCZYK, COBBAN \& HARRIES, pl. 42, fig. 2, 11; pl. 44, figs 2, 4

2001. \textit{Inoceramus sp.indet.}; ODIN, pl. 3, fig. 27.

TYPE: The holotype, by original designation, is YPM 191001, the original of WALASZCZYK \& \textit{al.} (2001, pl. 42, fig. 2), from the upper part of the \textit{Baculites baculus} ammonite Zone of the Glendive section, Montana, USA. YPM 191002 (pl. 42, fig. 11), USNM 507649 and USNM 507650 are paratypes.

MATERIAL: Three specimens; IW-141 from level 148.2; IW-137 from level 157.0 and IW-124 from level 169.0.

DESCRIPTION: All three specimens are internal moulds of single valves. The valves are of rather small to moderate size, weakly inflated. The umbo is delicate, with the beak projecting clearly above the hinge line. The valves are moderately oblique and are characterised by a relatively long, broadly convex anterior margin, passing into a regularly rounded ventral margin, and with a rather short, almost straight posterior margin. The hinge line is long and straight. The posterior auricle is subtriangular and moderately well separated from the disc.

The valves are regularly ornamented with subevenly spaced concentric rugae, with interspaces increasing in size gradually ventralward and weakening slightly when passing onto the posterior auricle.

REMARKS: As remarked already by WALASZCZYK \& \textit{al.} (2001) \textit{C.? glendivensis} resembles SORNAY’s (1973) species \textit{Inoceramus bebahoaensis} described from the Lower Maastrichtian of Madagascar. The Madagascan species is, however, markedly more inflated and moreover, is characterised by different ornament. It also resembles \textit{Cataceramus beckumensis} (GIERS, 1964) known from the upper \textit{Lower} and lowermost Upper Campanian of Europe and North America. GIERS’ species is less regular in ornament.

INOCERAMIDS FROM THE CAMPAIGN AND MAASTRICHTIAN OF THE TERCIS SECTION 281
**Cataceramus goldfussianus** (d’Orbigny, 1847)

(Pl. 1, Fig. 1; Pl. 2, Fig. 3; Pl. 3, Fig. 10; Pl. 4, Fig. 6; Pl. 5, Figs 2-3; Pl. 7, Fig. 3; Pl. 8, Fig. 5)

1847. *Inoceramus Goldfussianus* D’Orbigny, p. 517, pl. 411, figs 1-2.

1939. *Inoceramus* aff. *regularis* d’Orbigny; Aliev, p. 224, pl. 3, fig. 2.

1956. *Inoceramus gandjaensis* Aliev, p. 463, pl. 1, fig. 1; pl. 2, fig. 1.

1957. *Inoceramus* goldfussi d’Orbigny; Sornay, no. 57.


1969. *Inoceramus* {Cataceramus} goldfussianus d’Orbigny; Cox in Moore, p. N315, fig. C46.4 [=Cataceramus marckii (Giers, 1964)]

1976. *Inoceramus goldfussi* D’Orbigny; Sornay, p. 9, text-fig. 9, pl. 4, figs 4-5, pl. 5.

1993. “Cataceramus” goldfussianus D’Orbigny; Dhondt, p. 218, pl. 2, figs 1-3.

2001. *Cataceramus gandjaensis* (Aliev); Walaszczyk & al., pl. 13, figs 2-3; pl. 19, fig. 1.

**TYPE:** The lectotype, by subsequent designation of Sornay (1957) is MNHP 7593, the original of d’Orbigny [1847, pl. 411, figs 1-2, reillustrated by Sornay (1957, fig. 3) and Sornay (1976, fig. Fig. 5), from the ?Upper Campanian of Royan (Charente-Maritime), SW France.

**MATERIAL:** IW-27 from level 47.1; IW-12 from level 34.5; IW-28 from level 45.6; ?IW-29 from level 46.1; IW-37 from level 47.5; IW-45 from level 65.0; IW-50 from level 66.5; IW-73 from level 86.5; IW-91 from level 66.5; IW-203 from level 67; IW-232 from level (47); IW-245 from level (47) [or it may be a juvenile of a very large *Sphaeroceramus pertenuiformis*]; IW-253 and IW-254 from level (47); IW-282 from level 85.1; IW-296 from level 80.5.

**DESCRIPTION:** Species of moderate to large size for the genus, inequilateral, ?equivalve, moderately inflated. The valve outline is subquadrate to subrectangular. The anterior margin is moderately long, passing into broadly convex antero-ventral and ventral margins. The posterior margin is regularly rounded. The hinge line is long and straight. The Beak projecta slightly above the hinge line.

The posterior auricle is only slightly separated from the disc. The ornament is composed of regular to subregular co-marginal rugae, with the interspaces increasing in size gradually ventralward.

**REMARKS:** The obliquity, valve outline and the type of ornament are the main features displaying a wide range of intraspecific variability. The valve outline ranges from distinctly subrectangular (e.g. Pl. 5, Fig. 2) to subquadrate (e.g. Pl. 3, Fig. 10). Most of the specimens are moderately oblique, with δ around 60°, although the actual values range between 40° (e.g. in the type of the species) and 75°. Although the ornament consists usually of subregularly spaced, round-edged rugae, with interspaces of moderate size, specimens with distinctly larger interspaces do occur (see e.g. Sornay 1976, pl. 4, figs 1-2).

Into the synonymy of *C. goldfussianus* we put *Inoceramus gandjaensis* Aliev, 1956, the latter species was interpreted as a separate species based on the different valve outline and ornament (Walaszczyk & al. 2001). High variability in respect of both features, as found in the Tercis material, makes separation of “I.” gandjaensis and *C. goldfussianus* rather arbitrary.

**OCCURRENCE:** In Tercis the species is known from the interval spanning the *Sphaeroceramus pertenuiformis* Zone through basal “*Inoceramus* obllangs” Zone (which corresponds to the *Bostrychoceras polyplocum* through lower *Nostoceras hyatti* ammonite Zones). Known from the *Didymoceras stevensoni* through the *Baculites compressus* Zones of the US Western Interior.

**Cataceramus mortoni** (Meek, 1876)

(Pl. 1, Fig. 4)

1856. *Inoceramus proxima* Toumey, p. 171 [nomen nudum]

1876a. *Inoceramus proximus* Toumey?; Meek, p. 53, pl. 12, fig. 7a, b.

?1983. *Inoceramus* (Endocostea) sp. aff. 1. (E.) proximus Toumey; Noda, p. 106, Fig. 4; pl. 1, figs 1-8.

1984. *Inoceramus proximus* Toumey; Bolanos & Buitron, p. 411, pl. 1, fig. 5.


2001. *Cataceramus mortoni* (Meek & Hayden, 1860); Walaszczyk & al., Pl. 7, figs 2-3, 6; Pl. 11, figs 6-8, 10, 12.

**TYPE:** The holotype is Meek’s (1876, pl. 12, fig. 7) original, reillustrated by Walaszczyk & al. (2001, pl. 11, fig. 12) from the Middle/Upper Campanian boundary interval of the Great Bend of the Missouri River, below Pierre,
South Dakota; USA, Gregory Member of the Pierre Shale. In ammonite terms, this corresponds to the uppermost Middle Campanian Baculites gregoryensis and B. scotti Zones.

MATERIAL: Single specimen IW-23 from level 30.1.

DESCRIPTION: The Tercis specimen is a single internal mould of the LV. The shell is of moderate size with \( h_{\text{max}} = 56 \text{ mm} \), weakly inflated. The beak is small, not projecting above the hinge line. The anterior margin is relatively long, passing into a broadly convex ventral margin. The posterior margin is short, almost straight. The hinge line is moderately long, straight. The Posterior auricle is of moderate size, not separated from the disc. The shell is covered with closely and regularly spaced, sharp-edged concentric rugae.

REMARKS: WALASZCZYK & al. (2001) provided the re-description and illustration of the original American material of the species. The general outline of the shell displays a relatively wide range of infraspecific variation.

OCCURRENCE: In Tercis Cataceramus mortoni comes from level 30.1. The species is known from the US Western Interior, from the middle Upper Campanian (Baculites gregoryensis through Didymoceras nebrascense ammonite Zones of the US Western Interior ammonite division). It probably also occurs in Japan.

**Cataceramus? oviformis** WALASZCZYK, COBBAN & HARRIES, 2001
(Pl. 14, Fig. 13)

1929. *Inoceramus* sp. DANE, pl. 25, fig. 1.
1988. *Inoceramus balticus* BOHM; ALIEV & KHARITONOV in ALIZADE & al., p. 266, pl. 21, fig. 1.
2001. **Cataceramus? oviformis** WALASZCZYK, COBBAN & HARRIES, pl. 41, fig. 3

TYPE: The holotype, by original designation, is USNM 131542, the original of *Inoceramus* sp. in DANE (1929, pl. 25, fig. 1) (reillustrated by WALASZCZYK & al. 2001, pl. 41, fig. 3), from the Nacatoch Sand of the high bluff on the Ouachita River, 1.5 miles north of Arkadelphia, Clark County, Arkansas, USA.

MATERIAL: Single specimen, IW-120 from level 117.8.

DESCRIPTION: The specimen is an internal mould of a single RV, moderate-size, with \( L_{\text{max}} = 80 \text{ mm} \). The beak projects only slightly above the hinge line. The hinge line is very long and straight. The valve possesses characteristically a strongly convex anterior margin, passing into a very long, broadly convex ventral margin. The posterior margin is not completely preserved but may be inferred to be similar to the anterior one. The valve is weakly inflated, the disc not separated from the posterior auricle.

The valve is ornamented with regular, subevenly spaced concentric rugae with round-floored interspaces, which increase in size very slowly ventralward.

REMARKS: The species is characterised by a strongly convex anterior margin and strong valve elongation. The type of ornament is identical with that of *Cataceramus? palliseri* (DOUGLAS). In deformed material this may cause difficulties in specific identification of the taxa.

OCCURRENCE: The single specimen from Tercis comes from the very base of the Maastrichtian. The type comes from the Lower Maastrichtian of Arkansas, in the Gulf Coast Plain, but no precise location is known so far. Also known from Montana (*Baculites baculus* ammonite Zone) in the US Western Interior, from the Lower Maastrichtian (*Belemnella lanceolata* Zone) of the Middle Vistula section, central Poland, and from the lowermost Maastrichtian of the Caucasus.

**Cataceramus? palliseri** (DOUGLAS, 1942)
(Pls. 8, Figs 1-2; Pl. 10, Fig. 4)
1847. *Inoceramus regularis* D’ORBIGNY, p. 516, pl. 410, figs 1-2
1880. *Inoceramus vanuxemi* MEEK & HAYDEN; WHITFIELD, p. 396 (pars), pl. 7, figs 8, 79 [non pl. 7, fig. 10 = ?*Inoceramus vanuxemi* MEEK & HAYDEN].
1942. *Inoceramus palliseri* DOUGLAS, p. 62, pl. 1, fig. 2.
1958. *Inoceramus balticus* BOHM; KOCIUBYNSKII, p. 18 (pars), pl. 8, fig. 33.
1958. *Inoceramus impressus* D’ORBIGNY; KOCIUBYNSKII, p. 144 (pars), pl. 28, fig. 1.
1974. *Inoceramus impressus* ORBIGNY; KOCIUBYNSKII, p. 84, pl. 21, fig. 1.
1976. *Inoceramus regularis* D’ORBIGNY, SORNAY, p. 7, pl. 2, fig. 3;
pl. 3, figs 3-4.
1976. *Inoceramus artigesi* Sornay, p. 3 (pars), pl. 1, fig. 2 [non pl. 1, fig. 1].

1993. *Selenoceramus sornayi* Dhondt, p. 236, pl. 6, fig. 3; pl. 7, fig. 5.


1997. *Cataceramus sornayi* (Dhondt); Walaszczyk, p. 26, pl. 32, figs 1-3.

1997. *Inoceramus artigesi* Sornay; Walaszczyk, pl. 32, figs 4-5.

2001. *Cataceramus? palliseri* (Douglas); Walaszczyk & al., p. 57, pl. 27, fig. 2; pl. 33, fig. 2; pl. 37, fig. 1

**TYPE:** The holotype, by original designation, is GSC 8928, the original of Douglas (1942, pl. 1, fig. 2), from Boxelder Creek, Canada, about 180 m below the top of the Bearpaw Formation, Canada.

**MATERIAL:** 12 specimens: IW-76 from level 84.7; IW-174 from level 93; IW-192 from level 67; IW-193 from level 67.1; IW-195 from level 69.2; IW-197 from level 67; IW-200 from level 66.9; close form is IW-211 from level 47.9; IW-262 from level 85.3; IW-278 from level 85.3; IW-280 from level 85.3 and IW-281 from level 85.3

**DESCRIPTION:** All of the specimens are represented by internal mould of single valves. The species is of moderate size, mostly with preserved juvenile stage, sometimes with part of the adult stage. Both stages contact along positive geniculation. The anterior margin is broadly convex, passing into the broadly convex ventral margin and thence into the rounded posterior margin. The hinge line is long and straight. The posterior auricle is not separated from the disc. The beak is indistinct, projecting weakly above the hinge line. The juvenile stage is covered with closely and regularly spaced concentric rugae. The adult stage possesses irregular ornament or is almost smooth, at least in the part preserved.

**REMARKS:** *Cataceramus palliseri* (Douglas, 1942) is the correct name for forms referred in Europe to *Cataceramus sornayi* (Dhondt, 1993), which was a new name proposed by Dhondt (1993) for d’Orbigny’s pre-occupied *Inoceramus regularis* (see Walaszczyk & al. 2001). [the name *sornayi* was moreover also pre-occupied at that date – see Chapat 1963]. The species is very similar to the early Campanian *Cataceramus balticus* (Bohm, 1907), from which it differs in higher obliquity, finer ornament, and distinctly higher stratigraphical location.

**OCCURRENCE:** The species comes from the middle part of the Nostoceras hyatti ammonite Zone of the Tercis section. It is known from the *Baculites reesidei* and *Baculites baculus* ammonite Zones of the US Western Interior. It is probably common in the topmost Campanian and ?Lower Maastrichtian of Europe, but details on its distribution are still to be studied.

*Cataceramus* cf. *pseudoregularis* (Sornay 1962) (Pl. 6, Fig. 1)


**TYPE:** By original designation the holotype is 721 B from Collignon collection of the Laboratoire de Paléontologie, Paris, the original of Sornay (1962, pl. 7, fig. 1), from the region between Apamba and Antsira, Madagascar; boundary beds between Lower and Middle Campanian.

**MATERIAL:** IW-201 from level 66.5

**DESCRIPTION:** IW-201 is a moderate sized double-valved internal mould. The beak is small, projecting slightly above the hinge line. The posterior auricle is not separated from the disc. The anterior margin is relatively short, passing into broadly convex, long antero-ventral and ventral margins. The posterior margin is regularly rounded. The hinge line is straight and long. The specimen shows the presence of two ornamental stages. The juvenile stage, comprising most of the shell is ornamented with regularly spaced, sharp-edged co-marginal rugae. Interspaces increase in size gradually ventralward in the very juvenile part (up to 30 mm axial length), then remain almost constant over the entire shell surface. The adult ornament stage, at least in the part preserved, is almost smooth.

**REMARKS:** Our specimen resembles *Cataceramus* *pseudoregularis* in general outline and type of ornament. It differs from the type in the lack of the “Cordiceramus” sulcus in the posterior part of the shell. It must be emphasized, however, that this feature does not appear regularly (as e.g. in Sornay’s 1968, pl. D, fig. 2).

**OCCURRENCE:** The Madagascan material was dated as Lower – Middle Campanian; a single specimen from SW France, referred by Sornay (1962) to *Inoceramus* (Haenleinia) cf. *pseudoregularis* comes from the Upper Campanian; our specimen is from the “Inoceramus” *altus* Zone, cooresponding to the lower *Nostoceras hyatti* ammonite Zone of the upper Upper Campanian.
**Cataceramus** cf. *pteroides* (GIERS, 1964)

(Pl. 1, Fig. 2)

*Compare to:*

1964. *Inoceramus balticus pteroides* GIERS, p. 240, pl. 1, fig. 6.
1997. *Cataceramus pteroides* (GIERS); WALASZCZYK, p. 25, pl. 9, figs 1-3; pl. 10, figs 1-5; pl. 11, figs 1-4 (and synonymy therein).

**TYPE:** The holotype, by original designation, is specimen Kr 1025, the original of GIERS (1964, pl. 1, fig. 6), from the *Bostrychoceras polyplocomum* ammonite Zone of Haldem, Westphalia, Germany. The specimen is housed in the Niedersächsisches Landesamt für Bodenforschung, Hannover, Germany.

**MATERIAL:** Single specimen, IW-4, from level 6.7.

**DESCRIPTION:** IW-4 is an incomplete LV, with the ventral and posterior parts missing and with a poorly preserved juvenile part. It is strongly oblique, moderately inflated in the juvenile and weakly inflated in the adult stage, with a long, straight hinge line. The maximum inflation is in the umbonal part. The beak projects moderately above the hinge line. The surface is ornamented with relatively strong concentric rugae, which seem to weaken with growth. The juvenile ornament, as may be judged despite the poor preservation, was more regular.

**DISCUSSION:** The character of ornament, the umbonal part projecting above the hinge line and the general outline of the specimen allow it to be assigned questionably to *Cataceramus pteroides* (GIERS, 1964).

**OCCURRENCE:** The Tercis specimen comes from the basal part of the section. Known from the lower Upper Campanian (from the base of the substage up to *Bostrychoceras polyplocomum* ammonite Zone) of Westphalia, Germany.

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**Cataceramus aff. pteroides** (GIERS, 1964)

(Pl. 10, Fig. 2)

*Compare:*

1976. *Inoceramus balticus pteroides* GIERS; SORNAY, p. 6, pl. 3, figs 1-2.

**MATERIAL:** Single specimen; IW-175 from level 93.5.

**DESCRIPTION AND REMARKS:** IW-187 is a single, incomplete RV, with the postero-ventral part missing. The preserved part suggests a distinctly posteriorly elongated valve outline, typical for members of the "balticus" group, with a relatively short, convex anterior margin, passing into a broadly convex ventral margin, and with a long and straight hinge line. The juvenile part is markedly inflated, with a massive appearance, and with the umbo projecting clearly above the hinge line. Toward the ventral and posterior parts the valve becomes gradually less convex. The posterior auricle is large, triangular in outline and rather weakly separated from the disc.

The surface is covered with subregular, asymmetrical co-marginal rugae, which weaken ventrally and dorsally. Growth lines are clearly visible, parallel to the rugae.

The valve outline and type of ornament of *C. aff. pteroides* described herein resembles closely representatives of *Inoceramus balticus pteroides* GIERS of SORNAY (1976, pl. 3, figs 1-2), from the Upper Campanian of Dauphiné. Although Tercis specimen differs from Sornay's specimens in juvenile valve outline it is difficult to judge to what extent this may be a result of secondary deformation. The evolutionary relationship to *Cataceramus pteroides* (GIERS, 1964) is unknown.

**OCCURRENCE:** A single specimen from the "Inoceramus" oblongus Zone (Nostoceras hyatti ammonite Zone) of the upper Upper Campanian.

1996. "*Inoceramus*" sp. cf. *planus* (of authors) MüNSTER; WALASZCZYK & al., pl. 5, fig. 4.

1997. *Inoceramus buguntaensis* DOBROV & PAVLOVA; ATABEKIAN, p. 68, pl. 27, fig. 1.

2001. *Cataceramus subcircularis* (MEEEK); WALASZCZYK & al., pl. 31, fig. 3; pl. 34, fig. 8; 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 *Selenoceramus sornayi*; ODIN, pl. 2, fig. 17.

?2001. (tentatively) *Trochoceramus aff. ianjonaensis* (SORNAY); ODIN, pl. 2, fig. 19.


**TYPE:** The holotype, by original designation, is USNM 479, the specimen illustrated by MEEEK (1876a, p. 12, fig. 2; reillustrated by WALASZCZYK & al. 2001, pl. 36, fig. 8), from Yellowstone River, about 150 miles above its mouth, from most probably Lower Maastrichtian strata [upper part of Pierre Shale near Glendive, Montana, USA].

**MATERIAL:** IW-140 from level 148.2; IW-129 from level 155; IW-135 from level 161.4; IW-139 from level 169.1a; IW-138 from level (155); IW-136 from level (155); IW-156 from level 149.0; IW-122 from level 169.1a; IW-133 from level 117.4a; IW-123 from level 161.5; IW-300 from level 117.4a; IW-116 from level 117.4a.

**DESCRIPTION:** All of the specimens are small-sized internal moulds of single valves and are partly deformed. The valves are subrounded in outline, with estimated δ attaining about 65°. The anterior growth angle is relatively large, approximately 135°. The anterior margin is long, almost straight, passing into the rounded ventral margin. The posterior margin is not preserved. The umbo is moderately inflated with the beak projecting distinctly above the hinge line. The hinge line is not completely preserved, but where preserved it is apparently of moderate length and straight.

The valve is ornamented with regularly spaced, round-topped rough rugae, with interspaces increasing in size slowly ventralward. The rugae are slightly asymmetrical with ventral slopes steeper. Growth lines are not visible.

**REMARKS:** In the studied material there is one other specimen (IW-155), from the same stratigraphic level, equally large (h max = 180 mm), which may belong to the same species. It is, however, too incompletely preserved to allow an unequivocal identification.

In general outline, and in their robust type of ornament, the specimens resemble large representatives of late Early/earliest Late Campanian inoceramids of the group of *Cataceramus dariensis*. Even the most similar species, however, such as "*Inoceramus*" karakalaensis (ARZUMANOVA 1964, pl. 2, fig. 1) or *Inoceramus* sp. (ARZUMANOVA 1965, fig. 1) possess much less regular ornament.

In general outline, and in their robust type of ornament, the specimens resemble large representatives of late Early/earliest Late Campanian inoceramids of the group of *Cataceramus dariensis*. Even the most similar species, however, such as "*Inoceramus*" karakalaensis (ARZUMANOVA 1964, pl. 2, fig. 1) or *Inoceramus* sp. (ARZUMANOVA 1965, fig. 1) possess much less regular ornament.

**OCCURRENCE:** In the Tercis section the species starts at the base of the Maastrichtian, where it is rare, and ranges to the top of the exposed part of the succession. Known from the *Baculites reesidei* through *Baculites clinolobatus* ammonite Zones of the US Western Interior. Also known from the Lower Maastrichtian of Poland, The Ukraine, Russia, the Caucasus, the Arabian Peninsula, and from Madagascar.

**Cataceramus sp.**

**MATERIAL:** Single specimen, IW-13 from level 42.4 m.

**DESCRIPTION:** The specimen is a large-sized (h max = 150) internal mould of a RV, incompletely preserved; its posterior part is missing. The valve is weakly inflated, prosocline, subrounded in outline, with estimated δ attaining about 65°. The anterior growth angle is relatively large, approximately 135°. The anterior margin is long, almost straight, passing into the rounded ventral margin. The posterior margin is not preserved. The umbo is moderately inflated with the beak projecting distinctly above the hinge line. The hinge line is not completely preserved, but where preserved it is apparently of moderate length and straight.

The valve is ornamented with regularly spaced, round-topped rough rugae, with interspaces increasing in size slowly ventralward. The rugae are slightly asymmetrical with ventral slopes steeper. Growth lines are not visible.

**REMARKS:** In the studied material there is one other specimen (IW-155), from the same stratigraphic level, equally large (h max = 180 mm), which may belong to the same species. It is, however, too incompletely preserved to allow an unequivocal identification.

In general outline, and in their robust type of ornament, the specimens resemble large representatives of late Early/earliest Late Campanian inoceramids of the group of *Cataceramus dariensis*. Even the most similar species, however, such as "*Inoceramus*" karakalaensis (ARZUMANOVA 1964, pl. 2, fig. 1) or *Inoceramus* sp. (ARZUMANOVA 1965, fig. 1) possess much less regular ornament.

**OCCURRENCE:** The species comes from level 42.4, which is referred to the *Bosychoceras pohlocicum* Total Range Zone (ODIN & al. 2001), which corresponds to the basal *Didymoceras donezianum* ammonite Zone of the Boreal Realm, and probably corresponds to the lower part of the *Sphaeroceramus pertenuiformis* Zone.
Genus Sphaeroceramus Heinz, 1932


REMARKS: As emphasised by Chris Woods (personal communication, letter August 12, 2002) it is not sure whether Woods’ (1911, text-fig. 48) original, the type of the type species of Sphaeroceramus Heinz, 1932, comes from the Lower Campanian. The specimen is very close to representatives of the genus Cremnoceramus Cox, 1969, and might come from the Lower Coniacian. If this would be proved [e.g. by nannofloral analysis] a series of species, as Sphaeroceramus samusensis (Woods, 1912), S. subsarumensis (Heinz, 1932), S. pertenuis (Meek & Hayden, 1856) and S. pertenuiformis (Walaszczyk, Cobban & Harries, 2001), should be referred to a new genus.

Sphaeroceramus pertenuiformis Walaszczyk, Cobban & Harries, 2001
(Pl. 2, Figs 1-2, 4-5; Pl. 3, Figs 1-3, 5-6)

PARS 1976. Inoceramus borilensis dauerensis Sornay, p. 5; pl. 1, fig. 3; pl. 2, figs 2 [non pl. 2, fig. 1].
2001. Sphaeroceramus pertenuiformis Walaszczyk, Cobban & Harries, pl. 13, figs 1, 5-6; pl. 14, figs 2, 4; pl. 17-18; pl. 19, figs 2-3; pl. 20, fig. 3; pl. 21, figs 1, 3-4.

TYPE: The holotype, by original designation, is USNM 507552, the original of Walaszczyk & al. (2001, pl. 14, fig. 2) from the Pierre Shale near Red Bird, Niobrara County, Wyoming, USA (the USGS Mesozoic locality D 1948); the Didymoceras stevensoni and the Exiteloceras jenneyi ammonite Zones.

MATERIAL: IW-29 from level 46.1; IW-40 from level 47.5; IW-42 from level 47.4; IW-30 from level 45.4; IW-41 from level 47.0; IW-39 from level (47.2); IW-212 from level 45.4; IW-217 from level 45.9; IW-218 from level 49.2; IW-224 from level 47; ?IW-227 from level (47); IW-231 from level (47); ?IW-234 from level (47) [or it is Inoceramus aff. tenuilineatus]; IW-239 from level (47); IW-241 from level (47); IW-242 from level (47); ?IW-243 from level (47); IW-247 from level (47); IW-248 from level (47); IW-250 from level (47); IW-251 from level (47); IW-252 from level (47); IW-255 through 257, all from level (47).

DESCRIPTION: All of the specimens are internal moulds of single valves, with only fragments of shell preserved. Except for IW-42 (Pl. 3, Fig. 2) all specimens are juveniles and are medium sized. The juvenile stage, with subrounded outline, is relatively small, with small to moderate obliquity. The umbo is indistinct with the beak projecting slightly above a straight, moderately long hinge line. The posterior auricle is clearly separated from the disc only in more oblique specimens. The adult stage is preserved in a single specimen. It is relatively large, growing in a plane almost perpendicular to the plane of the juvenile stage. The adult anterior margin is long, straight, slightly concave, passing into the rounded ventral margin. The adult posterior auricle is well separated from the disc. One specimen possesses distinct “Hohlkehle” (Pl. 10, Fig. 3).

Juvenile and adult stages are covered with irregular rugae, in parts almost smooth. The rugae are low, indistinct, covered with raised growth lines.

REMARKS: The species was described and illustrated by Walaszczyk & al. (2001) based on the rich material from the US Western Interior. “Inoceramus” borilensis Jolkicˇev, 1962 is similar to S. pertenuiformis in general adult outline. It differs, however, in its juvenile stage, which in contrast to that of S. pertenuiformis is distinctly posteriorly elongated and regularly rugate (see Pl. 3, Fig. 7 of the present paper).

OCCURRENCE: The Tercis specimens come from levels 45.4 through 47.5, which belong to the upper part of the Bostrychoceras polyplcon Total Range ammonite Zone, and correspond to the Sphaeroceramus pertenuiformis inoceramid Zone. The species is known from the Didymoceras stevensoni and the Exiteloceras jenneyi ammonite Zones of the US Western Interior.

Genus Endocostea Whitfield, 1877

TYPE SPECIES: Endocostea typica Whitfield, 1877, p. 32, from the Baculites baculus ammonite Zone of the Lower Maastrichtian, of the Old Woman Fork of the Cheyenne River, Black Hills area in easternmost Wyoming, USA.

Endocostea typica Whitfield, 1880
(Pl. 13, Figs 1-5, 7-8, 11)

1880. Endocostea typica Whitfield; Whitfield, p. 403
(pars), pl. 9, figs 1-3, 7 [non pl. 9, figs 4-6 = ? Cataceramus barabini (Morton)]
1913. Inoceramus Barabini Morton; Bose, p. 35, pl. 3, fig. 1.
1931. Endocostea typica Whitfield; Riedel, p. 664, pl. 75, figs 2-4; pl. 76, fig. 1.

?1958. *Inoceramus* (*Endocostea*) stanislauensis Anderson, p. 105 (pars), pl. 74, fig. 4-6.

1967. *Inoceramus* (*Endocostea*) typicus Whitfield; Seitz, pp. 50-55, pl. 2, figs 3-4.

1967. *Inoceramus* (*Cordiceramus*) (?) juven. sp. Seitz, p. 51, pl. 2, fig. 1.

1967. *Inoceramus* (*Endocostea*) cf. *cymba* J. Bohm; Seitz, p. 52, pl. 2, fig. 2.

1968. *Inoceramus impressus* Orbigny; Kocubański, p. 144 (pars), pl. 29, figs 4-5 [non pl. 28, fig. 1 = *Cataceramus palliseri* (Douglas)]

1970. *Inoceramus* (*Endocostea*) typicus (Whitfield); Kauffman, pl. 1, figs 2, 7.

non 1984. *Inoceramus* (*Endocostea*) typicus Whitfield; Bolanos & Buitron, p. 410, pl. 1, figs 2-3.


2001. *Inoceramus* sp.indet.; Odin, pl. 1, figs 10-11; pl. 3, fig. 24.

2001. *Trochoceramus* sp.; Odin, pl. 3, fig. 22.

TYPE: The lectotype, by subsequent designation of Seitz (1967, p. 55) is USNM 12261, the original of Whitfield (1880, pl. 9, fig. 3), from the lower Maastrichtian (*Baculites baculus* ammonite Zone) of the Old Woman Fork of the Cheyenne River in the Black Hills, Wyoming, USA.

MATERIAL: IW-114 from level 117.4a; IW-109 from level 117.2a; IW-115 from level 117.5a; IW-119 from level 117.3; IW-132 from level 117.7; IW-131 from level 117.7; IW-113 from level 117.7; IW-128 from level 117.7; IW-110 from level 117.5a; IW-117 from level 147.6a; IW-112 from level 145.6a; IW-118 from level 117.7; IW-301 from level 117.5a; IW-303 from level 117.5a; IW-305 from level 117.5a; IW-306 from level 117.4a; IW-308 from level 117.4a and IW-309 from level 117.2a.

DESCRIPTION: All of the specimens are small-sized, internal moulds of single valves. The valves are strongly prosocline, moderately inflated with maximum inflation dorso-centrally and with the beak projecting slightly to moderately above the hinge line. The disc is usually well separated from the posterior auricle, which is small, sub-triangular and elongated parallel to the hinge line. Most of the specimens possess a variably developed internal rib.

The valves are covered with subregularly and closely spaced concentric regular, weakening when passing on to the posterior auricle.

REMARKS: The taxonomy and stratigraphic position of the species was recently discussed by Walaszczyk & al. (2001), who showed that the species concepts formerly applied in Europe were mostly incorrect.

OCCURRENCE: In *Tercis* *E. typica* appears suddenly approximately at the base of the Maastrichtian. It ranges up to about level 150 m but occurs only sporadically there. The species occurs commonly in the basal Lower Maastrichtian (*Baculites baculus* ammonite Zone) of the Western Interior and the Gulf Coast, USA. Known from numerous places in Europe (see synonymy list), presumably from equivalent horizons.

*Endocostea aff.* typica Whitfield, 1880

(Text-fig. 7)


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Fig. 7. *Endocostea aff. typica* Whitfield, 1877; 1 – IW-259 from level 88.1; 2 – IW-260 from level 88.1 [both specimens – section I]. ×1.2
MATERIAL: IW-259 and IW-260 from level 88.1

DESCRIPTION AND REMARKS: We have two specimens from level 88.1 matching closely the characteristics of US Western Interior forms compared with *E. typica* and referred consequently to *E. sp. aff. typica* by WALASZCZYK & al. (2001). Although our specimens are not very well preserved they still show the characteristic ornament, composed of lamellate, asymmetrical, evenly spaced rugae, as well as the general valve outline.

OCCURRENCE: Known from Tercis and the US Western Interior; in both areas limited to the *Inoceramus oblongus* Zone, corresponding to the *Baculites reesidei* ammonite Zone in the Western Interior ammonite succession.

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**Endocostea jolkicevi** sp. nov.

(Pl. 13, Fig. 9)

1996. “*Inoceramus*” ex gr. *impressus* D’ORBIGNY; WALASZCZYK & al., p. pl. 4, fig. 1.


2001. *Inoceramus* sp.indet.; ODIN, pl. 3, fig. 25.

HOLOTYPE: The holotype is IW-121 from level E3.3 of the Tercis quarry; lowermost Maastrichtian, lowermost part of the *Endocostea typica* Zone.

MATERIAL: Two specimens; W-121 from level 117.4a, and W-304 from level 117.3a.

DERIVATION OF NAME: After Nikola JOLKICEV, Bulgarian geologist, who made a significant contribution to the knowledge of the late Cretaceous inoceramids.

DESCRIPTION: The following description is based mainly on a well preserved specimen IW-121, an internal mould of a small-sized RV. The beak projects very slightly above the hinge line. The valve is subquadrate, increasing in size ventrally, with a well developed, wide, radial sulcus. The hinge line is long and straight. The posterior auricle is subtriangular in outline, elongated parallel to the hinge line and well separated from the distinctly raised disc, along a well developed auricular sulcus. The disc is subtriangular in outline. In the axial part of the radial sulcus lies a “Hohlkehle”.

The valve is ornamented with strong, regular concentric rugae, which emphasise the radial sulcus. The rugae almost disappear on the posterior auricle.

REMARKS: The specimen differs from all other *Endocostea* specimens in the collection studied in distinctly lower obliquity, strong and regular rugae, and in the well developed radial sulcus. Probably conspecific with the specimen from Tercis is *Endocostea* sp. illustrated by WALASZCZYK & al. (2001, pl. 39, fig. 9), from the lowermost Maastrichtian of the US Western Interior. Also apparently identical is “*Inoceramus*” ex gr. *impressus* D’ORBIGNY, reported from the basal Maastrichtian of Aimaki section by WALASZCZYK & al. (1996, pl. 4, fig. 1), showing all the characteristic features of *E. jolkicevi*, despite being clearly deformed. In general outline, *E. jolkicevi* resembles *Endocostea coxi* (REYMENT, 1955), from which it differs in possessing a radial sulcus and by a lack of radial ornament, the typical feature of REYMENT’s species.

OCCURRENCE: The specimen comes from level 117.8 of the Tercis section, lowermost Maastrichtian.

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**Genus Trochoceramus** HEINZ, 1932

TYPE SPECIES: *Trochoceramus helveticus* HEINZ (1932, p. 19).

*Trochoceramus costaecus* (KHALAFOVA, 1966)

(Pl. 11, Figs 1-7; Pl. 12, Figs 2-3, ?7)

1959. *Inoceramus alaeformis* ZEKELI; DOBROV & PAVLOVA, p. 154, pl. 18, fig. 1.

1966. *Inoceramus costaecus* KHALAFOVA, p. 52, pl. 1, fig. 1.

1969. *Inoceramus zitteli* KOCIUBYNSKIJ non PETRASCHEK; SORNAY in ANTUNES & SORNAY, p. 89, pl. 7, fig. 1.

1988. *Inoceramus alaeformis* ZEKELI; ALIEV & KHARITONOV in ALI-ZADE & al., p. 262, pl. 16, figs 1-3.

2001. *Trochoceramus costaecus* (KHALAFOVA); WALASZCZYK & al., p. 157, pl. 1, figs 1-5; pl. 3, fig. 3; pl. 6, fig. 2.

2001. *Trochoceramus morgani* (SORNAY); WALASZCZYK & al., pl. 156, pl. 2, figs 1-8; pl. 3, fig. 2.

2001. *Trochoceramus* sp.; WALASZCZYK & al., pl. 42, fig. 10; Pl. 43, figs 7-9.

2001. *Trochoceramus* sp.; ODIN, pl. 3, fig. 23.


TYPE: The holotype, by original designation, is the specimen illustrated by KHALAFOVA (1966, pl. 1, fig. 1) from the ?uppermost Maastrichtian of the Gerga section, Daghestan of NE Caucasus, Russia.

MATERIAL: Numerous specimens with variable preservation; IW-90 from level 97.5 and IW-85 from level 98.2; IW-86 from level 101.1; IW-88 from level 101.9; IW-89 from level 101; IW-100 from level 96.7; IW-161 from level 97.7; IW-164 from level 98.6; IW-165 from level 98.6; IW-
DESCRIPTION: The specimens are medium-sized internal moulds of single valves. The valve outline ranges from ellipsoidal to subquadrate, with variable obliquity, ranging between 40 and 90°. Complete valves show two distinct growth stages, separated by a positive positive geniculation. The juvenile stage is weakly inflated, with its anterior margin strongly convex anteriorly, passing into a broadly convex ventral margin. The posterior margin is relatively long, weakly convex. The hinge line is moderately long and straight. The posterior auricle is not separated from the disc. The umbo is indistinct, with the beak very weakly or not projecting above the hinge line. The hinge line is straight, relatively long.

The valve is ornamented with closely spaced, fine rugae, and with superimposed radial ribs. Radial ribs become dominant over the concentric ornament in the ventral part of the valve.

REMARKS: The species as interpreted herein, ranges between elliptically shaped, weakly oblique forms, very close to the type of the species, and markedly oblique, posteriorly elongated subquadrate forms. Previously the oblique forms were referred to a separate species, *Trochoceramus morgani* (Sornay, 1973) (see Walaszczyk & al. 1996), or to *Trochoceramus* sp. (Walaszczyk & al. 2001). The collection from Tercis showed, however, that firstly these two extremes are more tightly linked by intermediate forms than thought previously, and secondly, a similar pattern of variability is seen in an ancestral species, i.e. “Inoceramus” *alaeformis* of authors, as well as in forms transitional between these two species, e.g., IW-160, IW-168, and IW-167, from levels 96.7 and 96.9 (Pi. 11, Figs 1, 5). *Trochoceramus morgani* (Sornay, 1973), to which the more oblique forms were referred, comes from a distinctly higher stratigraphical level, and seems to represent the more oblique form of *Trochoceramus morgani* (Sornay, 1973).

To *Trochoceramus costaeus* belong most forms referred in the Russian literature to *Inoceramus alaeformis* (see also discussion in Dhondt 1993).

OCCURRENCE: All of the Tercis specimens come from an interval between levels 96.7 and 101.9. The species is known from the uppermost Campanian of the Nacatoch Sand, Canyon Creek, Texas, US Gulf Coast, and from the topmost Campanian of Dagestan (Caucasus) in Europe.

*Trochoceramus radiosus* (Quaas, 1902) (Pi. 14, Fig. 10)

1902. *Inoceramus Cripsi var. radiosus* Quaas, p. 170 (pars), pl. 20, fig. 9 (only).
1962. *Inoceramus (Inoceramus) regularis var. radiosus* (Quaas); Abbass, p. 41, pl. 5, fig. 1.
1970. *Inoceramus (Trochoceramus) radiosus* Quaas; Seitz, p. 123, pl. 23, fig. 1.
?1993. *Trochoceramus radiosus* (Quaas); Dhondt, p. 240, pl. 7, fig. 3.

pars 1993. *Trochoceramus nahorianensis* (Kochubynskij); Dhondt, p. 238, unfigured specimen [pl. 7, fig. 4 – Cataceramus subcircularis (Meek)].
1996. *Trochoceramus radiosus* (Quaas); Walaszczyk & al., p. 158, pl. 4, fig. 4; pl. 5, fig. 1; pl. 6, figs 3-4.
1996. *Inoceramus (Trochoceramus) radiosus* Quaas; Seibertz, p. 329 (pars), figs 16-17.

pars 2000. *Trochoceramus radiosus* (Quaas); Dhondt in Robaszynski & al., p. 417, pl. 11, fig. 4 [non pl. 11, figs 1-2]
2000. *Trochoceramus nahorianensis* (Kochubynskij); Dhondt in Robaszynski & al., p. 417; fig. 45; pl. 9, fig. 5.
2001. *Trochoceramus radiosus* (Quaas); Walaszczyk & al., pl. 42, figs 3-4, 6-9; Pl. 43, figs 3-5.
?2001. (tentatively) *Trochoceramus aff. ianjonaensis* (Sornay); Odin, pl. 2, fig. 19.

TYPE: The lectotype, designated by Walaszczyk & al. (1996, p. 158), is the original of Quaas (1902, pl. 20, fig. 9) from the Maastrichtian of Ammonitenberge, Egypt. The original is probably lost; its plaster cast preserved in the collections of Niedersächsisches Landesamt für Bodenforschung, Hannover, Germany.

MATERIAL: Specimen V1 from unit V of Hancock & al. (1993), and possibly also M1 (KBIN TCM 10538), the original to Dhondt (1993, pl. 7, fig. 3).

DESCRIPTION AND REMARKS: Specimen V1 is a very incomplete internal mould of a RV. The preserved part is a fragment of the posterior portion of the valve; part of the hinge line and posterior auricle are visible. Only a fragment of the posterior part of the umbonal section of the valve is present. The hinge line is clearly straight and moderately long. It may be inferred that the posterior auricle is clearly separated from the disc. This is also emphasised by differences in ornament; rugae weaken markedly or disappear completely on the posterior auricle. The ornament of the disc is composed in the adult of strong, widely spaced, concentric rugae with
superimposed radial ribs, clearly seen in the ventral part of the valve.

All of the discerned features, despite the poor preservation state of the specimen, allow a fairly confident specific identification. DHONDT (1993, p. 240) referred this specimen to *Trochoceramus nahorianensis* (KOCIUBINSKI).

In contrast to our specimen, *T. nahorianensis* is characterised by fine ornament and a posterior auricle that is not separated from the disc. Specimen M1, the original of *T. nahorianensis*, was found loose. In the US Western Interior the species is known from the Baculites grandis ammonite Zone (*Trochoceramus radiosus* inoceramid Zone); known from the Lower Maastrichtian (without further details) of Europe (The Ukraine, Poland, Germany - Rügen) and North Africa (Egypt).

**OCCURRENCE:** Among the Tercis specimens only V1 possesses a certain stratigraphical location; it comes from the V unit of HANCOCK & al. (1993) from the *Pachydiscus epiplectus* Zone. The other specimen, M1 (=KBIN TCM 10538), referred questionably to *T. radiosus*, was found loose. In the US Western Interior the species is known from the Baculites grandis ammonite Zone (*Trochoceramus radiosus* inoceramid Zone); known from the Lower Maastrichtian (without further details) of Europe (The Ukraine, Poland, Germany - Rügen) and North Africa (Egypt).

**Inoceramids with unknown generic affiliation**

Several forms are referred here to *Inoceramus sensu lato*. Based on overall similarity, some of them are clustered into informal groups, suggesting their evolutionary connections. Their generic affinities require, however, further study.

**“Inoceramus” alaeformis** ZEKELI, 1852, of authors

(Pl. 8, Fig. 4; Pl. 9, Figs 3-4; Pl. 10, Fig. 1)

?non 1852. *Inoceramus Cripsi* MANT. var. *alaformis* ZEKELI, p. 102, pl. 1, fig. 1.

?non 1866. *Inoceramus Cripsi* Mant. var. *alaformis* ZEKELI; ZITTEL, pl. 14, fig. 5.

?non 1959. *Inoceramus alaeformis* ZEKELI; DOBRON & PAVLOVA, p. 154, pl. 18, fig. 1.


?non 1988. *Inoceramus alaeformis* ZEKELI; ALIEV & KHARITONOV in ALI-ZADE & al., p. 262, pl. 16, figs 1-3.

?non 1993. *Platyceramus alaeformis* (ZEKELI); DHONDT, p. 228, pl. 5, figs 2, 4.

?non 2001. *Platyceramus alaeformis* (ZEKELI); ODIN, pl. 2, fig. 14. [*=Cataceramus barubiti* (MORTON)]

**MATERIAL:** 5 specimens: IW-78 from level 93.5 and IW-81 from level 87.6; IW-172 from level 93; IW-173 from level 93.3; IW-291 from level 84.4

**DESCRIPTION:** IW-78 is a moderately large internal mould of LV, with h max = 88 mm, almost completely preserved. IW-81 is a small outer mould of LV, with Lmax = 46 mm.

The species is of moderate size, inaequilateral, equirotal. The valve is weakly inflated, with maximum inflation in the dorso-central part. The posterior auricle is very weakly separated from the disc. The umbonal part is only slightly raised with the umbo projecting very slightly above the hinge line. The valve outline is subrounded to subquadrate. Low obliquity, with δ ranging between 65 and 75°. The anterior margin is moderately long, broadly convex, passing into the long, convex antero-ventral margin. The regularly rounded ventral margin passes into long, broadly rounded posterior margin. The hinge line is straight and moderately long.

The valve possesses two ornament stages. The juvenile stage, possesses regularly and closely spaced co-marginal rugae; the growth lines are parallel to the rugae. The adult ornament stage is covered with irregular, low rugae, or the shell is covered exclusively with growth lines.

**REMARKS:** The juveniles of the species resemble closely finely ribbed specimens of *Cataceramus goldfussianus*. The presence of two distinct ornament stages as well as the lack of distinct ventralward increase of interspaces in “I.” *alaformis* of authors make these two species clearly distinct.

In the character and outline of rugae “I.” *alaformis* of authors is also close to “I.” aff. *gandjaeformis*. The latter possesses, however, a distinct anterior auricle and oblique rugae.

“Inoceramus” *alaformis* of authors, the commonly accepted concept of the Austrian species, is most probably different from ZEKELI’s type. Although ZEKELI’s original specimen can no longer be found (TROGER & al. 2002), the type, as may be judged from drawings in ZEKELI (1852, pl. 1, fig. 1) and ZITTEL (1866, pl. 14, fig. 5) [ZITTEL’s drawing seems to be based on ZEKELI’s original], was rather a “balticus”-like form with extended anterior margin.

“Inoceramus” *alaformis* of authors seems to be a direct ancestor of *Trochoceramus costaeceus*; the transitional forms are represented (see Pl. 11, Figs 1-2, 5). They are all from an interval between levels 96.7 and 96.9.

Conspecific with “Inoceramus” *alaformis* of authors are probably two specimens from Tercis illustrated by DHONDT (1993, pl. 5, figs 2, 4), although they may represent incompletely preserved “Inoceramus” aff. *gandjaeformis*. 
OCCURRENCE: The Tercis specimens are from levels 87.6 and 93.5, which are upper *Nostoceras hyatti* ammonite Zone, corresponding to the “*Inoceramus* oblongus Zone. The specimens described by DHONDT (1993) come from a similar level. Known from the same level in the Piotrawin Quarry in the Middle Vistula section, Central Poland (WALASZCZYK, in prep.). So far not reported outside Europe.

"*Inoceramus* borilensis JOLKÍČEV, 1962
(Pl. 3, Fig. 7)

1962. *Inoceramus borilensis* nov. sp.; JOLKÍČEV, p. 145, pl. 7, fig. 1.
non 1976. *Inoceramus borilensis dauensis*; SORNAY, p. 5, pl. 1, fig. 3; pl. 2, figs 1-2.
non 1978. *Inoceramus aff. borilensis*; SORNAY & BILOTTE, p. 33, fig. 4.
1982. *Inoceramus borilensis* JOLKÍČEV; SORNAY, p. 7, pl. 2, fig. 1; pl. 3, fig. 3.
part 1982. *Inoceramus cf. borilensis* JOLKÍČEV; SORNAY, p. 9, pl. 3, fig. 2 (non pl. 3, fig. 1)
non 1993. "*Inoceramus*" cf. *borilensis* JOLKÍČEV; DHONDT, p. 215, pl. 1, fig. 1; pl. 3, fig. 2.
non 1993. "*Inoceramus*" cf. *borilensis* JOLKÍČEV; DHONDT, p. 216, pl. 4, fig. 1.
1997. *Inoceramus aff. borilensis* JOLKÍČEV; WALASZCZYK, p. 37, pl. 28, figs 1-5.
non 1999. *Inoceramus cf. borilensis* JOLKÍČEV; TRÖGER & al., p. 46, text-fig. 10.
non 2001. *Inoceramus borilensis* JOLKÍČEV; ODIN, pl. 1, figs 8-9 [=*Inoceramus redbirdensis*]

TYPE: The holotype, by original designation, is the specimen of JOLKÍČEV (1962, pl. 7, fig. 1), from the Campanian of Medven, Bulgaria [originally interpreted as Maastrichtian – see WALASZCZYK, LEES & JOLKÍČEV, in prep]. The specimen is housed at the University Museum of Sofia University.

MATERIAL: IW-34, from level 47.4; IW-158 from level 33.8; IW-213 from level 45.4; IW-214 from level 49.2; IW-215 from level 43; IW-216 from level 46.8; IW-219 from level 46.9; IW-220 from level 50.6; ?IW-223 from level II 50.6; IW-225 from level 47; ?IW-228 from level (47); IW-237 from level (47); IW-238 from level (47); IW-244 from level (47) [or it may be juvenile palliser]; IW-246 from level (47).

DESCRIPTION: IW-34 is a mould of a single RV, with preserved juvenile and part of the adult stage. The juvenile contacts the neck stage at approximately a right angle, with a well developed positive geniculation. The contact between the neck and adult stages is marked by a negative geniculation. The juvenile stage is *balticus*-like, strongly oblique, and elongated postero-ventrally. The beak is small, indistinct, projecting slightly above the hinge line. The hinge line is straight and long. The surface is covered with closely and regularly spaced concentric rugae. Growth lines not observed. Neck and adult parts ornamented with very low, indistinct rugae or smooth.

REMARKS: The species is characterised by a small juvenile stage, with *balticus*-like outline and ornament, a short neck, and a very long, irregularly ornamented adult stage. The juvenile/neck stage boundary is marked by positive geniculation and the neck/adult stage boundary by a negative geniculation (the species is discussed at length by WALASZCZYK, LEES & JOLKÍČEV, in prep.).

In the Upper Campanian distinctly geniculated forms assigned to "*Inoceramus* borilensis" are not rare. They differ, however, from the Bulgarian species in the characters of the juvenile stage and the outline of the adult. Some of these forms, e.g. SORNAY & BILOTTE (1978, fig. 4), SORNAY, from the Pyrenees, and of DHONDT (1993, pl. 1, fig. 1; pl. 3, fig. 2 and pl. 4, fig. 1) from Tercis, are characterised by a regularly ornamented juvenile stage, the outline of which is, however, quite different. Moreover, they possess only a single, positive geniculation and are much less oblique.

Also distinct from JOLKÍČEV’S species is *Inoceramus borilensis dauensis*, described by SORNAY (1976) from the Upper Campanian of south-western France. *I. dauensis* was subsequently synonymised with *I. borilensis* by SORNAY (1982). It possesses, however, a subcircular, almost smooth juvenile stage, and the species is very weakly oblique. This subspecies should be retained as a separate taxon, and is regarded here as a separate species, which is closely related to *Sphaeroceras pertenuiformis* WALASZCZYK, COBBAN & HARRIES, 2001.

To "*I. borilensis* belongs most probably *Inoceramus aff. borilensis* described by WALASZCZYK (1997) from the lower Upper Campanian of Westphalia. WALASZCZYK (op. cit.) referred the Westphalian form to as aff. *borilensis* because of the supposed stratigraphical gap when compared to the Bulgarian material. However, it is now known that the type and other Bulgarian specimens of *I. borilensis* were mis-dated and come actually from the mid-Upper Campanian (see WALASZCZYK, LEES & JOLKÍČEV, in prep.).

OCCURRENCE: The described specimen comes from level 47 of the Tercis section. As currently demonstrated (WALASZCZYK, LEES & JOLKÍČEV, in prep.) the type of the species comes from the middle Upper Campanian of
Bulgaria. It is also known from the lower Upper Campanian of Westphalia (Walaszczyzk 1997).

"Inoceramus" conlini Walaszczzyk, Cobban & Harrles, 2001
(Pl. 1, Fig. 3)

1967. Inoceramus (Endocostea) cymba Bohm; Seitz, p. 66, pl. 3, fig. 2 [non pl. 2, fig. 2 – Endocostea typica; non pl. 7, fig. 3 – Caniceramus? subcompressus]

TYPE: The holotype, by original designation, is USNM 507476, the original of Walaszczyzk & al. (2001, pl. 3, fig. 2) from near the top of the Telegraph Creek Formation, in the NW part of Fergus County, Montana, USA (USGS Mesozoic locality 21568); Haresiceras placentiforme ammonite Zone of the Lower Campanian.

MATERIAL: Single specimen, IW-8, from level 11.

DESCRIPTION: IW-8 is a medium-sized, single RV, relatively complete, with parts of the shell preserved in the neck and adult stages. The specimen clearly displays the characters of the species, i.e. the presence of three growth stages, with two geniculation points. The juvenile part, 44 mm in h, is weakly inflated, strongly oblique, with the posterior auricle well separated from the disc. The hinge line is long and straight. The beak is indistinct, pointed anteriorly, weakly projecting above the hinge line. The disc is covered with regularly spaced concentric rugae, weakening markedly when passing onto the posterior auricle, where the ornament is represented mainly by growth lines. The adult stage is elongated posteriorly. The adult and neck stages are covered with widely spaced and low rugae, disappearing in the posterior part.

REMARKS: The morphotype represented by "Inoceramus" conlini is characterised by the generally baliticus-like shape of the adult stage and the presence of a juvenile part separated from the adult by a neck, with two geniculation points. It is the same morphotype as represented by "Inoceramus" incurvus Meek & Hayden 1856, "Inoceramus" mclearni Douglas, 1942, and "Inoceramus" furnivali Douglas, 1942, from the Late Campanian and Early Maastrichtian of the US Western Interior (see Walaszczyzk & al. 2001). To the same group belongs "Inoceramus" cymbaeformis described by Pergament (1974, pl. 45, fig. 9) from the ?Upper Campanian of Koryakia, Russian Far East. All of these species are distinctly younger stratigraphically. The other American forms differ, moreover, in the ornamentation of the juvenile stage (see also discussion in Walaszczyzk & al. 2001).

OCCURRENCE: The species is known from the Scaphites hippocrepis III ammonite Zone in the US Western Interior and from the lower Lower Campanian (probably Sphaeroceramus patootensiformis Zone) of Germany.

"Inoceramus" aff. gandjaeformis Walaszczzyk, Cobban & Harrles, 2001
(Pl. 8, Figs 3, 6)

1978. Inoceramus (Platyceramus) aff. alaeformis Zekele; Sornay & Bilotte, p. 30, pl. 1, figs 1, 3.

MATERIAL: IW-293 from level 84.0; IW-294 from level 84.7.

DESCRIPTION: Species of medium to moderately large size, ?equivalve, ?inequilateral. The valves are weakly inflated, with the maximum inflation dorso-central. The obliquity is small, with δ ranging up to 90°. The beak does not project above the hinge line. The posterior auricle is large, expanded posteriorly, and well separated from the disc along a shallow and wide auricular sulcus. The species possesses a well developed anterior auricle, well separated from the disc. The anterior margin is convex, moderately long, passing into the broadly convex, long ventral margin. The posterior margin is not preserved in the available specimens. The hinge line is straight and long.

The shell surface is ornamented with regularly spaced and sharp-edged rugae, with v-shaped interspaces. The rugae are distinctly oblique. They pass onto the posterior auricle, where they curve outward when crossing the auricular sulcus and then beak-ward when reaching the hinge line.

REMARKS: The presence of the anterior auricle, the distinct obliquity of the rugae, and the sinuous trace of the rugae on the posterior auricle make this species a very distinct form. Incomplete juveniles (lacking the anterior auricle) are very similar to juveniles of "Inoceramus" alaeformis of authors, and juvenile "Inoceramus" gandjaeformis.

OCCURRENCE: In Tercis the species is known from levels 84 and 84.7. The Pyrenean report of Sornay & Bilotte (1978) [as Inoceramus (Platyceramus) aff. alaeformis] from the transitional beds between Marnes de la
Plagne and la Calcaire Nankin in Maillau was originally regarded as Late Maastrichtian in age, but was shown recently to be latest Campanian, thus corresponding well to its position in Tercis.

**“Inoceramus” redbirdensis WALASZCZYK, COBBAN & HARRIES, 2001**

(Pl. 13, Figs 12-16)

2001. “Inoceramus” redbirdensis sp. nov.; WALASZCZYK, COBBAN & HARRIES, pl. 31, figs 1, 4; pl. 32, figs 2-3; pl.34, fig. 1

2001. Endocostea baltica elliptica; ODIN, pl. 1, fig. 4.

2001. Inoceramus borilensis; ODIN, pl. 1, figs 8-9.

**TYPE:** The holotype, by original designation, is USNM 507655, the original of WALASZCZYK & al. (2001, pl. 32, fig. 2) from the Baculites eliasi ammonite Zone of the Red Bird section, Wyoming, USA; USNM 507653, USNM 507654, and USNM 507656 through USNM 507660, from the same locality are paratypes.

**MATERIAL:** IW-101 from level 108.4; IW-102 from level 108.4; IW-95 from level 110.0; IW-97 from level 110.1; IW-99 from level 110.1; IW-96 from level 109; IW-98 from level 110.5; IW-100 from level 110.5; IW-103 from level 110.8; IW299 from level –2.8a.

**DESCRIPTION:** Besides IW-103 (Pl. 13, Fig. 15) all of the other specimens are single valves; all are internal moulds with only small fragments of shell preserved. Although all of the specimens are deformed they display clearly the set of features characterising the species. The moderately to strongly inflated valves, with maximum inflation dorso-centrally, possess a subpentagonal outline (similar to the stratigraphically older cordiceramids) with a well separated posterior auricle and with the radial sulcus located posteriorly to the growth axis, less distinctly developed. The umbo is markedly inflated, with the beak projecting distinctly above the hinge line. The anterior margin is relatively short, straight, passing into the long, broadly convex antero-ventral margin, and thence into a short, posterodorsal one. The posterior margin is short and almost straight. Two specimens (IW-96 and IW-99 in Pl. 13, Figs 12 and 13 respectively) possess a well developed “Hohlkehle”.

The valves are covered with strong, subregularly spaced, sharp-edged rugae, passing onto the posterior auricles. The rugae are usually closely spaced in the umbalonal part, with interspaces distinctly increasing in size in the adult stage. Irregular ribs appear sometimes in various parts of the interspaces.

REMARKS: Despite the deformations, the Tercis material leaves no doubt as to its conspecificity with the recently described “Inoceramus” redbirdensis WALASZCZYK, COBBAN & HARRIES, 2001.

Very close to “I.” redbirdensis are two other specimens, i.e. IW-101 and IW-102 (Pl. 12, Figs 4 and 8), which, however, differ in their valve outline and more regular ornament. Both specimens are less oblique, with subrectangular outline, and possess subevenly spaced rugae. They have a well developed radial sulcus in the posterior part of the disc. Taking into account these morphological differences, and the fact that both specimens occur stratigraphically below the typical “I.” redbirdensis, they may represent its ancestral form, and are referred consequently to “I.” aff. redbirdensis WALASZCZYK, COBBAN & HARRIES 2001.

**OCCURRENCE:** The species was described from the Baculites eliasi ammonite Zone of the US Western Interior. In Tercis it is limited to the narrow interval between levels 109 and 110.8. Both specimens referred herein to “I.” aff. redbirdensis come from level 108.4.

**The group of Inoceramus altus**

This group, comprising beside “I.” altus also “Inoceramus” sagensis, “Inoceramus” vanuxemi, and “Inoceramus” altusformis, is a very characteristic inoceramid fauna of the Baculites compressus ammonite Zone in the US Western Interior, ranging slightly down into the Didymoceras chenomense Zone and slightly up into the Baculites cuneatus Zone. As is demonstrated by the Tercis succession, this fauna is also well represented here in Europe. Inoceramus launartensis SORNAY, 1978, and Inoceramus lapparenti SORNAY, 1978, described from the Pyrenean Cretaceous are synonymous with I. altus.

**“Inoceramus” altus MEEEK, 1871**

(Pl. 4, Figs 4-5; Pl. 5, Fig. 1; Pl. 6, Figs 2, 6)

1871. Inoceramus altus MEEEK, p. 302.

1876a. Inoceramus altus MEEEK; MEEEK, p. 43, pl. 14, fig. 1.

1880. Inoceramus altus MEEEK; WHITFIELD, p. 391, pl. 9, fig. 1 [= Mytiloides sp.].

1898. Inoceramus altus MEEEK; LOGAN, p. 506, pl. 107, fig. 1.

1978. Inoceramus lapparenti SORNAY, p. 36, pl. 5, fig. 1; pl. 6, figs 1-2.

1978. Inoceramus launartensis SORNAY, p. 34, pl. 5, fig. 1.

1993. Endocostea baltica beckumensis (GIERS); DHONDT, p. 221, pl. 3, fig. 3.

2001. Inoceramus altus MEEEK; WALASZCZYK & al., pl. 22, figs 1-8; pl. 23, figs 1, 3-5; pl. 24, fig. 1
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TYPE: The holotype, by original designation, is USNM 12462, the specimen illustrated by MEEK (1876a, pl. 14, fig. 1) from near Medicine Bow station, Wyoming, USA; Baculites compressus ammonite Zone.

MATERIAL: IW-47 from level 67; IW-46 from level 67; IW-52 from level 66.5; IW-68 from level 93.6; IW-190 from level 67.1; IW-196 from level 67.1; IW-204 from level 67.1; IW-205 from level 66.5; IW-206 from level 66.5; IW-207 from level 66.5; IW-208 from level 66.9.

DESCRIPTION: All of the specimens are internal moulds of single valves, of moderate to moderately large size (h max of IW-46 equals 98; of IW-52 equals 98; of IW-47 equals 88.4, and of IW-68 equals 130 mm). The valves are weakly inflated (although the specimens are more or less laterally compressed), moderately to weakly oblique, with δ ranging from 55° to 65°, inequilaterial, prosocline. The umbo is weakly developed, with the beak only slightly projecting above the hinge line. The hinge line is relatively short, straight. The posterior auricle is relatively small, very poorly separated from the disc. The anterior margin is long, broadly convex, passing into the narrowly convex ventral margin, which passes into the long weakly convex posterior margin.

The valves are ornamented with closely, regularly spaced, round-topped rugae. The rugae are asymmetrical (with steeper ventral slope).

REMARKS: The species was recently re-described and illustrated by Walaszczyk & al. (2001), based on the originals and additional material from the US Western Interior.

"Inoceramus" altus closely resembles "I." altusiformis Walaszczyk, Cobban & Harries, 2001, from which it differs in smaller h/l value (see IW-209 from level 67.6 – Pl. 13, fig. 5). From the equally close "Inoceramus" vanuxemii MEEK & Hayden, 1860 it differs in higher obliquity, slightly higher inflation, and in the ornament; "I." vanuxemii possesses more regular rugae, sharp-edged with more distinct interspaces.

Into the synonymy of "I." altus falls Inoceramus lapparenti Sornay, 1978, described from the Spanish Pyrenees. This species possesses an identical valve outline and type of ornament. The source locality was thought to be Maastrichtian but it was shown recently to be Upper Campanian (Prof. M. Bilotte, personal communication, March 2002). Similarly, synonymous with "I." altus is another species described from the same region by Sornay (in Sornay & Bilotte 1978), Inoceramus lapparenti. The specimen illustrated is a huge, well preserved specimen, the juvenile part of which shows clearly the outline and type of ornament characteristic of MEEK's species. As in the case of I. lapparenti, it was thought originally to be of Maastrichtian age but was shown recently to be Late Campanian (Prof. M. Bilotte, personal communication).

Small specimens of "I." altus resemble some of the Santonian platyceramids; compare e.g. with Platyceramus ahsenensis (Seititz, 1961, pl. 1, figs 9-10). The latter possesses usually finer ornament. However, almost identical specimens are to be found.

To MEEK's species should also be referred the specimen from Tercis referred to Endocostea baltica beckumensis (Giers) by Dhondt (1993, pl. 3, fig. 3). Giers' species possesses less regular ornament and higher obliquity (see Walaszczyk 1997, pl. 14, fig. 4; pl. 15, figs 2-5; pls 16-18).

OCCURRENCE: In Tercis the species is noted from levels 66 up to 93.6, thus being limited to the Nostoceras hyatti ammonite Zone as applied in Europe. In inoceramid terms, it ranges from the "I." altus through "I." oblongus Zone, which in North American ammonite zonation would correspond to the Baculites compressus Zone through the Baculites reesidei Zone. The species is known from the US Western Interior from the Didymoceras cheyenense, Baculites compressus and Baculites cuneatus Zones. A single specimen is known from the Piotrawin quarry, where it is assigned to the Upper Campanian "I." oblongus Zone, corresponding to the middle Nostoceras hyatti ammonite Zone (Walaszczyk, in press).

"Inoceramus" sagensis Owen, 1852 (Pl. 4, Fig. 3 ; Pl. 5, Figs 4, 6 ; Pl. 6, Fig. 4)

1852. Inoceramus Sagensis (N.S.) Owen, p. 582, pl. 7, fig. 3.
1876. Inoceramus Sagensis var. Nebrascensis, Owen; MEEK, p. 52, pl. 13, fig. 2.
Non 1880. Inoceramus sagensis Owen; Whitfield, p. 393, pl. 7, fig. 12.
Non 1885. Inoceramus sagensis Owen; Whitfield, p. 76, pl. 14, fig. 15; pl. 15, fig. 2.
Non 1896. Inoceramus sagensis Owen; Gilbert, pl. 66, fig. 3 ["Inoceramus piemont Walaszczyk, Cobban & Harries"].
1898. Inoceramus sagensis var. nebrascensis Owen; Logan, p. 506, pl. 109, fig. 2.
Non 1913. Inoceramus cfr. Sagensis Owen; Bose, pl. 3, fig. 6.
1959. Inoceramus sagensis Owen; Dobrov & Pavlova, p. 155 (pars), pl. 22, fig. 3 [Non pl. 23, fig. 5 = ?Inoceramus nebrascensis Owen].
1963. Inoceramus nebrascensis Owen; Tsagareli, p. 98, pl. 4, fig. 4.
1970. Inoceramus sagensis Owen; Soboleva, p. 145, pl. 1, figs 1-2.
1970. Inoceramus balchii Meeke; Soboleva, p. 148, pl. 4, fig. 1.
1970. Inoceramus dyusatiensis Soboleva, p. 151, pl. 5, fig. 1; pl. 7, fig. 1
1970. Inoceramus conveae Hall & Meeke; Soboleva, p. 149, pl. 5, fig. 2; pl. 7, fig. 2.
1970. Inoceramus karakatensis Soboleva, p. 152, pl. 8, fig. 5.

1974. Inoceramus sagensis Owen; Kocurbinski, p. 85, pl. 24, fig. 2.
1993. "Inoceramus" sagensis Owen; Atabekian, p. 217, pl. 111, fig. 2; pl. 112, fig. 1.
1999. Inoceramus sagensis Owen; Tröger & al., p. 48, pl. 2, fig. 4. [=Sphaeroceramus santamensis (Woods).
2001. "Inoceramus" sagensis Owen; Walaszczyk & al., pl. 24, fig. 2-4; pl. 36, fig. 9-10

TYPE: The holotype, by monotypy, is Owen's (1852, p. 582, pl. 7, fig. 3) specimen, USNM 20246, Upper Cretaceous of Fox Hills, Sage Creek, South Dakota, USA; Baculites compressus ammonite Zone.

MATERIAL: Three specimens: IW-43 from level 66.5, IW-48 from level 66.8 and IW-55 from level 67.0, IW-191 from level 67.

DESCRIPTION: All three specimens are internal moulds of single valves. IW-48 and IW-55 are larger representatives, with \( h_{\text{max}} = 92 \) and 98.6 mm respectively. IW-43 is smaller, with \( h_{\text{max}} = 76 \) mm. All are moderately inflated, prosocline, with subrounded outline. In IW-48 and IW-55 the umbo is weakly inflated, and the beak projects only moderately above the hinge line. Stronger inflation is observed only in IW-43. All of the specimens possess a broadly convex anterior margin, passing into a rounded ventral margin and weakly convex posterior margin. The small posterior auricle is very weakly separated from the moderately inflated disc. The juvenile stage is ornamented with subregularly spaced, rounded-topped rugae. In adult stages the rugae become much less regular.

REMARKS: The specimens from Tercis do not differ from the American material (see recent discussion and illustration by Walaszczyk & al. 2001). IW-43 most closely resembles Owen's (1952, pl. 7, fig. 3) type. Two other specimens are more rounded in outline but they closely match other representatives of the species from the Pierre Shale as illustrated by Walaszczyk & al. (2001). Juveniles of "I." sagensis may be very similar and difficult to separate from "Inoceramus" altusiformis Walaszczyk, Cobban & Harries, 2001.

OCCURRENCE: All of the specimens in Tercis come from around level 66.0, from the lower Nostoceras hyatti ammonite Zone. It is known from the Baculites compressus ammonite Zone of the US Western Interior. Reported from the Upper Campanian of The Ukraine and Western Central Asia, but without more precise location.

"Inoceramus" vanuxemi Meeke & Hayden, 1860
(Pl. 4, Fig. 2; Pl. 5, Fig. 5; Pl. 7, Figs 1, 4)
1876. Inoceramus Vanuxemi Meeke & Hayden; Meeke, p. 57, pl. 14, fig. 2.
1880. Inoceramus vanuxemi Meeke & Hayden; Whitfield, p. 396, pl. 7, figs 8-9; pl. 8, figs 4-5.
1880. Inoceramus vanuxemi; var.?; Whitfield, p. 398, pl. 7, fig. 10.
1941. Inoceramus vanuxemi Meeke & Hayden; Stephenson, p. 99, pl. 13, figs 1-4
1961. Inoceramus sp. ex gr. vanuxemi Meeke & Hayden; Sornay, pl. 2, fig. 4.
1993. Platyceramus cf. artigesi (Sornay); D'Orbigny; D'Orbigny.
2001. "Inoceramus" vanuxemi Meeke & Hayden; Walaszczyk & al., pl. 35, fig. 3; pl. 37, fig. 3

TYPE: The holotype, by original designation is USNM 483 from the Upper Campanian of Sage Creek (probably Baculites compressus ammonite Zone), South Dakota, USA.

MATERIAL: 2 specimens; IW-49 and IW-54; both from level 67.0; IW-273 from level 73.9; IW-285 from level 73.9.

DESCRIPTION: IW 49 is an incomplete internal mould of the LV of a large specimen. \( h_{\text{max}} \) of the preserved part is 92 mm. The specimen is weakly oblique, with \( \delta = 63^\circ \), and with a straight growth axis. The anterior margin is broadly rounded, convex. The hinge margin is long and straight. The posterior auricle is large, poorly separated from the disc. The ornament is composed of regularly to subregularly spaced, sharp-edged, increasing in size ventralward concentric rugae. Rugae well developed on the posterior auricle. IW 54 is large sized (\( h_{\text{max}} \) of the preserved part 121 mm) incomplete LV, with hinge margin and posterior auricle missing. The specimen is clearly of very low obliquity, with a straight growth axis. The anterior margin is broadly convex.
Remarks: The low obliquity, ventral shell elongation, and the concentric ornament composed of sharp-edged, regular to subregular rugae allow the two specimens to be referred to *I.*" magniumbonatus MEEK & HAYDEN, 1860. From "I." *altus*, a very similar Late Campanian species, it differs in its smaller obliquity, more regular ornament and the sharp edges of the concentric rugae. The species closely resembles the Santonian representatives of the genus *Platyceramus*, e.g. *Platyceramus cycloides* cf. *vanuxemiformis* NAGAO & MATSUMOTO in SEITZ (1961, pl. 2, fig. 7). The species was recently discussed by WALASZCZYK & al. (2001).

Occurrence: Upper Campanian, basal part of the *Nostoceras hyatti* ammonite Zone of the Tercis section; Known from the *Baculites compressus* Zone of the US Western Interior.

The group of “Inoceramus” oblongus

“Inoceramus” magniumbonatus DOUGLAS, 1942

(Text-fig. 8)

1942. *Inoceramus barabini* var. *magniumbonatus* DOUGLAS, p. 63, pl. 1, fig. 1.


2001. “Inoceramus” magniumbonatus DOUGLAS; WALASZCZYK & al., p. 225, pl. 19; pl. 31, fig. 2; pl. 32, figs 1, 4-5.

Type: The holotype, by original designation, is GSC 8930, illustrated by DOUGLAS (1942, pl. 1, fig. 1) from the uppermost Campanian of the Boxelder Creek, c. 190 m above the base of the Bearpaw Formation, Sasksatchewan, Canada.

Material: Single specimen, IW-181 from level 93.2.

Description: It is a huge (*hmax = 165 mm*), single, internal mould of a RV. It is a strongly convex, posteriorly elongated valve, with a subrectangular outline. The anterior margin is short, passing into a broadly rounded ventral margin. The posterior margin is not completely preserved.

The juvenile part is covered with strong, widely spaced co-marginal rugae. The medium and adult parts of the shell are almost smooth.

Discussion: The Tercis specimen is very close to the Canadian type, which is characterised by strong inflation, and a rugate juvenile part and a large, almost smooth adult part. The geniculation, seen clearly in the type, is not seen in our specimen, but this may be due to subsequent lateral compression.

To “I.” *magniumbonatus* belongs most probably the specimen illustrated by TZANKOV (1981, pl. 40, fig. 1) and referred by him to *Inoceramus borilensis*. It is a massive, posteriorly elongated double-valved specimen, with strong rugae in the juvenile and medium parts, weakening ventralward, with the shell almost smooth in the ventralmost part. It is quite different from *I. borilensis*, which possesses a regularly rugate, relatively small juvenile part, succeeded by a large, almost smooth adult part, characterised by much lower obliquity than DOUGLAS’ species.

*Inoceramus barabini* aff. var. *magniumbonatus* DOUGLAS of JOLKICˇEV (1962, pl. 5, fig. 1) possesses much finer ornament, with round-topped rugae and rounded interspaces. Moreover, it seems to be less oblique than the Canadian species.

Occurrence: The type, and other American specimens come from the “*Inoceramus* oblongus” Zone of the Upper Campanian, which corresponds to the *Baculites resinoid* ammonite Zone. The species is known from the *Nostoceras hyatti* Zone of the Vistula section, central Poland. The Bulgarian specimen (=*I. borilensis* in TZANKOV, 1981, pl. 40, fig. 1) comes from Medven, which was dated originally as Maastrichtian. However, at least part of the material from that locality (e.g. the type of *Inoceramus borilensis*) represents the Campanian as dated recently with nannofossils by Jackie Lees (WALASZCZYK, LEES & JOLKICˇEV, in prep.; *I. magniumbonatus* reported by GALLEMI & al. (1995, 1997) from the Lower Maastrichtian of southeast Spain should be re-examined.

“Inoceramus” oblongus MEEK, 1871

(PL. 9, Figs 1-2; PL. 10, Fig. 5)


1879. *Inoceramus oblongus* MEEK; White, p. 285, pl. 2, fig. 1.

2001. “*Inoceramus* oblongus” MEEK; WALASZCZYK & al., pl. 26, figs 2, 5; pl. 27, figs 1, 3; pl. 28, pl. 31, fig. 5

Type: The holotype, by MEEK’s original designation, is USNM 774, also the original of WHITE (1879, p. 285, pl. 2, fig. 1; reillustrated by WALASZCZYK & al. 2001, pl. 31, fig. 5), from the uppermost Campanian, south of Fort Collins, Colorado, USA.

Material: IW-67 from level (93.6); IW-80 from level 94.0; IW-74 from level 93.0; IW-258 from level 87.1; IW-263 from level (85).
DESCRIPTION: All of the specimens are internal moulds of single RVs. IW-67 and IW-74 are moderately large sized (with $h_{\text{max}} = 151$ and 131 respectively). IW-80 is a small-sized specimen, with $h_{\text{max}} = 63.8$ mm. The valves are prosocline, subtriangular in outline, moderately inflated and strongly elongated posteriorly. The anterior margin is relatively short, weakly convex, passing into a long to very long anterior-ventral margin, which forms a very characteristic feature of the species. The posterior margin is narrowly rounded. The hinge line is long, straight. The posterior auricle is poorly separated from the disc and elongated parallel the hinge line.

Juvenile valves are ornamented with regularly and closely spaced rugae. In the adult stage the rugae are much less regular. In parts the ornament is dominated by raised growth lines.

REMARKS: North American material, including the type, was recently re-described and illustrated by WALASZCZYK & al. (2001). The general outline of the Tercis specimens, characterised by an extremely long antero-ventral margin, strong obliquity and postero-ventral elongation, as well as the type of ornament, makes them very similar to the American material. “I.” oblongus resembles “I.” wyomingensis WALASZCZYK, COBBAN & HARRIES 2001. The latter is, however, markedly more inflated and possesses a different rugae outline, running parallel to the hinge line in the axial part of the valve.

OCCURRENCE: Tercis specimens are all from a level around 93-94, which represents the “I.” oblongus Zone, corresponding to the upper part of the Nostoceras hyatti ammonite Zone. American specimens, known exclusively from the Baculites reesidei Zone, come from the same stratigraphical level as those from Tercis. Also known from the upper Nostoceras hyatti Zone of the Piotrawin section in the Middle Vistula section, in central Poland (WALASZCZYK, in prep.).
“Inoceramus” wyomingensis WALASZCZYK, COBBAN & HARRIES, 2001
(Pl. 12, Figs 5-6)

2001. “Inoceramus” wyomingensis sp. nov.; WALASZCZYK, COBBAN & HARRIES, pl. 34, figs 2-5.

TYPE: The holotype is USNM 507735, the original of WALASZCZYK & al. (2001, pl. 34, fig. 5), from the Baculites eliasi ammonite Zone of the Lewis Shale, Natrona County, Wyoming, USA.

MATERIAL: Two specimens; IW-105 from level 109.8 and IW-104 from level 109.8.

DESCRIPTION: Both specimens are medium sized (h max of IW-105 and IW-104 is 109 mm and 82 mm respectively) internal moulds of a single LV. The valves are strongly elongated postero-ventrally with a massive, markedly inflated umbo. The beak projects slightly above the hinge line. The hinge line is long, straight. The valve outline is characterised by a relatively short anterior margin passing into a broadly rounded, very long antero-ventral margin. The posterior auricle is small, subtriangular, relatively well separated from the disc.

The juvenile portion is covered with subregularly spaced, rounded rugae and the adult portion is ornamented with irregularly spaced rugae. In the antero-ventral part the rugae display the characteristic elongation parallel to the hinge line.

REMARKS: The Tercis specimens closely resemble the American forms recently described (WALASZCZYK & al. 2001). They differ slightly in more rigorous ornament in the adult part, but this may partly be due to preservation. For further discussion see WALASZCZYK & al. (2001).

Fig. 9. “Inoceramus” balchiformis Walaszczyk, Cobban & Harries, 2001, IW-180 from level 93.2 [section I]; x0.7
OCCURRENCE: The species was described from the *Baculites eliasi* ammonite Zone of the US Western Interior. In Tercis it is known from level 109.7-109.8.

The group of “*Inoceramus* scotti”

“*Inoceramus* balchiformis” WALASZCZYK, COBBAN & HARRIES, 2001
(Text-fig. 9)

2001. “*Inoceramus* balchiformis sp. nov.; WALASZCZYK, COBBAN & HARRIES, p. 210, pl. 25, figs 2, 5; pl. 30.

TYPE: The holotype, by original designation, is USNM 507622 from Round Butte, north of Fort Collins, Lahtimer County, Colorado, USA (USGS Mesozoic locality D372); *Baculites reesidei* ammonite Zone.

MATERIAL: Single specimen IW-180, from level 93.2.

DESCRIPTION: The Tercis specimen is a huge (hmax = 174mm) LV, very weakly inflated, with maximum inflation in the umbalon part. The anterior margin is long (60% of the respective axial length), straight, passing into the regularly rounded ventral margin. The posterior margin is broadly rounded. The hingeline is long and straight. The anterior face is low. The umbo projects only slightly above the hinge-line and curves slightly anteriorly. The shell is weakly ornamented. The regular rugae are well developed in the anterior juvenile part. The rest of the shell is almost smooth, covered in parts with raised growth lines.

DISCUSSION: Our specimen is very close to the huge USNM 507621 from the US Western Interior (WALASZCZYK & al. 2001, pl. 30).

Fig. 10. “*Inoceramus* cobbani sp. nov., IW-186 from level 93.2 [section I]: ×0.8
OCCURRENCE: The Tercis specimen comes from level 93.2; it occurs in the *Baculites reesidei* Zone of the US Western Interior.

"*Inoceramus*" cobbani sp. nov.  
(Text-fig. 10)

?part 1981. *Inoceramus planus* MÜNSTER; TZANKOV, p. 86, pl. 33, fig. 2 [non pl. 32, figs 1-2; pl. 33, fig. 1]

TYPE: The holotype is IW-186 from level 93.2 of the Tercis section (Text-fig. 10).

DERIVATION OF NAME: After William A. COBBAN, American paleontologist and geologist, who made a very significant contribution to Cretaceous paleontology and stratigraphy.

DIAGNOSIS: Medium to large-sized, weakly oblique, prosocline. Umbo massive, projecting distinctly above hingeline. Anterior margin moderately long, straight, concave below umbo. Ventral margin narrowly rounded. Hingeline moderately long, straight. Posterior auricle triangular, well separated from disc in juvenile part. Valve ornamented with subregular, strong rugae, with interspaces increasing in size gradually ventralward. Rugae continue onto posterior auricle.

MATERIAL: IW-179 from level 93.3; IW-185 from level 93.3; IW-186 from level 93.2; IW-177 from level 93.

DESCRIPTION: The material consists of three specimens, represented by internal moulds of single valves. The holotype is a large LV, completely preserved, with \( h_{max} = 160 \) mm. It possesses a massive umbo, incurved dorso-anteriorly. The anterior margin is straight and concave below the umbo, which in the type is slightly obliterated by lateral compression. The ventral margin is regularly rounded, passing into a moderately long, stragith posterior margin. The hingeline is long and straight. The valve is covered with strong rugae, slightly asymmetrical in cross section, with interspaces increasing in size distinctly ventralward. The rugae are best developed in the anterior and antero-ventral parts, whereas they weaken in the axial part and over the posterior auricle.

IW-185 is similarly large specimen, with \( h_{max} = 150 \) mm. The specimen is crushed in its anterior part, but it shows the type of ornament well, as well as the general outline of the holotype.

The third specimen, IW-177, is markedly smaller, but it displays all the characters of the species well: low obliquity, the umbo projecting above the hingeline, and the rugae pattern.

REMARKS: "*Inoceramus*" cobbani sp. nov. resembles representatives of the Lower Campanian group of *Cataceramus dariensis* (DOBROV & PAVLOVA, 1959) (see e.g. ARZUMANOVA 1964, 1965; WALASZCZYK 1997). In contrast to our species some species of the 'dariensis' group are characterised by a more massive umbo, located more posteriorly, and have a broadly convex anterior margin. Some specimens, e.g. the type of *Cataceramus karakalensis* (ARZUMANOVA, 1964, pl. 2, fig. 1), are very close.

Into the synonymy of our species most probably falls the large specimen of *Inoceramus planus* MÜNSTER in TZANKOV (1981, pl. 33, fig. 2). It possesses a weakly oblique outline, posterior umbo, straight anterior margin, slightly concave below the umbo, and similar ornament.

OCCURRENCE: The specimens studied here are all from around level 93 of the Tercis section, corresponding in the ammonite scheme to very high *Nostoceras hyatti* Zone. It equates with the upper part of the "*Inoceramus*" oblongus Zone in the inoceramid scheme. The species is also known from the *Nostoceras hyatti* Zone of the Piotrawin quarry, central Poland. The stratigraphical position of the Bulgarian specimen, referred here with a question mark, is poorly known. It was originally assigned to the Maastrichtian, but it may appear to be highest Campanian.

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