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# Inoceramids and inoceramid biostratigraphy of the Campanian and Maastrichtian of the United States Western Interior Basin

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**Abstract**

The taxonomy of Campanian and Lower Maastrichtian inoceramids from the United States Western Interior Basin is revised on the basis of MEEK and HAYDEN's classic collections as well as on extensive new collections. The type materials of DOUGLAS from Canada, as well as some specimens from the U.S. Gulf Coast and Atlantic Coast are also included. Fifty-four species are described of which 14 are new: *"Inoceramus" conlini*, *Cataceramus ? glendivensis*, *"Inoceramus" scotti*, *"Inoceramus" pierrensis*, *Sphaeroceramus pertenuiformis*, *"Inoceramus" whitfieldi*, *"Inoceramus" altusiformis*, *"Inoceramus" balchiformis*, *"Inoceramus" convexiformis*, *Cataceramus? gandjaeformis*, *"Inoceramus" redbirdensis*, *"Inoceramus" wyomingensis*, *Cataceramus? oviformis*, and *"Inoceramus" stephensoni*. Three forms are left in open nomenclature. Approximately half of the species described are referred to the genus *"Inoceramus"*, *sensu lato*; the remainder are placed in other inoceramid genera. The Campanian and Lower Maastrichtian inoceramids from the Western Interior are very similar to those occurring in Europe. This includes the genus *Trochoceramus*, hitherto regarded as virtually absent from North America. This similarity will allow precise biostratigraphic correlation between the two continents, providing additional links to augment the existing ammonite-based correlation.

All forms are placed into stratigraphic context based on the standard ammonite zonation for the Western Interior. In addition, a correlation of our new inoceramid zonation with the standard ammonite zonation is presented.

In the Campanian, close to the Middle/Late Campanian boundary, inoceramids underwent the main evolutionary turnover in their Campanian – Early Maastrichtian history. It is possible that the similarity between many forms from the Lower-Middle Campanian and from the Lower Maastrichtian results from iterative evolutionary processes. In the *Baculites clinolobatus* Zone or within the base of the succeeding *Hoploscaphites birkelundi* Zone, virtually all inoceramids (with the exception of *Tenuipteria*) became extinct.

**Keywords**

Campanian, Maastrichtian, Late Cretaceous, Western Interior, North America, Inoceramids, Biostratigraphy.

**Résumé**

Cet article présente la revision d'inocérames de Campanien et de Maastrichtien inférieur d'États-Unis. Les conclusions taxonomiques se base sur les collections de MEEK, HAYDEN et DOUGLAS et sur le matérial nouveau. Cinquante cing espèces sont decriré avec quatorze espèces nouveau: *"Inoceramus" conlini*, *?Cataceramus glendivensis*, *"Inoceramus" scotti*, *"Inoceramus" pierrensis*, *Sphaeroceramus pertenuiformis*, *"Inoceramus" whitfieldi*, *"Inoceramus" altusiformis*, *"Inoceramus" balchiformis*, *"Inoceramus" convexiformis*, *Cataceramus? gandjaeformis*, *"Inoceramus" redbirdensis*, *"Inoceramus" wyomingensis*, *Cataceramus? oviformis*, et *"Inoceramus" stephensoni*. Trois formés reste au nomenclature ouvert. Demi d'espèces decriré appartissent à genre *"Inoceramus" sensu lato* et de reste à divers genres d'inocérames. L'inocérames de Campanien et de Maastrichtien inférieur d'États-Unis ressemble l'ensemble d'Europe. Cette similarité peut sutenir la correlation biostratigraphicque d'Europe et d'Amérique du Nord. Tous les formes sont situé en standard ammonite zonation et la correlation de zonations d'ammonites et d'inocérames est présenté. À la Campanien la faune d'Inocérames depend d'important changement évolutionaire. À *Baculites clinolobatus* Zone où la base de *Hoploscaphites birkelundi* Zone presque tous d'inocérames disparaissent.

**Mots-clés**

Campanien, Maastrichtien, Crétacé supérieur, Western Interior, Amerique du Nord, Inocérams, Biostratigraphie.

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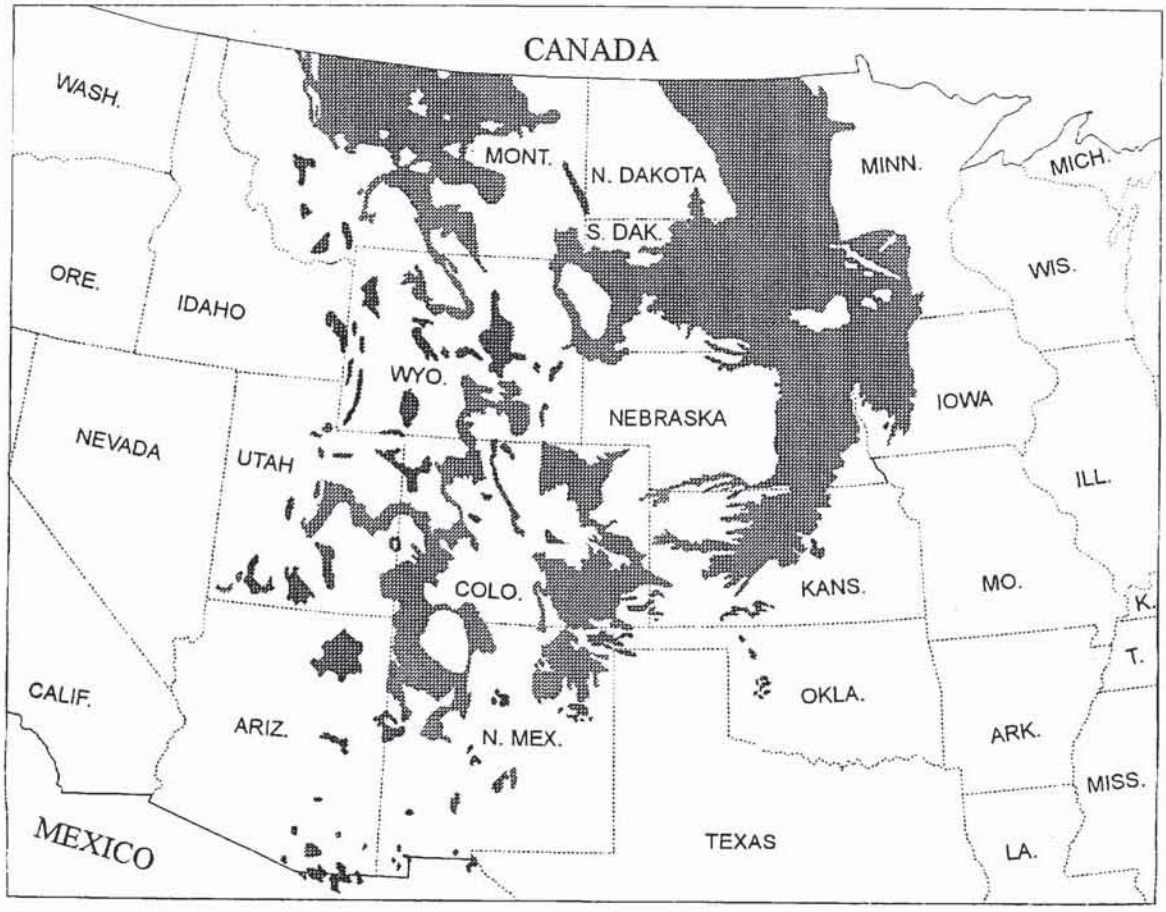
## INTRODUCTION

The United States Western Interior (Fig. 1) has a unique record of the Campanian – Maastrichtian marine succession; the sequence is apparently continuous, very fossiliferous, and contains a series of bentonite beds that provide the most reliable numerical ages for the interval (OBRADOVICH, 1994). The ammonite fauna allows an exceptionally refined biozonation to be erected, with a series of about 30 ammonite zones, the number of which is at least four times higher than that in Europe for the equivalent interval. The effective use of the Western Interior section as the global biostratigraphic standard is hindered, however, by the pronounced endemism of the ammonites, the lack of many other commonly used macrofaunal groups, such as belemnites, and other microfossil groups. The only relatively common group found in conjunction with the ammonites at numerous horizons throughout the interval are inoceramids. These bivalves are extremely important stratigraphic indicators for the early Late Cretaceous (Cenomanian – Santonian) but, apart from local application, were long regarded as practically useless for Campanian and Maastrichtian biostratigraphy. As shown by the material studied herein, and suggested earlier by the stratigraphic charts in KAUFFMAN *et al.* (1994), they still represent a group with high evolutionary rate and dispersal potential and, consequently, high biostratigraphic value in the Campanian and Early Maastrichtian. This was also suggested by some theoretical considerations and recent studies of the European fauna (WALASZCZYK, 1996, 1997). The high percentage of widespread and/or cosmopolitan taxa among the faunas studied distributed widely at least throughout the entire Euroamerican Palaeogeographical Region (*sensu* KAUFFMAN, 1973), will provide an effective correlation tool between the North American Western Interior, Gulf and Atlantic Coasts of North America, and Europe, resulting in the improvement of the stratigraphic resolution between the Campanian and Maastrichtian Stages in the two latter regions.

The present paper provides taxonomic description, illus-

Fig. 1: Sketch-map showing outcrop area of the Cretaceous rocks in the Western Interior of the United States. Modified from COBBAN & REESIDE (1952).

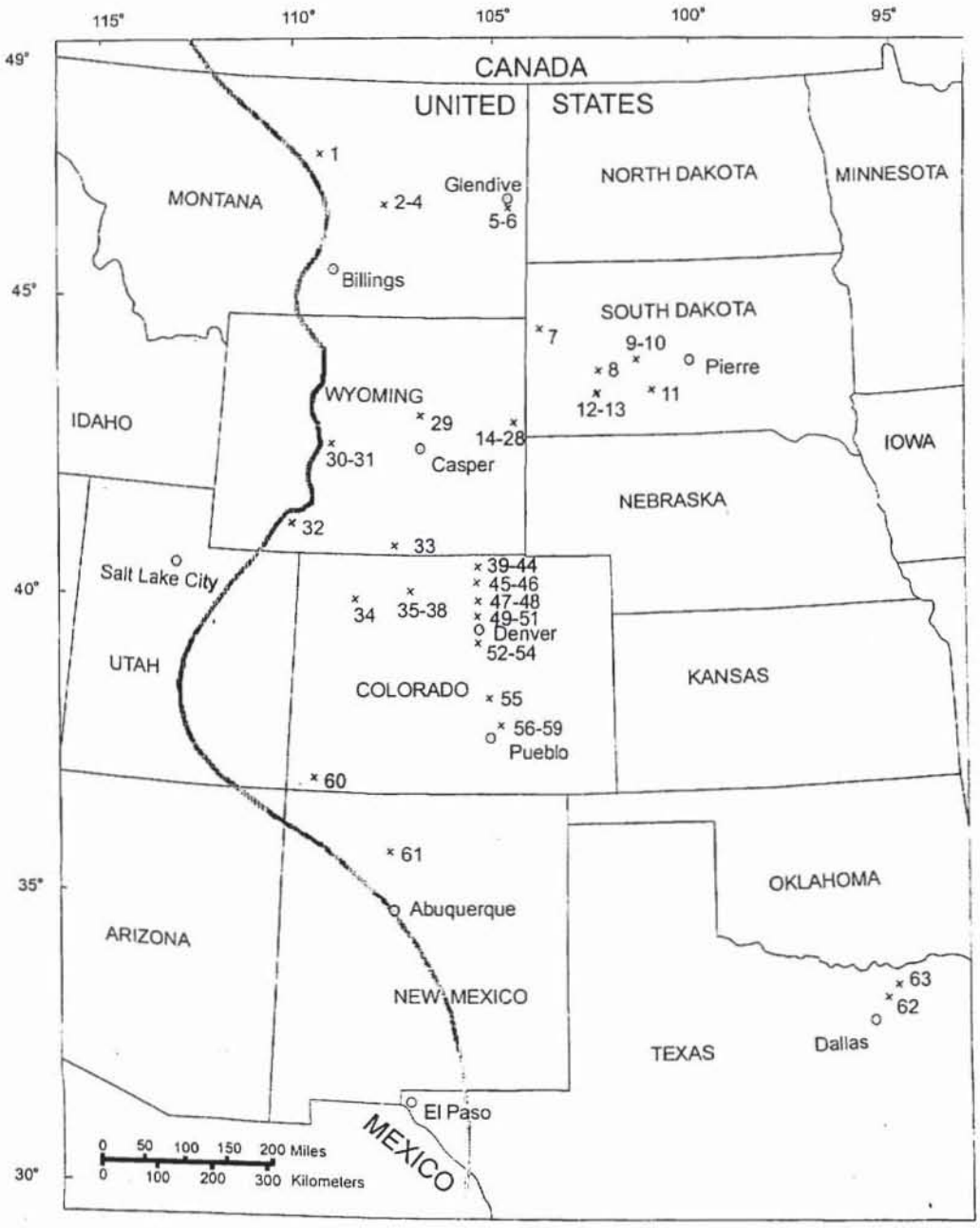


tration and stratigraphic range data for the Campanian and Lower Maastrichtian inoceramid species that are common in the U.S. Western Interior sequences. We also propose an inoceramid biostratigraphy for the interval, with its corrrelation to the ammonite standard. The study provides the description, and, in many cases, the first photographic illustration of numerous inoceramid taxa originally described from the US Western Interior in the 19th Century, during the initial geologic exploration of the region, and never subsequently treated in more taxonomic detail.

## GEOLOGICAL SETTING

During the Late Cretaceous sea-level highstands, the Western Interior of North America was covered by a broad, elongated seaway extending from the Gulf of

Fig. 2: Map showing the localities of collections mentioned in the text. Curved line shows approximate position of western shoreline during the early Campanian zones of *Scaphites hippocrepis* I-III.



Mexico in the south to the Arctic Ocean in the north. The seaway filled an asymmetric foreland basin that was initially flooded in the late Albian and existed until the Palaeocene (GILL & COBBAN, 1973; KAUFFMAN, 1977, 1984; KAUFFMAN & CALDWELL, 1994; DYMAN *et al.*, 1994a, b). To the west, the basin was bounded by the active Sevier Orogenic belt developed as the result of subduction occurring along the North American plate's western margin, and to the east by a relatively stable, cratonic platform. During pulses of orogenic activity along the western margin, thick, clastic wedges formed. As a consequence, the Cretaceous strata grade from coarse-grained sandstone facies in the west, through interbedded sandstone and shales, to shale and chalk facies in the eastern part. They range in thickness from about 6 000 m along the western margin to less than 1 000 m along the eastern portion of the basin. At the end of the Cretaceous, the basin was deformed by Laramide movements, represented by crustal block uplift and basin fragmentation.

The Cretaceous succession records large-scale cyclicity, representing a sequence of transgressive-regressive cycles, that are at least partly globally recognisable (KAUFFMAN, 1973, 1977). Three of these are recognised in the Campanian and Maastrichtian: the Claggett and Bearpaw transgressions, followed by Judith River and Fox Hills regressions, respectively (the earliest Campanian is marked by the Telegraph Creek-Eagle regression) (GILL & COBBAN, 1973), representing KAUFFMAN's (1977) Claggett and Bearpaw cyclothems (the Telegraph Creek-Eagle regression represents the upper part of the Niobrara cyclothem). The Claggett transgression (GILL & COBBAN, 1973; KAUFFMAN, 1977; COBBAN *et al.*, 1994) started in the *Baculites obtusus* Zone and peaked in the *Baculites* sp. (smooth) Zone. The Bearpaw transgression began in the *Didymoceras nebrascense* Zone and persisted until the *Baculites cuneatus* Zone (GILL & COBBAN, 1973). The withdrawal of the sea was at first very slow and irregular, with local transgressions (GILL & COBBAN, 1973), and only in the Maastrichtian (*Baculites baculus – Baculites grandis – Baculites clinolobatus* Zones) did the sea retreat from the Western Interior.

## LOCALITY DETAILS

U.S. Geological Survey Mesozoic localities, referred to in this report, are given below. Numbers preceding the USGS number refer to location numbers in Text-figure 2. Prefix D indicates Denver Mesozoic locality numbers; others are Washington, D.C., Mesozoic locality numbers.

(1) 21568 J.B. REESIDE, JR. and others, 1949. Stream cut in NW 1/4 sec. 13, T. 22 N., R. 16 E., Fergus County, Montana. Telegraph Creek Formation, near top.

(2) 21574 J.B. REESIDE, JR. and others, 1949. Six km northeast of Mosby in NW 1/4 sec. 4, T. 14 N., R. 31 E., Garfield County, Montana. Bearpaw Shale, from lower 22 m, *Didymoceras stevensoni* Zone.

(3) 16732 G.L. WAIT, 1911. About 8 km north of Musselshell River [probably near Mosby, Garfield County, Montana]. Bearpaw Shale.

(4) D 5670 J. R. GILL, 1966. SW 1/4 sec. 33, T. 15 N., R. 31 E., Garfield County, Montana. Bearpaw Shale, from sandy limestone concretions about 247 m above base.

(5) D 1048 W.A. COBBAN, 1956. South of Glendive in E 1/2 sec. 27, T. 14 N., R. 55 E., Dawson County, Montana. Pierre Shale, from calcareous concretions in upper 10 m.

(6) 24180 C. SIMPSON, 1938. South of Glendive in sec. 27, T. 13 N., R. 56 E., Prairie County, Montana. Pierre Shale.

(7) D 2139 W.A. COBBAN, 1959. North of Belle Fourche in the SE 1/4 sec. 22, T. 11 N., R. 2 E., Butte County, South Dakota. Pierre Shale, from Groat Sandstone Bed.

(8) D 1598 H.A. TOURTELOT, 1957. NE 1/4 sec. 32, T. 5 N., R. 13 E., Meade County, South Dakota. Pierre Shale, upper part.

(9) D 2386 W.A. COBBAN, 1959. East side of Snake Creek in SW 1/4 sec. 6, T. 6 N., R. 22 E., Haakon County, South Dakota. Pierre Shale, from Virgin Creek Member.

(10) D 13994 W.A. COBBAN, 1939. West Fork of Plum Creek, Haakon County, South Dakota. Pierre Shale, from Virgin Creek Member.

(11) D 877 W.A. COBBAN, 1956. North bank of Bad River southwest of Midland in NW 1/4 sec. 11, T. 1 N., R. 24 E., Haakon County, South Dakota. Pierre Shale, from calcareous concretions in Virgin Creek Member.

(12) 23071 J.B. REESIDE, JR., H.R. CHRISTNER, and W.A. COBBAN, 1950. Mouth of Sage Creek in SW 1/4 sec. 5, T. 1 S., R. 14 E., Pennington County, South Dakota.

(13) 23072 J.B. REESIDE, JR., H.R. CHRISTNER, and W.A. COBBAN, 1950. Cheyenne River 2 km north of mouth of Sage Creek, Pennington County, South Dakota. Pierre Shale, about 18-21 m below top of Virgin Creek Member.

(14) D 1042 W.A. COBBAN, 1956. NW 1/4 sec. 25, T. 39 N., R. 62 W., Niobrara County,

Wyoming. Pierre Shale, from calcareous concretions 18-32 m below top.

(15) D1898 W.A. COBBAN, 1958. Near Red Bird in SW 1/4 sec. 13, T. 38 N., R. 62 W., Niobrara County, Wyoming. Pierre Shale, from calcareous concretions 93 m above base of Red Bird Silty Member.

(16) D 1900 J.R. GILL and others, 1958. Near Red Bird in SW 1/4 sec. 13, T. 38 N., R. 62 W., Niobrara County, Wyoming. Pierre Shale, from calcareous concretions 98-102 m above base of Red Bird Silty Member.

(17) D 1908 J.R. GILL and others, 1958. Near Red Bird in SW 1/4 sec. 13, T. 38 N., R. 62 W., Niobrara County, Wyoming. Pierre Shale, from calcareous concretions 145 m above base of Red Bird Silty Member.

(18) D 1912 W.A. COBBAN, 1958. Near Red Bird in SW 1/4 sec. 13, T. 38 N., R. 62 W., Niobrara County, Wyoming. Pierre Shale, from calcareous concretions 157 m above base of Red Bird Silty Member.

(19) D 1923 J.R. GILL and others, 1958. Near Red Bird in E 1/2 sec. 14, and NW 1/4 sec. 13, T. 38 N., R. 62 W., Niobrara County, Wyoming. Pierre Shale, from calcareous concretions 205 m above base of Red Bird Silty Member.

(20) D 1924 J.R. GILL and others, 1957, 1958. Near Red Bird in sec. 23, T. 38 N., R. 62 W., Niobrara County, Wyoming. Pierre Shale, Red Bird Silty Member.

(21) D 1925 J.R. GILL and others, 1957, 1958. E 1/2 sec. 14, and NW 1/4 sec. 13, T. 38 N., R. 62 W., Niobrara County, Wyoming. Pierre Shale. Same stratigraphic level as D 1924.

(22) D 1948 W.A. COBBAN, 1958. Near Red Bird in SE 1/4 sec. 14, T. 38 N., R. 62 W., Niobrara County, Wyoming. Pierre Shale, 133 m below top of Kara Member.

(23) D 1949 W.A. COBBAN, 1958. Near Red Bird in SE 1/4 sec. 14, T. 38 N., R. 62 W., Niobrara County, Wyoming. Pierre Shale, from concretions 125-129 m below top of Kara Bentonitic Member.

(24) D 1961 J.R. GILL and others, 1958. Near Red Bird in SE 1/4 sec. 14, T. 38 N., R. 62 W., Niobrara County. Pierre Shale, 29 m below top of Kara Bentonitic Member.

(25) D 1970 W.A. COBBAN, 1958. Near Red Bird in SE 1/4 sec. 14, T. 38 N., R. 62 W., Niobrara County, Wyoming. Pierre Shale, 21 m above top of Kara Member.

(26) D 1986 J.R. GILL and others, 1958. Near Red Bird in SE 1/4 sec. 14, T. 38 N., R. 62 W., Niobrara County, Wyoming. Pierre Shale, 91 m below top.

(27) D 2115 W.A. COBBAN, 1959. Near Red Bird in SW 1/4 sec. 13, T. 38 N., R. 62 W., Niobrara County, Wyoming. Pierre Shale, from calcareous concretions 24 m below D 1898.

(28) D 2121 W.A. COBBAN, 1959. Near Red Bird in NE 1/4 sec. 14, T. 38 N., R. 62 W., Niobrara County, Wyoming. Pierre Shale, 28-32 m below top.

(29) 6217 R.W. STONE and M.W. CAMPBELL, 1909. Salt Creek oilfield in sec. 10, T. 40 N., R. 78 W., Natrona County, Wyoming. Lewis Shale.

(30) D 8852 M.W. REYNOLDS and A.R. ECKEL, 1973. SE 1/4 sec. 23, T. 34 N., R. 95 W., Fremont County, Wyoming. Cody Shale, 68 m below top.

(31) 21564 G.N. PIPIRINGOS, 1949. Southeast of Alkali Butte in SW 1/4 sec. 19, T. 34 N., R. 94 W., Fremont County, Wyoming. Cody Shale, 61 m below top.

(32) D 2413 J.H. SMITH, 1959. SE 1/4 sec. 13, T. 18 N., R. 105 W., Sweetwater County, Wyoming. Blair Formation, 46-76 m below top.

(33) D 7950 V.C.S. BARCLAY, 1971. Sec. 4, T. 13 N., R. 88 W., Carbon County, Wyoming. Steele Shale, from *Baculites asperiformis* Zone.

(34) D 2173 W.A. COBBAN and A.D. ZAPP, 1959. State Highway 13 in NW 1/4 sec. 32, T. 2 N., R. 93 W., Rio Blanco County, Colorado. Iles Formation, about 91 m above base.

(35) D 1351 G.R. SCOTT and W.A. COBBAN, 1957. SW 1/4 sec. 17, T. 3 N., R. 80 W., Grand County, Colorado. Pierre Shale, from sandy concretions in upper part.

(36) D 1352 G.R. SCOTT and W.A. COBBAN, 1957. SW 1/4 sec. 17, T. 3 N., R. 80 W., Grand County, Colorado. Pierre Shale, from huge sandstone concretions, 10 m above D 1351.

(37) D 1786 G.R. SCOTT and W.A. COBBAN, 1958. SW 1/4 sec. 17, T. 3 N., R. 80 W., Grand County, Colorado. Pierre Shale, from between levels of D 1351 and D 1352.

(38) D 2654 W.R. BROWN, 1957. SE 1/4 sec. 12, T. 3 N., R. 81 W., Grand County, Colorado. Pierre Shale.

(39) D 372 G.R. SCOTT and W.A. COBBAN, 1955. North of Fort Collins at Round Butte in W 1/2 sec. 19, T. 11 N., R. 68 W., Larimer County, Colorado. Pierre Shale, from equivalent of Larimer Sandstone Member.

(40) D 1465 G.R. SCOTT and W.A. COBBAN, 1959. SW 1/4 sec. 13 and NW 1/4 sec. 24, T. 9 N., R. 69 W., Larimer County, Colorado. Pierre Shale, from Larimer Sandstone Member.

(41) D 1466 G.R. SCOTT and W.A. COBBAN, 1957. Rocky Ridge Reservoir in NW 1/4 sec. 11, T. 8 N., R. 69 W., Larimer County, Colorado. Pierre Shale, Rocky Ridge Sandstone Member.

(42) D 2719 G.R. SCOTT, 1960. SW 1/4 sec. 12, T. 9 N., R. 69 W., Larimer County, Colorado. Pierre Shale, from Larimer Sandstone Member.

(43) D 2854 W.A. COBBAN, 1960. SW 1/4 sec. 11, T. 8 N., R. 69 W., Larimer County, Colorado. Pierre Shale, from Terry Sandstone Member (*Exiteloceras jenneyi* Zone).

(44) 16215 R.G. COFFIN, 1932. Sec. 24, T. 10 N., R. 69 W., Larimer County, Colorado. Pierre Shale.

(45) D 2768 G.R. SCOTT and W.A. COBBAN, 1960. NW 1/4 sec. 6, T. 1 S., R. 70 W., Boulder County, Colorado. Pierre Shale.

(46) D 10987 G.R. SCOTT, 1979. SE 1/4 sec. 35, T. 6 N., R. 69 W., Larimer County, Colorado. Pierre Shale, from Rocky Ridge Sandstone Member.

(47) 760 T.W. STANTON, 1890. About 8 km north of Boulder, Boulder County, Colorado. Pierre Shale.

(48) D 3713 G.R. SCOTT, 1960. SW 1/4 sec. 17, T. 4 N., R. 69 W., Larimer County, Colorado. Pierre Shale, from calcareous concretions in shaly sandstone.

(49) D 831 R. Van HORN, 1956. East shore of Ralston Reservoir in NE 1/4 sec. 5, T. 3 S., R. 70 W., Jefferson County, Colorado. Pierre Shale, from lower part.

(50) D 1574 J.D. WELLS and F.D. SPENCER, 1957. Community Ditch in SW 1/4 sec. 29, T. 1 S., R. 70 W., Boulder County, Colorado. Pierre Shale.

(51) D 2864 G.R. SCOTT and W.A. COBBAN, 1961. Community Ditch in SE 1/4 sec. 30, T. 1 S., R. 70 W., Boulder County, Colorado. Pierre Shale.

(52) D 283 G.R. SCOTT, 1955. North of Kassler, in NE 1/4 sec. 22, T. 6 S., R. 69 W., Jefferson County, Colorado. Pierre Shale, from ferruginous concretions.

(53) D 343 G.R. SCOTT, 1955. Southeast of Morrison in NE 1/4 sec. 29, T. 5 S., R. 69 W., Jefferson County, Colorado. Pierre Shale.

(54) D786 G.R. SCOTT, 1956. NW 1/4 sec. 18, T. 7 S., R. 68 W., Douglas County, Colorado. Pierre Shale, from ferruginous concretions.

(55) D 3789 G.R. SCOTT and W.A. COBBAN, 1962. West bank of Fountain Creek in NW 1/4 sec. 20, T. 16 S., R. 65 W., El Paso County, Colorado. Pierre Shale, from concretions in *Didymoceras stevensoni* Zone.

(56) D 79 G.R. SCOTT and W.A. COBBAN, 1954, 1955. Tom Hollow in secs. 14, 23, 24, T. 19 S., R. 64 W., Pueblo County, Colorado. Pierre Shale, from ferruginous concretions.

(57) D 1498 G.R. SCOTT and W.A. COBBAN, 1957. Tom Hollow in S 1/2 sec. 24 and E 1/2 sec. 23, T. 19 S., R. 64 W., Pueblo County, Colorado. Pierre Shale, lower than D 79.

(58) D 1520 G.R. SCOTT and W.A. COBBAN, 1957. Tom Hollow in NW 1/4 sec. 16, T. 20 S., R. 64 W., Pueblo County, Colorado. Pierre Shale, from ferruginous concretions.

(59) D 13589 W.G. CAMACK and W.A. COBBAN, 1997. Tom Hollow in SE 1/4 sec. 23, T. 19 S., R. 64 W., Pueblo County, Colorado. Pierre Shale.

(60) D 10840 G.R. SCOTT, 1977. Roadcut in NE 1/4 sec. 32, T. 36 N., R. 12 W., La Plata County, Colorado. Mancos Shale, from calcareous concretions.

(61) D 4075 G.R. SCOTT, 1963. NE 1/4 sec. 11, T. 23 N., R. 1 W., Rio Arriba County, New Mexico. Mancos Shale, from concretions 180 m below top in *Scaphites leei* III Zone.

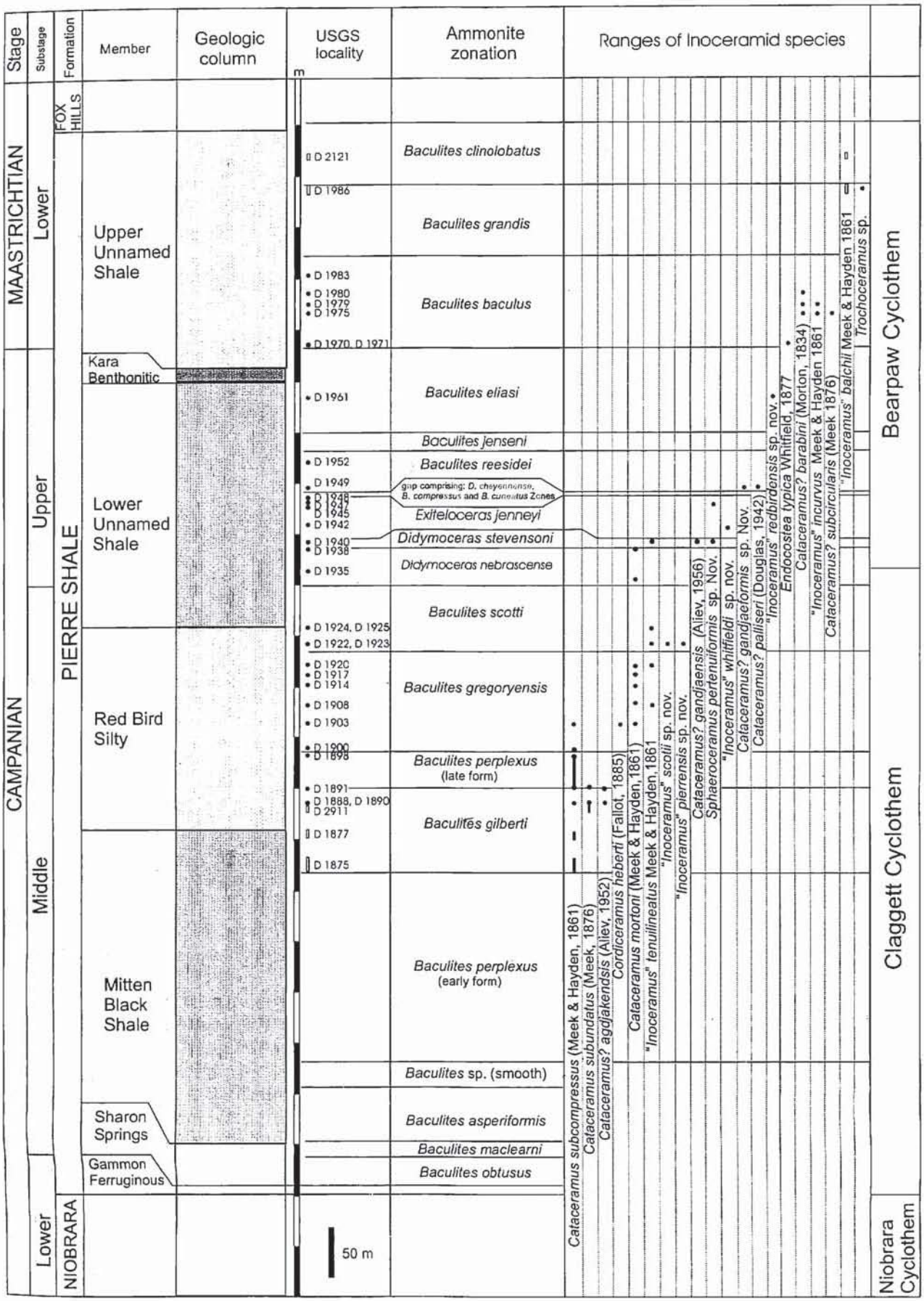
(62) 9710 L.W. STEPHENSON, 1916. Railroad cut 2.4 km northeast of Wolfe City, Hunt County, Texas. Wolfe City Sand, *Baculites maclearni* Zone.

(63) D 6896 J.R. GILL, J.P. CONLIN, and W.A. COBBAN, 1969. Quarry 1.8 km north of Roxton, Lamar County, Texas. Gober Tongue of Austin Chalk, Zone of *Scaphites hippocrepis* III.

## MEASURED SECTIONS

Most of the material studied comes from localities which, although located mostly within the standard ammonite zonation, were not precisely located in the succession. Precisely located material is limited to two sections, one of which spans almost the entire Campanian – Lower Maastrichtian interval whereas the other spans the Lower Maastrichtian. They provide a

Fig. 3: Litho-, chrono-, and biostratigraphy of the Red Bird section, Wyoming, with the stratigraphic ranges of inoceramid bivalves; geologic column, lithostratigraphy, and ammonite zonation after GILL & COBBAN (1966); T/R – transgressive - regressive cyclothems, after GILL & COBBAN (1973) and KAUFFMAN (1977).



majority of the inoceramids here treated. These collections also provide the basis of the inferred stratigraphic succession of inoceramid faunas presented here. These are the Red Bird section, in Wyoming (general succession and ammonite zonation after GILL & COBBAN, 1966; see also SOHL, 1967 for study of gastropods and MELLO, 1971 for study of foraminifers), and the Glendive section, Montana (sampled and measured by P.J. HARRIES).

### *Red Bird section*

The Red Bird section is a vast, almost continuous exposure of the Pierre Shale outcropping on the western limb of the Old Women Anticline, in Niobrara County, easternmost Wyoming (Fig. 3). This extensively studied section (GILL & COBBAN, 1961, 1966, and literature cited therein; SOHL, 1967; MELLO, 1971; BERGSTRESSER, 1983; HICKS *et al.*, 1999) is regarded as an informal reference section for the Campanian and Lower Maastrichtian ammonite biostratigraphy of the Western Interior.

The Pierre Shale of the Red Bird section is represented by an 1100 m thick succession of shales with thin beds of bentonite and limestone concretions, spanning an interval from at least the basal Middle Campanian (but potentially ranging even lower, into the *Scaphites hippocrepis* III Zone of the mid-Lower Campanian) through the Lower Maastrichtian. It is unconformably underlain by calcareous marine deposits of the Niobrara Formation and overlain by marginal marine terrigenous deposits of the Fox Hills Formation, the base of which is dated to the *Hoploscaphites birkelundi* Zone (Fig. 3). The succession represents two huge transgressions (Claggett and Bearpaw) and subsequent regressions (Judith River and Fox Hills) (GILL & COBBAN, 1973), referred subsequently to as the Claggett and Bearpaw cyclothems, corresponding to KAUFFMAN's (1973, 1977) global transgressive-regressive cycles T8-R8 and T9-R9.

The succession is very fossiliferous, although fossil occurrences are primarily limited to the concretionary horizons found throughout the sequence. Inoceramids are well represented in virtually all these horizons although the best record comes from the Middle Campanian and from the lowermost Maastrichtian (*Baculites baculus* ammonite Zone). The sequence contains a significant discontinuity that spans the *Didymoceras cheyennense*, *Baculites compressus* and *Baculites cuneatus* Zones. Localities and ranges of inoceramid taxa recognised are shown in Fig. 3.

### *Glendive section*

The Glendive section, in Cedar Creek Anticline, eastern Montana, is a 22 m thick shaly succession with horizons of calcareous concretions, representing the Unnamed Shale Member as distinguished in Red Bird section. It is overlaid by silty shales of the Fox Hills Formation that in this region probably corresponds to the *B. grandis* Zone. The section and inoceramid ranges are shown in Fig. 4. Biostratigraphically the Unnamed Shale Member represents here the *Baculites baculus* Zone. Taking into account the lack in the basal part of *Endocostea typica* WHITFIELD, the lowermost part of the zone is missing, but based on the presence in the topmost part of the "*Inoceramus*" *glendivensis* sp. nov., and common *Cataceramus? subcircularis* (MEEK, 1876a) the section ranges very high in the *B. baculus* Zone. The section and inoceramid ranges are shown in Fig. 4.

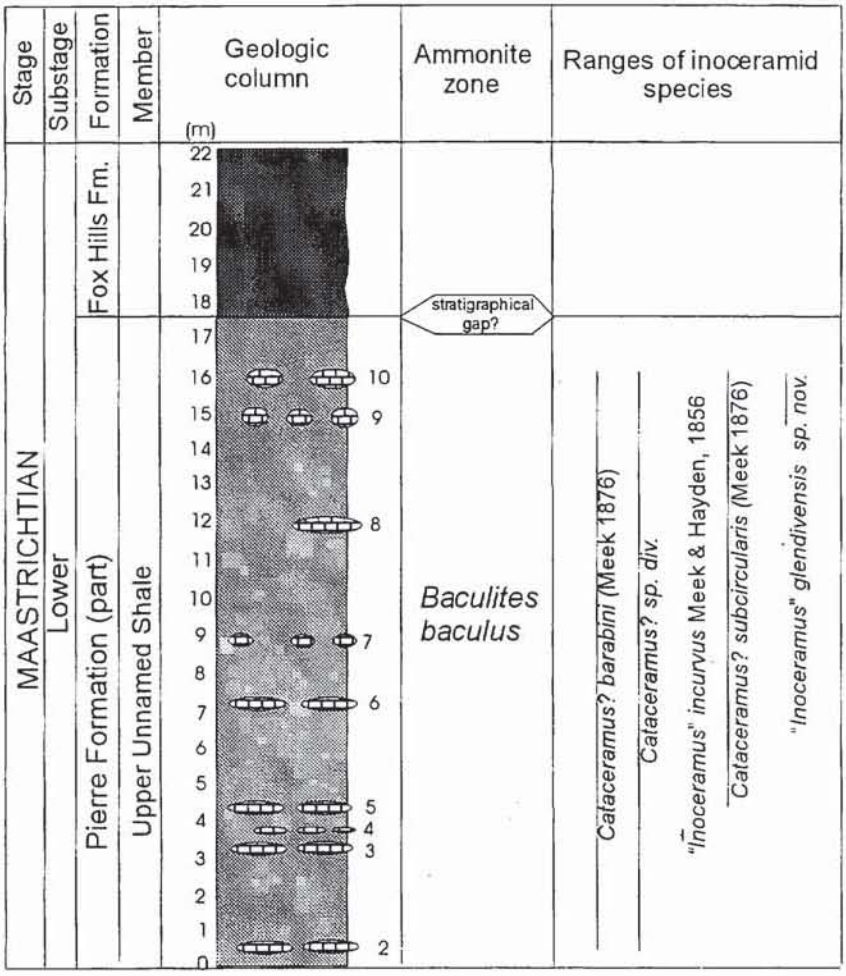
## STAGE AND SUBSTAGE DIVISION

The lower boundaries of the Campanian and of the Maastrichtian Stages are defined here according to the recommendations of the Brussels Symposium on Cretaceous Stage Boundaries, Brussels, 1995; the extinction-level of the pelagic crinoid *Marsupites testudinarius* (SCHLOTHEIM) defines the base of the Campanian Stage (HANCOCK & GALE, 1996); the first appearance of the ammonite *Pachydiscus neubergicus* (VON HAUER) is the boundary marker for the base of the Maastrichtian Stage (ODIN, 1996).

In the Western Interior the base of the Campanian is placed at the first appearance of the ammonite *Scaphites leei* III, as recently defined by COBBAN (1994). Its appearance post-dates the interval with *Marsupites*, known from the Western Interior to co-occur with its immediate ancestor, *Scaphites leei* II (COBBAN, 1995). The Western Interior correlative horizon of the base of the Maastrichtian Stage was variably interpreted in the 1970s and 1980s, ranging from as low as the base of the *Baculites obtusus* Zone (BERGSTRESSER & FRERICHS, 1982) up to the base of the *Baculites baculus* Zone (JELETZKY, 1968; see also EATON, 1987). Subsequent studies based on eustatic changes (HANCOCK & KAUFFMAN, 1989; HANCOCK, 1993), on $^{87}Sr/^{86}Sr$ ratios (McARTHUR *et al.*, 1992) and on the ammonite faunas (KENNEDY *et al.*, 1992) showed the boundary, as defined in Europe by the first occurrence of the belemnite *Belemnella lanceolata*, to lie somewhere at the base of the *Baculites eliasi* or even at the base of the succeeding zone of the *Baculites baculus*. As demonstrated in the Vistula Valley sequence in central Poland, the Brussels recommended boundary marker, i.e. *Pachydiscus neubergicus*, appears close to the first appearance of the *Belemnella lanceolata* and this does not influence substantially the location of the boundary in the Western Interior.

Recent study of the inoceramid faunas from Tercis, SW

Fig. 4: Geologic column, chrono-, litho-, and biostratigraphy of the Glendive section, Montana, with inoceramid ranges.




France, the potential stratotype for the Campanian – Maastrichtian boundary (ODIN, 1996), shows the close coincidence of the first appearance of *Pachydiscus neubergicus*, the ammonite marker of the boundary, and the first appearance of the inoceramid species *Endocostea typica* WHITFIELD (WALASZCZYK, DHONDT & ODIN, in prep.). In the Western Interior, *E. typica* first appears in the base of the *Baculites baculus* Zone and, consequently, we place the Campanian – Maastrichtian boundary at the base of this zone, one ammonite zone higher than recently placed by KENNEDY *et al.*, 1992 and COBBAN (1994). It agrees with the location of this boundary by JELEZTKY (1968), and recently by HANCOCK & KAUFFMAN (1989).

The substage division of the Campanian and Maastrichtian Stages is not uniformly agreed upon, and subdivisions in particular areas reflect local tradition. All that was agreed during the Brussels Symposium was a three-fold substage division of the Campanian, with substages ideally to be of equal duration (HANCOCK & GALE, 1996). In the Western Interior the Campanian is divided into the Lower, Middle, and Upper Substages (Fig. 6). In general, when compared to the European, two-fold subdivision into Lower and Upper, the Western Interior Lower Campanian corresponds to the European Lower Campanian, and the Middle and Upper Campanian is an equivalent of the Upper Campanian in European sense. More precisely, however, the top of the Western Interior Lower Campanian lies within the lowermost part of the European Upper Campanian (HANCOCK, 1991; WALASZCZYK, 1997). Herein, we will solely employ the subdivision erected for the Western Interior.

In the Western Interior the base of the Middle Campanian is placed at the base of the *Baculites obtusus* Zone, and the base of the Upper Campanian with the base of the *Didymoceras nebrascense* Zone.

The Maastrichtian Stage is divided into two substages, with the base of the Upper Maastrichtian placed at the base of the *Hoploscaphites birkelundi* Zone (see Fig. 6). The correlation with the European subdivision is still very weak and based so far only on the ammonite

*Jeletzkytes dorfi* LANDMAN & WAAGE, 1993, a species known in the Western Interior exclusively from the *Hoploscaphites birkelundi* Zone and found in the lower part of the *Belemnitella junior* Zone in Europe (JAGT & KENNEDY, 1994; see also KENNEDY *et al.*, 1999).

## THE INOCERAMID SUCCESSION IN THE CAMPANIAN AND LOWER MAASTRICHTIAN OF THE U.S. WESTERN INTERIOR

The inoceramids described herein span an interval from the topmost Santonian through Lower Maastrichtian, although the Santonian and Lower Campanian interval is represented herein by isolated specimens (Fig. 6). The Maastrichtian genus *Tenuipteria* is completely excluded (see SPEDEN, 1970a, b, for a more detailed treatment). *Cataceramus? simpsoni* (MEEK, 1860) is the only Upper Santonian species described herein. The species is widely distributed in the Upper Santonian of the Western Interior (see also SCOTT & COBBAN, 1964; WALASZCZYK & COBBAN, in prep.). It resembles the European *Cataceramus? flexibalticus* [=*Inoceramus* (*Endocostea*) *flexibalticus*] (SEITZ, 1967) described from the Upper Santonian and Lower Campanian of northern Germany (SEITZ, 1967).

There is insufficient material from the upper Upper Santonian and lower Lower Campanian (through the *Scaphites hippocrepis* II Zone) to allow a serious discussion of the inoceramid succession at that interval. According to KAUFFMAN *et al.* (1994) the interval is characterised by *Sphenoceramus* ssp., *Cataceramus* ex gr. *balticus*, *Cordiceramus* ssp., and *Platyceramus*. Worthy of note is that such an assemblage closely corresponds to the equivalent inoceramid assemblages found in the equivalent interval in Europe. Although forms such as *Platyceramus platinus* (LOGAN, 1898) and *Cordiceramus quadrans* (WHITFIELD, 1885) still require further study to determine their affinities to (or presence in) the European fauna, the rest of assemblage is represented by the same species in both Europe and the Western Interior: *Cataceramus balticus* (BÖHM, 1907), *Sphenoceramus patootensiformis* (SEITZ, 1965), *Sphenoceramus lundbreckensis* (McLEARN, 1929) [=*Sphenoceramus angustus* (BEYENBURG, 1936)], and *S. lingua* (GOLDFUSS, 1836) (see KAUFFMAN *et al.*, 1994).

The upper Lower Campanian zones of *Scaphites hippocrepis* III through *Baculites* sp. (weak flank ribs), are dominated by what is referred here to as *Cataceramus balticus* (BÖHM, 1907), accompanied by "*Inoceramus*" *conlini* sp. nov., *Cataceramus paraheberti* (SORNAY, 1968) and *Cataceramus beckumensis* (GIERS, 1964), known so far exclusively from the *Baculites* sp. (smooth) Zone. *Sphaeroceramus sarumensis* (WOODS, 1912) and *Sphaeroceramus pertenuis* (MEEK & HAYDEN, 1856) also probably come from the *S.? hippocrepis* Zone. These two latter species are rather poorly known in the Western Interior and, in the material studied, are represented only by MEEK's (1876a) originals of *Inoceramus pertenuis* (re-illustrated herein - Pl. VIII, figs 1-3, 5), from the mouth of the Judith River in central Montana. This assemblage is identical to that known from the upper Lower Campanian of Europe (see WALASZCZYK, 1997).

In the succeeding zone of *Baculites obtusus*, "*Inoceramus*" *azerbaydjanensis* ALIEV, 1939, and the apparently closely related "*Inoceramus*" *vorhelmensis* (WALASZCZYK, 1997) appear. Both forms range higher into the *Baculites maclearni* Zone. These radially sulcate species are well-known and widely distributed in Europe and western Asia. Although they were regarded as Lower Campanian key taxa for some decades (ALIEV, 1952, 1978, 1979; ALIEV *et al.*, 1982; PERGAMENT & SMIRNOV, 1972), the studies of KUZNETZOV (1968), COBBAN & KENNEDY (1993), and WALASZCZYK (1997) clearly showed that both characterise the lower part of the Middle Campanian (= the lower Upper Campanian in the European sense; see also discussion by C.J. WOOD *in* CHRISTENSEN *et al.*, 1975). Based on their radial sulcus and general appearance both species resemble members of the genus *Cordiceramus*. However, the record of the Lower/Upper Campanian boundary in Westphalia suggests that they may represent descendants of the Lower Campanian *Cataceramus beckumensis* lineage, suggesting the *Cordiceramus* resemblance to be homeomorphic in nature; consequently, the two taxa should be referred to distinct genera (WALASZCZYK, 1997).

The succeeding zones of *Baculites asperiformis*, *Baculites* sp. (smooth), *Baculites perplexus* and a large part of the *Baculites gregoryensis* Zone are characterised by a relatively uniform assemblage of *C. balticus*-type forms referred to *Cataceramus subcompressus* (MEEK & HAYDEN, 1856). This form is also common in Europe, where it has been referred to as *Inoceramus cymba* BÖHM, 1909 or as *Cataceramus haldemensis* (GIERS, 1964). The associated Western Interior species include: *Cordiceramus heberti* (FALLOT, 1885),

Fig. 5: Stratigraphic distribution of inoceramid faunas in the Campanian and Lower Maastrichtian of the Western Interior based on the material studied in this work.

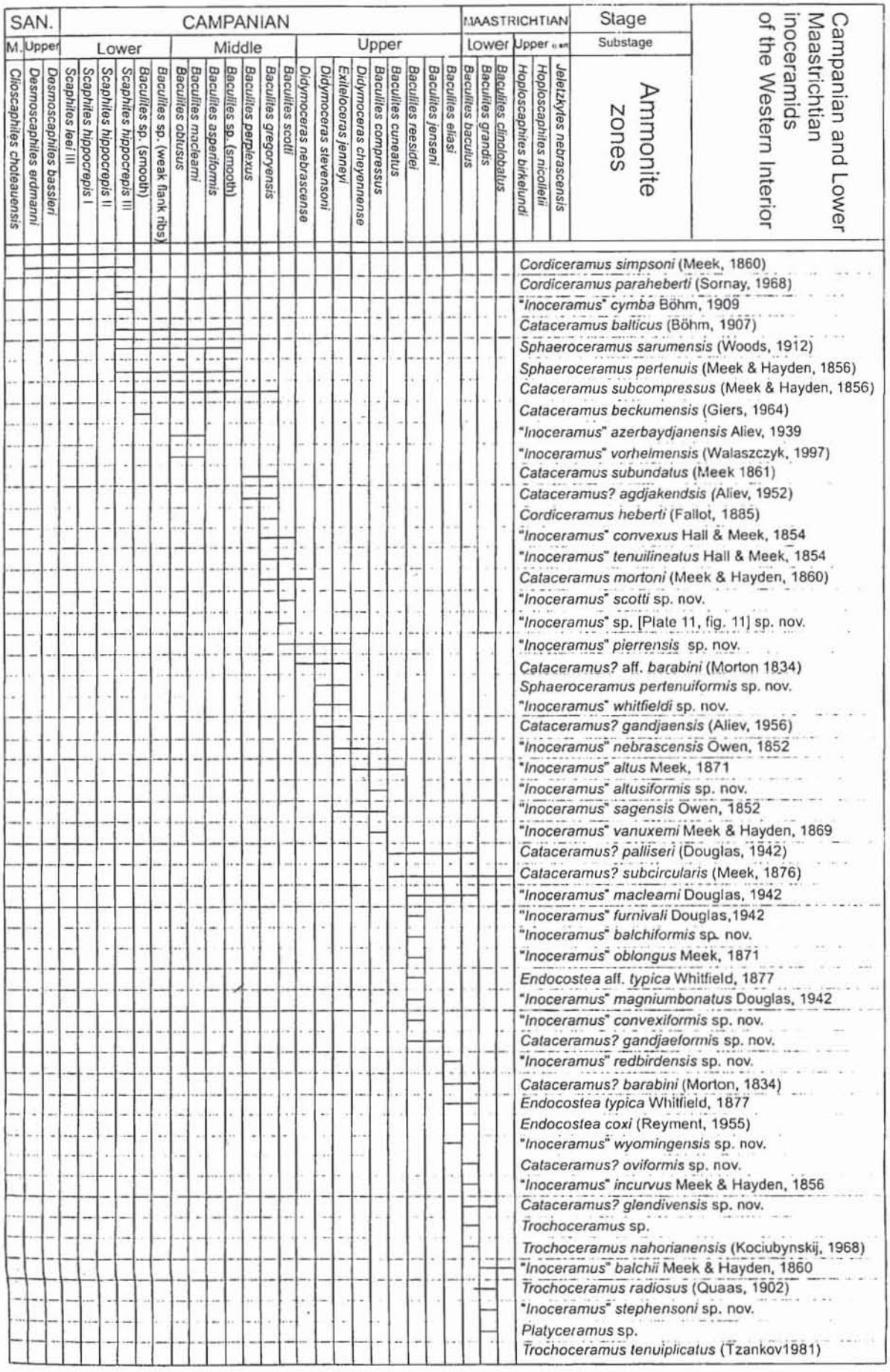

SAN.
CAMPANIAN
MAASTRICHTIAN
Stage
M.
Upper
Lower
Middle
Upper
Lower
Upper
Substage
Ammonite zones
Campanian and Lower Maastrichtian inoceramids of the Western Interior
Clioscaphites chateauensis
Desmoscaphites erdmanni
Desmoscaphites bassleri
Scaphites leei III
Scaphites hippocrepis I
Scaphites hippocrepis II
Scaphites hippocrepis III
Baculites sp. (smooth)
Baculites sp. (weak flank ribs)
Baculites obtusus
Baculites maclearni
Baculites asperiformis
Baculites sp. (smooth)
Baculites perplexus
Baculites gregoryensis
Baculites scotti
Didymoceras nebrascense
Didymoceras stevensoni
Exiteloceras jenneyi
Didymoceras cheyennense
Baculites compressus
Baculites cuneatus
Baculites reesidei
Baculites jenseni
Baculites elisi
Baculites baculus
Baculites grandis
Baculites clinolobatus
Hoploscaphites birkelundi
Hoploscaphites nicolletii
Jeletzkytes nebrascensis
Cordiceramus simpsoni (Meek, 1860)
Cordiceramus paraheberti (Sornay, 1968)
"Inoceramus" cymba Böhm, 1909
Cataceramus balticus (Böhm, 1907)
Sphaeroceramus sarumensis (Woods, 1912)
Sphaeroceramus pertenuis (Meek & Hayden, 1856)
Cataceramus subcompressus (Meek & Hayden, 1856)
Cataceramus beckumensis (Giers, 1964)
"Inoceramus" azerbaydjanensis Aliev, 1939
"Inoceramus" vorhelmensis (Walaszczyk, 1997)
Cataceramus subundatus (Meek 1861)
Cataceramus? agdjakendsis (Aliev, 1952)
Cordiceramus heberti (Fallot, 1885)
"Inoceramus" convexus Hall & Meek, 1854
"Inoceramus" tenuilineatus Hall & Meek, 1854
Cataceramus mortoni (Meek & Hayden, 1860)
"Inoceramus" scotti sp. nov.
"Inoceramus" sp. [Plate 11, fig. 11] sp. nov.
"Inoceramus" pierrensis sp. nov.
Cataceramus? aff. barabini (Morton 1834)
Sphaeroceramus pertenuiformis sp. nov.
"Inoceramus" whitfieldi sp. nov.
Cataceramus? gandjaensis (Aliev, 1956)
"Inoceramus" nebrascensis Owen, 1852
"Inoceramus" altus Meek, 1871
"Inoceramus" altusiformis sp. nov.
"Inoceramus" sagensis Owen, 1852
"Inoceramus" vanuxemi Meek & Hayden, 1869
Cataceramus? palliseri (Douglas, 1942)
Cataceramus? subcircularis (Meek, 1876)
"Inoceramus" maclearni Douglas, 1942
"Inoceramus" furnivali Douglas,1942
"Inoceramus" balchiformis sp. nov.
"Inoceramus" oblongus Meek, 1871
Endocostea aff. typica Whitfield, 1877
"Inoceramus" magniumbonatus Douglas, 1942
"Inoceramus" convexiformis sp. nov.
Cataceramus? gandjaeformis sp. nov.
"Inoceramus" redbirdensis sp. nov.
Cataceramus? barabini (Morton, 1834)
Endocostea typica Whitfield, 1877
Endocostea coxi (Reyment, 1955)
"Inoceramus" wyomingensis sp. nov.
Cataceramus? oviformis sp. nov.
"Inoceramus" incurvus Meek & Hayden, 1856
Cataceramus? glendivensis sp. nov.
Trochoceramus sp.
Trochoceramus nahorianensis (Kociubynskij, 1968)
"Inoceramus" balchii Meek & Hayden, 1860
Trochoceramus radiosus (Quaas, 1902)
"Inoceramus" stephensoni sp. nov.
Platyceramus sp.
Trochoceramus tenuiplicatus (Tzankov1981)

Fig. 6: Correlation of the inoceramid zonation, here proposed, with the standard ammonite zonation and its chronostratigraphic interpretation for the Western Interior (after GILL & COBBAN, 1973; COBBAN, 1994; KENNEDY *et al.*, 1999).

| Stage | Substage | Ammonite Zone | Inoceramid zones this paper |
|---|---|---|---|
| MAASTRICHTIAN | Upper (part) | *Jeletzkytes nebrascensis* | |
| | | *Hoploscaphites nicollettii* | |
| | | *Hoploscaphites birkelundi* | |
| | Lower | *Baculites clinolobatus* | *"Inoceramus" balchii* |
| | | *Baculites grandis* | *Trochoceramus radiosus* |
| | | *Baculites baculus* | *"Inoceramus" incurvus* / *Endocostea typica* |
| CAMPANIAN | Upper | *Baculites eliasi* | *"Inoceramus" redbirdensis* |
| | | *Baculites jenseni* | *"Inoceramus" oblongus* |
| | | *Baculites reesidei* | |
| | | *Baculites cuneatus* | *"Inoceramus" altus* |
| | | *Baculites compressus* | |
| | | *Didymoceras cheyennense* | |
| | | *Exiteloceras jenneyi* | *Sphaeroceramus pertenuiformis* |
| | | *Didymmoceras stevensoni* | |
| | | *Didymoceras nebrascense* | *"Inoceramus" tenuilineatus* |
| | Middle | *Baculites scotti* | |
| | | *Baculites gregoryensis* | |
| | | *Baculites perplexus* | *Cataceramus subcompressus* |
| | | *Baculites* sp. (smooth) | |
| | | *Baculites asperiformis* | |
| | | *Baculites maclearni* | *"Inoceramus" azerbaydjanensis - vorhelmensis* |
| | | *Baculites obtusus* | |
| | Lower | *Baculites* sp. (weak flank ribs) | *Cataceramus balticus* |
| | | *Baculites* sp. (smooth) | |
| | | *Scaphites hippocrepis* III | *Sphenoceramus lundbreckensis* |
| | | *Scaphites hippocrepis* II | |
| | | *Scaphites hippocrepis* I | |
| | | *Scaphites leei* III | |
| SAN. | Upper | *Desmoscaphites bassleri* | |
| | | *Desmoscaphites erdmanni* | *Cordiceramus muelleri* |
| | M. | *Clioscaphites choteauensis* | |

"*Inoceramus*" *agdjakendsis* (ALIEV), *Cataceramus balticus* (BÖHM, 1907), and *Cataceramus subundatus* (MEEK, 1876b).

The main turnover in the Campanian inoceramid assemblage occurs in the topmost part of the *Baculites gregoryensis* Zone, and in the succeeding *Baculites scotti* Zone. The *Cataceramus*-dominated assemblages of the Lower and of the majority of the Middle Campanian are replaced by a variable assemblage comprising "*Inoceramus*" *tenuilineatus* HALL & MEEK, 1856, "*I.*" *convexus* HALL & MEEK, 1856, "*I.*" *scotti* sp. nov., and "*I.*" *pierrensis* sp. nov. These taxa represent quite different morphotypes, but their generic affiliation remains to be determined. Cataceramids are represented by *C.?* aff. *barabini* (MORTON) and *C.? mortoni* (MEEK & HAYDEN). Still higher, in the *Didymoceras. stevensoni*

and in the succeeding *Exiteloceras jenneyi* Zones, very characteristic *Sphaeroceramus pertenuiformis* sp. nov., "*Inoceramus*" *whitfieldi* sp. nov., and *C.? gandjaensis* (ALIEV, 1956) appear. This fauna is very poorly known outside the Western Interior, more as a result of a lack of coeval material in the Gulf Coast Cretaceous or in Europe, than because of its endemic character. The succeeding assemblage, confined mainly to the *Baculites compressus* Zone is also poorly represented outside the Western Interior. It contains very characteristic species: "*Inoceramus*" *altus* MEEK, "*Inoceramus*" *altusiformis* sp. nov., "*I.*" *sagensis* OWEN, and "*I.*" *vanuxemi* MEEK & HAYDEN, easily identifiable and moreover, characterised by very narrow stratigraphic ranges.

This evolutionary turnover across the Middle/Late Campanian boundary suggests that all, or almost all, taxa occurring in the Upper Campanian and Lower Maastrichtian succession may possibly represent lineages distinct from those present in the Lower and most of the Middle Campanian as well as in the Santonian. The external similarity of numerous species appearing higher in the latest Campanian and Lower Maastrichtian succession, to those from the Lower-Middle Campanian may be due to homeomorphy and not to close evolutionary relationships. Detailed studies of this interval are required to further examine the evolutionary dynamics.

Taxonomically, the richest fauna in the Upper Campanian characterises the *Baculites reesidei* Zone, with a number of forms apparently limited to this interval. Besides such characteristic taxa as *I. balchiformis* sp. nov., *I. convexiformis* sp. nov., *C.? palliseri* (DOUGLAS) [= *C.? sornayi* (DHONDT)], or *C.? subcircularis* MEEK, 1876, it is the interval from which numerous species were originally described from Canada by DOUGLAS (1942); these are "*I.*" *palliseri* DOUGLAS, "*I.*" *maclearni* DOUGLAS, "*I.*" *furnivali* DOUGLAS, and *C.? magniumbonatus* (DOUGLAS). DOUGLAS' other forms, such as "*I.*" *mcshaniensis* DOUGLAS and "*I.*" *barabini* var. *inflatiformis* DOUGLAS are synonymous with "*I.*" *maclearni* DOUGLAS and *C.? barabini* (MORTON), respectively. The first small-sized individuals comparable to *Endocostea typica* WHITFIELD and referred here to as *E.* aff. *typica* WHITFIELD first appear in this interval.

The overlying *Baculites eliasi* Zone is characterised by *C.? barabini* (MORTON), "*Inoceramus*" *redbirdensis* sp. nov., and "*Inoceramus*" *wyomingensis* sp. nov. The latter taxon closely resembles *Inoceramus ghadamesensis* TRÖGER & RÖHLICH, 1981, described from the Lower Maastrichtian of Libya. Moreover, *C.? palliseri* (DOUGLAS, 1942) and *C.? subcircularis* (MEEK, 1876a) extend their ranges into this zone from the *B. reesidei* Zone.

*C.? barabini* and *E. typica* dominate the inoceramid record in the lower part of the succeeding *Baculites baculus* Zone. Based on the Red Bird section, the latter species first appears at this level. In the middle part of the zone "*Inoceramus*" *incurvus* MEEK & HAYDEN, 1856, a gregarious taxon with a characteristic juvenile stage appear. Its adult stage markedly resembles the species "*I.*" *maclearni* DOUGLAS, 1942, and the latter species may be a younger synonym. The inoceramid fauna found in the uppermost part of the *B. baculus* Zone closely resembles the assemblage known from the overlying *B. grandis* Zone.

In the Nacatoch Sand of the Gulf Coast, *C.? barabini* and *E. typica* are accompanied by a morphotype very similar to *E. typica*, but characterised by radial ornament, and referred here to *Endocostea coxi* (REYMENT, 1955), a very characteristic and widely distributed Lower Maastrichtian species (see REYMENT, 1955; WALASZCZYK *et al.*, 1996). It was not recognised in the Western Interior material.

In the Western Interior, the first trochoceramids are known from the uppermost part of the *B. baculus* Zone (informal transitional subzone of the *B. baculus* Zone) but the main interval of their occurrence is higher, in the *Baculites grandis* Zone. These are represented here by *Trochoceramus radiosus* (QUAAS, 1902) and *Trochoceramus tenuilineatus* (TZANKOV, 1981).

Representatives of the genus *Trochoceramus* are also known from the Gulf Coast Nacatoch Sand. Although we have no precisely located material from there, the species composition of the Nacatoch trochoceramids and the comparison with recently revealed inoceramid succession of the Tercis section (WALASZCZYK, DHONDT & ODIN, in prep.) indicate that Nacatoch trochoceramids are distinctly older that those described here from the Western Interior. The Nacatoch species, *Trochoceramus* sp. (=*Trochoceramus morgani* of WALASZCZYK *et al.*, 1996) and *T. nahorianensis* (KOCIUBYNSKIJ, 1968), appear in the Tercis section in an interval well below the first appearance of *Pachydiscus neubergicus*, which coincides with the first appearance of *Endocostea typica*, and thus their appearance would correspond to the basal *Baculites eliasi* or even *Baculites jenseni* Zones (see WALASZCZYK, COBBAN & ODIN, in prep.).

Until recently, the genus *Trochoceramus* was unidentified in the North American Cretaceous, including the Western Interior. However, at least two specimens of *Trochoceramus* were previously illustrated in the American literature; these are "*Inoceramus*" *vanuxemi* MEEK & HAYDEN from the Lower Maastrichtian of Texas illustrated by STEPHENSON (1941, pl. 13, fig. 3) (see also SORNAY, 1969 and DHONDT, 1993) and the other, referred to *Inoceramus proobliqua* by WHITFIELD (1885, pl. 14, fig. 17), from the Lower Maastrichtian of New Jersey. The latter is most probably a senior synonym of forms referred to *Trochoceramus nahorianensis* (KOCIUBYNSKIJ, 1968) (=*Inoceramus crippsi in* ZITTEL, 1866, pl. 13, fig. 7). However, trochoceramids are widely distributed in North America including vast areas of the Western Interior Seaway. The

group has high correlation potential (WALASZCZYK, COBBAN & ODIN, in prep.).

The youngest inoceramids (excluding representatives of the genus *Tenuipteria*) in the Western Interior succession are known from the *Baculites clinolobatus* Zone or potentially from the overlying *Hoploscaphites birkelundi* Zone (see KAUFFMAN *et al.*, 1993). With only a few specimens from the *B. clinolobatus* Zone at our disposal, the group in that interval may actually be more diverse than it is assumed here. In addition to *C.? subcircularis* (MEEK, 1876a), the forms recognised in this zone are "*Inoceramus*" *balchii* MEEK & HAYDEN, 1860 and huge, indeterminate specimens referred here to *Inoceramus* sp.

## INOCERAMID ZONATION

Herein we also present a preliminary inoceramid zonation for the Campanian and Lower Maastrichtian of the US Western Interior. Its further refinement requires more, precisely located collections. With a few exceptions, all zones proposed below are defined as interval zones. The correlation of the inoceramid scheme with the ammonite standard division for the Western Interior shows almost perfect coincidence of zonal boundaries between the two schemes (Fig. 6), because the inoceramid collections were most often referred simply to particular ammonite zones. The actual position of the boundaries may differ in detail.

The portion of the zonation proposed for the Lower and most of the Middle Campanian corresponds very closely to the European zonation as recently proposed by WALASZCZYK (1997). No zonation exists in Europe for the Upper Campanian and Lower Maastrichtian, and the proposed zonation for the Western Interior should be tested in Europe. The European inoceramid record from this interval, and particularly in the Upper Campanian, is very poorly known. However, because most of the Upper Campanian and the Lower Maastrichtian American species are also known from Europe this clearly suggests, that at least for most of the Late Campanian and the Early Maastrichtian, the entire Euramerican Region (*sensu* KAUFFMAN, 1973) was represented by the virtually identical inoceramid faunas.

### Cordiceramus ex gr. muelleri Zone

**Definition:** An interval zone, the base defined by the first appearance of the index taxon, the top by the first appearance of *Sphenoceramus lundbreckensis* (McLEARN, 1929).

**Remarks:** The base of the zone should probably be regarded as coeval with the base of the Upper Santonian, as currently defined, i.e. with the first occurrence (FO) of the crinoid genus *Uintacrinus* (see also KAUFFMAN *et al.*, 1994). In Europe, it is the inoceramid zone represented by *Cordiceramus muelleri* group.

### Sphenoceramus lundbreckensis Zone

**Definition:** The taxon-range zone of *Sphenoceramus lundbreckensis* (McLEARN, 1929).

**Remarks:** This zone corresponds to the *Sphenoceramus patootensiformis* Zone as commonly distinguished in Europe. *Sphenoceramus angustus* (BEYENBURG, 1936), which characterises the zone in Europe, is a junior synonym of *S. lundbreckensis* (McLEARN, 1929). It spans the upper Upper Santonian to lower Lower Campanian. No taxa from this interval were examined during the present study.

### Cataceramus balticus Zone

**Definition:** A partial-range zone, the base marked by the disappearance level of *Sphenoceramus lundbreckensis* (McLEARN, 1929), the top by the first appearance of "*Inoceramus*" *vorhelmensis* (WALASZCZYK, 1997) and/or "*Inoceramus*" *azerbaydjanensis* ALIEV, 1939.

**Remarks:** The zone is relatively well represented in the material studied. In addition to the index taxon, it is characterised by *Sphaeroceramus sarumensis* (WOODS, 1912), *Sphaeroceramus pertenuis* (MEEK & HAYDEN, 1856), *Cataceramus beckumensis* (GIERS, 1964), and *Cordiceramus paraheberti* (SORNAY). "*Inoceramus*" *conlini* sp. nov. also occurs in the zone. The zone corresponds to *Sphaeroceramus sarumensis – Cataceramus dariensis* Zone and to *Cataceramus beckumensis* Zone, as distinguished in the upper Lower and basal Upper Campanian of northern Germany (WALASZCZYK, 1997). In our opinion, *Cataceramus balticus* (BÖHM, 1907) is probably a better inoceramid marker of the interval, which is apparently well represented in the whole Euramerican Region. All species recognised here are also known from Europe.

### "Inoceramus" azerbaydjanensis-vorhelmensis Zone

**Definition:** The range zone of radially-sulcate inoceramids referred to "*I.*" *azerbaydjanensis* ALIEV, 1939 and to "*I.*" *vorhelmensis* (WALASZCZYK, 1997).

**Remarks:** Both index taxa of the zone are among the most characteristic Middle Campanian inoceramid species. Although WALASZCZYK (1997) interpreted these two species as probably representing two successive chronospecies (subspecies), the American material suggests rather that they are isochronous forms with different geographical preferences (possibly geographical subspecies); "*I.*" *azerbaydjanensis* favours "southern" regions, whereas "*I.*" *vorhelmensis* occurs in more northerly localities. The available material is still not extensive enough to allow a final statement of the matter. Nevertheless, all reports of ALIEV's species in Europe come from southern areas, whereas "*I.*" *vorhelmensis* is well represented in Northern Germany (see WALASZCZYK, 1997).

**Cataceramus subcompressus Zone**
**Definition:** A partial-range zone, the base marked by the disappearance of radially sulcate inoceramids, the top defined by the FO of *I. tenuilineatus*.
**Remarks:** The zone corresponds to the European zone of *Cataceramus haldemensis*, and is dominated by cataceramids.

**"Inoceramus" tenuilineatus Zone**
**Definition:** An interval zone, the base marked by the first appearance of the index taxon, the top by the first appearance of *"I." pertenuiformis* sp. nov., the index taxon of the succeeding Zone.
**Remarks:** This zone marks the main turnover level within the Campanian inoceramid faunas of the Western Interior: the change from the Lower-Middle Campanian *Cataceramus*-dominated interval to the Upper Campanian interval, with a very different inoceramid fauna. Most of the latter are referred to the genus *"Inoceramus" sensu lato* because their evolutionary relationships are unknown, but they surely represent a range of different lineages.

**Sphaeroceramus pertenuiformis Zone**
**Definition:** An interval zone, the base of which is defined by the first appearance of the index taxon, the top by the first appearance of *"I." altus*, the index taxon of the succeeding zone.
**Remarks:** As in the *"Inoceramus" tenuilineatus* Zone, the *Sphaeroceramus pertenuiformis* Zone is characterised by a number of forms of unknown generic affiliation, clearly distinct from the Lower-Middle Campanian inoceramid fauna. Besides the index taxon, the most characteristic species are: *"I." whitfieldi* sp. nov., *C.? gandjaensis* (ALIEV), *"I." nebrascensis* OWEN, 1852, and *"I." pierrensis* sp. nov. The whole assemblage is very poorly known in Europe, primarily because no inoceramid fauna from that interval, approximately middle *Didymoceras donezianum* Zone (of BLASZKIEWICZ, 1980) has been treated in sufficient detail.

**"Inoceramus" altus Zone**
**Definition:** The range zone of *"I." altus*.
**Remarks:** This Upper Campanian interval has a very characteristic inoceramid fauna; besides *"I." altus*, which itself is one of the most typical and easily recognisable species, the most typical forms of the zone are: *"I." altusiformis* sp. nov., *"I." sagensis* OWEN, 1852, and *"I." vanuxemi* MEEK & HAYDEN, 1856.

**"Inoceramus" oblongus Zone**
**Definition:** An interval zone, the base marked by the first appearance of the index taxon, the top by to the first appearance of *E. typica* WHITFIELD, 1877.
**Remarks:** This zone embraces one of the intervals with the most diverse inoceramid fauna within the Late Campanian and, actually, in the whole of the Campanian (see Fig. 6; see also KAUFFMAN *et al.*, 1993). The fauna described by DOUGLAS (1942) from the Campanian of Bearpaw Formation in Canada also comes from this interval. Most of the forms described here also occur in Europe in the *Nostoceras hyatti* Zone of the topmost Campanian of Piotrawin in the Middle Vistula section, central Poland (WALASZCZYK, in prep.).

**"Inoceramus" redbirdensis Zone**
**Definition:** An interval zone, the base marked by the first appearance of the index taxon, the top by the first appearance of *Endocostea typica* WHITFIELD.
**Remarks:** The zone is characterised by the occurrence of the index taxon and the other species, *"Inoceramus" wyomingensis* sp. nov., and accompanying *Cataceramus? subcircularis* (MEEK, 1876a) and *Cataceramus? barabini* (MORTON, 1834). This very characteristic assemblage was recently recognised in the Tercis section, in SW France (WALASZCZYK, DHONDT & ODIN, in prep.), where it directly underlies the level with first *Endocostea typica*, co-appearing with first *Pachydiscus neubergicus*, marking thus the youngest Campanian fauna. Thus we place this zone, and consequently the ammonite zone *Baculites eliasi* still in the Upper Campanian (Fig. 6).

**Endocostea typica Zone**
**Definition:** An interval zone, the base marked by the first appearance of the index taxon, the top by the first appearance of *"Inoceramus" incurvus* MEEK & HAYDEN, 1856.
**Remarks:** The zone corresponds to the lower part of the *Baculites baculus* ammonite Zone. The range as adopted here is taken from its occurrence in the Red Bird section. In this section, *E. typica* occurs abundantly at the base of the *B. baculus* Zone, although the section below this horizon is poorly known (Fig. 3). However, recent studies of the inoceramid succession across the Campanian – Maastrichtian boundary in the Tercis section, SW France (WALASZCZYK, DHONDT & ODIN, in prep.), as well as its manner of appearance in the Aimaki section, in Daghestan (WALASZCZYK *et al.*, 1996) suggest that the pattern seen at Red Bird faithfully records its appearance (WALASZCZYK, COBBAN & ODIN, in prep.). As demonstrated by the Tercis record, the first appearance of *Endocostea typica*, and consequently the base of the *E. typica* Zone, as here defined, is a good marker for the base of the Maastrichtian Stage as currently defined (WALASZCZYK, COBBAN & ODIN, in prep.).

**Inoceramus incurvus Zone**
**Definition:** An interval zone, the base defined by the first appearance of the index taxon, the top defined by the first appearance of *Trochoceramus radiosus* QUAAS, 1902.
**Remarks:** In both sections studied in detail herein, i.e.,

Red Bird and Glendive, the middle part of the *Baculites baculus* ammonite Zone is dominated by "*I.*" *incurvus* MEEK & HAYDEN. The species is accompanied by *C.? barabini* (MORTON, 1834), *C.? oviformis* sp. nov., and, in its upper part, by "*I.*" *glendivensis* sp. nov. Some other morphotypes, represented by rare specimens are not described here.

**Trochoceramus radiosus Zone**

**Definition:** The range zone of *Trochoceramus radiosus* (QUAAS, 1902).

**Remarks:** Trochoceramids characterize a very distinct interval in the Lower Maastrichtian of the Western Interior, with the *Trochoceramus radiosus* apparently dominant. In terms of the ammonite biostratigraphy, the first representatives of *Trochoceramus* appear in the topmost part of the *Baculites baculus* Zone, but they are common only in the *Baculites grandis* Zone.

Trochoceramids found in the Western Interior are distinctly younger than trochoceramids described here from the Nacatoch Sand from the Gulf Coast. Although the Gulf Coast material is not represented by precisely collected specimens their species composition, and partly other inoceramids from that material indicate that the Gulf Coast trochoceramids correspond to the oldest *Trochoceramus* fauna, appearing already in the topmost Campanian, as indicates the recently elaborated material from Tercis section, SW France (WALASZCZYK, DHONDT & ODIN, in prep.). These lowest trochoceramids are not represented in the material studied, coming from the Western Interior. According to the correlation with the Tercis section, they should be found in the basal *Baculites eliasi* Zone or in the *Baculites jenseni* Zone.

**"Inoceramus" balchii Zone**

**Definition:** An interval zone, the base marked by the last occurrence of representative of the genus *Trochoceramus*, the top is defined by the extinction of inoceramids, excluding the genus *Tenuipteria*.

**Remarks:** It is the uppermost zone based on true inoceramids, and the problem of constraining its upper boundary directly reflects the uncertainties associated with the timing of the inoceramid extinction. In the material at hand, the stratigraphically highest inoceramids are from the *Baculites clinolobatus* Zone, although KAUFFMAN *et al.* (1994) report a single species, referred by those authors to *Inoceramus* n. sp. cf. *I. pertenuis*, from a level one ammonite zone higher, i.e., from the *Hoploscaphites birkelundi* Zone.

REPOSITORIES

USNM: United States National Museum, Washington, USA.

AMNH: American Museum Natural History, New York, USA.

ANSP: Academy of Natural Sciences of Philadelphia, USA.

YPM: Peabody Museum, Yale University, New Haven, USA.

GSC: Geological Survey of Canada, Ottawa, Canada.

UWWG: Institute of Geology of the University of Warsaw, Poland.

MNHP: Muséum National d'Histoire Naturelle, Paris, France.

BMNH: The Natural History Museum, London, England.

## SYSTEMATIC PALEONTOLOGY

### General Remarks

The recognition of the Campanian and Maastrichtian inoceramids of the Euramerican Palaeobiogeographic Region is still far from complete. Although the number of species and/or subspecies level taxa described from that interval from North America and Europe is relatively high (from Europe alone approximately 150 species/subspecies taxa have been described), knowledge of the evolutionary relationships between them is minimal to non-existent. Consequently, the systematic interpretation offered here only partly delves into generic-level relationships, with numerous species referred to the genus "*Inoceramus*" *sensu lato*, a neutral term comprising all species with unknown generic affiliation, as opposed to the genus *Inoceramus sensu stricto* of SOWERBY, 1814. Previous generic interpretations of numerous species from the Upper Campanian or Lower Maastrichtian, based exclusively on external resemblance may be quite misleading. At the Middle/Late Campanian boundary, inoceramids underwent a massive turnover and, although the details are unknown, it is very probable that all or at least numerous species occurring after that boundary represent completely new lineages.

The descriptive terms and measurements used are shown in Fig. 7.

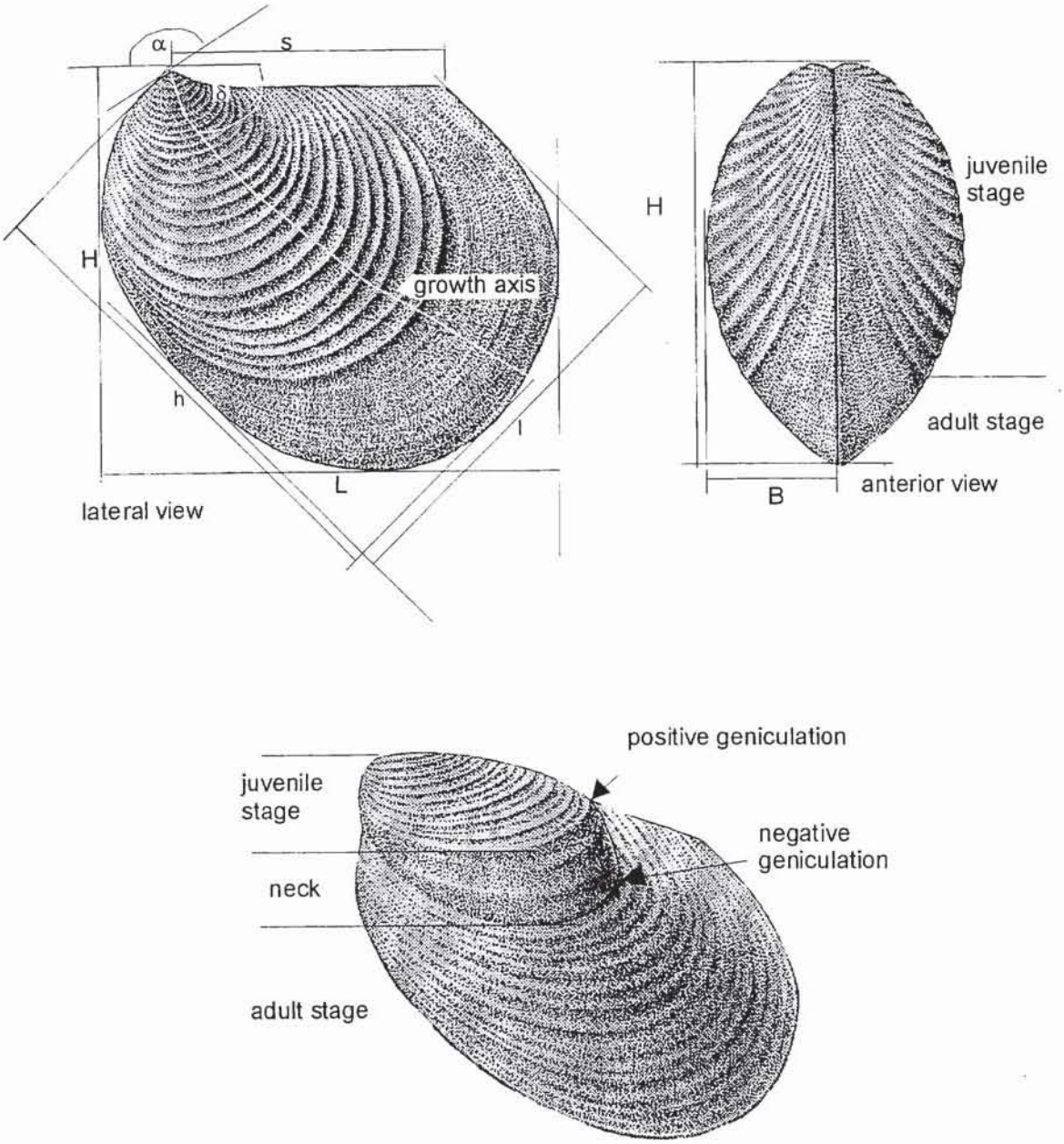
### Systematics

#### Genus *Cordiceramus* HEINZ, 1932

(Synonyms: *Germanoceramus* HEINZ, 1932; *Dimeroceramus* HEINZ, 1932; *Cyrtoceramus* HEINZ, 1932)

**Type species:** *Inoceramus cordiformis* SOWERBY (1823, p. 61, pl. 440), from Gravesend, England, most probably Santonian.

Fig. 7a, b: Terminology and measurements of the external morphologic features of inoceramid shell as applied in this paper (modified after WALASZCZYK, 1997).




**Description and remarks:** *Cordiceramus* is represented by equi- to subequivalve forms, pentagonal in outline, with variable inflation. Along the growth axis or lying just anterior to it, there is a prominent to faint radial sulcus. All other characters may vary markedly. Some specimens contain distinct radial ornament. Posterior auricles vary from indistinct to markedly posteriorly elongated.

COX (1969, p. N317) regarded *Cordiceramus* as a synonym of the genus *Haenleinia* BÖHM, 1909. As previously discussed by SEITZ (1967), the only distinguishing feature of BÖHM's genus is, however, a flexurate commissure, which occurs sporadically among many inoceramid genera, and should not be regarded as an important taxonomic feature. *H. flexuosa* (v. HAENLEIN) should be referred to genus *Cataceramus* HEINZ (= SEITZ, 1967 *Endocostea* WHITFIELD).

The weakly inflated, *balticus*-like forms with pentagonal outline were referred by TSAGARELI & GAMBASHIDZE (1984) to a new genus *Sornayceramus* [subgenotype *Inoceramus* (*Haenleinia*) *pseudoregularis*

SORNAY, 1962, pl. 7, fig. 1]. Where it would appear that pentagonal outline is a polyphyletic character, the *Cordiceramus muelleri* should be referred to this genus.

### *Cordiceramus* ex gr. *muelleri* (PETRASCHECK, 1906)
### Pl. I, fig. 2

1964. *Inoceramus simpsoni* MEEK var. - SCOTT & COBBAN, p. L20, pl. 10, fig. 1 [?pl. 11, fig. 5].
1977. "*Inoceramus*" (*Endocostea*) *balticus* BÖHM. - KAUFFMAN, pl. 28, fig. 2.
1986. *Inoceramus* (*Cordiceramus*) *muelleri* PETRASCHECK. - SCOTT *et al.*, fig. 13a, fig. 15c.
1986. *Inoceramus* (*Endocostea*) *balticus* BÖHM. - SCOTT *et al.*, fig. 12h.

**Material**: USNM 507486 from USGS Mesozoic locality D 10840, USNM 131523 and USNM 131524 (illustrated by SCOTT & COBBAN, 1964, pl. 10, fig. 1 and pl. 11, fig. 5 respectively), from USGS Mesozoic locality D3505; some unregistered specimens from Waxahachie Dam, Spillway section, Texas.

**Description**: Medium- to large-sized, prosocline, strongly posteriorly elongated. Valves moderately inflated with subpentagonal outline and with wide, shallow radial sulcus. Beak small, projecting slightly above hinge line. Anterior margin moderately long, weakly anteriorly convex, passing into long, broadly convex ventral margin and thence into rounded posterior margin. Hinge line very long, straight. Posterior auricle subtriangular in outline, separated from disc by an auricular sulcus.
Shell ornamented with subregularly spaced, narrow rugae with wide, flat-floored interspaces. Rugae quite regular in juvenile part. In middle anterior part of disc rugae are obliquely crossed by growth-lines. Adult stage with irregular, low, widely spaced rugae.
**Discussion**: Within PETRASCHECK's *Inoceramus* (*Cordiceramus*) *muelleri*, SEITZ (1961) distinguished four subspecies: *I.* (*C.*) *muelleri muelleri* PETRASCHECK, *I.* (*C.*) *muelleri germanicus* HEINZ, *I.* (*C.*) *muelleri gosauensis* SEITZ, 1961, and *I.* (*C.*) *muelleri recklingensis* SEITZ, 1961. The detailed relationships between these taxa are unknown, but taking into account their spatial and temporal co-occurrence, they will be considered here as separate species.
The illustrated specimens, as well as the material from Waxahachie Dam, Spillway section in Texas, closely resembles *Cordiceramus germanicus* (HEINZ, 1928, p. 82; 1933, p. 250; pl. 21, fig. 2; see also SEITZ, 1961, p. 131; pl. 7, fig. 6; pl. 8, figs 1, 6-7; pl. 15, fig. 1) which, besides a uniformly ovate juvenile growth stage, displays a fairly irregular adult stage with a well-developed radial sulcus. The specimen illustrated by SCOTT *et al.* (1986, fig. 15c) also belongs in *C. germanicus*. The other specimen illustrated by SCOTT *et al.* (1986, fig. 12h) and referred by these authors to *Inoceramus* (*Endocostea*) *balticus*, represents *Cordiceramus recklingensis* (SEITZ, 1961).
**Occurrence**: Upper Santonian and lower Lower Campanian of the Western Interior and of the Gulf Coast, exactly corresponding to their occurrence in Europe.

### *Cordiceramus paraheberti* (SORNAY, 1968)
### Pl. II, figs 5-6; Pl. IV, fig. 1

1968. *Inoceramus* (*Cordiceramus*) *paraheberti* SORNAY, p. 38, pl. G, pl. H, figs 1-2.
1978. *Inoceramus* (*Cordiceramus*) *paraheberti* SORNAY. - NODA & KANIE, p. 24, pl. 2, fig. 1.
1997. *Cataceramus marcki* (GIERS). - WALASZCZYK, p. 23 (*pars*), pl. 5, fig. 2; pl. 6, figs 3-4, 6; pl. 7, figs 1, 3, 5; pl. 8; pl. 11, fig. 2.

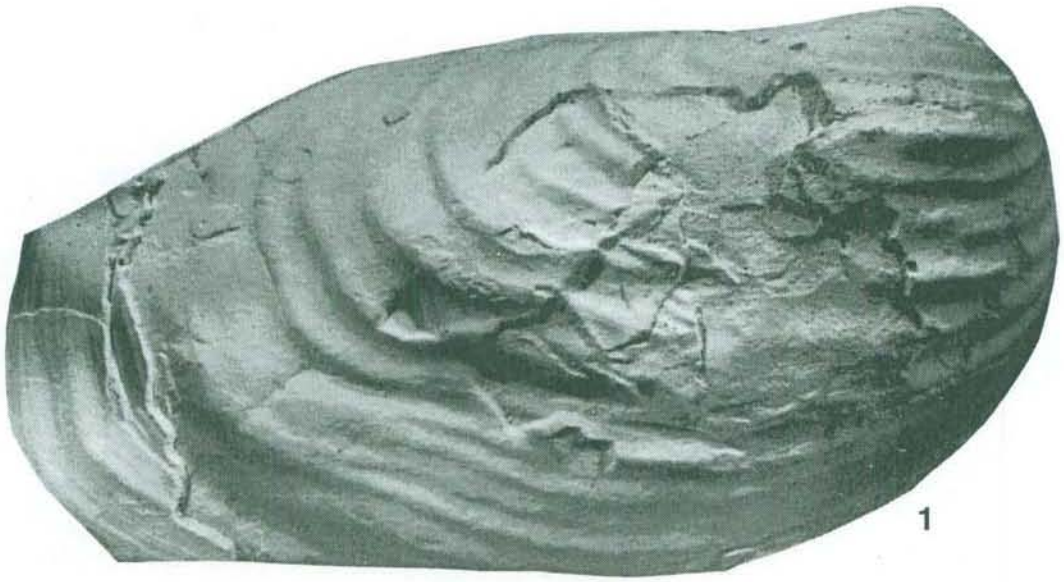
**Type**: The holotype, by original designation, is INHP 722 BA, figured by SORNAY (1968, pl. G, figs 1-2), from the Lower Campanian of Ampamba-Antsirasira, Madagascar.
**Material**: USNM 507477 from USGS Mesozoic locality 21546; USNM 507478, USNM 507479, USNM 507480, USNM 507481, from USGS Mesozoic locality D8852; USNM 507484 and USNM 507485 from USGS Mesozoic locality D2413.

*Dimensions*

| Specimen | h | l | H | L | s | α | δ | hmax |
|---|---|---|---|---|---|---|---|---|
| USNM 507477 | 75.5 | 77.0 | 70.0 | 79.5 | — | 140 | 56 | 105 |
| USNM 507478 | 75.0 | 86.0 | 71.0 | 89.0 | 49.0 | 143 | 58 | 110 (LV) |
| USNM 507479 | 68.0 | 65.0 | 58.0 | 73.0 | — | 140 | 45 | 115 (LV) |
| USNM 507481 | 69.5 | — | 63.5 | — | 41.0 | — | 55 | 76 (LV) |
| USNM 507484 | 73.5 | 74.0 | 64.5 | 80.5 | 49.5 | 135 | 48 | 98 (RV) |
| USNM 507485 | 79.8 | 79.0 | 70.0 | 85.0 | 48.0* | — | — | 116 (RV) |

Plate I

Fig. 1: *Cataceramus? simpsoni* (MEEK, 1860) USNM 12320, the holotype, original of MEEK (1877, pl. 13, fig. 2); North Platte River, Wyoming; x 0.7.
Fig. 2: *Cordiceramus?* ex gr. *muelleri* (PETRASCHECK, 1906); USNM 507486 from USGS Mesozoic locality D 10840; Santonian; x 0.8.



1

2

**Description**: Medium- to large-sized, inequilateral, equivalved, prosocline species. Valves weakly inflated, subquadrate in outline; anterior margin relatively long, passing into long, broadly convex ventral margin, and thence into rounded posterior margin. Hinge line long, straight. Beak projecting slightly above hinge line. Posterior auricle small not separated from disc.

Shell ornamented with widely spaced, sharp-edged rugae, narrow, with broad, flat-floored interspaces. Distinct growth lines, especially in interspaces. Rugae subpentagonal in outline, flattened or even slightly sulcate axially. In adult stage anteriorly of growth axis rugae obliquely crosscut growth lines.

**Remarks**: The American specimens very closely resemble the European material from the Campanian of Westphalia, Germany, referred incorrectly to *Cataceramus marcki* (GIERS) by WALASZCZYK (1997, pl. 5, fig. 2; pl. 6, figs 3-4, 6; pl. 7, figs 1, 3, 5; pl. 8; pl. 11, fig. 2). *C. paraheberti* differs from *C. marcki* (GIERS, 1964) in being less inflated and in having reduced posterior shell elongation. Moreover, GIERS' species is characterised by markedly stronger umbonal projection above the hinge line, and finally less-regular ornament.

The pentagonal shell outline in *Cordiceramus paraheberti*, diagnostic for the genus *Cordiceramus*, varies to some extent but in general is rather weakly developed.

**Occurrence**: In the Western Interior, *Cordiceramus heberti* (SORNAY, 1968) is known from the *Scaphites hippocrepis* III Zone; it is known from the Lower – Middle Campanian (although precise stratigraphic data are lacking) of Madagascar and from the Lower and lowermost Middle Campanian of Germany in Europe.

### *Cordiceramus heberti* (FALLOT, 1885)
### Pl. VII, figs 4, 8, 11

1885. *Inoceramus heberti* FALLOT, p. 249, pl. 7, fig. 1.

1968. *Inoceramus heberti* FALLOT - SORNAY, p. 41, pl. H, fig. 3.

?non 1978. *Inoceramus* (*Cordiceramus*) sp. cf. *heberti* FALLOT. - NODA & KANIE, p. 23, pl. 1, fig. 4; pl. 7, fig. 4.

non 1991. *Inoceramus* sp. aff. *heberti* FALLOT. - TRÖGER & RÖHLICH, p. 1371, pl. 3, fig. 6; fig. 11.

1997. *Inoceramus heberti* FALLOT. - WALASZCZYK, pl. 31, fig. 1.

non 1999. *Cordiceramus* ? aff. *heberti* (FALLOT). - TRÖGER, SUMMESBERGER & SKOUMAL, p. 49, pl. 1, fig. 2; text-figs 15-16.

**Type**: The holotype is the original of FALLOT (1885, pl. 7, fig. 1) housed in the E. FALLOT collection of the Institute de Paléontologie, Muséum national d'Histoire naturelle de Paris. According to SORNAY (1968, p. 41) the type comes from La Madeleine, 1500 m NE of the village Veynes in Hautes Alpes, SE France, from grey, hard Campanian limestones with *Ostrea vesicularis*, *Pinna* sp., *Terebratula* sp., *Rhynchonella* sp., and ?*Hoplitoplacenticeras* sp. The presence of *Hoplitoplacenticeras*, if the determination is correct, suggests a Middle Campanian age for this interval (see KENNEDY, 1986; WRIGHT, *et al.*, 1996).

**Material**: USNM 507526 from USGS Mesozoic locality D1908; USNM 507527 from USGS Mesozoic locality D1912, and USNM 507742 from USGS Mesozoic locality D1908; all from the *B. gregoryensis* Zone.

**Description**: Medium-sized, equivalved, moderately inequilateral, prosocline species. Outline subrounded to subquadrate. Beak small, pointed dorso-anteriorly with umbonal region indistinct, weakly inflated. Anterior margin relatively short, convex, passing into broadly convex, long antero-ventral and ventral margins. Posterior margin short, straight. Hinge line straight, short. Posterior auricle small, not separated from disc. Growth axis anteriorly convex.

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Plate II

Fig. 1-2, 4, 7: *Cataceramus balticus* (BÖHM,1907); 1 – USNM 507496, J.P. CONLIN's collection, 2 – USNM 507493, from USGS Mesozoic locality D 6896, 4 – USNM 507495, from USGS Mesozoic locality D 6896, 7 – USNM 507488, J.P. CONLIN collection; all from *Haresiceras placentiforme* Zone (=*Scaphites hippocrepis* II Zone); Lower Campanian; x 0.9.

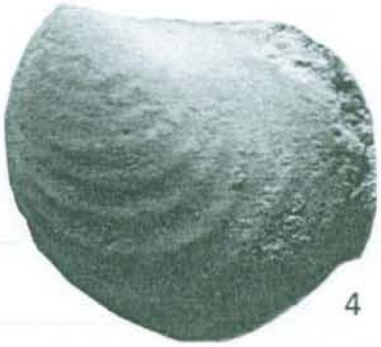
Fig. 3: *Cataceramus beckumensis* (GIERS, 1964); USNM 507482, from USGS Mesozoic locality D 2139, *Baculites* sp. (smooth) Zone, Lower Campanian; x 0.9.

Fig. 5-6: *Cordiceramus paraheberti* (SORNAY, 1968); 5 – USNM 507485, USGS D 2413, *Scaphites hippocrepis* Zone, 6 – USNM 507477, USGS 21546, *placentiforme* Zone (=*S. hippocrepis* II Zone); Lower Campanian; x 1.

1

2

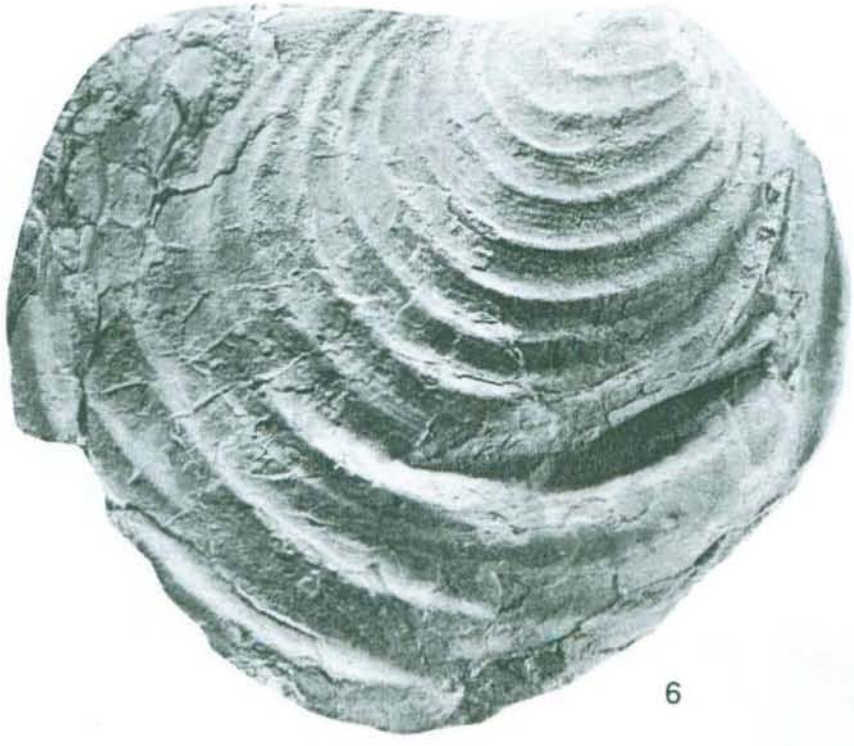
3



4

5a

5b



6

7

Shell ornamented with relatively widely spaced, sharp-edged concentric rugae, and distinct growth lines. Rugae narrow in cross-section in relation to interspaces, subsymmetrical. Interspaces flat-floored. In adult stage, anteriorly of growth axis, rugae display a narrow flexure zone, where they cross growth lines obliquely.

**Remarks**: Taking into account the type of ornament, we follow the generic interpretation of *I. heberti* after SORNAY (1968), who placed the species in the genus *Cordiceramus*. However, the subpentagonal outline, one of the diagnostic features of the genus, is poorly developed in the specimens studied. The cordiceramid outline is slightly better developed in later ontogenetic stages. This character is poorly developed also in FALLOT's original.

*Cordiceramus paraheberti* (SORNAY 1968, p. 38, pl. G; pl. H, figs 1-2) differs in more posterior valve elongation and more regular ornament (see also SORNAY, 1968, pp. 41-42 for full discussion).

*Inoceramus* (*Platyceramus*) sp. aff. *heberti* FALLOT described by TRÖGER & RÖHLICH (1991, p. 1371) from Libya differs from FALLOT's species in finer and more regular rugae, distinctly lower obliquity (higher δ angle which is between 60 and 70° in Libyan forms and about 50° in *C. heberti*), and straight growth axis, as opposed to convex in FALLOT's species. It is also the case with *Inoceramus* (*Cordiceramus*) sp. cf. *heberti* FALLOT, described from Madagascar by NODA & KANIE (1978, pl. 1, fig. 4), and *Cordiceramus*? aff. *heberti* (FALLOT), illustrated by TRÖGER *et al.* (1999, p. 49, pl. 1, fig. 2) from the Campanian of Austria. Their outline and fine ornament resemble "*Inoceramus*" *vanuxemi* MEEK & HAYDEN, 1860.

**Occurrence**: In the Western Interior known from the *Baculites gregoryensis* 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* BÖHM (1909, pl. 11, fig. 2) from Dülmen, Lower Campanian of Northern Germany.

**Remarks**: HEINZ (1932, p. 15) erected the subgenus *Cataceramus* with clear designation of *Inoceramus balticus* BÖHM, 1907, as its subgenotype. Thus the concept of the taxon is clear, and it encompasses what is commonly referred to as the *balticus* group. Consequently, as emphasised by DHONDT (1993), *Cataceramus* HEINZ, 1932, is not a *nomen nudum*, and there is no need to replace it by *Cataceramus* COX, 1969. [From the standpoint of the ICZN, however, the problem is not so clear, and, as remarked by DHONDT (1993), it probably should be submitted to the Commission.] The other problem is the synonymy of *Cataceramus* with *Endocostea* WHITFIELD. According to SEITZ's (1967, pp. 48-49) interpretation, the taxa are synonyms (of either generic or subgeneric rank). SEITZ thought that there was no taxonomic value of the inner rib attributing it to parasitic activity, taken by WHITFIELD (1877, 1880) as the diagnostic feature of his new genus. Through his reinterpretation of the types of *E. typica*, the type species of genus *Endocostea*, SEITZ (1967) came to the conclusion that WHITFIELD's originals (with some exceptions) belong to the *balticus* group, and consequently, *Cataceramus* should be regarded as a younger synonym of *Endocostea*. Although representatives of *E. typica* are morphologically quite similar to cataceramids (particularly when small specimens are considered), this species together with other very similar and apparently closely related species, such as *E. impressa* (D'ORBIGNY) and *E. coxi* (REYMENT), appear to represent a separate group. All these forms are close one to another in time, and moreover they differ morphologically from typical *Cataceramus* by possessing a more or less well-developed radial sulcus and usually more prominent umbone projecting distinctly above the hinge line. Contrary to SEITZ' view, WHITFIELD's originals of *Endocostea typica* are incomplete, small specimens. Larger specimens do not occur. *Endocostea typica* is a small species, most probably representing the oldest member of an evolutionary lineage. Although a definitive evaluation still

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Plate III

Fig. 1-2: "*Inoceramus*" *conlini* sp. nov.; 1 - USNM 507475, J.P. CONLIN collection; 2 - USNM 507476, holotype, USGS Mesozoic locality 21518; both specimens from *Haresiceras placentiforme* Zone (=*Scaphites hippocrepis* II Zone); Lower Campanian; x 1.

Fig. 3-7: *Cataceramus balticus* (BÖHM, 1907); 3 – USNM 507491, 4 – USNM 507494, 5 – UNSM 507490, 6 – USNM 507492, 7 – USNM 507489; all from USGS Mesozoic locality D6896, *Scaphites hippocrepis* III Zone; Lower Campanian; x 0.9.

Fig. 8: *Cataceramus beckumensis* (GIERS, 1964); USNM 507483, from USGS Mesozoic locality D 2139, *Baculites* sp. (smooth) Zone; Lower Campanian; x 1.


1a


3


4


1b


5


1c


7


6


2a


8a


2b


8b

requires further study, we regard the genus *Endocostea*, with its type species *E. typica* (WHITFIELD), as separate from the genus *Cataceramus* HEINZ, 1932, appearing in the latest Campanian and ranging into the Early Maastrichtian.

Only a few of the forms that may belong to *Cataceramus*, are referred to it here: these are: *Cataceramus beckumensis* (GIERS, 1964), *C. balticus* (BÖHM, 1907), *C. subcompressus* (MEEK & HAYDEN, 1856), *C. subundatus* (MEEK, 1876), and *C. mortoni* (MEEK & HAYDEN, 1860). The others, such as, "*I.*" *palliseri* (DOUGLAS), "*I.*" *buguntaensis* DOBROV & PAVLOVA, "*I.*" *barabini* MORTON, and "*I.*" aff. *barabini*, as well as "*I.*" *gandjaensis* ALIEV, 1956, and "*I.*" *gandjaeformis* sp. nov., are referred to *Cataceramus* with a query, as their relationships, in spite of marked morphological similarity to the Early – Middle Campanian cataceramids, is unclear.

**Occurrence**: The genus *Cataceramus* appeared in the Late Santonian (or possibly as early as the Middle Santonian) and ranges at least to the Late Campanian, and possibly to the Early Maastrichtian. It is the dominant form within Early and Middle Campanian inoceramid faunas.

### *Cataceramus beckumensis* (GIERS, 1964)
### Pl. II, fig. 3; Pl. III, fig. 8

1964. *Inoceramus beckumensis* GIERS, p. 241, pl. 2, fig. 1.

? 1965. *Inoceramus balticus* BÖHM subsp. *raricostata* ARZUMANOVA, p. 109, pl. 4, figs 2-3.

non 1967. *Inoceramus balticus* cf. *beckumensis* GIERS. - SEITZ, p. 70, pl. 7, fig. 2.

?non 1993. *Endocostea balticus beckumensis* (GIERS). - DHONDT, p. 221, pl. 3, fig. 3. *Cataceramus beckumensis* (GIERS). - WALASZCZYK, p. 20, pl. 14, fig. 4; pl. 15, figs 2-5; pls 16-18.

**Type**: the holotype, by original designation, is RE A, 1273, illustrated by GIERS (1964, pl. 2, fig. 1; reillustrated by WALASZCZYK, 1997, pl. 16, fig. 3), from the Beckumer Beds, *conica/mucronata* Zone in the belemnite/echinoid standard zonation of northern Germany (ERNST *et al.*, 1979; see also KAPLAN & KENNEDY, 1996); the original is housed in the Ruhrland Museum, Essen, Germany.

**Material**: USNM 507482 and USNM 507483 from USGS Mesozoic locality D2139.

*Dimensions*

| Specimen | h | l | H | L | s | α | δ | hmax |
|---|---|---|---|---|---|---|---|---|
| USNM 507482 | 71.4 | 61.8 | 62 | 66 | 37 | 128 | 52 | 81.4 (LV) |
| UNSM 507483 | 70.4 | 55 | 55 | 70.8 | 46 | 120 | 38 | 94 (RV)[bi-valved] |

**Description**: Medium sized for genus, inequilateral, equivalve, prosocline. Beak terminal curved anteriorly. Umbonal region indistinct. Disc weakly inflated. Posterior auricle relatively small, indistict from disc. Hinge line long, straight. Anterior margin moderately long, weakly convex, passing into long, broadly convex ventral margin, and then into rounded postero-ventral margin. Both specimens geniculated.

Ornament composed of concentric rugae, with interspaces increasing very regularly ventralward. Rugae asymmetrical with ventral slopes distinctly steeper.

**Remarks**: From other species of the *balticus* group *Cataceramus beckumensis* can be differentiated by the gradual increase of its interspaces and lower obliquity. WALASZCZYK (1997) interpreted the species as a member of the *copetdagensis – dariensis – beckumensis* lineage that is well represented in the upper Lower Campanian of Europe.

Among North American forms, representatives of the *copetdagensis – dariensis – beckumensis* lineage resemble "*Inoceramus*" *vancouverensis* SHUMARD, 1858 (see WHITEAVES, 1879). However, "*I.*" *vancouverensis* comes from the Pacific Province and, according to HAGGART (1984, 1991) most probably occurs higher

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Plate IV

Fig. 1: *Cordiceramus paraheberti* (SORNAY, 1968); USNM 507484, USGS Mesozoic locality D 2413, *Scaphites hippocrepis* Zone; Lower Campanian; x 1.

Fig. 2, 4, 7: "*Inoceramus*" *vorhelmensis* (WALASZCZYK, 1997); 2 – USGS 507498, USGS Mesozoic locality 9710, *Baculites obtusus – B. maclearni* Zone, Middle Campanian; 4 – USNM 507739 from USGS Mesozoic locality D 3750; 7 – USNM 507512 from USGS Mesozoic locality USGS D 831; both from *Baculites obtusus – B. maclearni* Zones; Middle Campanian; 2, 7 x 1; 4 x 0.7.

Fig. 3, 5-6: "*Inoceramus*" *azerbaydjanensis* ALIEV, 1939; 3 – USNM 507506 from USGS Mesozoic locality 9710, 5 – USNM 507500 from USGS Mesozoic locality 9523, and 6 – USNM 507501 from USGS Mesozoic locality 9710; all from *Baculites obtusus – B. maclearni* Zones; Middle Campanian; x 1.

1a

2

1b

3

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7

stratigraphically (it is described from above the *I. schmidti* Zone).

**Occurrence**: In the material studied, *C. beckumensis* is known only from the upper Lower Campanian *Baculites* sp. (smooth) Zone. The species is well represented in the European upper Lower Campanian (*conica/mucronata* Zone).

### *Cataceramus balticus* (BÖHM, 1907)
### Pl. II, figs 1-2, 4, 7; Pl. III, figs 3-7; Pl. VI, fig. 5; Pl. VII, fig. 1

1835. *Inoceramus Cripsii* MANT. - GOLDFUSS, p. 116 (pars), pl. 112, fig. 4b [non pl. 112, fig. 4a, c-d].
1907. *Inoceramus balticus* BÖHM, p. 114.
1909. *Inoceramus balticus* BÖHM, p. 47 (pars), pl. 11, fig. 2 [non pl. 12, fig. 1].
1967. *Inoceramus (Endocostea) balticus* BÖHM. - SEITZ, p. 67 (pars), pl. 6, fig. 2; pl. 7, fig. 1; pl. 12, figs 1-2 [non pl. 8, fig. 2]
1967. *Inoceramus balticus* BÖHM. - TRÖGER, p. 7 (pars), pl. 1, figs 2-4; pl. 2, figs 1-8 [non pl. 1, fig. 1].
1969. *Inoceramus balticus balticus* KHALAFOVA, pl. 27, figs 2-4, pl. 28, fig. 1.
1970. *Inoceramus balticus* BÖHM. - KAUFFMAN (pars), pl. 2, figs 2, 7, 9 [non pl. 2, fig. 9].
1974. *Inoceramus balticus* BÖHM. - KOCIUBYNSKIJ, p. 83(pars), pl. 24, fig. 1 [non pl. 22, fig. 2].
1978. *Inoceramus balticus* BÖHM. - LUPU & SORNAY, p. 76, pl. 2, fig. 4.
?1978. *Inoceramus (Endocostea) balticus* BÖHM subsp. nov.- NODA & KANIE, p. 63, pl. 5, fig. 4.
1992a. *Inoceramus (Endocostea) balticus* BOEHM. - COBBAN & KENNEDY, figs 6-9, 6-14, 6-15.
?1992b. *Inoceramus (Endocostea) balticus* BOEHM. - COBBAN & KENNEDY, pl. 7, figs 6, 10.
1996. *Inoceramus (Endocostea) balticus* BÖHM. - ELDER, p. 254, figures 3.17, 3.18, 3.20, 3.21, 4.19.
1997. *Cataceramus balticus* (BÖHM). - WALASZCZYK, p. 18, pl. 11, fig. 3; pl. 12, figs 1-5.

**Type**: The lectotype, by subsequent designation of GIERS (1964, p. 238), is the original to BÖHM (1909, pl. 11, fig. 2 = *Inoceramus Cripsii* in GOLDFUSS, 1835, pl. 112, fig. 4b), from the Lower Campanian of Dülmen, Westphalia, Germany. The original is housed in the University Museum, Bonn.

**Material**: USNM 507488 from J.P. CONLIN collection; USNM 507489, USNM 507490, USNM 507491, USNM 507492, USNM 507493, USNM 507494, USNM 507495, from USGS Mesozoic locality D6896; USNM 507496 from J.P. CONLIN collection; USNM 507514, from USGS Mesozoic locality D2115; USNM 507522 from USGS Mesozoic locality D 1908.

*Dimensions*

| Specimen | h | l | H | L | s | α | δ | hmax |
|---|---|---|---|---|---|---|---|---|
| USNM 507488 | 51.7 | 46 | 42.3 | 48.4 | 30.0 | 120 | 52 | 63 (RV) |
| USNM 507489 | 45.8 | 43.9 | 39.5 | 45.0 | 29.0 | — | 49 | 56 (LV) |
| USNM 507490 | 50.0 | 45.1 | 45.0 | 47.6 | 25.9 | 128 | 54 | 51.5 (LV) |
| USNM 507491 | 45.0 | 44 | 39.8 | 44.5 | 31.5 | — | 43* | 59.5 (LV) |
| USNM 507493 | 54.5 | 47 | 50.0 | 52.0 | 32.5 | 124 | 55 | 62 (LV) |
| USNM 507494 | 59.1 | 51.1 | 49.5 | 57.0 | 36.0 | 128 | 45 | 78.5 (LV) |
| USNM 507495 | 46.3 | 43 | 41.0 | 44.0 | 23.2 | 124 | 55 | 56 (LV) |
| USNM 507496 | 52.0 | 45.5 | 43.6 | 48.0 | 34.0 | 124 | 51 | 63.1 (LV) |
| USNM 507514 | 57.0 | — | 49.6 | 58.4 | 35.0 | 125 | 43 | — |
| USNM 507522 | 49.0 | — | 44.2 | 46.0 | 30.0 | 130 | 55 | 76 (LV) |

**Description**: Small to medium sized for genus, inequilateral, equivalve, prosocline. Valve outline subquadrate to obliquely trapezoidal. Growth axis evenly convex. Beak curved anteriorly, projecting slightly above hinge line. Disc moderately inflated with maximum inflation dorso-central. Hinge line long, straight. Anterior margin rounded, moderately long, passing into rounded ventral margin and then into rounded posterior margin.

Shell ornamented with distinct, sub-regularly spaced and sub-symmetrical concentric rugae, weakening anteriorly as well as, though to a lesser degree, on the posterior auricle.

**Remarks**: The variability of the species displayed by material studied is primarily confined to valve outline and juvenile obliquity; forms range in outline from

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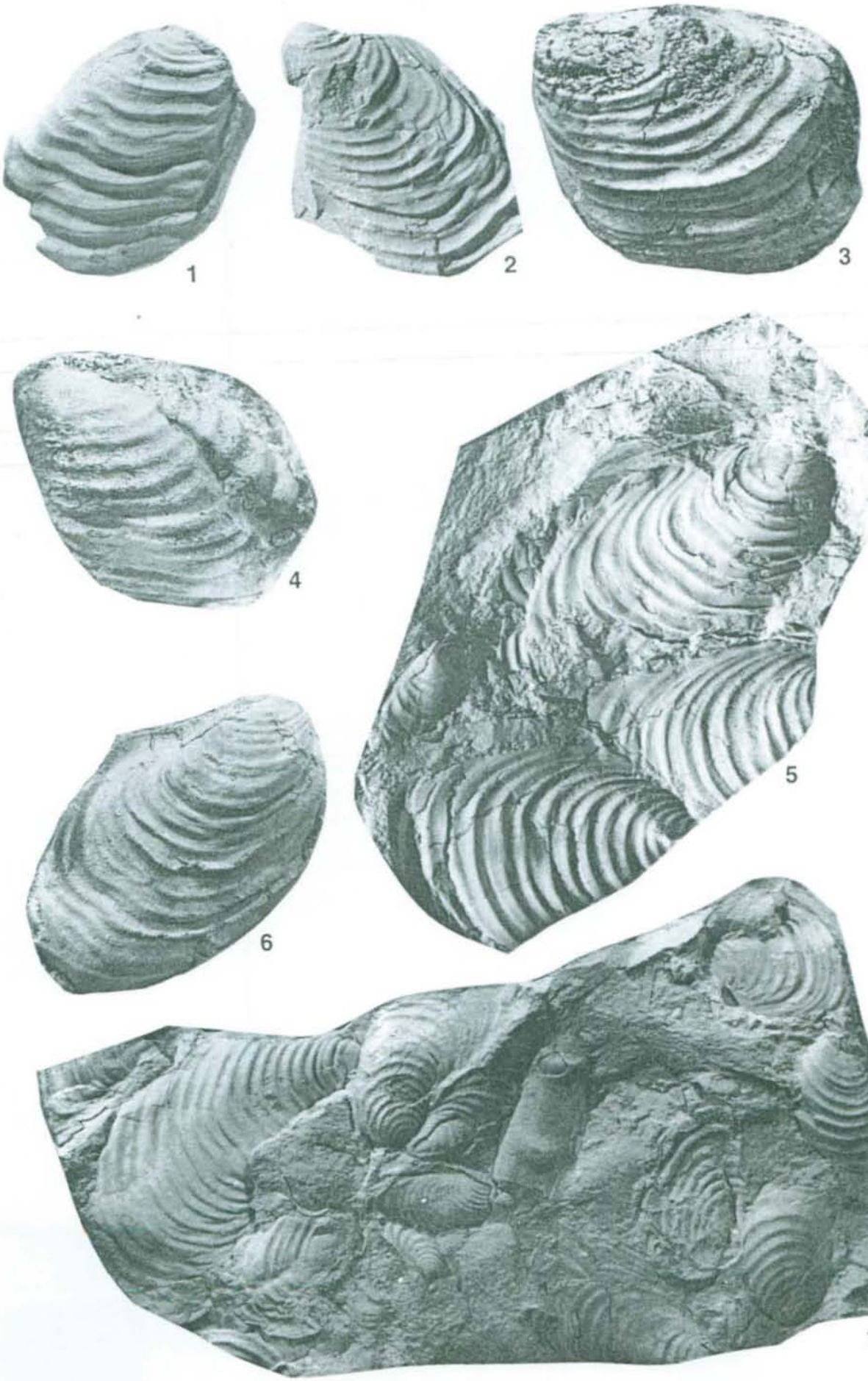
Plate V

Fig. 1-4, 6: "*Inoceramus*" *azerbaydjanensis* (ALIEV, 1939); 1 – USNM 507510 and 2 – USNM 507511 from USGS Mesozoic locality D 831; 3 – USNM 507497, 4 – USNM 507507, and 6 – USNM 507499, all from USGS Mesozoic locality 9710; all from *Baculites obtusus – B. asperiformis* Zones, lower Middle Campanian; x 1.

Fig. 5, 7: "*Inoceramus*" *vorhelmensis* (WALASZCZYK, 1997); 5 – USNM 507738, 7 – USNM 507737 both from USGS Mesozoic locality D 3750; *Baculites obtusus – B. maclearni* Zones; Middle Campanian; 5 x 1; 7 x 0.7.


1
2
3
4
5
6
7

rounded subquadrate morphotypes (Pl. III, figs 5, 7; Pl. VI, fig. 5) to more anteriorly oblique (Pl. II, figs 1-2). The correlation of the outline with obliquity (δ) is rather low. Although only a single specimen, USNM 507514 (Pl. VI, fig. 5), is geniculated, the feature usually characterises the adult specimens of the species. Its absence in the studied material is due to the rather small size of most specimens.

*C. balticus* is very similar to *Cataceramus subcompressus* (MEEK & HAYDEN). The latter is more oblique, and possesses higher H/L value. It differs from *C. beckumensis* (GIERS) in higher obliquity and different ornament pattern. In *C. balticus* the rugae are sub-evenly spaced with very slow ventralward increase of interspaces in contrast to *C. beckumensis* in which interspaces increase distinctly ventralward. *C. balticus* closely resembles *C. mortoni* (MEEK & HAYDEN, 1860) (=*Inoceramus proximus* of authors). *C. mortoni* differs in finer, more regular ornament.

**Occurrence**: In the Western Interior and Texas, *C. balticus* is known from the upper Lower and lower Middle Campanian. The species is very common in Europe (England, Germany, France, Spain, Poland, Romania, The Ukraine, Russia) and western Asia (Kazakhstan, Turkmenistan), where it occurs over a similar stratigraphic range.

### *Cataceramus subcompressus* (MEEK & HAYDEN 1860)
### Pl. VI, figs 1-4, 6-7; Pl. VII, figs 5, 9; Pl. XI, figs 5, 9; Pl. XXXVI, fig. 3

1835. *Inoceramus Cripsii* MANT. - GOLDFUSS, p. 116, pl. 112, fig. 4c.
1860. *Inoceramus subcompressus* MEEK & HAYDEN, p. 181.
1876a. *Inoceramus Cripsii*? var. *subcompressus* MEEK & HAYDEN. - MEEK, p. 48, pl. 38, fig. 2bis.
1909. *Haenleinia cymba* BÖHM, p. 56, pl. 12, fig. 2; pl. 13, fig. 2.
? 1964. *Inoceramus balticus haldemensis* GIERS, p. 243, p. 2, fig. 2.
non 1967. *Inoceramus balticus haldemensis* GIERS. - SEITZ, p. 75, pl. 12, fig. 3.
1967. *Inoceramus* (*Endocostea*) *cymba* BÖHM; SEITZ, p. 66 (pars), pl. 7, fig. 3.
1982. *Inoceramus balticus haldemensis* GIERS. - TRÖGER & RÖHLICH, p. 104 (pars), pl. 1, figs 1-2, 4, 6.
1991. *Inoceramus* (*Endocostea*) *balticus haldemensis* GIERS. - TRÖGER & RÖHLICH, p. 1361 (pars), pl. 1, figs 1-2, 4.
1991. *Inoceramus* (*Endocostea*) *balticus* cf. *haldemensis* GIERS. - TRÖGER & RÖHLICH, p. 1361 (pars), pl. 1, fig. 8 [non pl. 1, fig. 6].

**Type**: The holotype, by original designation, is USNM 4301, illustrated by MEEK (1876a, pl. 38, fig. 2bis) (reillustrated herein – Pl. XXXVI, fig. 3), from either the upper Lower Campanian *Scaphites hippocrepis* Zone or the lower Middle Campanian *Baculites asperiformis* Zone at the mouth of the Judith River, central Montana.

**Material**: USNM 507513, from USGS Mesozoic locality D1898, USNM 507515; USNM 507516, USNM 507517, USNM 507518, USNM 507519, all from USGS Mesozoic locality D 1898; USNM 507528, from USGS Mesozoic locality D1908; USNM 507730 from USGS Mesozoic locality D 1900; the type of the species (Pl. XXXVI, fig. 3)

*Dimensions*

| Specimen | h | l | H | L | s | α | δ | |
|---|---|---|---|---|---|---|---|---|
| USNM 507519 | 39.8 | — | 34.1 | 42.8 | 25.5 | 130 | 47 | |
| USNM 507518 | 41.3 | — | 34.6 | 39.2 | 24.0 | 133 | 45 | |
| USNM 507513 | 36.2 | — | 29.6 | 36.1 | 21.5 | 133 | 45 | |
| USNM 507515 | — | — | 40.9 | 50.0 | 30.5 | 125 | 48 | |
| USNM 507517 | 35.6 | — | 28.9 | 34.0 | 20.0 | 134 | 45 | |
| aff. *subcompressus* | | | | | | | | hmax |
| USNM 507545 | 62.0 | 55.0 | 47.1 | 63.8 | 43.5 | 110 | 35 | 80 (LV) |
| USNM 507546 | 57.0 | 48.0 | 39.0 | 60.0 | 43.0 | 124 | 35 | 63 (LV) |

**Description**: Small to moderatesized for genus, inequilateral, equivalved, prosocline. Beak small sub-terminal, curved anteriorly, projecting slightly above hinge line. Hinge line long, straight. Anterior margin rounded, extending markedly toward anterior in reference to beak, passing into broadly rounded ventral margin, and round-

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Plate VI

Fig. 1-4, 6-7: *Cataceramus subcompressus* (MEEK & HAYDEN, 1860); 1 – USNM 507528, USGS Mesozoic locality D1908, *Baculites gregoryensis* Zone; 2 – USNM 507519, 3 – USNM 507516, 4 – USNM 507517, 6 – USNM 507518, 7 – USNM 507515; all from USGS Mesozoic locality D1898, *Baculites gregoryensis – Baculites perplexus* Zones; Middle Campanian; x 1.

Fig. 5: *Cataceramus balticus* (BÖHM, 1907), USNM 507514, USGS Mesozoic locality D 2115, *Baculites gregoryensis – B. perplexus* Zones; Middle Campanian; x 1.


1a

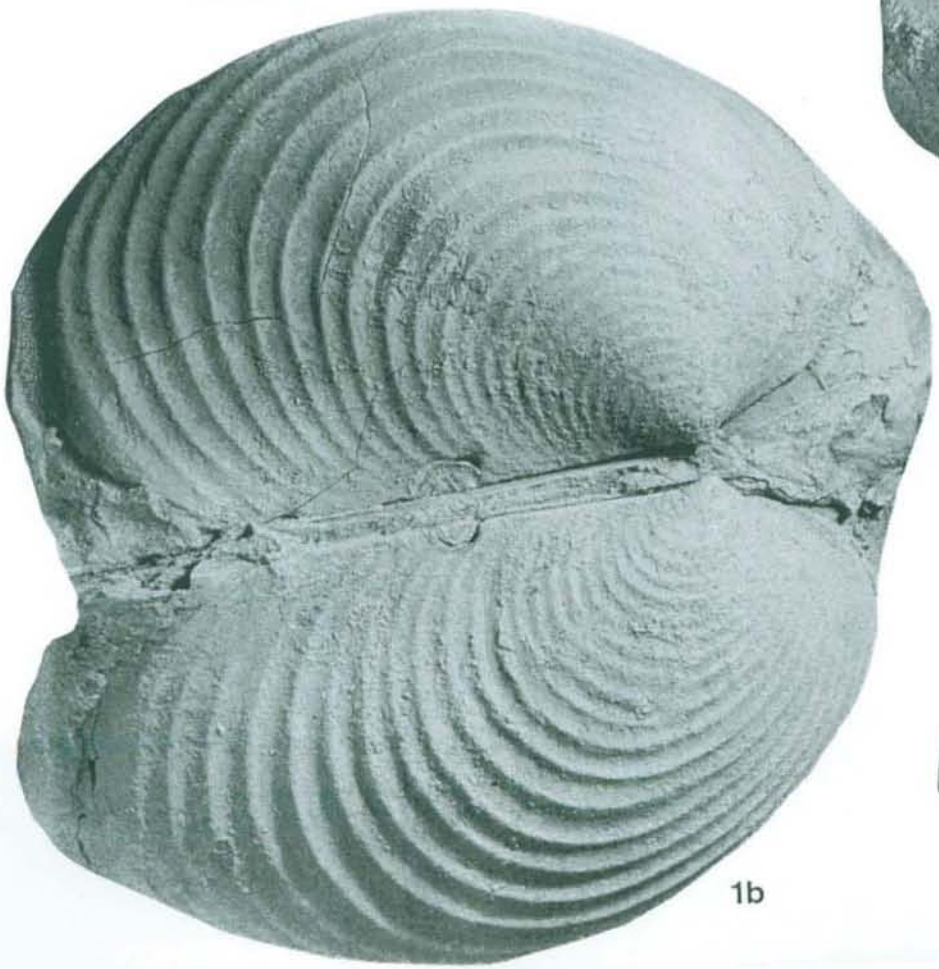

4


5a


2


3


5b


1b


6


7

ed posterior margin. Posterior auricle small, weakly separated from disc. All specimens geniculated with geniculation angle usually between 30° and 60°; juvenile stage weakly inflated. Geniculation well developed only in anterior and ventral parts;posteriorly, juvenile stage passes uninterruptedly into adult stage.

Juvenile stage ornamented with quite regularly, subequally spaced rugae continuing onto posterior auricle. Adult stage with less distinct and less regular rugae, rarely completely smooth.

**Remarks**: *Haenleinia cymba* BÖHM, 1909, described from northern Germany is conspecific with *Cataceramus subcompressus* (MEEK & HAYDEN), which, consequently, falls into synonymy of the American taxon. As in *C. subcompressus*, the type of *H. cymba* [for illustration and detailed description see SEITZ, 1967, p. 66, pl. 7, fig. 3 (only)] is an articulated specimen with two growth stages with variable ornament: finely ribbed, markedly oblique juvenile stage and weakly, irregularly ornamented adult stage. The two other specimens illustrated and referred to *I. (E.) cymba* by SEITZ (1967, pl. 2, fig. 2 and pl. 3, fig. 2) represent other species (*E. typica* and "*Inoceramus*" *conlini* sp. nov., respectively).

Some specimens, such as USNM 507528 (see Pl. VI, fig. 1), from USGS Mesozoic locality D1908, as well as some unnumbered specimens from the collections in Denver, differ from the type in their distinctly larger size. In all other respects, they posses the same characteristics, and consequently are referred to MEEK & HAYDEN's species.

*Cataceramus balticus haldemensis* (GIERS, 1964) originally described from Westphalia, northern Germany (GIERS, 1964, pl. 2, fig. 2) is very similar and possibly conspecific with *Cataceramus subcompressus* (MEEK & HAYDEN). Although GIERS's type itself seems less posteriorly elongated than the American species, his species was interpreted to comprise a broad spectrum of morphotypes, and numerous forms referred formerly to *C. balticus haldemensis* actually represent *C. subcompressus*. TRÖGER & RÖHLICH's (1982, 1991) variety 1 and a portion of variety 2 of *C. balticus haldemensis* should be attributed to *C. subcompressus.*

MEEK & HAYDEN's species differs from *C. balticus*, in the distinct posterior elongation of the valve outline and elongated antero-ventral margin. Both species may be geniculated, and it is not a solely characteristic feature of either taxon.

USNM 507545 and USNM 507546, from USGS Mesozoic locality 21574 from the lowest Upper Campanian ammonite zone of *Didymoceras nebrascense* Zone (Pl. XI, figs 5, 9) are very similar to *C. subcompressus*. They differ in their more robust ornament and in umbones more prominently projected above the hinge line. Because these two specimens occur distinctly higher stratigraphically, they are referred here to as *C.* aff. *subcompressus*. However more material is needed to better constrain the relationship between these two forms.

**Occurrence**: The holotype (MEEK 1876a, pl. 38, fig. 2) was collected from brown sandstones exposed at the mouth of the Judith River in central Montana and according to ammonite data may come from the upper Lower Campanian *Scaphites hippocrepis* Zone or from the lower Middle Campanian *Baculites asperiformis* Zone. In the Western Interior, the species occurs in the lower Middle Campanian (up to the *Baculites gregoryensis* Zone), where it dominates the inoceramid record. In Europe, it is known from the Middle Campanian and apparently from an equivalent interval in Libya (TRÖGER & RÖHLICH, 1982, 1991).

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Plate VII

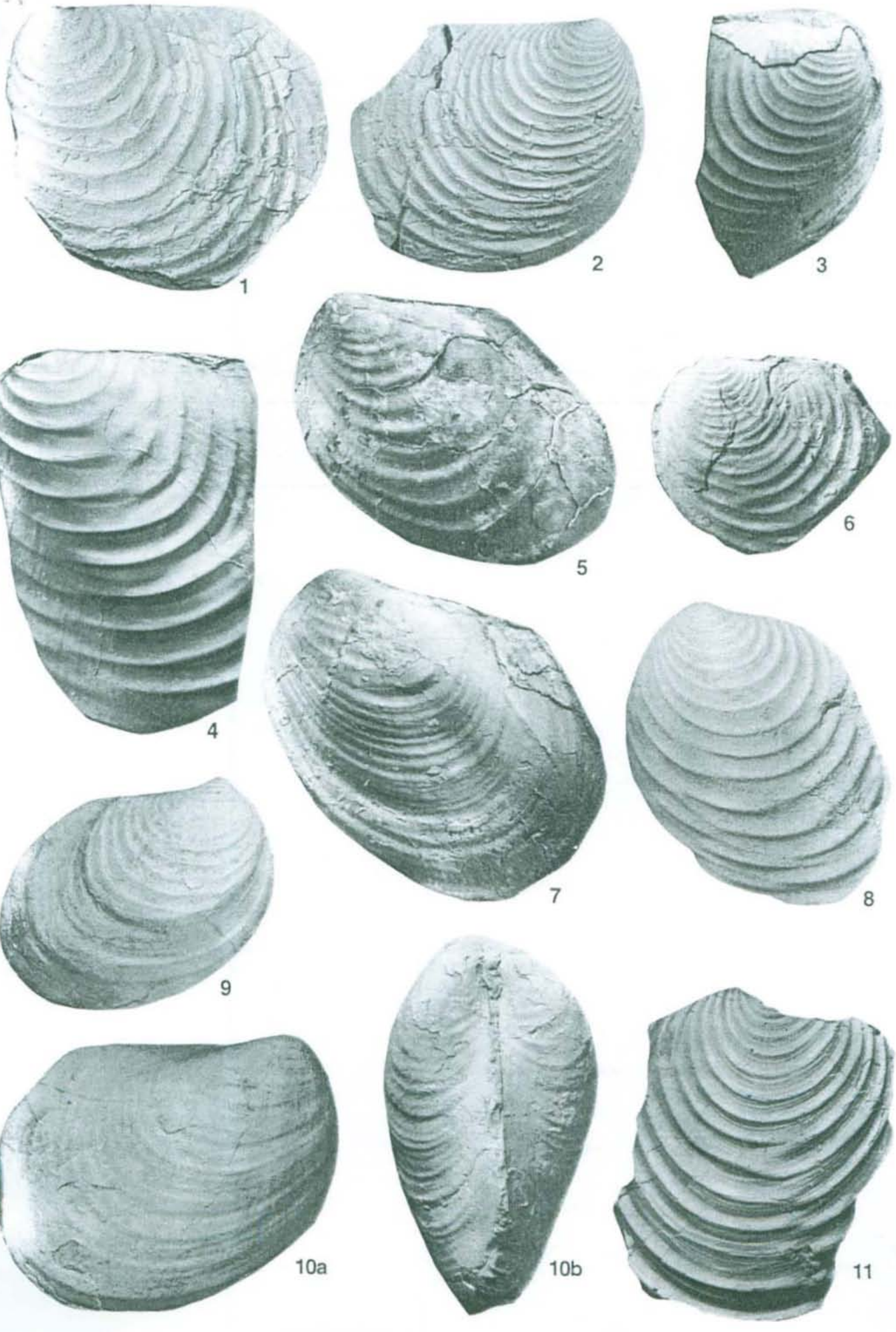
Fig. 1: *Cataceramus balticus* (BÖHM, 1907), USNM 507522 from USGS Mesozoic locality D 1908, *Baculites gregoryensis* Zone; Middle Campanian; _ 0.85

Fig. 2-3, 6: *Cataceramus mortoni* (MEEK & HAYDEN, 1860); 2 – USNM 507524, 3 – USNM 507521, 6 – USNM 507520; all from USGS Mesozoic locality D 1908, *Baculites gregoryensis* Zone; Middle Campanian; 2, 6 x 1; 3 x 0.9.

Fig. 5, 9: *Cataceramus subcompressus* (MEEK & HAYDEN, 1860), 5 – USNM 507730 from USGS Mesozoic locality D 1900, 9 - USNM 507513, from USGS Mesozoic locality D 1898; both from *Baculites gregoryensis - B. perplexus* Zones; Middle Campanian; x 1.

Fig. 4, 8, 11: *Cordiceramus heberti* (FALLOT, 1885), 4 – USNM 507742, 8 – USNM 507526; both from USGS Mesozoic locality D 1908, *Baculites gregoryensis* Zone; Middle Campanian; 11 – USNM 507527, from USGS Mesozoic locality D 1912, *Baculites gregoryensis* Zone; Middle Campanian; x 1.

Fig. 7, 10: *Cataceramus? agdjakendsis* (ALIEV, 1952); 7 – USNM 507731 and 11 – USNM 507525, both from USGS Mesozoic locality D 1900, *Baculites gregoryensis* Zone; Middle Campanian; x 1.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10a
10b
11

### *Cataceramus subundatus* (MEEK, 1861)
### Pl. XXXVI, fig. 5

1861. *Inoceramus subundatus* MEEK, p. 315.
1876a. *Inoceramus Cripsii*? var. *subundatus* MEEK. - MEEK, p. 358 (pars), pl. 3, fig. 1 [non pl. 3, fig. 3 = *Inoceramus succiensis* WHITEAVES, 1879]
1974. *Inoceramus barabini* MORTON. - KOCIUBYNSKIJ, p. 83 (pars), pl. 20, fig. 1.

**Type**: The lectotype, designated herein, is USNM 1262 illustrated by MEEK (1876a, pl. 3, fig. 1), which represents the most typical specimen of his species. The paratype is USNM 1261, an unillustrated specimen, from the MEEK's original collection. The second specimen illustrated by MEEK (1876a, pl. 3, fig. 3; reillustrated herein in Pl. XXXVI, fig. 1) differs considerably from *C. subundatus*.

*Dimensions*

| Specimen | h | l | H | L | s | α | δ | hmax |
|---|---|---|---|---|---|---|---|---|
| USNM 1261 (juv) | 36.0 | — | 34.0 | 37.0 | 20.0 | — | 50 | — |
| (adult) | 54.0 | — | 47.5 | 53.0 | 25.2 | — | 50 | — |
| USNM 1262 | 54.5 | | 47.4 | 52.0 | 32.0 | — | 53 | 56.5 |
| USNM 131548 | 41.2 | — | 40.0 | 42.4 | 21.0 | | 64 | 51.4 |

(DANE 1929, pl. 8, fig. 2)

**Description**: Species of small to moderate size, weakly inflated, weakly inequilateral, prosocline. Shell subrounded in outline, slightly longer than high, geniculated. Anterior margin regularly convex, rounded, passing into rounded ventral margin and thence into posterior margin. Hinge line relatively long, straight. Umbo indistinct, projecting weakly above hinge line. Juvenile valves covered with regularly spaced rugae with interspaces increasing regularly ventralward. Adult parts almost smooth.

**Remarks**: MEEK's (1876b) original *Cataceramus subundatus* collection consists of three specimens; in addition to his two illustrated specimens [USNM 1348 – MEEK, 1876b, pl. 3, fig. 3 (reillustrated herein in Pl XXXVI, fig. 1); and USNM 1262 – MEEK 1876b, pl. 3 fig. 1] there is one other, USNM 1261, illustrated herein (Pl. XXXVI, fig. 5). USNM 1348 is a relatively large specimen, and differs from the other two by its posterior elongation, resembling *Inoceramus barabini*, as mentioned by MEEK (1876b). Subsequently, WHITEAVES (1879, p. 173) referred the specimen to as a new variety *Inoceramus crippsii* var. *succiensis*. He included MEEK's other two specimens in *Inoceramus proximus* (WHITEAVES, 1879).

A small specimen illustrated by DANE (1929, pl. 8, figs 2-3), from the Tokyo Formation, Lockesburg Road, 1 mi. NW of Beu Lemond, in Sevier County, Arkansas, referred by him to *Inoceramus* sp. should probably be referred to *C. subundatus*.

*C. subundatus* is morphologically very similar to the Maastrichtian species *C.? subcircularis* (MEEK, 1876a). The resemblance is so great that distinguishing between small specimens of both species is practically impossible. These are treated here as separate taxa only because of the pronounced gap in their occurrences: middle Middle Campanian in the case of *C. subundatus* and Lower Maastrichtian in the case of *C.? subcircularis*.

In Europe, forms very close morphologically to *Cataceramus subundatus* are usually referred to *Cataceramus planus* (GOLDFUSS) (GIERS, 1964. WALASZCZYK, 1997). However, judging by the illustrations in GOLDFUSS (1836, pl. 113, fig. 1a, b), neither of his two specimens is conspecific with MEEK's *C. subundatus*. GOLDFUSS' smaller specimen (GOLDFUSS' figure 1a) represents a *Platyceramus* species; it is distinctly less oblique as well as more finely ornamented. His larger specimen (GOLDFUSS' figure 1b) is a posteriorly elongated, *balticus*-like specimen. Therefore, these small, subcircular in outline, European mid-Campanian forms should most probably be referred to *C. subundatus* (e.g. WALASZCZYK, 1997, pl. 30, fig. 2).

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Plate VIII

Fig. 1-2, 5: *Sphaeroceramus pertenuis* (MEEK & HAYDEN 1856); 1 – USNM 316192 B original of MEEK (1876a, pl. 37, fig. 3b), 2 – USNM 182, holotype, original of MEEK (1876, pl. 38, fig. 3b), 5 – UNSM 316192 A, original of MEEK (1876a, pl. 37, fig. 3a); brown sandstones at the mouth of Judith River, above Fort Union, and according to ammonite data may come from the Lower Campanian *Scaphites hippocrepis* Zone or from the lower Middle Campanian *Baculites asperiformis* Zone; x 1.

Fig. 3: *Sphaeroceramus sarumensis* (WOODS, 1912); USNM 316192c, original of *Inoceramus pertenuis* MEEK & HAYDEN, 1860, *in* MEEK (1876a, pl. 38, fig. 3a); brown sandstones at the mouth of Judith River, above Fort Union, and according to ammonite data may come from the Lower Campanian *Scaphites hippocrepis* Zone or from the lower Middle Campanian *Baculites asperiformis* Zone; x 1.

Fig. 4: "*Inoceramus*" *tenuilineatus* HALL & MEEK, 1854; AMNH 9362/1, original to HALL & MEEK (1854, pl. 2, fig. 3); upper Middle Campanian; x 1.

1

2

3a

3b

4b

4a

5

3c

**Occurrence**: According to HAGGART (1984, 1991), *Cataceramus subundatus* occurs above the level containing *Inoceramus schmidti*, which is known from the Lower or basal Middle Campanian. The *I. schmidti* Zone is characteristic of the Campanian throughout the entire North Pacific Province (TOSHIMITSU *et al.*, 1995, 1998). Should it appear to be isochronous throughout the whole province, *C. subundatus* would be expected to occur in the successive, *I. balticus* Zone. In the Western Interior, the species occurs in the middle Middle Campanian. European records are from an interval that correlates well with the North American records.

### *Cataceramus mortoni* (MEEK & HAYDEN, 1860)
### Pl. VII, figs 2-3, 6; Pl. XI, figs 6-8, 10, 12

non 1856. *Inoceramus proximus* TUOMEY, p. 171 [nomen nudum]

1876a. *Inoceramus proximus* TUOMEY?. - MEEK, p. 53, pl. 12, fig. 7a, b.

? 1983. *Inoceramus* (*Endocostea*) sp. aff. *I.* (*E.*) *proximus* TUOMEY. - NODA, p. 106, fig. 4; pl. 1, figs 1-8.

non 1984. *Inoceramus proximus* TUOMEY. - BOLANOS & BUITRON, p. 411, pl. 1, fig. 5.

**Type**: The holotype is MEEK's (1876a, pl. 12, fig. 7) original (reillustrated herein – Pl. XI, fig. 12) from the Middle/Upper Campanian boundary interval of the Great Bend of the Missouri River, below Pierre, South Dakota; Gregory Member of the Pierre Shale. In ammonite terms, this corresponds to the uppermost Middle Campanian *Baculites gregoryensis* and *B. scotti* Zones.

**Material**: USNM 507520, USNM 507521, USNM 507523, USNM 507524; all from USGS Mesozoic locality D1908; USNM 507543, from USGS Mesozoic locality 21574; USNM 507548, from USGS Mesozoic locality D283; USNM 507744, USNM 507745, USNM 507746 and 507747, all from USGS Mesozoic locality 760; the original of *I. proximus* of MEEK (1876, pl. 12, fig. 7) (Pl. XI, fig. 12).

*Dimensions*

| Specimen | h | l | H | L | s | α | δ | hmax |
|---|---|---|---|---|---|---|---|---|
| USNM507520 | 38.0 | — | 33.0 | 40.0 | 25.3 | 130 | 49 | — |
| USNM 507521 | 39.9 | — | 34.0 | 38.0 | 19.5 | 125 | — | 70 (RV) |
| USNM 507523 | 38.0 | — | 39.0 | 50.0 | 35.0 | — | 35 | 84 (LV) |
| USNM 507524 | 49.0 | — | 42.0 | 49.8 | 31.0 | 130 | 42 | — |
| USNM 507543 | 38.0 | 35.5 | 30.0 | 39.5 | 25.0 | 123 | 36 | 42 (RV) |
| USNM 507548 | 44.5 | 35.8 | 32.5 | 44.0* | — | — | 35* | — |

**Description**: Weakly inflated, small- to medium-sized, postero-ventrally elongated, prosocline species. Beak terminal, small, curved anteriorly, projecting slightly above hinge line. Umbonal region small, indistinct, weakly inflated. Hinge line relatively long, with s/h ratio ranging 0.6 - 0.65. Anterior margin moderately convex, passing into broadly convex ventral margin and hence into rounded posterior margin. Growth axis straight in juveniles, weakly ventrally convex in adult stage. Posterior auricle small, elongated parallel to hinge line, not separated from disc.

Shell ornamented with regular, sharp-edged, fine, evenly spaced rugae. In antero-ventral part they are crossed obliquely by growth lines. Rugae only slightly elliptical in outline, with l/h ratio of approximately 0.9.

**Remarks**: Forms described here correspond to what was commonly regarded as *Inoceramus proximus* of authors (*non* TOUMEY, 1856), based on MEEK's species concept (1876a, pl. 12, fig. 7). MEEK regarded his Western Interior specimen to be conspecific with TUOMEY 's (1856) *I. proximus*. He, however, had not seen TUOMEY 's original material; he only saw the specimens from Eufala, Alabama, regarded as "authentic examples of Professor TUOMEY 's *Inoceramus proximus*" (MEEK, 1876a, p. 54-55). TUOMEY 's original material has not been found and is probably lost (according to the late N.F. SOHL the original of *I. proximus* TUOMEY was lost in the Civil War – A. DHONDT, letter communication, March, 2001), but based on the locality - it came from Columbus, Mississippi - and the general impression of TUOMEY's concept of this species, it is probably distinctly older than MEEK's specimen. It is likely that TOUMEY's *I. proximus* represents a Late Santonian *Platyceramus* species, occurring commonly in the same locality from where TUOMEY (1856, p. 171) described his taxon. Therefore, there is no

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Plate IX

Fig. 1-3: *"Inoceramus" scotti* sp. nov.; 1 – USNM 507540 from USGS Mesozoic locality D 1574, a – posterior view, b – lateral view; 2 – holotype, USNM 507529 from USGS Mesozoic locality D 1520; 3 – USNM 507541 from USGS Mesozoic locality D 1574; uppermost Middle Campanian.

All figures in natural size

1a

2

1b

3

basis to regard MEEK's original as conspecific with TUOMEY 's *I. proximus*, and it is more likely that the two forms are separate species. Consequently, we refer MEEK's original and all conspecific forms to *Cataceramus mortoni*, the name proposed originally for this specimen by MEEK & HAYDEN (1860).

In shell outline, *C. mortoni* (MEEK & HAYDEN) is very similar to *Cataceramus balticus* (BÖHM) and *C? pallis-eri* (DOUGLAS). It differs from both species in shell ornament that consists of much finer and more closely spaced rugae.

Material illustrated by NODA (1983) from the ?Middle Campanian of Ominega-dai Hills, Shikoku, Japan is very similar to MEEK's concept of "*C. proximus*". Some of his specimens (NODA, 1983, pl. 1, figs 1-4, and 7-8) are indistinguishable from the material presented herein, but also the other, less oblique forms are comparable with the less common American morphotypes. Therefore, this Japanese material represents *C. mortoni* as well.

The specimen illustrated and referred to *C.? proximus* by BOLANOS & BUITRON (1984) from the Campanian of Mexico is striking different. The primary difference is in its ornament, which consists of robust rugae. They are prominent only on the disc and weaken markedly on the posterior auricle.

**Occurrence:** The type (MEEK, 1876a, pl. 12, fig. 7) comes from the Gregory Member of the Pierre Shale, from the Great Bend of the Missouri River, what in ammonite terms probably corresponds to the uppermost Middle Campanian *Baculites gregoryensis* and *B. scotti* Zones. Unequivocal specimens only come from the Western Interior starting in the upper Middle Campanian *B. gregoryensis* Zone and ranging up to basal Upper Campanian *D. nebrascense* Zone. Very similar material, which is questionably referred to MEEK's form has been reported from Japan.

### *Cataceramus? simpsoni* (MEEK, 1860)
### Pl. I, fig. 1

1860. *Inoceramus Simpsoni* MEEK, p. 312.
1877. *Inoceramus Simpsoni* MEEK. - MEEK, p. 142, pl. 13, fig. 3.
non 1880. *Inoceramus simpsoni* MEEK. - WHITFIELD, p. 395, pl. 8, fig. 1
non 1880. *Inoceramus simpsoni*? MEEK. - WHITFIELD, p. 395, pl. 9, fig. 9.
1894. *Inoceramus simpsoni* MEEK. - STANTON, p. 79, pl. 12, fig. 1.
1898. *Inoceramus simpsoni* MEEK. - LOGAN, p. 487, pl. 107.
non 1964. *Inoceramus simpsoni* MEEK. - SCOTT & COBBAN, p. 20, pl. pl. 10, fig. 1; pl. 11, fig. 5.
non 1997. *Cataceramus* cf. *simpsoni* (MEEK). - WALASZCZYK, pl. 2.

**Type**: The holotype, by monotypy, is MEEK's original (1877, pl. 13, fig. 2; reillustrated herein – Pl. I, fig. 1), from the North Platte River, near Casper, Wyoming. The original is housed in the US National History Museum of Natural History, Washington, DC.

**Description:** Medium- to large-sized, prosocline, strongly posteriorly elongated species. Valves moderately inflated, with wide, shallow radial sulcus in the adult stage. Beak small, projecting only slightly above hinge line. Anterior margin moderately long, weakly anteriorly convex, passing into long, broadly convex ventral margin and thence into rounded posterior margin. Hinge line very long, straight. Posterior auricle small, indistinct, not separated from disc.

Shell ornamented with regularly to subregularly spaced, rounded rugae with wide interspaces. Rugae quite regular in juvenile and middle parts. Adult stage with irregular, low, widely spaced rugae.

**Remarks**: The type of *Cataceramus? simpsoni* (MEEK, 1860) is a large, three-dimensionally preserved RV. Its anterior is incomplete, and apparently compressed. Furthermore, it lacks the hinge line and the ligamentat.

*C.? simpsoni* closely resembles forms referred by SEITZ (1967) to his new species *Inoceramus (Endocostea) flexibalticus*, and undoubtedly belongs to the same group. MEEK's species differs from both *I. (E.) flexibalticus flexibalticus* SEITZ, 1967, and *I. (E.) flexibalticus subpentagonus* SEITZ, 1967, in type of ornament and lower

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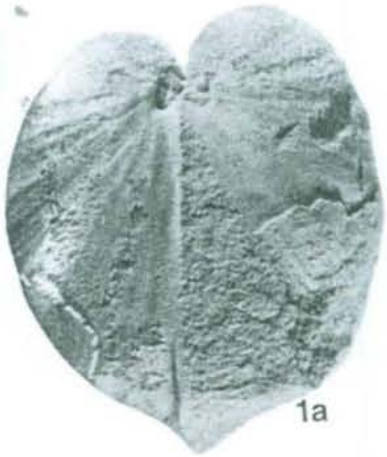
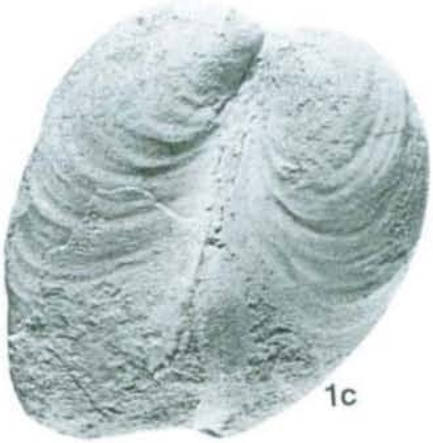
Plate X

Fig. 1-5: "*Inoceramus*" *tenuilineatus* HALL & MEEK, 1854; 1 – USNM 507537 from USGS Mesozoic locality D2173, 2 – USNM 507538 from USGS Mesozoic locality D 1925; 3 – USNM 507536 from USGS Mesozoic locality D2173, 4 – USNM 507539 from USGS Mesozoic locality D1924, 5 – USNM 507724 from USGS Mesozoic locality D1925; upper Middle Campanian.

All figures in natural size


1a


1b


1c


2a


2b

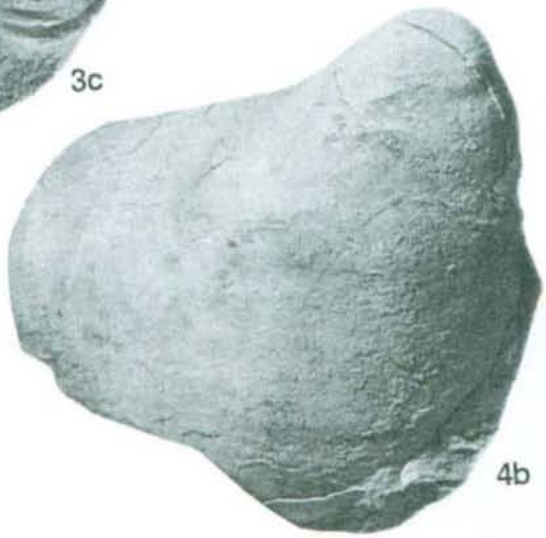

3a


3b


4a


3c


5


4b

obliquity. Unless more topotype material of *C.? simpsoni* is accessible, assessing the relationships between MEEK's species and the European forms is impossible. WHITFIELD's (1880, pl. 8, fig. 1) *I. simpsoni* is a large, posteriorly elongated specimen (refigured in Pl. XXXVII, fig. 8), with high obliquity, very moderate inflation and quite regular ornament at least in the juvenile stage that becomes less regular in adult stage. It differs from *C.? simpsoni* (MEEK) in lacking a radial sulcus and having a different ornament outline. Its valve outline resembles large specimens of "*Inoceramus*" *oblongus* MEEK or "*I.*" *magniumbonatus* DOUGLAS. Similar forms, not treated here, are also known to occur in the lower Upper Campanian (*Didymoceras stevensoni* and *Exiteloceras jenneyi* Zones) but further study is needed. The other specimen of WHITFIELD (1880, pl. 9, fig. 9), that he also included in his concept of *C.? simpsoni* (reillustrated herein in Pl. XXXVII, fig. 5), is a small, incomplete specimen of indeterminant taxonomy. During its adult growth stage, *C.? simpsoni* resembles members of the *muelleri* group, where it possesses a distinctive radial sulcus. Its juvenile part is, however, more *balticus*-like, and lacks any convincing signs of *Cordiceramus*' subpentagonal outline.

"*I.*" aff. *simpsoni* reported from California by ANDERSON (1958, p. 104) most probably represents a different taxon. ANDERSON (1958) did not illustrate his specimen, but he compared it to "*I.*" *simpsoni* of WHITFIELD (1880, pl. 8, fig. 1), whose interpretation of this species was quite distinct from MEEK's concept.

**Occurrence**: Upper Santonian and lower Lower Campanian of the Western Interior.

### *Cataceramus?* aff. *barabini* (MORTON, 1834)
### Pl. XI, figs 1-4; Pl. XV, fig. 3

?1880. *Inoceramus simpsoni* MEEK; WHITFIELD, p. 395, pl. 8, fig. 1

?1959. *Inoceramus barabini* MORTON. - DOBROV & PAVLOVA, p. 140, pl. 22, fig. 2.

**Material**: USNM 507544, USNM 507547, USNM 507549, USNM 507550, USNM 507551, all from USGS Mesozoic locality D283; USNM 507574 from USGS Mesozoic locality D79 and USNM 507575 from USGS Mesozoic locality D5026.

*Dimensions*

| Specimen | h | l | H | L | s | α | δ | hmax |
|---|---|---|---|---|---|---|---|---|
| USNM 507544 | 49.5 | 44.5 | 39.5 | 50.0 | 32.0 | 123 | 42 | 61.5 (LV) |
| USNM 507547 | 37.0 | 30.5 | 28.0 | 38.0 | 27.5 | — | 35 | 44 (LV) |
| USNM 507549 | 40.4 | 31.0 | 31.5 | 34.0 | 23.3 | 125 | 40 | 46.5 (LV) |
| USNM 507550 | 55.0 | 45.0 | 40.4 | 55.8 | 39.0 | 115 | 34 | 59 (LV) |
| USNM 507551 | 43.0 | 33.0 | 33.0 | 42.5 | 28.0 | 116 | 40 | 53 (RV) |
| USNM 507574 | 65.0 | 55.0 | 54.3 | 61.0 | 35.0 | 120 | 45 | 80 (LV) |
| USNM 507575 | 62.0 | 50.0 | 47.0 | 61.5 | 33.0 | 120 | 39 | 68 |

**Description**: Shell small to medium sized, weakly to moderately inflated, prosocline. Beak terminal, curved anteriorly. Umbonal part weakly to moderately inflated, with beak projecting slightly above hinge line. Disc subtriangular in outline, moderately inflated with maximum inflation dorso-central, becoming weakly inflated in adult stage. Growth-axis anteriorly convex. Anterior margin short, moderately convex, passing into broadly convex ventral margin. Posterior margin rounded, slightly concave at hinge line. Anterior and antero-ventral walls low but steep. Hinge line straight, long, ranging from 0.6 to 0.7 of the respective axial length. Posterior auricle very narrow and long, elongated parallel to hinge line, distinct from disc, marked by a shallow auricular sulcus.

Shells ornamented with regular to sub-regular, asymmetrical in cross-section concentric rugae (with their ventral sides markedly steeper), and with interspaces increasing gradually in width ventrally. Rugae are markedly axially elongated in outline with their edges usually sharp. On posterior auricle rugae usually distinctly weaker.

**Remarks**: The high inclination, axial elongation of the shell, and narrow, distinctly separated posterior auricle characterise this species. Although we referred this form to *C.?* aff. *barabini*, it is very similar to *C.? barabini* (MORTON, 1834), from which it differs slightly orna-

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Plate XI

Fig. 1-4: *Cataceramus* aff. *barabini* (MORTON, 1834); 1 – USNM 507549, 2 – USNM 507550, 3 – USNM 507544, 4 – USNM 507551; all from USGS Mesozoic locality D283; lower Upper Campanian; x 1.

Fig. 5, 9: *Cataceramus* aff. *subcompressus* (MEEK & HAYDEN, 1860); 5 - USNM 507545, 9 - USNM 507546; both from USGS Mesozoic locality 21574; lower Middle Campanian; x 1.

Fig. 6-8, 10, 12: *Cataceramus mortoni* (MEEK & HAYDEN, 1860); 6 – USNM 507543 from USGS Mesozoic locality 21574; 7 – USNM 507745, 8 – USNM 507744, 10 – USNM 507747, all from USGS Mesozoic locality 760; 12 – USNM 481, the holotype, original to MEEK (1876a, pl. 12, fig. 7); 6, 8, 10, 12 x 1; 7 x 0.9.

Fig. 11: "*Inoceramus*" sp.; USNM 507542, from USGS Mesozoic locality D2864; Upper Campanian; x 1.


1


2


3


4


5a


5b


6a


7


8


6b


9a


10


11


9b


12

mentation. The rugae in *C.? barabini* are symmetrical and besides umbonal part, where they resemble the ornament of *C.?* aff. *barabini*, they very quickly become less regular and less distinct ventrally. Moreover, *C.? barabini* often possesses a weak radial sulcus in the axial part of the disc, that is absent in *C.?* aff. *barabini*. The stratigraphic position of both taxa is also a very important difference; *C.?* aff. *barabini* is known from the *Didymoceras nebrascense* through the *Exiteloceras jenneyi* Zones, whereas *C.? barabini* occurs in the uppermost Campanian (*B. eliasi* Zone) through lowermost Maastrichtian (*B. grandis* Zone).

**Occurrence**: *Cataceramus?* aff. *barabini* occurs in the Western Interior from the *Didymoceras nebrascense* to *Exiteloceras jenneyi* Zones.

### *Cataceramus? barabini* (MORTON, 1834)
### Pl. XXXIII, figs 1, 3; Pl. XXXV, fig. 1; Pl. XXXVI, figs 2, 4, 6-7; Pl. XXXIX, figs 4-5; ?Pl. XL, fig. 5

1834. *Inoceramus Barabini* MORTON. p. 62, pl. 13, fig. 11; pl. 17, fig. 3.

? 1860. *Inoceramus cuneatus* MEEK & HAYDEN, p. 181.

1876a *Inoceramus Cripsii*?, 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 cripsii* var. *barabina* (sic) MORTON. - LOGAN, p. 504, pl. 109, fig. 2.

1913. *Inoceramus Barabini* MORTON. - BÖSE, 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. - KOCIUBYNSKIJ, p. 83 (?pars), ?pl. 23, fig. 2 [non pl. 20, fig. 1 = ?*Cataceramus subundatus* (MEEK)].

**Type**: The lectotype, by subsequent designation of MEEK (1876a, p. 55) is ANSP 15469, the original of MORTON's (1834, pl. 17, fig. 3; reillustrated herein in Pl. XXXIII, fig. 4) from the Upper Cretaceous strata of Greene County, Alabama.

**Material**: USNM 507662 from USGS Mesozoic locality D5670; USNM 507663; USNM 507664, USNM 507665 and USNM 507666 from USGS Mesozoic locality 24180; USNM 507667 from USGS Mesozoic locality D1048, USNM 507668 locality unknown.

USNM 507639 from "Fossil Creek just south of Fort Collins, Colorado. Obtained by C.A. White" [and old USNM locality 9974], located near locality 42 on fig. 3; Larimer Sandstone Member of the Pierre Shale; plaster cast of *Inoceramus barabini* var. *inflatiformis* DOUGLAS, 1942. Two unillustrated specimens of *Inoceramus barabini*, from the MEEK's original collection in the Smithsonian Museum, illustrated here in Pl. XXXVI, fig. 6-7.

*Dimensions*

| Specimen | h | l | H | L | s | α | δ | hmax |
|---|---|---|---|---|---|---|---|---|
| USNM 507663 | 54.5 | 42.0 | 39.6 | 53.5 | 34.5 | 117 | 37 | 67 (LV) |
| USNM 507668 | 63.0 | 51.5 | 46.0 | 63.4 | 41.5 | 110 | 33 | 79 (LV) |
| USNM 477 [MEEK 1876a, pl. 13, fig. 1a] | 79.0 | 55.0 | 57.0 | 75.5 | 41.5 | — | 36 | 102 (RV) |
| USNM 477 [MEEK 1876a, pl. 13, fig. 1b-c] | — | — | 53.0 | 35.0 | 30.0 | — | 34 | 63 (LV) |

**Description**: Small- to medium-sized, prosocline and distinctly oblique species. Anterior margin relatively short, straight, or slightly convex, passing into long antero-ventral margin, and thence into long, broadly convex ventral margin. Hinge line long, straight. Umbo small, trending dorso-anteriorly, projecting slightly, if at all, above hinge line. Posterior auricle small, triangular in outline, elongated parallel hinge line, weakly separated from disc.

Initial juvenile stage ornamented with regular commarginal rugae which become progressively less regular ventrally. Adult stage ornamentation ranging from irregularly spaced, low rugae to almost smooth.

**Remarks**: The type of MORTON's *Inoceramus barabini* represents one of the most common morphotypes among Campanian – Maastrichtian inoceramids; medium-sized, moderately inflated, posteriorly elongated with length markedly larger than height, strongly prosocline, and covered with regularly spaced rugae in juvenile stages becoming increasingly irregular in adult. Because of the type's incomplete preservation, which

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Plate XII

"*Inoceramus*" *pierrensis* sp. nov.; USNM 507566 from USGS Mesozoic locality D 3789; x 0.8.

lacks the postero-dorsal portion, the morphology of the posterior auricle is unclear. Judging by the preserved umbonal region, the auricle was most probably small and weakly separated from the disc.

Although we refer *C.? barabini* to Lower Maastrichtian forms, the *barabini* morphotype initially appears in the Campanian and then reappears in the Lower Maastrichtian. Sometimes almost identical forms may be found as less typical representatives of otherwise morphologically distinct species, as in case of Middle Campanian *Cataceramus subcompressus* (MEEK & HAYDEN, 1860; see Pl. VI, fig. 6 in this paper). On the other hand, as in lower Upper Campanian *Cataceramus*? aff. *barabini* (MORTON, 1834), the entire population is very similar to MORTON's species. Without knowing its stratigraphic position, a single specimen can be very difficult if not impossible to be correctly identified. We refer them to distinct taxa based on the stratigraphic gaps between particular occurrences, but further studies are needed to definitively demonstrate their taxonomic and evolutionary relationships.

Of the specimens referred to *I. barabini* by MEEK (1876a), only the small RV (MEEK 1876a, pl. 12, fig. 3) and two other unillustrated specimens (illustrated herein - Pl. XXXVI, figs 6 and 7) closely resemble MORTON's type (compare with Pl. XXXIII, fig. 4). His two other specimens (MEEK 1876a, pl. 13, fig. 1) differ considerably from MORTON's type; they have a distinctly raised umbonal part and a distinct posterior auricle, with well-developed auricular sulcus. Moreover, they have a slight axial radial sulcus not seen in MORTON's original. Both of MEEK's specimens are from the *Baculites grandis* Zone; a distinctly younger interval than the main occurrence interval of *C.? barabini*. However, identical forms are also known from the *Baculites baculus* Zone (see USNM 507668 and USNM 507663 – Pl. XXXIX, figs 4-5 herein), where they co-occur with forms typical of MORTON's species. Whether MEEK's specimens should still be included within the range of morphologic variability of *Cataceramus? barabini* or assigned to a separate species requires further study. If they are determined to be a separate species they should be referred to MEEK & HAYDEN's designated species *C.? cuneatus*.

The larger specimen of MEEK (1876a, pl. 13, fig. 1a) is a bivalved specimen with a well-preserved RV; the LV is markedly incomplete, lacking most of the anterior and antero-ventral parts. MEEK's smaller specimen (1876a, pl. 13, fig. 1b-c) is a single LV. In MEEK's original collection there are, moreover, two unillustrated specimens (one RV and one LV); these differ slightly from the illustrated forms, but are referred here also to the same species.

*Inoceramus barabini* var. *inflatiformis* of DOUGLAS (1942, p. 63, pl. 2, fig. 3 and reillustrated herein in Pl. XXXIII, fig. 3), described from the uppermost Campanian exposed along Boxelder Creek, Saskatchewan, Canada, about 190 m below the top of the Bearpaw Formation, is a large, distinctly geniculated specimen, about 130 mm long. Its juvenile part is weakly inflated. It is strongly oblique (with $\delta = 40°$) and ornamented with subregularly spaced, round-topped, closely spaced rugae, becoming less distinct ventrally. The adult stage is almost completely smooth. Thus, *I. barabini* var. *inflatiformis* represents a typical *Cataceramus? barabini* and, consequently, is regarded a junior synonym. The strong convexity mentioned by DOUGLAS (1942, p. 63) results from the preservation of the adult stage with growth almost perpendicular to the juvenile stage anteroventrally. The weak inflation of the juvenile stage is similar to MORTON's type.

**Occurrence**: According to MEEK, his originals (1876a, pl. 13, fig. 1) are from the "Yellowstone River, one hundred and fifty miles above its mouth, in Montana" and should come from the Lower Maastrichtian part of the Pierre Shale on the Cedar Creek anticline in eastern Montana. They are common in an interval spanning the *Baculites eliasi* through *Baculites baculus* Zones of the Western Interior.

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Plate XIII

Fig. 1, 5-6: *Sphaeroceramus pertenuiformis* sp. nov.; 1 – USNM 507557 from USGS Mesozoic locality D 1498; 5 – USNM 507554, from USGS Mesozoic locality USGS D 13589; 6 – USNM 507555 from USGS Mesozoic locality 760; 5 and 6 – juvenile stages only; lower Upper Campanian; 1, 6 x 1; 5 x 0.8.

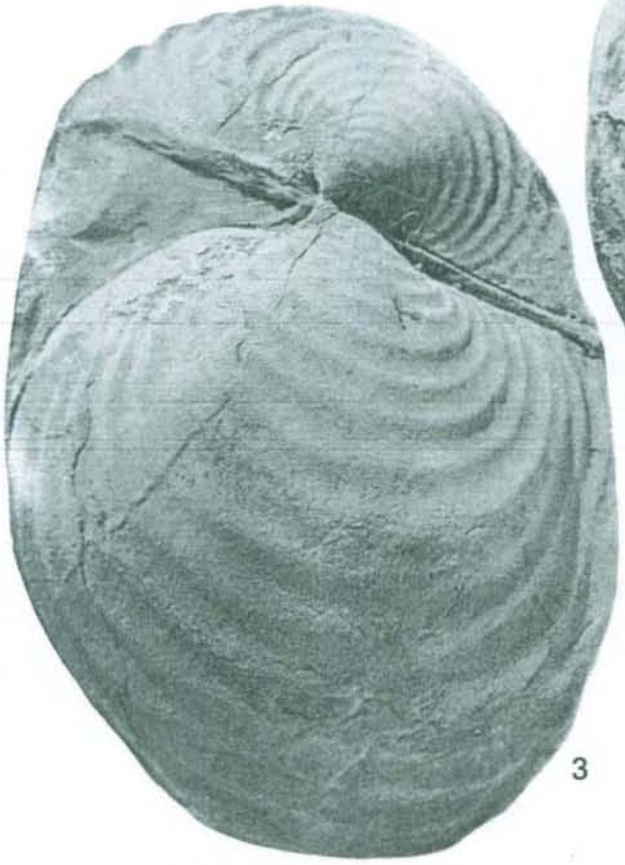
Fig. 2-3: *Cataceramus gandjaensis* (ALIEV, 1956); 2 – USNM 507564 and 3 – USNM 507565, both from USGS Mesozoic locality D 1498; Upper Campanian; 2 x 0.95; 3 x 0.9.

Fig. 4: "*Inoceramus*" cf. *tenuilineatus* HALL & MEEK, 1854; USNM 507559 from USGS Mesozoic locality D 1940; upper Middle Campanian; x 1.

1a

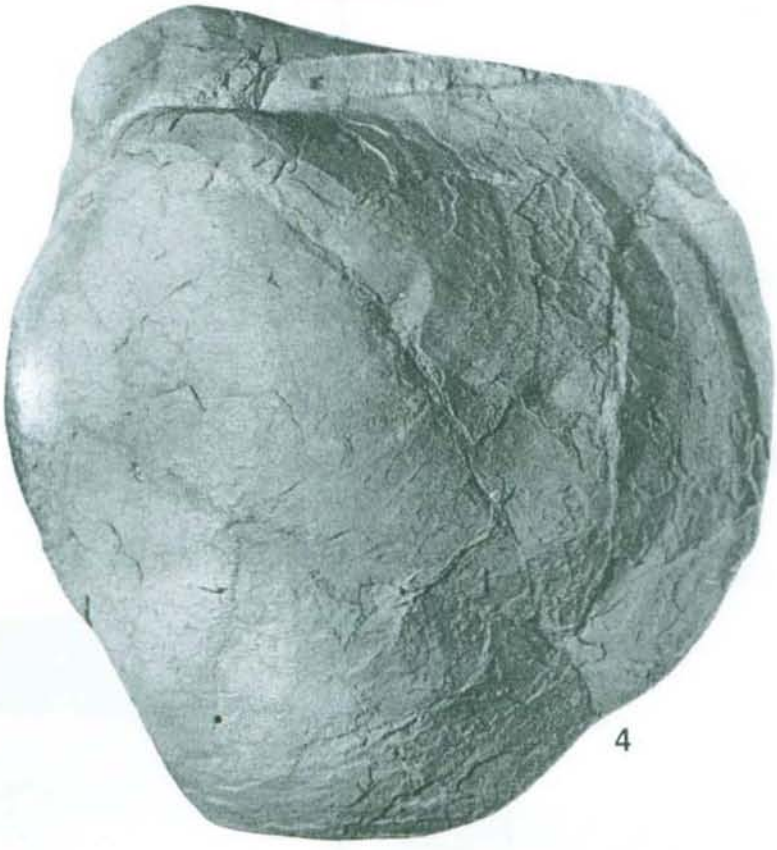
2a

2b



3

1b



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*Cataceramus? subcircularis* (MEEK, 1876a)
**Pl. XXXI, fig. 3; Pl. XXXVI, fig. 8; Pl. XXXVII, figs ?1, 2; Pl. XXXIX, figs 3, 6; Pl. XLI, fig. 1, ?2; Pl. XLII, fig. 1; Pl. XLIII, fig. 6; Pl. XLIV, fig. 5**

?1834. *Inoceramus Barabini* MORTON, p. 62 (pars), pl. 13, fig. 11 [non pl. 17, fig. 3 = *Inoceramus barabini* MORTON, 1834].
1876a. *Inoceramus proximus*? var. *subcircularis* MEEK, p. 55, pl. 12, fig. 2.
?1880. *Inoceramus vanuxemi* MEEK & HAYDEN. - WHITFIELD, p. 396 (pars), pl. 7, fig. 9 [non pl. 7, figs 8, 10].
?1913. *Inoceramus proximus* TOUMEY var. *subcircularis* MEEK. - BÖSE, p. 32, pl. 2, fig. 7.
1958. *Inoceramus regularis* D'ORBIGNY. - KOCIUBYNSKIJ, p. 19, pl. 9, figs 34-35.
1959. *Inoceramus buguntaensis* DOBROV & PAVLOVA, p. 140, pl. 22, fig. 1.
1968. *Inoceramus regularis* D'ORBIGNY. - KOCIUBYNSKIJ, p. 143, pl. 29, figs 1-2.
1969. *Inoceramus balticus rotatilis* KHALAFOVA, p. 231, pl. 28, fig. 2-4.
1974. *Inoceramus regularis* ORBIGNY. - KOCIUBYNSKIJ, p. 85, pl. 21, fig. 2; pl. 23, fig. 1.
1991. *Inoceramus regularis* D'ORBIGNY. - COBBAN & KENNEDY (pars), pl. 1, figs 16-17. [pl. 1, figs 18, 22 – *Trochoceramus* sp.].
1995. *Endocostea* (*Selenoceramus*) *semaili* MORRIS, p. 260, pl. 1, figs 5-6.
1996. "*Inoceramus*" sp. cf. *planus* (of authors) MÜNSTER. - WALASZCZYK, SMIRNOV & TRÖGER, pl. 5, fig. 4.
1997. *Inoceramus buguntaensis* DOBROV & PAVLOVA. - ATABEKIAN, p. 68, pl. 27, fig. 1.

**Type**: The holotype, by original designation, is USNM 479, the specimen illustrated by MEEK (1876a, p. 12, fig. 2; and reillustrated herein in Pl. XXXVI, fig. 8), from the Yellowstone River, about 150 miles above its mouth, from most probably the Lower Maastrichtian [upper part of Pierre Shale near Glendive, Montana].
**Material**: USNM 507635 from USNM locality 9974; USNM 507661 from USGS Mesozoic locality D5670; USNM 507670, USNM 507671 and USNM 507672 from USGS Mesozoic locality 24180; USNM 507673, USNM 507674, USNM 507675, USNM 507676, USNM 507677 and USNM 507678, all from USGS Mesozoic locality D877; USNM 507679 from USGS Mesozoic locality 24180; USNM 507680 from USGS Mesozoic locality D1048; USNM 507729 from USGS Mesozoic locality D5670; USNM 507714, Chadron, Nebraska, Conlin's collection, Lower Maastrichtian (*Baculites grandis* ammonite Zone); USNM 507732 from Canon Creek; YPM 191004, from the Glendive section, lowest Maastrichtian (*Baculites baculus* Zone); USNM 507651 from the Weston County, Wyoming (N1/2 sec. 10, T. 42 N., R. 62 W.), *Baculites grandis* Zone; USNM 507720 and USNM 507722, from USGS Mesozoic locality D 1042, *Baculites clinolobatus* Zone; USNM 507706 and USNM 507707 from USGS Mesozoic locality D 1986, *Baculites grandis* Zone; USNM 507748 from "Fossil Creek just south of Fort Collins, Colorado. Obtained by C.A. White" [and old USNM locality 9974], located near locality 42 on fig. 3; Larimer Sandstone Member of the Pierre Shale.

*Dimensions*

| Specimen | h | l | H | L | s | α | δ | hmax |
|---|---|---|---|---|---|---|---|---|
| USNM 507670 | 26.5 | 22.5 | 25.3 | 25.3 | 15.5 | 118 | 48 | 35 |
| USNM 507671 | 28.0 | 29.0 | 25.5 | 29.0 | 18.0 | 130 | 49 | 39 (RV) |
| USNM 507672 | 43.5 | 43.5 | 41.5 | 29.5 | 29.5 | 118 | 49 | 45 (RV) |
| USNM 507674 | 25.0 | 24.5 | 25.0 | 22.0 | — | 128 | 48 | — |
| USNM 507675 | 27.0 | 27.0 | 29.0 | 26.5 | — | 135 | 45 | 35 (LV) |
| USNM 507680 | 30.0 | 29.0 | 25.5 | 32.0 | 19.0 | 130 | 50 | 32 |
| USNM 507729 | 39.0 | 36.0 | 34.5 | 36.0 | 20.8 | 130 | 54 | 55 (RV) |
| USNM 507721 | 91.0 | 79.0 | 75.0 | 84.0 | 53.0 | 120 | 50 | 112 (RV) |
| USNM 507732 | 41.1 | 42.6 | 41.7 | 37.2 | — | 130 | 60 | 66.4 (RV) |

**Diagnosis**: Small- to moderate-sized, weakly inflated, prosocline species. Valves sub-circular in outline, moderately oblique. Juvenile stage ornamented with regular, sub-symmetrical comarginal rugae, with interspaces increasing gradually ventrally. Adult stage with rare, irregular rugae.
**Description**: Small to medium-sized, weakly inflated species. Valves moderately oblique (δ oscillating around 55°), rounded in outline, with rounded anterior, ventral and posterior margins. Hinge line moderately long, straight. Beak small, indistinct, does not or only slightly projecting above hinge line. Posterior auricle small or moderately large, not separated from disc.

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Plate XIV

Fig. 1, 3, 5: "*Inoceramus*" *pierrensis* sp. nov.; 1 – USNM 507740 from USGS Mesozoic locality D 1923; 3 – USNM 507562 and 5 – USNM 507563, both from USGS Mesozoic locality D 1048; *Baculites scotti* Zone; upper Middle Campanian; x 1 .
Fig. 2, 4: *Sphaeroceramus pertenuiformis* sp. nov.; 2 – USNM 507552 and 4 – USNM 507553, both from USGS Mesozoic locality D 1948; *Baculites scotti* Zone; upper Middle Campanian; x 0.8.


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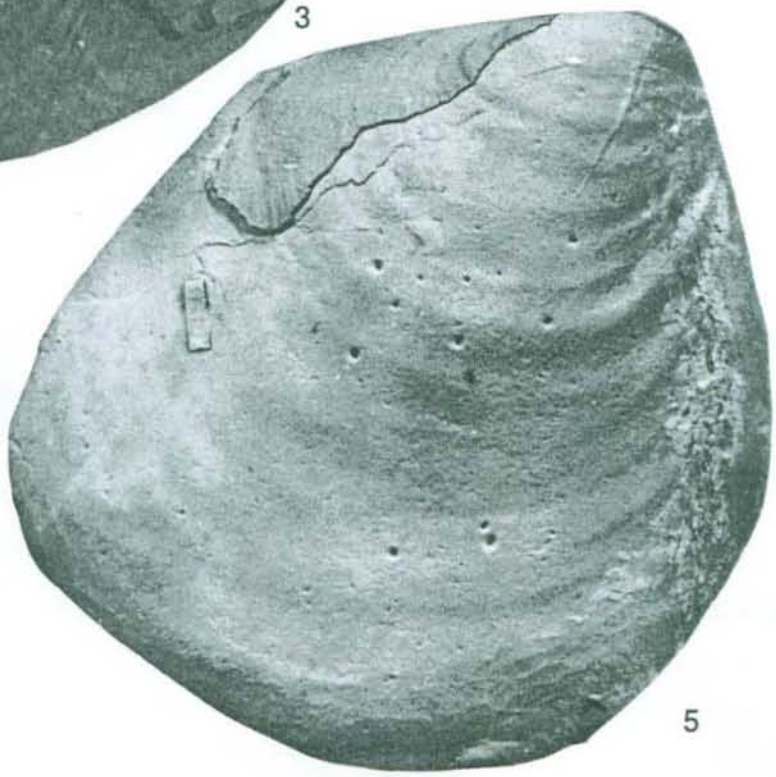
2


3


4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Juvenile stage ornamented with regularly spaced, subcircular, symmetrical rugae. Adult stage with more widely spaced, irregular rugae.

**Remarks**: *C.? subcircularis* is inevitably one of the most difficult species to interpret. The reasons are two-fold; firstly, the species was described based solely on juvenile specimens and, secondly, it represents a very simple morphotype, that is rather common in the fossil record, and consequently taxonomic decisions are difficult. There are a number of forms very similar to *C.? subcircularis*, and possibly conspecific, although current knowledge is insufficient to determine their definite taxonomic position.

*C.? subcircularis*, as interpreted herein, comprises weakly inflated, subcircular in outline specimens, with two distinct ontogenetic stages as well as with consistent ornament in the juvenile stage, whereas it becomes sub- to irregular in the adult. *Cataceramus? palliseri* (DOUGLAS) is morphologically almost indistinct, but differs in less circular ornament and distinctly higher shell obliquity (with δ approximately 40°) resulting from markedly increased posterior elongation. Moreover, the anterior margin is shorter in DOUGLAS's species. Both species differ also in the type of geniculation; *C.? palliseri* displays *balticus*-like geniculation, with a right-angle change of growth in the anterior and ventral parts and more or less continuous growth posteriorly whereas *C.? subcircularis* has a *Platyceramus*-type of geniculation with a rather weak change in growth direction and with juvenile and adult stages growing in the same planes.

Forms very similar to *C.? subcircularis* have been described from the Lower Maastrichtian of Madagascar and referred to *Inoceramus mandembataensis* by SORNAY (1973, p. 90, pl. 4, fig. 4). SORNAY based his concept on three small individuals, of which the one illustrated is identical to MEEK's species. The recently described species *Endocostea* (*Selenoceramus*) *semaili* MORRIS, 1995, from the Lower Maastrichtian of the United Arab Emirates-Oman border region is also very similar. *Inoceramus balticus rotatilis*, a subspecies described from the Lower Maastrichtian of the Lesser Caucasus by KHALAFOVA (1969, p. 231, pl. 28, figs 2-4), should also be included in *C.? subcircularis*. Numerous forms, such as *Inoceramus buguntaensis* DOBROV & PAVLOVA (see DOBROV & PAVLOVA, 1959, pl. 22, fig. 1; ATABEKIAN, 1997, pl. 27, fig. 1), from the Upper Campanian and/or Lower Maastrichtian of the Caucasus and the Crimea, are apparently conspecific with *C.? subcircularis*.

WHITFIELD's *Inoceramus vanuxemi* (WHITFIELD, 1880, pl. 7, fig. 9; pl. 8, fig. 5; reillustrated herein – Pl. XXXVII, fig. 2) and probably his second specimen (WHITFIELD, 1880, pl. 7, fig. 8; pl. 8, fig. 4; reillustrated herein – Pl. XXXVI, fig. 1) also belong to *C.? subcircularis*. Both have subcircular, regular ornament, and moderate obliquity typical of MEEK's taxon. The latter, however, may possibly represent less oblique *Cataceramus? palliseri* (DOUGLAS).

*C.? subcircularis* also resembles the Middle Campanian species, *C. subundatus* (MEEK), described from the US Pacific Coast. In Europe, specimens identical but not conspecific with *C.? subcircularis* from an equivalent stratigraphic position are usually referred to *Inoceramus planus* GOLDFUSS. The Middle Campanian forms differ in less regular ornament and relatively shorter hinge line.

**Occurrence**: In the Western Interior, the species spans the interval from the *Baculites reesidei* through *Baculites clinolobatus* Zones. It is known from the Lower Maastrichtian of Europe (Poland, The Ukraine, Russia, the Caucasus), and possibly from Asia (Arabian Peninsula) as well as from Madagascar.

*Cataceramus? palliseri* **(DOUGLAS, 1942)**
**Pl. XXVII, fig. 2; Pl. XXXIII, fig. 2; Pl. XXXVII, fig. 1**

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, ?9 [non pl. 7, fig. 10 = ?*Inoceramus vanuxemi* MEEK & HAYDEN].

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Plate XV

Fig. 1: "*Inoceramus*" *nebrascensis* OWEN, 1852; USNM 507581 from USGS Mesozoic locality D 79; *Exiteloceras jenneyi* Zone, lower Upper Campanian; x 1.

Fig. 2: *Cataceramus? agdjakendsis* ALIEV, 1952; USNM 507585 from USGS Mesozoic locality D 79; *Exiteloceras jenneyi* Zone, lower Upper Campanian; x 1.

Fig. 3: *Cataceramus* aff. *barabini* (MORTON, 1834); USNM 507574 from USGS Mesozoic locality D79; *Exiteloceras jenneyi* Zone, lower Upper Campanian; x 0.85.

Fig. 4: "*Inoceramus*"*pierrensis* sp. nov.; USNM 507578 from USGS Mesozoic locality D 79; *Exiteloceras jenneyi* Zone, lower Upper Campanian; x 1.

1

2a

2b

4

3

1942. *Inoceramus palliseri* DOUGLAS, p. 62, pl. 1, fig. 2.
1958. *Inoceramus balticus* BÖHM. - KOCIUBINSKIJ, p. 18 (pars), pl. 8, fig. 33.
1958. *Inoceramus impressus* D'ORBIGNY. - KOCIUBINSKIJ, p. 20, pl. 9, fig. 36.
1962. *Inoceramus regularis* D'ORBIGNY. - SORNAY, p. 120, fig. 1C; pl. 7(sic), fig. 3.
1964. *Inoceramus* cf. *regularis* D'ORBIGNY. - GIERS, p. 247, pl. 3, figs 3-4.
1968. *Inoceramus impressus* D'ORBIGNY. - KOCIUBINSKIJ, p. 144 (pars), pl. 28, fig. 1.
1974. *Inoceramus impressus* ORBIGNY. - KOTSUBINSKY, 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.
1995. *Endocostea* ? (*Cataceramus*) sp. indet. MORRIS, p. 261, fig. 2.
1997. *Cataceramus sornayi* (DHONDT). - WALASZCZYK, p. 26, pl. 32, figs 1-3.
1997. *Inoceramus artigesi* SORNAY. - WALASZCZYK, pl. 32, figs 4-5.

**Type**: The holotype, by original designation, is DOUGLAS's specimen GSC 8928, the original to DOUGLAS (1942, pl. 1, fig. 2), from Boxelder Creek, Saskatchewan, Canada about 180 m below the top of the Bearpaw Formation.

**Material**: USNM 507634 from USGS Mesozoic locality D 1949; USNM 507728, from USGS Mesozoic locality D5670; GSC 8928, plaster cast of the type of *Inoceramus palliseri* DOUGLAS.

*Dimensions*

| Specimen | h | l | H | L | s | α | δ | hmax |
|---|---|---|---|---|---|---|---|---|
| GSC 8928 (juvenile stage) | 66.0 | — | 45.0 | 71.0 | — | — | 43 | 110 |
| USNM 507728 | 37.0 | 35.5 | 32.3 | 37.8 | 23.0 | 140 | 45 | 57 (LV) |
| USNM 507748 (juveniles) | 70.0 | 56.0 | 60.0 | 75.0 | — | 150 | 55 | — |

**Description**: Medium to large-sized, inequilateral, equivalve, distinctly geniculated species. Juvenile part weakly inflated, adult part contacting juvenile at a very high angle (up to 90°). Beak small, indistinct, projecting slightly above hinge line. Anterior margin relatively short, rounded, passing into long broadly rounded ventral margin, and thence into rounded posterior margin. Hinge line long, straight. Posterior auricle very small, not separated from disc. Juvenile stage covered with regular, evenly spaced concentric rugae, relatively narrow. Adult stage almost smooth or with irregular, low rugae.

**Remarks**: *C.? palliseri* (DOUGLAS, 1942) is the correct name for forms referred in Europe to *C.? sornayi* (DHONDT, 1993), which was a new name proposed by DHONDT (1993) for D'ORBIGNY's *Inoceramus regularis*. It represents a prominently geniculated species, with weakly inflated and regularly ornamented juvenile stage, and with faintly rugate to smooth adult stage, especially on the posterior portion of the disc. The species is very similar to *Cataceramus balticus* (BÖHM), from which it differs in more postero-ventral elongation of ornament outline in juvenile stage. Moreover, both forms occur in stratigraphically distinct levels.

USNM 507748 [from "Fossil Creek just south of Fort Collins, Colorado, obtained by C.A. WHITE" (old USNM locality 9974), from the Larimer Sandstone Member of the Pierre Shale] represented by large, double-valved specimen (Pl. XXXI, fig. 3) is almost identical to DOUGLAS' type.

*Inoceramus* (*Selenoceramus*) *gladbeckensis* SEITZ (1967, p. 102, pl. 14, figs 1-4; pl. 15, figs 1-7), regarded by DHONDT (1993) as a very close associate of *I. regularis*, possesses a very similar outline, but its ornament is less regular on the juvenile stage and, moreover, its adult stage is strongly and quite regularly rugate.

Some forms referred by SORNAY (1976) to *I.* (*Platyceramus*) *artigesi* are conspecific with *C.? palliseri*, although this does not include the type of this species (SORNAY, 1976, pl. 1, fig. 1) which, with its circular ornament, narrow, regular rugae, and with flat-floored and wide interspaces, may represent a *Platyceramus* species. The second specimen of *I. artigesi* illustrated by SORNAY (1976, pl. 1, fig. 2) is, however, quite different in terms of both its valve outline and ornament. Some other specimens not illustrated but referred by SORNAY

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Plate XVI

Fig. 1: "*Inoceramus*" *pierrensis* sp. nov.; USNM 507568 from USGS Mesozoic locality D 79; *Exiteloceras jenneyi* Zone; lower Upper Campanian.

Fig. 2: "*Inoceramus*" *nebrascensis* OWEN, 1852; USNM 507567 from USGS Mesozoic locality D 79; *Exiteloceras jenneyi* Zone; lower Upper Campanian.

Both figures in natural size

1

2

to his new species, and housed in the Natural History Museum in Paris (see illustration in WALASZCZYK, 1997, pl. 32, figs 4-5) show, moreover, obvious geniculation. These two latter specimens are quite likely *C.? palliseri*.

Two specimens referred to *Inoceramus vanuxemi* by WHITFIELD (1880, pl. 7, figs 8-?9) also should be included within DOUGLAS' species. The third specimen of WHITFIELD's *I. vanuxemi* is much less oblique, most probably representing *Cataceramus? subcircularis*.

**Occurrence**: Western Interior; the *B. reesidei* and *B. baculus* Zones; it is known from the topmost Campanian and Lower Maastrichtian in Europe.

### *Cataceramus? oviformis* sp. nov.
### Pl. XLI, fig. 3

1929. *Inoceramus* sp. DANE, pl. 25, fig. 1.
1988. *Inoceramus balticus* BÖHM. - ALIEV & KHARITONOV *in* ALI-ZADE *et al.*, p. 266, pl. 21, fig. 1.
1996. *Endocostea* ex gr. *baltica* (BÖHM). - WALASZCZYK *et al.*, pl. 3, fig. 6.

**Type**: The holotype is USNM 131542, the original of *Inoceramus* sp. in DANE (1929, pl. 25, fig. 1) (Pl. XLI, fig. 3), from the Nacatoch Sand of the high bluff on the Ouachita River, 1.5 miles north of Arkadelphia, Clark County, Arkansas.

**Derivation of name**: Due to subrounded valve outline.

**Material**: USNM 131542, the holotype, from the Lower Maastrichtian Nacatoch Sand, and YPM 191000, from the *Baculites baculus* Zone, of the Glendive section, Montana.

**Diagnosis**: Species of moderate size, inequilateral, moderately inflated, with strongly, anteriorly convex anterior margin. Ornament composed of regular, evenly spaced rugae, with very gradual ventralward increase of interspaces.

**Description**: Moderate-sized, inequilateral, equivalve species. Valves oval in outline with elongation parallel to hinge line. Anterior margin strongly convex anteriorly, forming a regular, rounded lobe, passing into broadly convex ventral and posterior margins. Hinge line very long, straight. Umbo small, indistinct, not projecting above hinge line. Valves moderately inflated, with maximum inflation dorso-central. Posterior auricle small, narrow, elongated parallel to hinge line, not separated from disc.

Valves ornamented with regular, evenly to subevenly spaced rugae, with narrow interspaces, increasing progressively ventrally.

**Remarks**: The pattern of ornament present in *Cataceramus? oviformis* sp. nov. is very similar to that of *Cataceramus? palliseri* (DOUGLAS). It differs from this species first of all in shell outline, possessing a strongly convex anterior margin, forming a distinct anterior lobe. Moreover, it is more inflated in the juvenile stage, although this is a feature that is difficult to examine.

**Occurrence**: The species is known from the Lower Maastrichtian of Arkansas, in the Gulf Coast, and from Montana (*Baculites baculus* Zone) in the Western Interior. Rare specimens are known from the Lower Maastrichtian, *Belemnella lanceolata* Zone of the Middle Vistula section, central Poland (WALASZCZYK, in prep.), and from the Lower Maastrichtian of the Caucasus.

### *Cataceramus? gandjaensis* (ALIEV, 1956)
### Pl. XIII, figs 2-3; Pl. XIX, fig. 1

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.

**Type**: The lectotype, designated herein, is the original of ALIEV (1939, pl. 3, fig. 2 and reillustrated in ALIEV 1956, pl. 1, fig. 1) from the Upper Campanian of Kilidgad Mount, northern Minor Caucasus. According to ALIEV (1956, p. 463), the original is housed, in the Museum of the Gubkin Institute of Geology of the Azerbajian Academy of Sciences in Baku.

**Material**: USNM 507564 and USNM 507565 from USGS Mesozoic locality D1498; USNM 507570 from USGS Mesozoic locality D79; USNM 507594 from USGS Mesozoic locality 23072.

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Plate XVII

*Sphaeroceramus pertenuiformis* sp. nov.; USNM 507583 from USGS Mesozoic locality D 79; *Exiteloceras jenneyi* Zone; lower Upper Campanian; x 0.8.

*Dimensions*

| Specimen | h | l | H | L | s | α | δ | hmax |
|---|---|---|---|---|---|---|---|---|
| USNM 507564 | 74.5 | 82.5 | 67.5 | 83.0 | 51.0 | 135 | 45 | 85 (LV) |
| USNM 507565 | 66.2 | 74.0 | 62.1 | 74.3 | 42.0 | 130 | 55 | 94 (LV) [bi-valved] |
| USNM 507570 | 91.0 | 97.0* | 87.0 | 94.0 | 52.0 | 128 | 57 | 103 (RV) |
| USNM 507594 | 87.0 | 90.5 | 84.5 | 92.0 | 42.0 | 138 | 63 | 112 (LV) |

**Description**: Moderate to large sized for genus, inequilateral, equivalved. Shell weakly to moderately inflated, prosocline, with beak terminal, curved anteriorly. Valve outline subquadrate (with h/l ratio averaging 0.9), weakly elongated postero-ventrally. Growth axis slightly convex anteriorly, with inclination angle between 50 and 60°. Umbonal region small, indistinct. Anterior margin markedly convex anteriorly, slightly concave near beak, with anterior face low, flattened. Ventral margin broadly convex, rounded in outline, passing into slightly convex to almost straight posterior margin. Hinge line straight, moderately long, with s/h ratio ranging from 0.5 to 0.6. Posterior auricle of moderate size, other than in umbonal region transition is continuous onto disc.

Ornament composed of regular, widely spaced, symmetrical rugae. No discernible offset when passing from disc onto posterior auricle. Their relation to growth lines was not observed on specimens studied, but seems to lie parallel.

**Remarks**: *Cataceramus? gandjaensis* is very similar to *Cataceramus? gandjaeformis* sp. nov. from the *Baculites reesidei* Zone, from which it differs in the character of the ornament. Concentric rugae in the latter species are sharp-edged and, moreover, they form a distinct angle in the posterior part of the disc, running virtually perpendicular to the hinge line, and thence approximating the hinge line they curve toward the umbo.

It differs from *Inoceramus goldfussianus* D'ORBIGNY due to a higher h/l ratio, which in *C.? gandjaensis* varies around 0.9, and which in D'ORBIGNY's species, including the type (SORNAY, 1957a, 1976; DHONDT, 1993) averages approximately 0.6. Moreover, the ornament in *I. goldfussianus* is, in general, more robust.

*Inoceramus artigesi*, described from the uppermost Campanian/lowermost Maastrichtian of SW France (SORNAY, 1976, pl. 1, fig. 1) is very similar to *C.? gandjaensis*. SORNAY (1976, and in collections) referred a series of forms to his new species which should be referred to *Cataceramus? palliseri* (DOUGLAS).

**Occurrence**: Known from the *Didymoceras stevensoni* through the *Baculites compressus* Zones in the Western Interior. Known from the Caucasus where it is imprecisely constrained to the Late Campanian.

### *Cataceramus? gandjaeformis* sp. nov.
### Pl. XXV, fig. 3; Pl. XXVI, fig. 1; Pl. XLI, fig. 5

1974. *Inoceramus wegneri* BOEHM. - KOCIUBYNSKIJ, p. 84, pl. 20, fig. 2.

? 1993. *Platyceramus* cf. *artigesi* SORNAY. - DHONDT, p. 231, pl. 5, fig. 5.

**Type**: The holotype is USNM 507648 from USGS locality D2849 (Pl. XXV, fig. 3); *Baculites reesidei* ammonite Zone of the upper Upper Campanian.

**Derivation of name**: Similar to *Cataceramus? gandjaensis* (ALIEV, 1956).

**Material**: USGS 507647 from USGS Mesozoic locality D 373. USNM 507648, from USGS Mesozoic locality D2849; USNM 507633, from USGS Mesozoic locality D1949.

*Dimensions*

| Specimen | h | l | H | L | s | α | δ | hmax |
|---|---|---|---|---|---|---|---|---|
| USNM 507647 | 61.5 | 70.0 | 56.5 | 72.0 | 35.0 | 135 | 68 | 127 |
| USNM 507648 | 42.0 | 47.0 | 39.5 | 48.0 | 23.5 | 135 | 67 | 94(RV) |

**Diagnosis**: Medium-sized, prosocline, flat, inequilateral species with subquadrate outline and very low obliquity. Valves ornamented with regular, symmetrical rugae.

**Description**: Moderate-sized, prosocline, weakly oblique and very weakly inflated species. Beak small, indistinct, projecting slightly above hinge line. Anterior margin short, weakly convex, passing into long, rounded antero-ventral margin and thence into rounded ventral margin. Posterior margin almost straight, running almost perpendicular to hinge line with distinct anterior curve at very dorsal part. Hinge line straight, long, and about 60% of respective axial length. Posterior auricle large, very weakly separated from disc.

Shell ornamented with regularly spaced, symmetrical rugae, with interspaces increasing regularly ventralward. In anterior portion in close proximity to growth axis, rugae sometimes become faint disrupting the regular outline.

**Remarks**: In the material studied, the species is known from the three specimens, the holotype (Pl. XXV, fig. 3), USNM 507633 and USNM 507647. The latter specimen

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Plate XVIII

*Sphaeroceramus pertenuiformis* sp. nov.; USNM 507584 from USGS Mesozoic locality D 2854; *Exiteloceras jenneyi* Zone; lower Upper Campanian; x 0.8.

(Pl. XLI, fig. 5) is more rounded ventrally resembling *Cataceramus? gandjaensis* (ALIEV). It possesses, however, a very characteristic ornament outline in the posterior part of the shell with straight rugae, oriented virtually perpendicular to the hinge line. *Inoceramus wegneri* BÖHM from the Upper Campanian of the Ukraine (KOCIUBYNSKIJ, 1974, pl. 20, fig. 2) is very similar to this specimen. It most probably belongs to our species. Specimens from the Vistula section (WALASZCZYK, in prep.) are closer to the holotype.

*Platyceramus* cf. *artigesi* (SORNAY, 1976), reported from the uppermost Campanian *Nostoceras hyatti* Zone, of Tercis, SE France, by DHONDT (1993, pl. 5, fig. 5) is very similar to our specimens, particularly to KOCIUBYNSKIJ's specimen. As in *C.? gandjaeformis*, it possesses a distinct disc, with a large posterior auricle, bearing rugae running parallel to the posterior margin. *Inoceramus artigesi*, to which it was compared by DHONDT (1993), possesses almost circular rugae outline, with sharp edges and flat-floor interspaces (SORNAY, 1976, pl. 1, fig. 1).

**Occurrence**: In the Western Interior, *Cataceramus? gandjaeformis* is known from the *Baculites reesidei* and *Baculites jenseni* Zones. It is also found in the Upper Campanian of The Ukraine and in the uppermost Campanian *Nostoceras hyatti* Zone of the Vistula section, Central Poland.

### *Cataceramus? glendivensis* sp. nov.
### Pl. XLII, fig. 2, 11; Pl. XLIV, figs 2, 4

**Type**: The holotype is YPM 191001 (Pl. XLII, fig. 2) from the upper part of the *Baculites baculus* Zone of the Glendive section. YPM 191002 (PL. XLII, fig. 11), USNM 507649 and USNM 507650 are paratypes.

**Derivation of the name**: After the Glendive section, where this species is very well represented.

**Material**: YPM 191001, YPM 191002, from unit 10 of the Glendive section, Montana (Fig. 4); USNM 507649 and USNM 507650, from the *Baculites grandis* Zone of Weston County, Wyoming (N1/2sec. 10, T. 42 N., R. 62 W.); numerous unregistered specimens in the collections of the University of South Florida from the upper part of the *Baculites baculus* and from the *Baculites grandis* Zones.

**Description**: Species of medium to large size, weakly inflated, with maximum inflation dorsal. Valves markedly oblique (with measured δ values ranging between 38 and 45°). Anterior margin very short, slightly convex, passing into very long, broadly convex ventral margin, and thence into acutely convex posterior margin. Hinge line long, straight. Umbo pointed, projecting slightly above hinge line. Posterior auricle narrow, weakly separated from disc.

Valves ornamented with sub-regularly spaced, rounded, sub-symmetrical rugae, with interspaces increasing distinctly ventrally. Interspaces generally rounded in cross-section.

**Remarks**: In valve outline and type of ornament our specimens are very similar to *Inoceramus bebahoaensis* described by SORNAY (1973, pl. 3, figs 1-2), from the Lower Maastrichtian of Madagascar, particularly to his weakly inflated specimen no. 18-3 (SORNAY, 1973, pl. 3, fig. 2). The type of *I. bebahoensis*, MNHP 494-10, and the third illustrated specimens (SORNAY, 1973, pl. 3, fig. 1 and pl. 4, fig. 5 respectively), judging by his illustrations, are much more inflated and moreover, their ornament is more regular. '*Endocostea*' *bebahoaensis* of MORRIS (1995, pl. 2, figs 1-2) is even more distinct. His specimens are markedly more inflated and moreover, are characterised by different ornament.

**Occurrence**: To date, the species is known from the upper part of the *Baculites baculus* and from the *Baculites grandis* ammonite Zones of the Western Interior, and from the Lower Maastrichtian of Madagascar.

### *Cataceramus? agdjakendsis* (ALIEV, 1952)
### Pl. VII, fig. 7, 10; Pl. XV, fig. 2

1952. *Inoceramus agdjakendsis* ALIEV, p. 601, unnumbered figure.
1959. *Inoceramus adgiakendsis* (sic) ALIEV. - DOBROV & PAVLOVA, p. 139, pl. 16, figs 1-2.
1964. *Inoceramus balticus sublevigatus* GIERS, p. 245, pl. 3, fig. 1.
1964. *Inoceramus balticus ellipticus* GIERS, p. 244 (pars).

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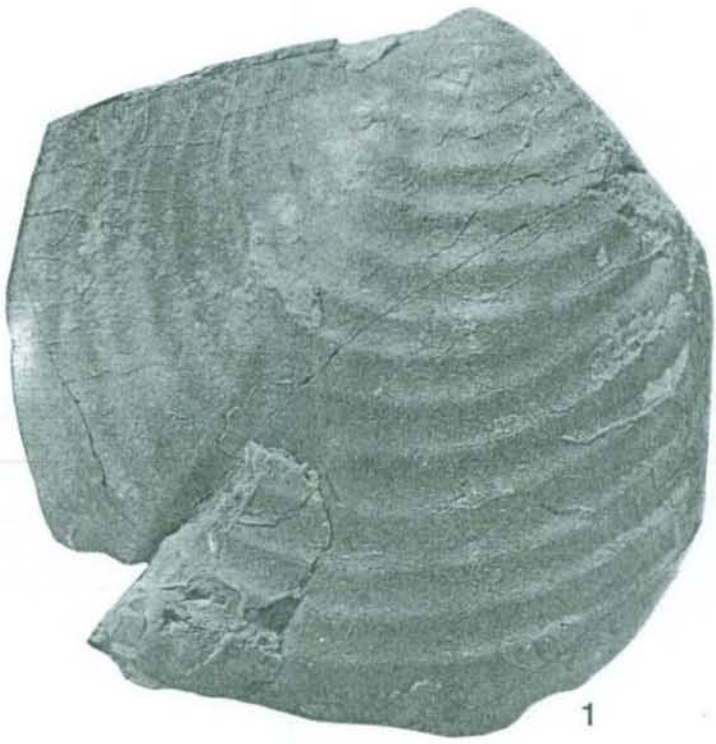
Plate XIX

Fig. 1: "*Cataceramus*" *gandjaensis* (ALIEV, 1956); USNM 507570 from USGS Mesozoic locality D 79; *Exiteloceras jenneyi* Zone; lower Upper Campanian.

Fig. 2-3: *Sphaeroceramus pertenuiformis* sp. nov.; 2 – USNM 507572 and 3 – USNM 507571, both from USGS Mesozoic locality D 79; *Exiteloceras jenneyi* Zone; lower Upper Campanian.

All figures in natural size



1

2a

3

2b

non 1982. *Inoceramus agdjakendensis* (sic) ALIEV. - MASSLENNIKOVA, pl. 9, fig. 3.
1994. *Inoceramus (Cataceramus) balticus* BÖHM. - HAUSCHKE, pl. 20, fig. 2.
1997. *Inoceramus agdjakendsis* ALIEV. - WALASZCZYK, p. 33, pl. 10, fig. 6; pl. 25, figs 2-3; pl. 26, figs 1-3; pl. 29, fig. 2.

**Type**: The holotype, by original designation, is the original to ALIEV (1952, unnumbered figure), from the Campanian of Agdjakend in the Caucasus, and according to ALIEV (1952), it is housed in the Museum of the Geological Institute at the Azerbaijan Academy of Sciences in Baku.
**Material**: USNM 507525 and USNM 507731 from USGS Mesozoic locality D1900, and probably also USNM 507585, from USGS Mesozoic locality D79.

*Dimensions*

| Specimen | h | l | H | L | s | δ | α | γ | hmax |
|---|---|---|---|---|---|---|---|---|---|
| USNM 507525 | 61.0 | — | 46.0 | 58.6 | 39 | 35 | 117 | 125 | 82.0 |
| USNM 507585 | 55.0 | — | 40.5 | 53.5 | 39.5 | 40 | 114 | — | 55.0 (bivalved) |
| USNM 507731 | 60.8 | 47.0 | 46.0 | 58.7 | — | 38 | 124 | — | 60.8 (bivalved) |

**Description**: Medium sized for genus, inequilateral, equivalved. Shell elongated distinctly postero-ventrally, hinge line straight, long. Umbo moderately massive, located anteriorly, projecting slightly above the hinge line. Anterior margin rounded, convex, passing into long broadly convex ventral margin, and relatively short, slightly concave posterior margin. Growth axis straight in juvenile part, slightly convex ventrally in adult. Posterior auricle moderately large, in juvenile stage distinct from disc, but in adult stage continuous onto disc. Ornament consists of irregular, low, concentric rugae and weak, regularly spaced, sub-even concentric ribs.
**Remarks**: When compared to the type specimen (ALIEV, 1952) or German material from Westphalia (WALASZCZYK, 1997, pl. 10, fig. 6; pl. 25, figs 2-3; pl. 26, figs 1-3; pl. 29, fig. 2), where the species is common, the American forms are more inflated with more massive umbones. However, the material from Europe is represented by laterally compressed specimens.
**Occurrence**: In the Western Interior, *C.? agdjakendsis* occurs in the *Baculites perplexus* and *Baculites gregoryensis* Zones. Known from the lowermost Middle Campanian of Germany; commonly reported from Russia, The Ukraine, the Caucasus, western Central Asia, apparently from the same interval.

## Genus *Sphaeroceramus*, HEINZ, 1932

**Type species**: *Inoceramus subsarumensis* RENNGARTEN, 1926 (=*Inoceramus pila* HEINZ, 1932), the concept based on *Inoceramus inconstans* WOODS (1912, fig. 48) from the ?Lower Campanian of England (locality unknown).
**Description and remarks**: The genus comprises highly inflated to almost spherical species, weakly ornamented with growth lines and relatively rare rugae to almost completely smooth. Usually they have a well-developed posterior auricle that is distinct from disc and separated by a weak posterior radial sulcus. Hinge line long, straight. Species within the genus *Sphaeroceramus* include: *Sphaeroceramus sarumensis* (WOODS, 1912), *Sph. subsarumensis* (RENNGARTEN, 1926) (= *Sph. pila* HEINZ, 1932), *Sph. pertenuis* (MEEK & HAYDEN, 1856), and *Sph. pertenuiformis* sp. nov.
COX (1969, p. N315) synonymised the genus with subgenus *Cremnoceramus* COX, 1969, and similarly sphaeroceramid species were referred to *Cremnoceramus* by DHONDT (1993) and TRÖGER *et al.* (1999). However, the *Cremnoceramus* lineage apparently terminated prior to the end of the Early Coniacian. *Sphaeroceramus* is more similar to *Cordiceramus* than to latest Turonian/early Coniacian *Cremnoceramus*.
**Occurrence**: Lower through lower Upper Campanian of Europe and North America.

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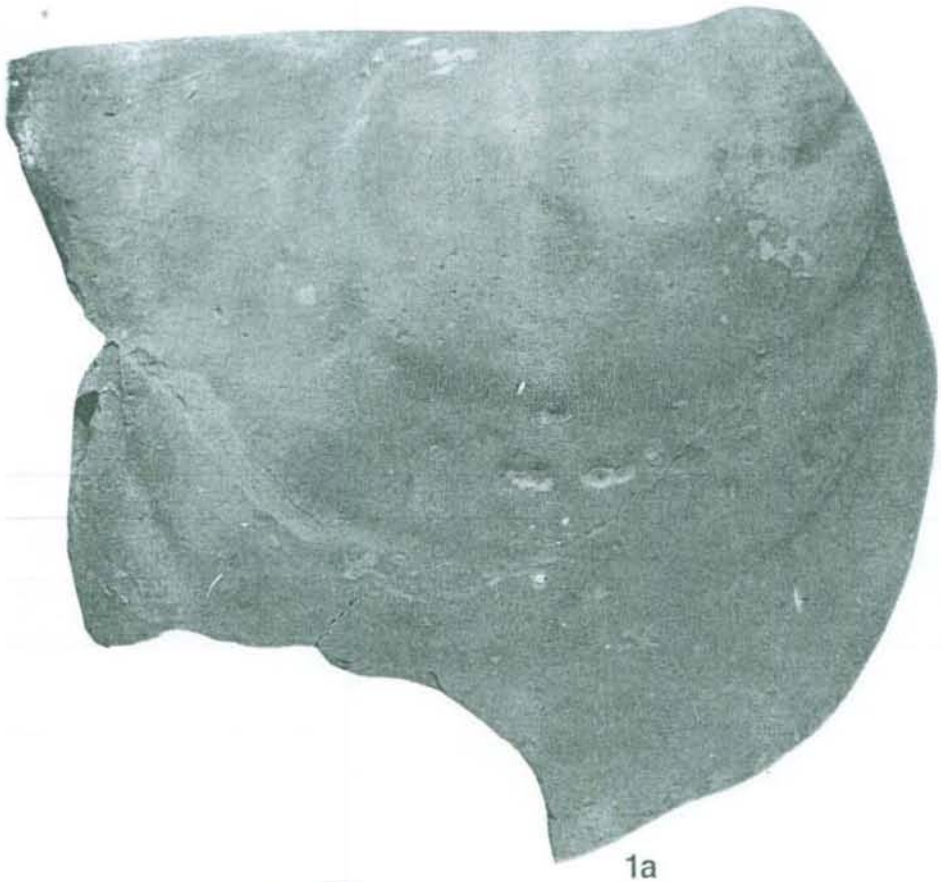
Plate XX

Fig. 1: "*Inoceramus*" *nebrascensis* OWEN, 1852; USNM 507586 from USGS Mesozoic locality D 79; *Exiteloceras jenneyi* Zone; lower Upper Campanian.
Fig. 2: "*Inoceramus*" *whitfieldi* sp. nov.; USNM 507579 from USGS Mesozoic locality D 3713; *Exiteloceras jenneyi* Zone; lower Upper Campanian.
Fig. 3: *Sphaeroceramus pertenuiformis* sp. nov.; USNM 507571 from USGS Mesozoic locality D 79; *Exiteloceras jenneyi* Zone; lower Upper Campanian.

All figures in natural size



1a

1b

2

3

### *Sphaeroceramus sarumensis* (WOODS, 1912)
### Pl. VIII, fig. 3

1876a. *Inoceramus pertenuis* MEEK & HAYDEN. - MEEK, p. 47 (pars), pl. 38, fig. 3a (only).
1912. *Inoceramus inconstans* var. *sarumensis* WOODS, p. 293, pl. 52, figs 2-3.
1928. *Inoceramus sarumensis* WOODS. - HEINZ, pl. 3.
1974. *Inoceramus subsarumensis* RENNGARTEN. - ATABEKIAN, p. 216, pl. 107, fig. 2.
1982. *Inoceramus sarumensis* WOODS. - SORNAY, p. 5, pl. 1, fig. 3; pl. 2, figs 2-3.
1997. *Sphaeroceramus sarumensis* (WOODS). - WALASZCZYK, p. 31, pl. 1, figs 1-2, 5; pls 21-22.
? 1999. *Cremnoceramus sarumensis* (WOODS). - TRÖGER, SUMMESBERGER & SKOUMAL, p. 50, pl. 1, fig. 1; pl. 4, fig. 4.
1999. *Inoceramus sagensis* OWEN. - TRÖGER, SUMMESBERGER & SKOUMAL, p. 48, pl. 2, fig. 4.

**Type**: The lectotype, by subsequent designation of WALASZCZYK (1997, p. 31) is the Natural History Museum specimen illustrated by WOODS (1912, pl. 52, fig. 2) from the H.P. BLACKMORE collection, Upper Chalk of England, Lower Campanian *G. quadrata* Zone, East Harnham, Salisbury, Wiltshire.

**Material**: Single specimen, USNM 316192c, from MEEK's original collection.

**Description**: USNM 316192c is a bivalved, medium-sized specimen, apparently undeformed internal sandstone mould with large parts of the shell preserved, primarily from adulthood. The ligament is not preserved. Its juvenile stage is moderately inflated. The beak is small, pointed, curved anteriorly, and does not project above the hinge line. A small, indistinct step which may represent a minor positive geniculation, or possibly the effects of secondary deformation, delineates the onset of the adult stage. Shell surface almost smooth, with very low, irregularly spaced rugae best developed in juvenile stage.

**Remarks**: USNM 316192c referred here to *Sphaeroceramus sarumensis* is one of MEEK's originals of *I. pertenuis* (MEEK, 1876a, pl. 38, fig. 3a). It differs, however, from the latter species in lacking a negative geniculation as well as in the postero-ventral elongation of the adult shell.

*Sphaeroceramus pertenuis* and *Sphaeroceramus sarumensis* are closely allied forms. *Sph. pertenuis* differs from WOODS' species dominantly by the presence of a distinctly geniculated juvenile stage (with negative geniculation). Moreover, when compared to larger specimens of *Sph. sarumensis* (e.g., those illustrated by WALASZCZYK, 1997, pls 21-22), *Sph. pertenuis* is markedly more expanded anteriorly in the adult stage (possessing lower H/L ratio). This comparison is somewhat problematic, however, because larger European specimens are significantly deformed.

**Occurrence**: According to MEEK (1876a, p. 48), the specimen comes from a brown sandstone outcropping at the mouth of the Judith River in central Montana. There are two sandstones found in faulted structures at the mouth of Judith River. One is the Eagle Sandstone, dated to the *Scaphites hippocrepis* Zone, and the other is a regressive sandstone at the top of the Claggett Shale that probably correlates to the *Baculites asperiformis* Zone. *Sph. sarumensis* is well known from Europe, where it occurs in the upper Lower Campanian and lowermost Middle Campanian (*stobaei/basiplana* and *conica/mucronata* Zones in echinoid/belemnite zonation) of England, Germany, Belgium, and the Caucasus.

### *Sphaeroceramus pertenuis* (MEEK & HAYDEN 1856)
### Pl. VIII, figs 1-2, 5

1856. *Inoceramus ventricosus* MEEK & HAYDEN, p. 87.
1856. *Inoceramus pertenuis* MEEK & HAYDEN, p. 276.
1876a. *Inoceramus pertenuis* MEEK & HAYDEN. - MEEK, p. 47 (pars), pl. 37, fig. 3; pl. 38,

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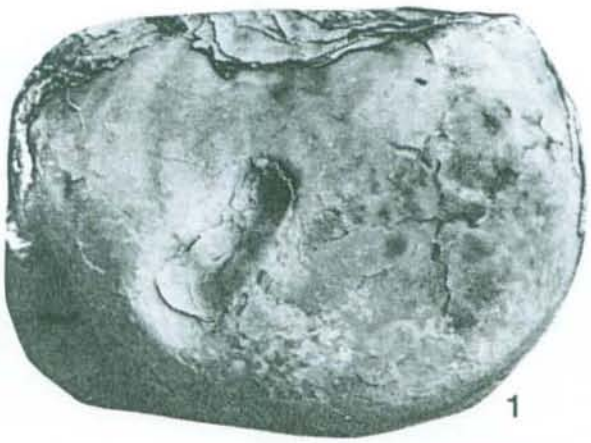
Plate XXI

Fig. 1, 3-4: *Sphaeroceramus pertenuiformis* sp. nov.; 1 – USNM 507620, 3 – USNM 507757, 4 – USNM 507756; all from the boundary interval between the *Didymoceras stevensoni and Exiteloceras jenneyi* Zones, in Weston County, Wyoming (SW1/4 sec. 29, T. 43 N., R. 61 W.); lower Upper Campanian.

Fig. 2: "*Inoceramus*" *whitfieldi* sp. nov.; USNM 507627 from the boundary interval between the *Didymoceras stevensoni and Exiteloceras jenneyi* Zones, in Weston County, Wyoming (SW1/4 sec. 29, T. 43 N., R. 61 W.); lower Upper Campanian.

All figures in natural size



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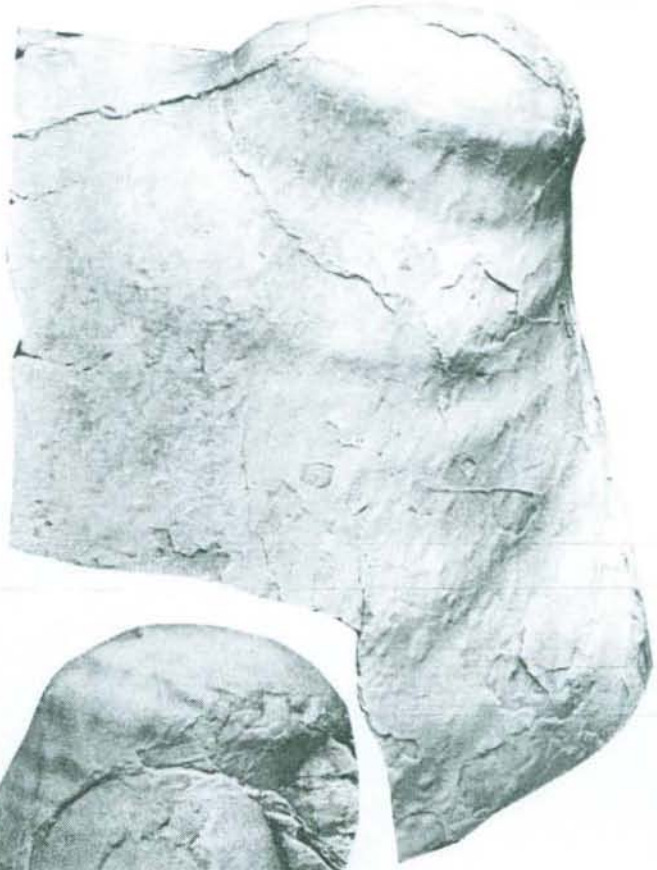
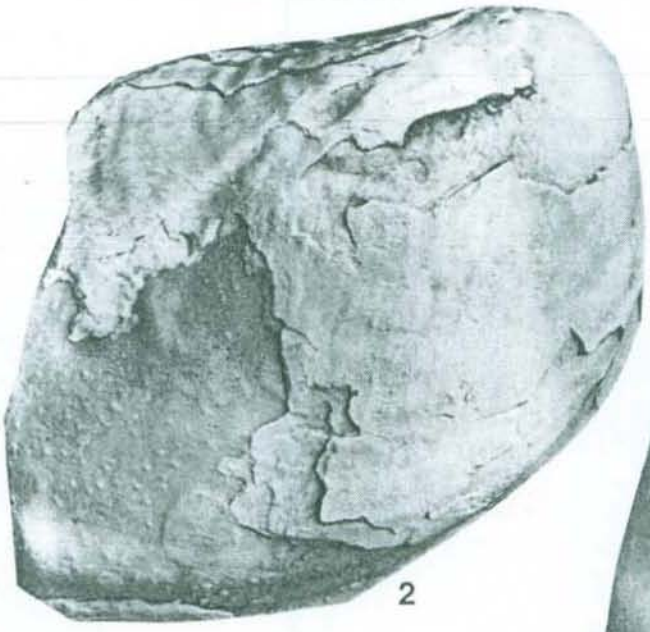
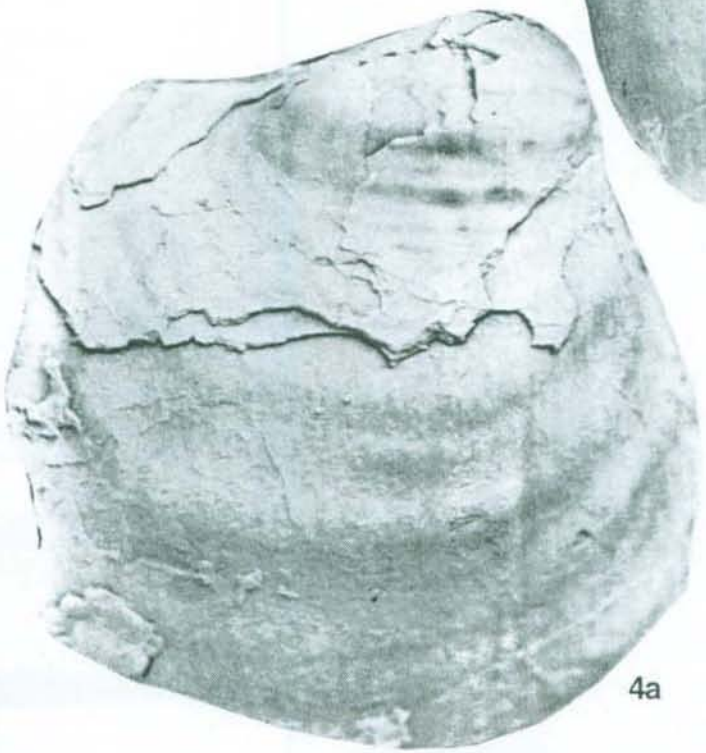


3a



2

4b



4a

3b

fig. 3b [non pl. 38, fig. 3a = *Sphaeroceramus sarumensis* (WOODS, 1912)].

non 1959. *Inoceramus pertenuis* MEEK. - DOBROV & PAVLOVA, p. 156, pl. 20, fig. 2.

**Type**: The holotype, by original designation, is USNM 182, the original of MEEK (1876a, pl. 38, fig. 3b) (reillustrated herein – Pl. VIII, fig. 2) from a brown sandstone at the mouth of Judith River in central Montana, uppermost Lower (*Scaphites hippocrepis* Zone) or basal Middle Campanian (*Baculites asperiformis* Zone).

**Material**: Three specimens from MEEK's (1876a) original collection.

**Description**: Medium-sized, inequilateral, equivalve, moderately inflated species. Beak small, projecting slightly above hinge line. Umbonal region small, indistinct. Valves with two distinct ontogenetic stages separated by well-developed negative geniculation. Juvenile stage relatively small, subrounded in outline, moderately to strongly inflated, moderately oblique. Adult stage much larger, growth oriented in the same direction as juvenile stage, subquadrate to subrounded in outline.

Both juvenile and adult stages are weakly ornamented, almost smooth with the exception of raised growth lines. Irregular concentric rugae are limited to juvenile stage and to the ventralmost part of adult stage.

**Remarks**: *Sphaeroceramus pertenuis* closely resembles *Sph. sarumensis*; it can be differentiated through its distinct juvenile stage, which, moreover, is less oblique and completely smooth in comparison to WOODS' species, which may possess irregular ornament. The other species, which potentially is closer to *Sph. pertenuis* than we interpret here, is *Sphaeroceramus pertenuiformis* sp. nov. It comes from the basal Upper Campanian *Didymoceras stevensoni* and *Exiteloceras jenneyi* Zones, and differs in the manner of growth during the adult stage, with a long, straight to even slightly concave anterior margin. Moreover, it possesses two geniculation points, one positive and one negative, with usually a well-developed neck. The number of specimens of *Sph. pertenuis* we studied was too limited (consisting solely of MEEK's types) to assess more thoroughly the range of variation of this taxon.

The only European report of "*I.*" *pertenuis* is that of DOBROV & PAVLOVA (1959), and it cannot be confirmed. Their specimen, from the "Upper Campanian" of Daghestan, possesses a distinctly ornamented, *balticus*-like juvenile part, as well as a relatively large adult stage, which is clearly distinct from that observed in MEEK's species. The specimen is markedly deformed but, most probably, it represents a form allied to *C. subcompressus* (MEEK & HAYDEN).

**Occurrence**: The types illustrated by MEEK (1876a, pl. 37, fig. 3; pl. 38, fig. 3) are from brown sandstones at the mouth of Judith River and according to ammonite data may come from the Lower Campanian *Scaphites hippocrepis* Zone or from the lower Middle Campanian *Baculites asperiformis* Zone.

### *Sphaeroceramus pertenuiformis* sp. nov.
### Pl. XIII, figs 1, 5-6; Pl. XIV, figs 2, 4; Pl. XVII-XVIII; Pl. XIX, figs 2-3; Pl. XX, fig. 3; Pl. XXI, figs 1, 3-4

**Type**: The holotype is USNM 507552 (Pl. XIV, fig. 2) from the USGS Mesozoic locality D 1948. USNM 507553 (Pl. XIV, fig. 4), USNM 507554 (Pl. XIII, fig. 5), USNM 507555 (Pl. XIII, fig. 6), USNM 507556, USNM 507557 (Pl. XIII, fig. 1), USNM 507558, USNM 507571 (Pl. XIX, fig. 3; Pl. XX, fig. 3), USNM 507572 (Pl. XIX, fig. 2), USNM 507573, USNM 507583 (Pl. XVII), USNM 507584 (Pl. XVIII), USNM 507620, USNM 507756, and USNM 507757 are paratypes.

**Derivation of the name**: Similar to *Sphaeroceramus pertenuis* (MEEK & HAYDEN, 1856).

**Material**: USNM 507552 and USNM 507553 from USGS Mesozoic locality D1948; USNM 507554 from USGS Mesozoic locality D1358; USNM 507555 from USGS Mesozoic locality 760; USNM 507556, USNM 507557 and USNM 507558, from USGS Mesozoic locality D1498; USNM 507571, USNM 507572 and USNM 507573, from USGS Mesozoic locality D79;

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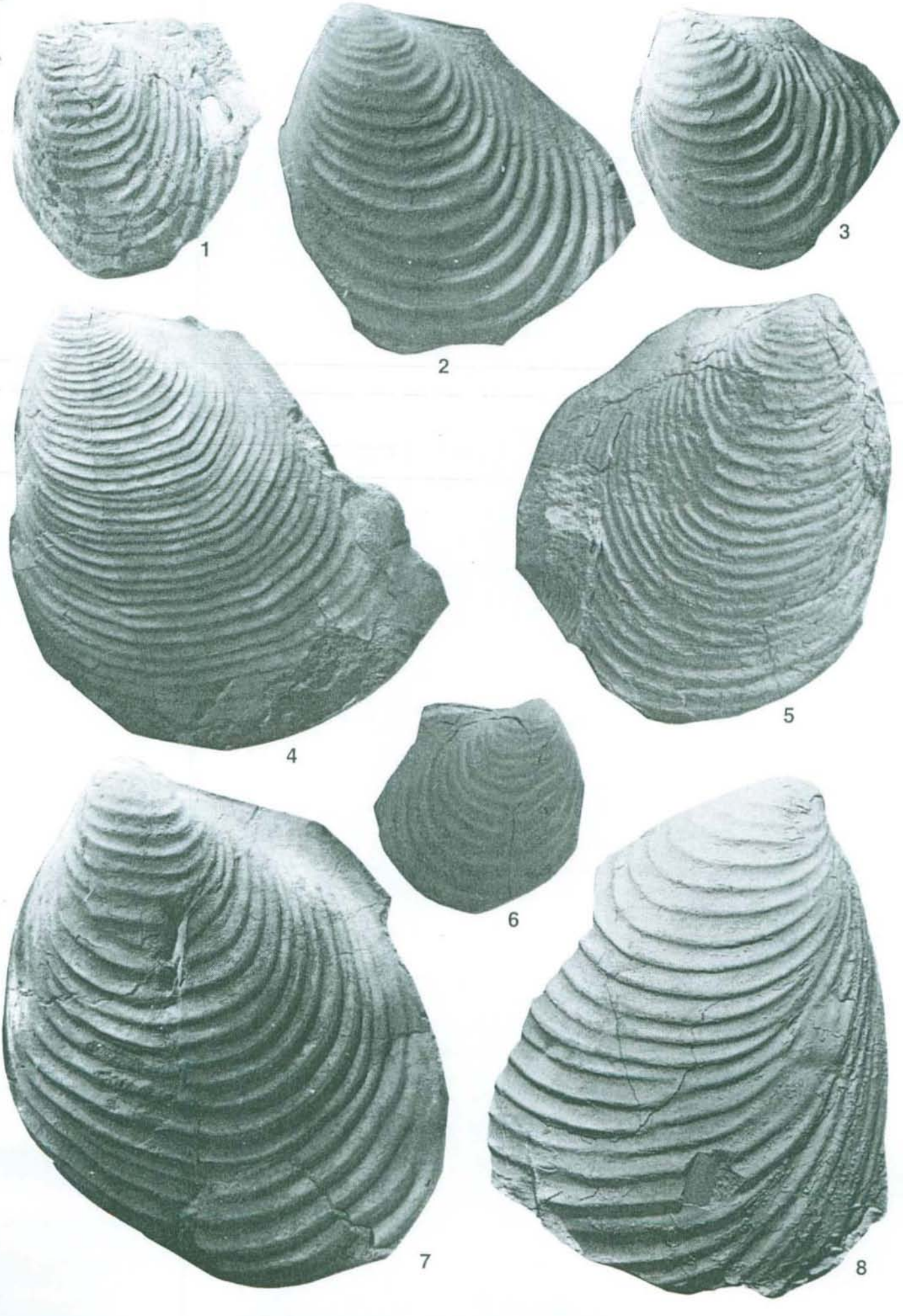
Plate XXII

Fig. 1-8: "*Inoceramus*" *altus* MEEK, 1871; 1 – USNM 507605, 2 – USNM 507613, 3 – USNM 507608, all from USGS Mesozoic locality D 1786; 4 – USNM 507618 from USGS Mesozoic locality D 2654; 5 – USNM 507598 from USGS Mesozoic locality D 1351; 6 – USNM 507611 from USGS Mesozoic locality 23072; 7 – USNM 507599 from USGS Mesozoic locality D 1786; 8 – 507610 from USGS Mesozoic locality D 2654; *1-7* – *Baculites compressus* Zone; middle Upper Campanian, 8 – *Didymoceras cheyennense* Zone; middle Upper Campanian.

Besides fig. 4, which is x 0.6, all other figures are in natural size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USNM 507583 from USGS Mesozoic locality D79 and USNM 507584 from USGS Mesozoic locality D2854; USNM 507620, USNM 507756, and USNM 507757 are from the boundary interval between the *Didymoceras stevensoni and Exiteloceras jenneyi* Zones, in Weston County, Wyoming (SW1/4 sec. 29, T. 43 N., R. 61 W.).

**Description**: Medium- to large-sized, distinctly geniculated species. Juvenile stage relatively small, moderately oblique with rounded outline. Beak projecting slightly above straight, moderately long hinge line. Growth axis straight.

Adult stage relatively large, developed at distinctly different plane in reference to juvenile stage; often contacting juvenile stage at right angle. Anterior margin straight, moderately long, turns rapidly at right or acute angle into long, ventral margin. Posterior margin broadly rounded. Sometimes adult stage markedly axially elongated, with very small l/h ratio.

Valves almost smooth. Juvenile stage varies from smooth to irregularly rugate. Adult stage usually smooth, sometimes irregularly rugate with low, wide rugae in ventral part.

**Remarks**: The species is very similar to *Sphaeroceramus pertenuis* (MEEK & HAYDEN), collected from the Lower/Middle Campanian boundary interval, from which it differs primarily in its adult stage. The adult stage of *Sphaeroceramus pertenuiformis* sp. nov. expands ventrally, with its anterior margin straight or even distinctly concave, while in *Sph. pertenuis* it is short, rounded, passing quickly into long antero-ventral margin. Some large specimens, USNM 507583 and USNM 507584 resemble "*Inoceramus*" *borilensis* JOLKICEV, 1962, in general outline. In contrast to the subcircular and almost smooth equivalent stage in *Sph. pertenuiformis*, however, the juvenile stage of JOLKICEV's species, is regularly rugate and posteriorly elongated. Moreover, the adult stage of "*I.*" *borilensis* is strongly posteriorly elongated, while being distinctly elongated ventralward in *Sph. pertenuiformis*. Moreover, its anterior margin is straight or even concave.

**Occurrence**: Known only from the Western Interior, from the *Didymoceras stevensoni* and the *Exiteloceras jenneyi* Zones.

### Genus *Endocostea* WHITFIELD, 1877

**Type species**: *Endocostea typica* WHITFIELD, 1877, p 32, from the Lower Maastrichtian, *Baculites baculu:* Zone, of the Old Woman Fork of the Cheyenne River Black Hills area in easternmost Wyoming.

**Remarks**: The genus *Endocostea* WHITFIELD, 1877, is interpreted here as a morphotype, well exemplified by its type species, *Endocostea typica* WHITFIELD, 1877, irrespective of the presence of the internal rib. The latter has been interpreted by TOOTS (1964) and SEITZ (1967) as caused by a parasite, and recently by MORRIS (1995) as an integral architectural character of the shell. Judged on its distribution among known inoceramid fens (morphotypes; species/subspecies; see SEITZ, 1967, pp. 14-40), it seems to have no taxonomic value, and is regarded herein as representing a feature which is not unique to *Endocostea*. Forms referred here to *Endocostea* are: *E. typica* WHITFIELD, 1877, *E.* aff. *typica* WHITFIELD, and *E. coxi* (REYMENT, 1955). *Endocostea impressa* (D'ORBIGNY, 1845) (see D'ORBIGNY, 1845; SORNAY, 1957b), *Endocostea biroi* (STINNESBECK, 1986), and *Endocostea stanislausensis* (ANDERSON, 1958) also belong to WHITFIELD's genus.

**Occurrence**: *Endocostea* sp. aff. *typica*, regarded herein as the oldest member of the *Endocostea* lineage appeared most probably in the latest Campanian (*Baculites reesidei* Zone). The other *Endocostea* occur in the Lower Maastrichtian. The genus is known from Europe, Western Asia, Africa, as well as North and South America.

### *Endocostea typica* WHITFIELD, 1880
### Pl. XL, figs 1-4, 7-8

1877. *Endocostea typica* WHITFIELD, p. 32.
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. - BÖSE, p. 35, pl. 3, fig. 1.

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Plate XXIII

Fig. 1, 3-5: "*Inoceramus*" *altus* MEEK, 1871; 1 – USNM 507604, 3 – USNM 507603 both from USGS Mesozoic locality D 1786; 4 – 507597 and 5 – USNM 507600, from USGS Mesozoic locality 23072; all from *Baculites compressus* Zone; middle Upper Campanian; 1, 4 x 1; 3, 5 x 0.85.

Fig. 2, 6-8: "*Inoceramus*" *altusiformis* sp. nov.; 2 – USNM 507601 from unknown locality; 6 – USNM 507612 from USGS Mesozoic locality D 1786; 7 – USNM 76373, original to *Inoceramus vanuxemi* MEEK & HAYDEN? *in* STEPHENSON (1941, pl. 13, fig. 1); 8 – USNM 507592 from USGS Mesozoic locality D 1352; 4, 6, 8 – *Baculites compressus* Zone; middle Upper Campanian; 2 x 0.5; 6 x 0.8; 7-8 x 1.


1
2
3
4
8b
5
6
7
8a

non 1931. *Endocostea typica* WHITFIELD. - RIEDEL, p. 664, pl. 75, figs 2-4; pl. 76, fig. 1.

non 1936. *Endocostea typica* WHITFIELD. - BEYENBURG, p. 295.

? 1958. *Inoceramus (Endocostea) stanislausensis* 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* ?) juv. sp. SEITZ, p. 51, pl. 2, fig. 1.

1967. *Inoceramus (Endocostea)* cf. *cymba* J. BÖHM. - SEITZ, p. 52, pl. 2, fig. 2.

1967. *Inoceramus impressus* ORBIGNY. - KOCIUBINSKIJ, 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.

? 1995. *Endocostea (Endocostea) coxi* (REYMENT). - MORRIS, p. 258, pl. 1, figs 2-4.

**Type**: The lectotype, by subsequent designation of SEITZ (1967, p. 55) is USNM 12261, the original to WHITFIELD (1880, pl. 9, fig. 3; reillustrated herein Pl. XL, fig. 3), from the lower Maastrichtian (*B. baculus* Zone) of the Old Woman Fork of the Cheyenne River in the Black Hills, easternmost Wyoming.

**Material**: USNM 507669 from USGS Mesozoic locality D 1970 and USNM 506734 from USGS Mesozoic locality 10143; USNM 507752 from USGS Mesozoic locality D1971;numerous unregistered specimens in the Denver collections.

*Dimensions*

| Specimen | h | l | H | L | s | α | δ | hmax |
|---|---|---|---|---|---|---|---|---|
| USNM 507669 | 57.8 | 44.6 | 41.3 | 56.2 | 34.2 | 110 | 35 | 68 (RV) |
| USNM 507734 | — | 42.0 | 24.5 | — | — | — | — | 41 (RV) |

**Description**: Small-sized, equivalve, inequilateral species. Valves prosocline, moderately inflated. Beak small, projecting slightly above hinge line. Anterior margin short, straight or slightly convex, passing into broadly rounded ventral margin. Posterior auricle small, narrow, elongated parallel to hinge line, distinct from disc. Almost every specimen with internal shell rib, which differ in shape, length and strength.

Shell ornamented with regular, relatively strong rugae, weakening ventralward and toward posterior end, being very weak on posterior auricle.

**Remarks**: WHITFIELD's original material (1880, pl. 9, figs 1-7) was discussed at length by SEITZ (1967, p. 50) who concluded that the material was polyspecific. Examination of very large collections, including the specimens illustrated herein (Pl. XL, fig. 1-5, 7-8), as well as numerous unregistered specimens from the collections in Denver and Tampa, indicates that *Endocostea typica* displays a relatively wide range of morphologic variation. Besides a single specimen, USNM 12261e (WHITFIELD 1880, pl. 9, figs 4-6; see also Pl. XL, fig. 5 of this paper), which as correctly suggested by SEITZ (1967, p. 53) belongs instead to *Inoceramus barabini*, the remainder of WHITFIELD's specimens clearly fall into the morphologic range for the species.

*E. coxi* (REYMENT, 1955, pl. 3, fig. 4), described originally from the Maastrichtian of Nigeria, is very similar to *Endocostea typica* is. It differs from WHITFIELD's species also in possessing radial ornament. *Inoceramus (Endocostea) stanislausensis* ANDERSON (1958, pl. 74, figs 4-6), described from the Maastrichtian of California, and *Endocostea biroi* (STINNESBECK, 1986), from the Lower Maastrichtian of central Chile are very close and possibly conspecific with WHITFIELD's species.

All European reports of *Endocostea typica* (e.g., RIEDEL, 1931; BEYENBURG, 1936) are based on a different species concept and represent other species (see discussion in SEITZ, 1967, p. 56).

**Occurrence**: The species is known from the lower Maastrichtian (*Baculites baculus* Zone) of the Western Interior; it is also known from the lower Maastrichtian of the Gulf Coast. WHITFIELD's material comes from the

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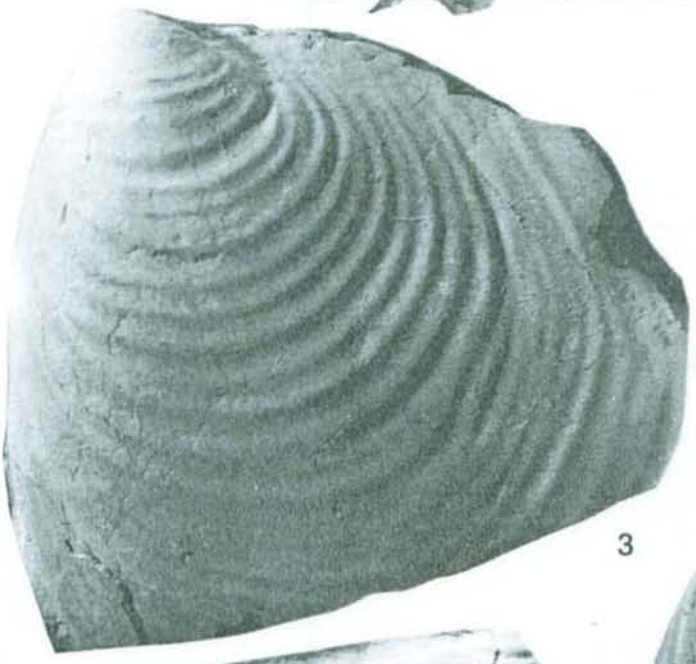
Plate XXIV

Fig. 1: "*Inoceramus*" *altus* MEEK, 1871; lectotype, USNM 12462, the original of MEEK (1876a, pl. 14, fig. 1), from near the Medicine Bow station, Wyoming, *Baculites compressus* Zone; middle Upper Campanian; x 1.

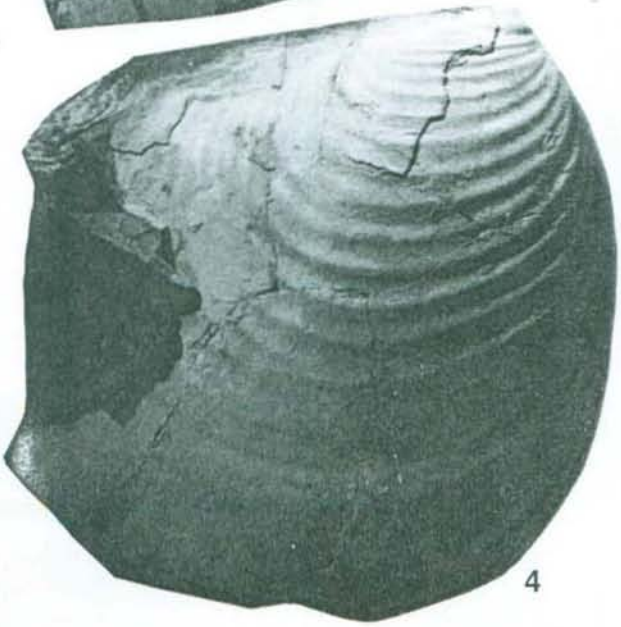
Fig. 2-4: "*Inoceramus*" *sagensis* OWEN, 1852; 2 USNM 485, original to *Inoceramus sagensis* var. *nebrascensis* in MEEK 1876a, pl. 13, fig. 2a, b, according to MEEK (1876a, p. 53) from White River, above Bad Lands; 3 – USNM 507593 from unknown locality, 4 – USNM 507617 from USGS Mesozoic locality 23072; middle Upper Campanian; 2 x 0.8; 3 x 0.55; 4 x 0.75.

1a

2



3



4

1b

lower Maastrichtian (*Baculites baculus* Zone) of the Old Woman Fork of the Cheyenne River in the Black Hills area, Wyoming.

### *Endocostea* sp. aff. *typica* WHITFIELD, 1877
### Pl. XXVI, fig. 3

**Material**: USNM 507624, USNM 507625, USNM 507626, USNM 507627, USNM 507628, USNM 507629, USNM 507630, USNM 507631; all from USGS Mesozoic locality D2768.

**Description and remarks**: Seven small specimens collected from USGS Mesozoic locality D 2768 (USNM 507626 is illustrated herein – Pl. XXVI, fig. 3), resemble *Endocostea typica* WHITFIELD, 1877 except in their ornament. In contrast to WHITFIELD's species the ornament in these forms is composed of lamellate, uniform, strongly asymmetrical rugae (see Pl. XXVI, fig. 3). Some specimens are characterised by ornament more similar to *E. typica*.

We regard *E.* aff. *typica* as closely akin WHITFIELD's species, although the exact relationship is, at the moment, unknown, and more material collected with stratigraphic precision is required. It is possible that *E.* aff. *typica* represents the oldest member of the *Endocostea* lineage.

**Occurrence**: Known from the *Baculites reesidei* Zone of the Western Interior.

### *Endocostea coxi* (REYMENT, 1955)
### Pl. XL, fig. 6

1955. *Inoceramus coxi* REYMENT, p. 140, pl. 3, fig. 4.
1991. *Inoceramus* (*Trochoceramus*) sp. aff. *radiosus* QUAAS. - TRÖGER & RÖHLICH, p. 1375 (pars), pl. 4, fig. 5 [non pl. 4, fig. 4].
1991. *Inoceramus* (*Trochoceramus*) *ianjonaensis* SORNAY. - TRÖGER & RÖHLICH, p. 1376 (pars), pl. 5, fig. 4 (only).
?1995. *Endocostea* (*Endocostea*) *coxi* (REYMENT). - MORRIS, p. 258, pl. 1, figs 2-4.

**Type**: The holotype, by original designation, is BMNH L82963, illustrated by REYMENT (1955, p. 140, pl. 3, fig. 4), from the Maastrichtian of Auchi, Nigeria.

**Material**: USNM 507709, USNM 507710, USNM 507711, USNM 507712; all from USGS Mesozoic locality 7459; USNM 507713 from USGS Mesozoic locality 13543.

*Dimensions*

| Specimen | h | l | H | L | s | α | δ |
|---|---|---|---|---|---|---|---|
| USNM 507709 | 42.0 | 35.2 | 28.0 | 45.0 | — | 114 | 38 |

**Description**: Small-sized, inequilateral, equivalve, prosocline species. Anterior and ventral margins relatively long, weakly convex, posterior margin moderately long, concave posteriorly of disc. Hinge line straight, long. Posterior auricle distinctly separated from disc by deep auricular sulcus. Beak projecting prominently above hinge line. Ornament composed of regular and subregular commarginal rugae in the juvenile and adult stages, respectively. In adult more-or-less well-developed radial ornament, sometimes with distinct nodes when crossing concentric rugae. Usually prominent *hohlkehle*.

**Remarks**: *Endocostea coxi* (REYMENT, 1955) is very similar to *E. typica* and differs only in possessing weak radial ornament. Specimens illustrated by MORRIS (1995, pl. 1, figs 2-4) do not show radial ornament at all and should be referred to WHITFIELD's species. On the other hand, radial ornament is sometimes very poorly depicted in photographs, as is the case with the specimen illustrated herein (Pl. XL, fig. 6).

The radial ornament characteristic of the species is rarely well developed; usually it is limited to a regular thickening on the commarginal rugae rather than well-developed radial rugae.

**Occurrence**: All specimens described here are exclusively from the Gulf Coast, from the high bluff representing the Nacatoch Sand on the Ouachita River, 1.5 km north of Arkadelphia, Clark County, Arkansas where the species co-occurs with trochoceramids. This is the common association of *E. coxi* in all areas of its occurrence.

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Plate XXV

Fig. 1: "*Inoceramus*" *convexiformis* sp. nov.; USNM 507652 from USGS Mesozoic locality 16213; Upper Campanian; x 0.9.

Fig. 2, 5: "*Inoceramus*" *balchiformis* sp. nov.; 2 – USNM 507622 from USGS Mesozoic locality D 372, 5 – USNM 507623 from USGS Mesozoic locality D 2719; Upper Campanian; x 1.

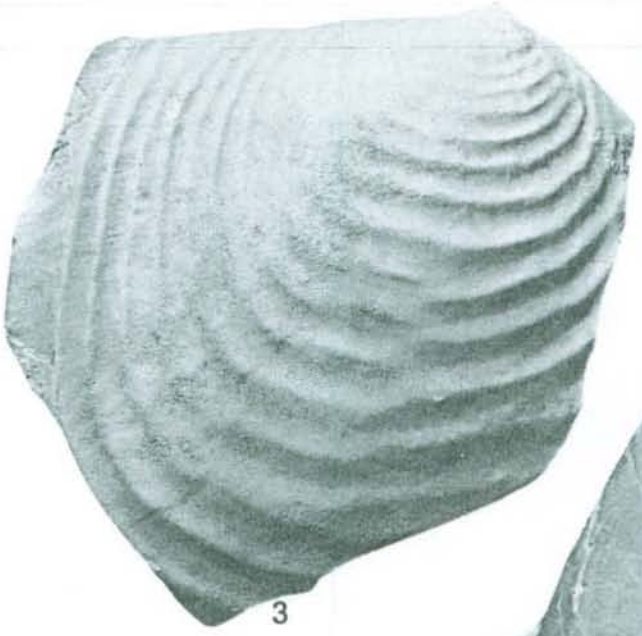
Fig. 3: *Cataceramus gandjaeformis* sp. nov.; USNM 507648 from USGS Mesozoic locality D 2849; x 1.

Fig. 4: "*Inoceramus*" *furnivali* DOUGLAS, 1942; holotype, GSC 8927, original to *Inoceramus furnivali* in DOUGLAS (1942, pl. 3); Upper Campanian (see Pl. XXVI, fig. 4 for a dorsal view); x 0.9.

1

2a

1b



3



4



5

The species, which is exclusively Maastrichtian and probably restricted to its lowest part, is known from Nigeria, Madagascar, Arabian Peninsula.

## Genus *Trochoceramus* HEINZ, 1932

**Type species**: *Trochoceramus helveticus* HEINZ (HEINZ, 1932, p. 19)

**Remarks**: Diagnosis and discussion see SEITZ (1970). *Trochoceramus* is a good index fossil for the Lower Maastrichtian, and has been reported from Europe, Africa, and South America (SORNAY, 1973; TRÖGER, 1980; DHONDT, 1983, 1992). STEPHENSON's (1941) specimen of *Inoceramus vanuxemi* MEEK & HAYDEN?, from the Lower Maastrichtian of Texas (reillustrated herein in Pl. XLIII, fig. 2 ; also see remarks in SORNAY, 1969 and DHONDT, 1993) is the only previous documented occurrence of this genus from North America. It appears, however, that the genus is well represented, both in the Atlantic and Gulf Coasts as well as in the Western Interior. In addition, previous work overlooked WHITFIELD's *Inoceramus proobliqua*, from the Greensand Marls of New Jersey (WHITFIELD, 1885, p. 80), which undoubtedly represents a *Trochoceramus* species. It is very probable that it is a senior synonym of what has been referred to as *Trochoceramus nahorianensis* (KOCIUBYNSKIJ, 1968).

**Occurrence**: The genus is common in the Lower Maastrichtian. The recent discovery of trochoceramid specimens in the Tercis section, SW France (ODIN, 2001; WALASZCZYK, DHONDT & ODIN, in prep.) shows that its first appearance is topmost Campanian occurring in the upper portion of the *Nostoceras hyatti* Zone. This zone corresponds to the basal *Baculites eliasi* Zone or even lower *Baculites jenseni* Zone in the Western Interior (WALASZCZYK, COBBAN & ODIN, in prep.). Earlier claims of its occurrence throughout the Middle and Upper Campanian were based more on mere suggestions than actual records (as in the case of the Austrian material revised by SEITZ 1970). The genus is known from Europe (Germany, Poland, Austria, The Ukraine, Russia, Spain, France), Africa (Tunisia, Libya, Algeria, Egypt, Madagascar, Angola), South Ameri (Columbia) and from North America (Gulf and Atlant coasts, as well as the Western Interior).

### *Trochoceramus* sp.
### Pl. XLII, fig. 10; Pl. XLIII, figs 7-9

1996. *Trochoceramus morgani* (SORNAY). WALASZCZYK, SMIRNOV & TRÖGER, p 156, pl. 2, figs 1-8; pl. 3, fig. 2.

**Material**: USNM 507716, USNM 507717, both from USGS Mesozoic locality 13543; USNM 507718 and USNM 507750 both from the Ripley Formation along Coon Creek, McNairy County, Tennesee.

**Description**: Moderate-sized, weakly inflated, prosocline species. Valves elongated posteriorly. Anterior margin relatively long, anteriorly convex, passing into broadly convex ventral margin. Posterior margin rounded. Hinge line long, straight. Beak small, projecting only slightly above hinge line. Posterior auricle of moderate size, not separated from disc. *Hohlkehle* present in postero-ventral part. Valves ornamented with distinct, sharp-edged commarginal rugae, regularly spaced in juvenile stage, subregular in adult. Radial ornament ranging from moderate to relatively strong, never dominates the commarginal rugae.

**Remarks**: The specimens here studied are characterised by subquadrate outline, posterior shell elongation, fine and regular concentric ornament with superimposed radial ribs. This material is conspecific with *Trochoceramus morgani* (SORNAY, 1973) as described by WALASZCZYK *et al.* (1996) from the Aimaki section, in Daghestan. The study of the type material of SORNAY revealed, however, that *T. morgani* as interpreted by these authors differs clearly from French material and should be referred to a separate species.

**Occurrence**: All specimens here described are from the ?uppermost Campanian of the Nacatoch Sand, Canyon Creek, Texas, US Gulf Coast. The species is known from the uppermost Campanian and ?lowermost Maastrichtian of Tercis section, SW France, and from the topmost Campanian of Daghestan (the Caucasus).

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Plate XXVI

Fig. 1: *Cataceramus gandjaeformis* sp. nov.; USNM 507633 from USGS Mesozoic locality D 1949; x 1.

Fig. 2, 5: ?"*Inoceramus*" *oblongus* MEEK, 1871, ?juvenile specimens; 2 – USNM 507646 from USGS Mesozoic locality D 2849 5 – USNM 507645 from USGS Mesozoic locality D 2805; Upper Campanian; x 1.

Fig. 3: *Endocostea* sp. aff. *typica* WHITFIELD, 1877; USNM 507626 from USGS Mesozoic locality D 2768; x 1.

Fig. 4: "*Inoceramus*" *furnivali* DOUGLAS, 1942; holotype, GSC 8927, original to *Inoceramus furnivali* in DOUGLAS (1942, pl. 3); upper Upper Campanian; x 0.8.

1

2

3



4



5

### *Trochoceramus radiosus* (QUAAS, 1902)
### Pl. XLII, figs 3-4, 6-9; Pl. XLIII, figs 3-5

1902. *Inoceramus Cripsi* var. *radiosa* QUAAS, p. 170 (pars), pl. 20, fig. 9 (only).
1962. *Inoceramus* (*Inoceramus*) *regularis* var. *radiosa* (QUAAS). - ABBASS, p. 41, pl. 5, fig. 1.
1970. *Inoceramus* (*Trochoceramus*) *radiosus* QUAAS. - SEITZ, p. 123, pl. 23, fig. 1.
1974. *Inoceramus* aff. *monticuli* FUGGER & KASTNER. - KOCIUBYNSKIJ, p. 86, pl. 22, fig. 1.
1989. *Inoceramus monticuli* FUGGER & KASTNER. - BLASZKIEWICZ & CIEŚLIŃSKI, p. 257, pl. 162, fig. 1.
non 1993. *Trochoceramus radiosus* (QUAAS). - DHONDT, p. 240, pl. 7, fig. 3.
1996. *Trochoceramus radiosus* (QUAAS). - WALASZCZYK, SMIRNOV & TRÖGER, 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.

**Type**: The lectotype, designated by WALASZCZYK *et al.* (1996, p. 158), is the original to QUAAS (1902, pl. 20, fig. 9) from the Maastrichtian of Ammonitenberge, Egypt (see DHONDT *in* ROBASZYNSKI *et al.* 2000). The original is probably lost; its plaster cast preserved in the State Geological Survey in Hannover, Germany.
**Material**: USNM 507702, USNM 507703, USNM 507704, and USNM 507715; two unregistered specimens from Warsaw collections (Pl. XLII, fig. 7, 9); three specimens from Tampa (Pl. XLII, fig. 4, 6, 8).
**Description**: Medium-sized, weakly prosocline, moderately to weakly inflated species. Hinge line moderately long, straight. Posterior auricle relatively small not separated from disc. Beak pointed dorsally, projecting slightly above hinge line.
Valves ornamented with strong, asymmetrical, widely spaced commarginal rugae, with interspaces increasing gradually ventralward. Radial ornament ranging from rather weak to moderately well developed.
**Remarks**: With their strong, widely spaced rugae with subcircular outline, and weak shell obliquity, American specimens closely correspond to the Egyptian type (QUAAS, 1902, pl. 20, fig. 9; reillustrated in WALASZCZYK *et al.*, 1996, pl. 6, fig. 4).
**Occurrence**: Lower Maastrichtian of Europe (The Ukraine, Poland), North Africa (Egypt) and North America (Western Interior).

### *Trochoceramus nahorianensis* (KOCIUBYNSKIJ, 1968)
### Pl. XLI, fig. 4

1866. *Inoceramus latus* MANTELL. - ZITTEL, p. 100, pl. 13, fig. 7.
1959. *Inoceramus salisburgensis* FUGGER & KASTNER. - DOBROV & PAVLOVA, p. 155 (pars), pl. 19, fig. 1 [non pl. 19, fig. 2]
1968. *Inoceramus nahorianensis* KOCIUBYNSKIJ, p. 145 (pars) [non pl. 28, fig. 4]
1969. *Inoceramus zitteli* KOCIUBYNSKIJ non PETRASCHECK. - SORNAY, p. 89, pl. 7, fig. 1.
1970. *Inoceramus* (*Trochoceramus*) aff. *helveticus* HEINZ. - SEITZ, p. 114, pl. 15, fig. 1.
?1993. *Trochoceramus nahorianensis* KOCIUBYNSKIJ. - DHONDT, p. 238, pl. 7, fig. 4.
1996. *Trochoceramus nahorianensis* (KOCIUBYNSKIJ). - WALASZCZYK, SMIRNOV & TRÖGER, p. 160, pl. 1, fig. 6; pl. 6, fig. 1.

**Type**: The lectotype, designated by DHONDT (1993, p. 238), is the original to ZITTEL's (1866, pl. 13, fig. 7) *Inoceramus latus* MANTELL, from the ?Maastrichtian of Maiersdorf, Austria; the original housed in the Natural History Museum in Vienna, Austria.
**Material**: USNM 507741 from Coon Creek, Tennessee, Ripley Formation.
**Description**: Moderate-sized, weakly inflated, orthocline species. Valve outline suboval, margins flattened. Posterior auricle moderately large, not separated from disc. Hinge line moderately long, straight. Beak small, pointed dorsally, only weakly projecting above hinge line. Ornament composed of relatively closely spaced, sub-symmetrical, subregularly spaced, commarginal rugae, with gradual ventral increase in interspaces. Radial ribs weak in juvenile part; markedly stronger in adult stage.

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Plate XXVII

Fig. 1, 3: "*Inoceramus*" *oblongus* MEEK, 1871; 1 – USNM 507644 from USGS Mesozoic locality D 373, 3 – USNM 507755 from USGS Mesozoic locality D 1466; upper Upper Campanian; x 0.9.
Fig. 2: *Cataceramus? palliseri* (DOUGLAS, 1942); USNM 507634 from USGS Mesozoic locality D 1949; upper Upper Campanian; x 1.


1
2
3

**Remarks**: *T. nahorianensis* differs from the very similar *Trochoceramus costaecus* (KHALAFOVA, 1966, pl. 1, fig. 1) by its lower relative length (smaller h/l ratio) and shorter hinge line. It differs in a similar manner from juveniles of *Trochoceramus ianjonaensis* (SORNAY, 1973, pl. 1, figs 1-5; pl. 2, figs 1-6; TRÖGER, 1980, pl. 1, figs 4-8). The specimen from Nagorzany, illustrated by KOCIUBYNSKIJ (1968, pl. 28, fig. 4), differs from the holotype (ZITTEL, 1866, pl. 13, fig. 7) in ornament, possessing widely spaced, sharp-edged rugae, with flat-floored interspaces. It should be referred to *Trochoceramus helveticus* (HEINZ, 1932; see WALASZCZYK *et al.*, 1996).

*T. nahorianensis* (KOCIUBYNSKIJ, 1968) should probably be synonymised with *Trochoceramus proobliqua* (WHITFIELD, 1885), but further study of the latter species is required for a more definitive evaluation.

**Occurrence**: The described specimen comes from the ?uppermost Campanian of the Nacatoch Sand, US Gulf Coast; it is also known from Daghestan (the Caucasus), Austria, and France.

### *Trochoceramus tenuiplicatus* (TZANKOV, 1981)
### Pl. XLIII, figs 1-2

1906. *Inoceramus salisburgensis* FUGGER & KASTNER. - PETRASCHECK, p. 165, fig. 3.
1941. *Inoceramus vanuxemi* MEEK & HAYDEN? - STEPHENSON, p. 99, pl. 13, fig. 3.
1970. *Inoceramus* (*Trochoceramus*) aff. *monticuli* FUGGER & KASTNER; SEITZ, p. 199, pl. 18, fig. 2.
1981. *Inoceramus* (*Inoceramus*) *tenuiplicatus* TZANKOV, p. 85 (pars) [type only], non pl. 30, fig. 1.
1996. *Trochoceramus tenuiplicatus* (TZANKOV). - WALASZCZYK, SMIRNOV & TRÖGER, p. 160, pl. 2, fig. 9; pl. 5, fig. 2.

**Type**: The holotype, by original designation, is the original of *Inoceramus salisburgensis* FUGGER & KASTNER *in* PETRASCHECK (1906, fig. 3), from the Maastrichtian of Leopoldsberge near Vienna, Austria, housed in the Natural History Museum in Vienna, Austria.

**Material**: Two specimens: USNM 449225, originally assigned to *Inoceramus regularis* D'ORBIGNY b COBBAN & KENNEDY (1993, pl. 1, fig. 22), from th *Nostoceras alternatum* Zone in southwestern Arkansas and USNM 76374, originally assigned to *Inoceramu vanuxemi* MEEK & HAYDEN? by STEPHENSON (1941, pl. 13, fig. 3), from the Nacatoch Sand, Navarro County, Texas.

**Description**: Medium-sized, inequilateral, equivalved weakly inflated species. Outline *balticus*-like with regularly rounded anterior margin, long weakly convex ventral margin, and long, straight hinge line. Ornament subregular, composed of distinct rugae, with interspaces increasing ventralward. Radial ornament particularly well developed axially weakening toward anterior and posterior margins.

**Remarks**: The original specimen illustrated by TZANKOV (1981, pl. 30, fig. 1) should be excluded from the synonymy of *T. tenuiplicatus*. This specimen (No. 520, housed in the University Museum in Sofia, Bulgaria) is not radially ornamented and elements seen in his illustration are actually the result of deformation and trend parallel across the entire valve.

**Occurrence**: *T. tenuiplicatus* is known from the Lower Maastrichtian of The Ukraine, Poland, and Austria in Europe, and from the Gulf Coast of North America.

## Inoceramids with unknown generic affiliation

When possible the forms with unknown generic affinity, referred here to "*Inoceramus*" *sensu lato* are clustered here into informal groups, based on their overall similarity and stratigraphic relationships, suggesting their common evolutionary history, and, consequently, possible supraspecific position.

### "*Inoceramus*" *conlini* sp. nov.
### Pl. III, figs 1-2

1967. *Inoceramus* (*Endocostea*) *cymba* J. BÖHM. - SEITZ (pars), p. 66, pl. 3, fig. 2 [non pl. 2, fig. 2 – *Endocostea typica*, and non pl. 7, fig. 3 – *Cataceramus? subcompressus*].

**Type**: The holotype is the specimen USNM 507476 from USGS Mesozoic locality 21568. USNM 507475, from

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Plate XXVIII

"*Inoceramus*" *oblongus* MEEK, 1871; USNM 507754 from USGS Mesozoic locality D 1466; *Baculites reesidei* Zone; upper Upper Campanian; x 0.9.

1a

1b

the J.P. CONLIN collection, *Haresiceras placentiforme* Zone, is the paratype.

**Derivation of name**: After late James P. CONLIN, a prolific collector of Upper Cretaceous fossils.

**Material**: Two specimens: USNM 507475, from the J.P. CONLIN's collection, *placentiforme* Zone, and USNM 507476, from USGS Mesozoic locality 21568.

*Dimensions*

| Specimen | h | l | H | L | δ | hmax |
|---|---|---|---|---|---|---|
| USNM 507475 | 35.0 | 22.0 | 23.0 | 33.0 | 28 | 80 |
| USNM 507476 | — | — | — | — | 28 | 68 |

**Description**: Medium-sized, inequilateral, equivalve, prosocline species, with distinct ontogenetic pattern composed of three stages. Juvenile stage small, weakly inflated, strongly oblique. Beak small, indistinct, pointed anteriorly, subterminal. Anterior margin short, convex. Ventral margin broadly convex, passing into narrow postero-ventral margin, and thence into short, straight posterior margin. Hinge line short, straight. Juvenile stage passes into adult stage with well-developed positive geniculation; anteriorly and ventrally adult stage abuts juvenile stage at right angle, posteriorly at slightly lower angle. At the boundary between both stages, shell is rounded. Passage from adult into gerontic stage is best developed posteriorly. Gerontic stage, similar to juvenile stage with distinctly elongated parallel hinge line.

All three stages ornamented with commarginal rugae. Rugae becoming less regular ventrally.

**Remarks**: The pronounced geniculation, with juvenile and adult stages oriented distinctly above the gerontic stage, as well as the posterior elongation of the gerontic stage makes this species a unique morphotype. It resembles some of the ?latest Campanian/lower Maastrichtian species group, comprising "*Inoceramus*" *incurvus* MEEK & HAYDEN, 1856, "*I.*" *mclearni* DOUGLAS, 1942, and "*I.*" *furnivali* DOUGLAS, 1942 (see further in this report), but differs from them in the type of juvenile ornament.

The specimen from the Lower Campanian of Stimmberg near Oer-Erkenschwick, figured by SEITZ (1967, pl. 3, fig. 2), and referred by him to *Inoceramus* (*Endocostea*) *cymba* (BÖHM, 1909) is most probably conspecific with our species. It possesses three distinct growth stages and a clearly raised umbone as in "*Inoceramus*" *conlini* sp. nov. The type of *Haenleinia cymba* BÖHM is conspecific with the North American *Cataceramus subcompressus* (see description of the latter species in the present paper).

PERGAMENT (1974, p. 189, pl. 45, fig. 9) referred the Stimmberg specimen to his new species *Inoceramus cymbaeformis*, which he described from a single Upper Campanian specimen of Pacific Russia. Although the type of *I. cymbaeformis* is very close to the Stimmberg specimen, and consequently also to our specimens, PERGAMENT's specimen comes from the Campanian/Maastrichtian boundary interval and may thus be taxonomically quite different. Consequently, we retain this species. PERGAMENT's (1974) specimen may correspond to the same group as "*I.*" *incurvus*, "*I.*" *mclearni*, and "*I.*" *furnivali*, common in the uppermost Campanian and lowermost Maastrichtian of the Western Interior.

*Inoceramus* (*Endocostea*?) sp. aff. *I.* (*E.*?) *cymbaeformis* PERGAMENT, 1974, described from the Santa Cruz Mountains of California by ELDER (1991, p. E9, pl. 1, fig. 10; pl. 2, figs 6-7, 10) differs in many respects from PERGAMENT's (and BÖHM's) species. It is ventrally elongated, non-geniculated form, with a massive umbo, large, moderately inflated disc, and moderately large, distinct posterior auricle. Instead, this species belongs to the *Cataceramus dariensis* (DOBROV & PAVLOVA) – *Cataceramus copetdagensis* (ARZUMANOVA) plexus, well represented in the upper Lower Campanian of Europe (WALASZCZYK 1997). USNM 445007 (ELDER, 1991, pl. 2, figs 6-7, 11) is particularly close to the type of *Inoceramus atabekiani* ARZUMANOVA (1965, pl. 4, fig. 1), a younger synonym of *C. dariensis* (DOBROV & PAVLOVA) (see WALASZCZYK, 1997, p. 22).

**Occurrence**: The species is known from the *Scaphites hippocrepis* III Zone in the Western Interior. It occurs in the lower Lower Campanian (probably *patootensiformis* Zone) of Europe.

### "*Inoceramus*" sp.
### Pl. XI, fig. 11

*compare*:

1997. *Cataceramus pteroides* (GIERS, 1964). - NIEBUHR *et al.*, pl. 6, fig. 2.

**Material**: Single specimen, USNM 507542, from USGS Mesozoic locality D2864.

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Plate XXIX

"*Inoceramus*" *magniumbonatus* DOUGLAS, 1942; USNM 507753 from USGS Mesozoic locality D 1466; *Baculites reesidei* Zone; upper Upper Campanian; x 0.8.

1a

1b

*Dimensions*

| Specimen | h | l | H | L | s | δ | α | hmax |
|---|---|---|---|---|---|---|---|---|
| USNM 507542 | 73.0 | 64.5 | 61.8 | 69.3 | 46 | 45 | 119 | 85 |

**Description and remarks**: It is a single LV, slightly deformed, with partially preserved adult stage. The specimen, however, has a distinct set of distinguishing features. The form is subovate in outline, prosocline, moderately inflated, with maximum inflation dorso-central. Posterior auricle moderately large, narrow, distinct from the disc. The disc is covered with widely spaced, broad commarginal rugae, and with rounded interspaces, giving a wavy appearance. Rugae run parallel to raised growth lines, uniformly developed over entire shell.

The specimen resembles a specimen from the *bipunctatum/roemeri* Zone of the Middle Campanian of the Lerther Westmulde, northern Germany, referred to *Cataceramus pteroides* (GIERS) and illustrated by NIEBUHR *et al.* (1997, pl. 6, fig. 2). Among the Western Interior taxa it resembles "*Inoceramus*" *scotti* sp. nov., from which it differs in more prominent ornament, with distinct increase of interspaces ventrally.

**Occurrence**: The specimen comes from the *Baculites scotti* Zone of the USGS locality D2864.

### "*Inoceramus*" *whitfieldi* sp. nov.
### ?Pl. XX, fig. 2; Pl. XXI, fig. 2; Pl. XXXVII, fig. 4

non 1852. *Inoceramus Cripsii* MANTELL var. *sulcata* ROEMER, p. 56, pl. 7, fig. 2. [= *Cataceramus balticus* (BÖHM)].

1880. *Endocostea sulcata* (ROEMER). - WHITFIELD, p. 404, pl. 10, fig. 6.

**Type**: The holotype is USNM 12323, the original of *Endocostea sulcata* of WHITFIELD (1880, p. 404, pl. 10, fig. 6; reillustrated herein – Pl. XXXVII, fig. 4); according to WHITFIELD (1880, p. 406) the specimen was found in float on the East Fork of Beaver Creek, in the Black Hills area; Pierre Shale. USNM 507577 and USNM 507582 from the *Exiteloceras jenneyi* Zone, ?USNM 507579 from D3713, and USNM 507627 the boundary interval between the *Didymoceras stevensoni* and *Exiteloceras jenneyi* Zones, in Weston County, Wyoming (SW1/4 sec. 29, T. 43 N., R. 61 W.), are paratypes.

**Derivation of name**: After R.P. WHITFIELD, American 19th century paleontologist.

**Material**: USNM 507577 and USNM 507582 from USGS Mesozoic locality D 79; ?USNM 507579 from D3713, and USNM 507627 and numerous unnumbered specimens in the collections of the Warsaw University, from the boundary interval between the *Didymoceras stevensoni and Exiteloceras jenneyi* Zones, in Weston County, Wyoming (SW1/4 sec. 29, T. 43 N., R. 61 W.).

*Dimensions*

| Specimen | h | l | H | L | s | α | δ | hmax |
|---|---|---|---|---|---|---|---|---|
| USNM 507577 | 93.0 | 74.0 | 69.0 | 88.0 | 54.5 | 108 | 40 | 122 (RV) |
| USNM 507582 | 62.0 | 61.0 | 51.0 | 64.8 | 46.0 | 124 | 46 | 115 (LV) |
| USNM 507579 | — | — | — | — | — | — | 45 | 154 (LV) |

**Diagnosis**: Moderate- to large-sized species, prosocline with valves, elongated postero-ventrally, strongly inflated in antero-dorsal part, with almost smooth surface.

**Description**: Medium- to large-sized, inequilateral, equivalved, prosocline species. Valves strongly inflated, particularly in antero-dorsal part, moderately oblique. Anterior margin straight or weakly convex, relatively long, passing into long, broadly convex antero-ventral margin. Posterior margin rounded. Posterior auricle small, very narrow, elongated parallel to straight, long hinge line. Beak small oriented anteriorly, projecting slightly above hinge line. *Hohlkehle* common. *Platyceramus*-type geniculation developed after relatively long juvenile stage.

Valves almost smooth, juvenile stage with indistinct, fine, closely spaced rugae slightly more distinct in dorsal part. Rare, irregular, widely spaced, very low rugae observed sometimes in adult stage.

**Remarks**: WHITFIELD's (1880, pl. 10, fig. 6) *Endocostea sulcata* (ROEMER) specimen, designated here as the holotype of "*I.*" *whitfieldi* sp. nov., differs markedly from the type of ROEMER's species (1852, pl. 7, fig. 2). The latter represents a weakly inflated, posteriorly elongated, rugate form, and can be included within the morphologic variability of *Cataceramus balticus* (BÖHM, 1907; see also SEITZ 1967, p. 12). The only common feature is the *Hohlkehle*, which, however, has no taxonomic value.

USNM 507579 is referred to "*I.*" *whitfieldi* with a question mark. Based on its juvenile stage, it is identical to the holotype of the species, it is, however, the only geniculated specimen in the material studied despite other specimens being as large.

**Occurrence**: Known only from the Western Interior, from the *Didymoceras stevensoni* and *Exiteloceras jenneyi* Zones.

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Plate XXX

"*Inoceramus*" *balchiformis* sp. nov.; USNM 507621 from USGS Mesozoic locality 16215; *Baculites reesidei* Zone; upper Upper Campanian; x 1.

### *"Inoceramus" redbirdensis* sp. nov.
### Pl. XXXI, figs 1, 4; Pl. XXXII, figs 2-3; Pl. XXXIV, fig. 1

**Type**: The holotype is USNM 507655 (Pl. XXXII, fig. 2) from Red Bird section (D 1961), *Baculites eliasi* Zone; USNM 507653, USNM 5076554, and USNM 507656 through USNM 507660 are paratypes.

**Derivation of name**: From the Red Bird section, eastern Wyoming, from where most of the specimens were collected.

**Material**: USNM 507653, USNM 507654, USNM 507655, USNM 507656, USNM 507657, USNM 507658, USNM 507659, USNM 507660, all from USGS Mesozoic locality D1961.

*Dimensions*

| Specimen | h | l | H | L | s | α | δ | hmax |
|---|---|---|---|---|---|---|---|---|
| USNM 507654 | 54.5 | 55.0 | 41.8 | 54.0 | — | 118 | 50 | 64.5 (LV) |
| USNM 507655 | 57.4 | 49.5 | 54.0 | 49.0 | — | 115 | 53 | — (LV) |
| | 57 | 54 | 50.0 | 56.7 | — | 120 | 58 | — (RV) |
| USNM 507656 | 51.3 | 52.0 | 43.0 | 55.5 | — | 120 | 49 | — (LV) |
| | 51.3 | 50.5 | 42.5 | 52.5 | — | 120 | 52 | — (RV) |
| USNM 507657 | 62.0 | 59.0 | 49.0 | 63.0 | 44.0 | — | 53 | 69.5 (LV) |
| USNM 507658 | 55.0 | 53.8 | 46.5 | 54.5 | 39.3 | 120 | 52 | 67 (RV) |

**Diagnosis**: Small- to moderate-sized species, prosocline, and subquadrate in outline. Valves moderately to strongly inflated, but without distinct geniculation or accompanied change in ornament. Ornament composed of sharp-edged rugae, with relatively wide interspaces and with subordinate ribs. In adult stage, radial sulcus appears posteriorly.

**Description**: Species of small to moderate size, prosocline, moderately to strongly inflated. Maximum inflation dorso-central. Umbo massive, projecting distinctly above hinge line, curved anteriorly. Anterior margin short, concave, passing into long antero-ventral margin and thence, with distinct bent in ventral part, into long, almost straight postero-ventral margin. Posterior margin short, straight. Hinge line relatively long, straight. Posterior auricle small, elongated, subtriangular, relatively well separated from disc. Irregular, posterior radial sulcus appears in adult stage.

Valves ornamented with strong, sharp-edged rugae, passing onto posterior auricles. Rugae relatively closely spaced in umbonal part, with rapid increase of interspaces in adult stage. Irregular ribs appear sometimes in various parts of interspaces.

**Remarks**: Completely preserved specimens are distinct from any other species known from the Upper Campanian or Lower Maastrichtian. Juvenile stages (e.g. Pl. XXXII, fig. 2a) may easily be mistaken for *Cataceramus? barabini*.

**Occurrence**: Known exclusively from the *Baculites eliasi* Zone of the Western Interior.

### The group of *Inoceramus azerbaydjanensis*

Two species, *"I." vorhelmensis* (WALASZCZYK), and *"I." azerbaydjanensis* ALIEV, are included within this plexus.

### *"Inoceramus" vorhelmensis* (WALASZCZYK, 1997)
### Pl. IV, figs 4, 7; Pl. V, figs 5, 7

1997. *Cataceramus vorhelmensis* WALASZCZYK, p. 27, pl. 12, fig. 6; pl. 19; pl. 20, figures 2-3, 5-7.
1997. *Inoceramus tausiensis* ALIEV. - WALASZCZYK, p. 42, pl. 20, figures 1, 4, 8.

**Type**: The holotype, by original designation, is RE A 1419, illustrated by WALASZCZYK (1997, pl. 19, fig. 4) from the Vorhelmer Beds, Westphalia, Germany; *stobaei/basiplana – vulgaris/basiplana* Zone of the lower Middle Campanian; original housed in the Ruhrland Museum, Essen, Germany.

**Material**: USNM 507512 from USGS Mesozoic locality D831; USNM 507737, USNM 507738, and USNM 507739, from USGS Mesozoic locality D7950; USNM 507498 from USGS Mesozoic locality 9710.

**Description**: Small- to medium-sized, strongly prosocline, inequilateral, equivalve, weakly inflated species.

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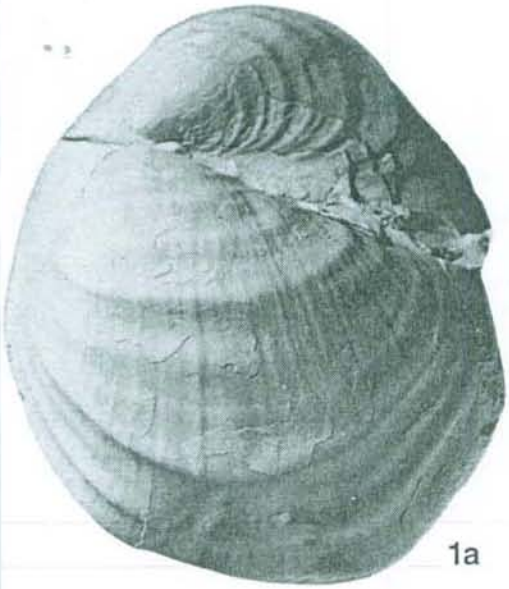
Plate XXXI

Fig. 1, 4: *"Inoceramus" redbirdensis* sp. nov.; 1 – USNM 507657, 4 – 507656, both from USGS Mesozoic locality D 1961; *Baculites eliasi* Zone; uppermost Campanian; x 1.

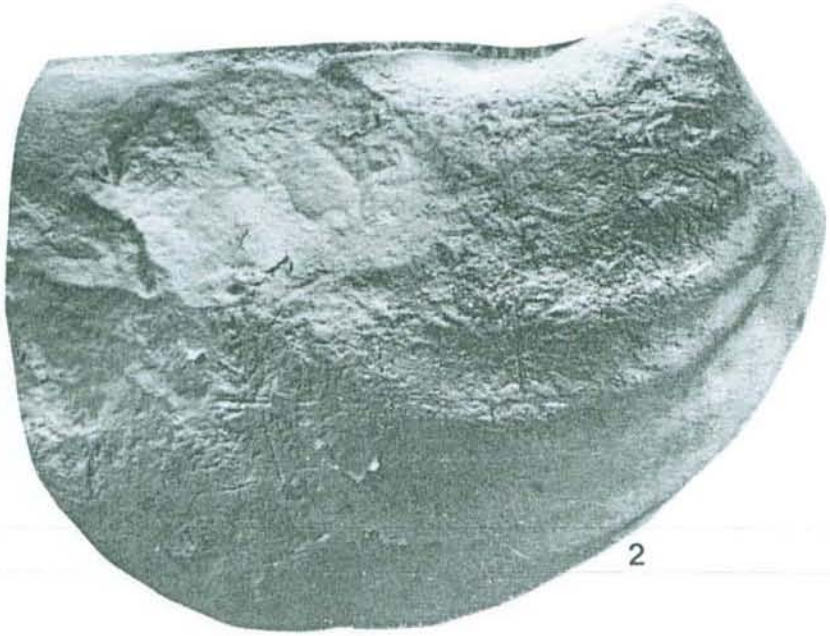
Fig. 2: *"Inoceramus" magniumbonatus* DOUGLAS, 1942; holotype, juvenile view; original to *Inoceramus barabini* var. *magniumbonatus* n. var. *in* DOUGLAS (1942, pl. 1, fig. 1); upper Upper Campanian; x 1.

Fig. 3: *Cataceramus? subcircularis* (MEEK, 1876a); USNM 507748 from "Fossil Creek just south of Fort Collins, Colorado. Obtained by C.A. WHITE" [an old USNM locality 9974], located near locality 42 on the locality map; Larimer Sandstone Member of the Pierre Shale; x 1.

Fig. 5: *"Inoceramus" oblongus* MEEK, 1871, holotype, juvenile view; USNM 774, original to WHITE (1879, p. 285, pl. 2, fig. 1), about 6 miles south of Fort Collins, Colorado; upper Upper Campanian; x 0.9.



1a



2

3

1b

4

5

Beak small, indistinct, projecting slightly above hinge line. Anterior margin low, convex, relatively short, passing into broadly convex, long antero-ventral margin. Postero-ventral margin rounded; posterior margin relatively long, straight or even slightly concave. Disc subtriangular in outline, elongated postero-ventrally, uniformly, relatively weakly inflated. Axial part often contains delicate radial sulcus. Narrow, posterior auricle elongated parallel to hinge line.

Shells ornamented with regularly to subregularly spaced commarginal rugae, asymmetrical, with ventral slopes distinctly steeper. Ventrally, ornament becomes less regular.

**Remarks**: Specimens of "*Inoceramus*" *vorhelmensis* with well-developed axial sulci resemble weakly rugate "*Inoceramus*" *azerbaydjanensis* (e.g. Pl. V, fig. 6). However, the latter are usually more inflated and do not show the subtriangular outline, characteristic of "*I.*" *vorhelmensis*.

Based on Westphalian material, WALASZCZYK (1997) assumed "*I.*" *vorhelmensis* represented a descendant of the *Cataceramus copetdagensis – C. dariensis – C. beckumensis* lineage. The external similarity of "*I.*" *vorhelmensis* to cordiceramids represents morphologic convergence and not a phylogenetic relationship to the genus *Cordiceramus*. The species should be referred to either a new genus, an evolutionary descendant of *Cataceramus*, or should still be retained in *Cataceramus*. "*I.*" *azerbaydjanensis*, which is closely related to "*I.*" *vorhelmensis*, would, consequently, also be referred to this new genus and not to the genus *Cordiceramus*, where it has traditionally been placed. Until the evolutionary relationships between these various taxa are finalised, we refer both species to "*Inoceramus*" *sensu lato*.

**Occurrence**: The species was described originally from Westphalia, Germany from the *stobaei/basiplana – vulgaris/basiplana* Zone of the lower Middle Campanian (lower Upper Campanian European sense). In the Western Interior it is known from the *Baculites obtusus* and *Baculites mclearni* Zones.

### "*Inoceramus*" *azerbaydjanensis* ALIEV, 1939
### Pl. IV, figs 3, 5-6; Pl. V, figs 1-4, 6

1939. *Inoceramus cordiformis* SOW. var. *azerbaydjanensis* ALIEV, p. 228, pl. 2, fig. 2a-b, pl. 3, fig. 3.
1954. *Inoceramus azerbaidjanensis* sp. n. ALIEV, p. 96, pl., figs 1-4.
1954. *Inoceramus tausiensis* ALIEV, p. 97, unnumbered pl., fig. 5.
1959. *Inoceramus azerbaydjanensis* ALIEV. - DOBROV & PAVLOVA, p. 148, pl. 15, figs 2-3.
1968. *Inoceramus azerbaidjanensis* ALIEV. - KUZNETZOV, p. 225, pl. 17, figs 1-2; pl. 18, fig. 2.
1973. *Inoceramus* (*Sphenoceramus*?) *pachti* ARCHANGUELSKY. - KENNEDY, KAUFFMAN & KLINGER, p. 97, pl. 2, fig. 2.
1974. *Inoceramus azerbaydjanensis* ALIEV. - KOCIUBYNSKIJ, p. 82, pl. 17, figs 3-6.
1982. *Inoceramus* (*Haenleinia*) *azerbaydjanensis* ALIEV. - MASLENNIKOVA, p. 96, pl. 10, fig. 7.
1993. *Inoceramus* (*Cordiceramus*) *azerbaidjanensis* ALIEV. - COBBAN & KENNEDY, p. 81, figs 8.1-8.13.
1997. *Inoceramus* cf. *azerbaydjanensis* ALIEV. - WALASZCZYK, p. 35, pl. 29, fig. 5.
1997. *Inoceramus azerbaidjanensis* ALIEV. - ATABEKIAN, p. 67, pl. 26, fig. 1.

**Type**: The lectotype, by subsequent designation of ALIEV (1954, p. 95), is one of his earlier originals (ALIEV 1939, pl. 2, fig. 2), from the Lower Campanian of Avas-Tapa Mount, Tauz district, Azerbaijan, and, according to ALIEV (1939, 1954), the specimen is kept in the Geological Museum of the I.M. Gubkin Institute of Geology of the Azerbaijan Academy of Sciences.

**Material**: USNM 507497, USNM 507498, USNM 507499, USNM 507501, USNM 507502, USNM 507503, USNM 507504, USNM 507505, USNM 507506, USNM 507507, USNM 507508, USNM 507509; all from USGS Mesozoic locality 9710; USNM

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Plate XXXII

Fig. 1, 4-5: "*Inoceramus*" *magniumbonatus* DOUGLAS, 1942; 1 – USNM 507638, 4 – USNM 507749, and 5 – USNM 507640; all from USNM locality 9974; ?*Baculites compressus* Zone; middle Upper Campanian.

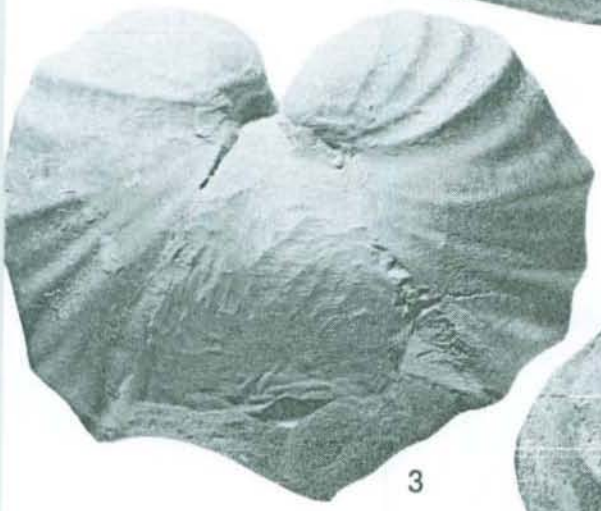
Fig. 2-3: "*Inoceramus*" *redbirdensis* sp. nov.; 2 - holotype is USNM 507655 from Red Bird section (D 1961), *Baculites eliasi* Zone; 3 – USNM 507657 from USGS Mesozoic locality D 1961; uppermost Campanian.

All figures are in natural size

1

2a

2b



3

4

5

2c

507510 and USNM 507511 from USGS Mesozoic locality D831; USNM 507500 from USGS Mesozoic locality 9523.

**Description**: Small-sized, inequilateral, prosocline species. Beak small, curved anteriorly. Umbonal part projecting distinctly above hinge line. Hinge line relatively short, straight. Valves moderately to strongly inflated. Anterior margin usually very long, straight to slightly convex. Anterior face steep. Disc relatively narrow, elongated postero-ventrally, with two distinct sulci; an axially elongated one and other running parallel to anterior margin. Axial sulcus paralleled by two radial ridges (*Schalenkante* 2 and 3 of SEITZ, 1961, p. 110). Variably developed anterior ridge (Schalenkante 1 of SEITZ, 1961, p. 110; see e.g. Pl. IV, fig. 3; Pl. V, fig. 2, 4) occur anteriorly of anterior radial sulcus. Posterior auricle relatively small, axially elongated, separated from disc by a generally well-developed auricular sulcus. Geniculation occasionally well developed.

Shells ornamented with sub- to irregularly spaced, relatively fine commarginal rugae, with narrow interspaces. Rugae sometimes discontinuous in axial sulcus (Pl. V, fig. 1).

**Remarks**: "*I.*" *azerbaydjanensis* displays a wide range of morphologic variability in almost all shell characters, including: length and development of the anterior margin, development of the anterior sulcus, development of the auricular sulcus, strength of the axial sulcus, regularity of ornament, presence/absence of geniculation.

The type of "*I.*" *tausiensis* ALIEV (1954, pl., fig. 5) possesses all the characteristics of "*I.*" *azerbaydjanensis*, i.e., anterior, axial and auricular sulci, axial and anterior ridges (*Schalenkanten* 1, 2, and 3), and distinct posterior auricle, and consequently is placed in synonymy with "*I.*" *azerbaydjanensis*.

**Occurrence**: In the Western Interior and Texas, "*I.*" *azerbaydjanensis* occurs in the *Baculites obtusus* and *Baculites maclearni* Zones of the lowermost Middle Campanian. It ranges broadly, and it is known from Europe (Germany, Poland, The Ukraine, Russia), Asia (Azerbaijan, Turkmenistan, Kazakhstan) and possibly Africa (South Africa) (KENNEDY *et al.*, 1973). When precise dating is possible it always occurs in the lower Middle Campanian. This inludes the *B. obtusus-B. maclearni* Zones in North America (COBBAN & KENNEDY, 1993, and this paper), the *stobaeilbasiplana* Zone in Germany (aff. *azerbaydjanensis* – see WALASZCZYK, 1997), and the *B. polyplocum* Zone in Tuarkyr (KUZNETZOV, 1968; see also discussion in CHRISTENSEN *et al.*, 1975). In eastern Europe and western Asia, regions where the species is commonly cited, it is described as found in the Lower Campanian (e.g., ALIEV, 1979, 1981), but most probably this results from imprecise correlation of the Campanian substages with western Europe (see also discussion in WALASZCZYK, 1997). Both "*I.*" *azerbaydjanensis* and "*I.*" *vorhelmensis* are very useful markers of the basal Middle Campanian.

**The group of *Inoceramus tenuilineatus*:** three species are referred to the group. In addition to "*I.*" *tenuilineatus* HALL & MEEK, 1856, "*I.*" *convexus* HALL & MEEK, 1856 and "*I.*" *convexiformis* sp. nov. are also included in this plexus.

### "*Inoceramus*" *tenuilineatus* HALL & MEEK, 1856
**Pl. VIII, fig. 4; Pl. X, figs 1-5; ?Pl. XIII, fig. 4**

1854. *Inoceramus tenuilineatus* HALL & MEEK, p. 387, pl. 2, fig. 3.
1876a. *Inoceramus tenuilineatus* HALL & MEEK. - MEEK, p. 57, pl. 12, fig. 6.
non 1880. *Inoceramus tenuilineatus* MEEK & HAYDEN. - WHITFIELD, p. 400, pl. 9, figs 12-13.

**Type**: The lectotype, here designated, is AMNH 0362/1 the original of HALL & MEEK (1856, pl. 2, fig. 3; reillustrated herein Pl. VIII, fig. 4) from the topmost Middle Campanian (*Baculites gregoryensis* and *Baculites scotti* Zones) of the Great Bend of the Missouri, South Dakota.

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Plate XXXIII

Fig. 1, 3: *Cataceramus? barabini* (MORTON, 1834); 1 – USNM 507639 from "Fossil Creek just south of Fort Collins, Colorado. Obtained by C.A. WHITE" [an old USNM locality 9974], located near locality 42 on the locality map; Larimer Sandstone Member of the Pierre Shale; 3 – GSC 8929, holotype of *Inoceramus barabini* var. *inflatiformis* DOUGLAS (1942, pl. 2, fig. 3); juvenile view.

Fig. 2: *Cataceramus? palliseri* (DOUGLAS, 1942); GSC 8928, holotype, original to DOUGLAS (1942, pl. 1, fig. 2); juvenile view; *Baculites reesidei* Zone; upper Upper Campanian.

All figures are in natural size

1

2

3

**Material**: Material: USNM 507530, USNM 507531, USNM 507532, USNM 507533, USNM 507534, USNM 507535, USNM 507536, USNM 507537, all from USGS Mesozoic locality D2173; USNM 507538 from USGS Mesozoic locality D1925; USNM 507539 from USGS Mesozoic locality D1924; USNM 507724 from USGS Mesozoic locality D1925; ?USNM 507559 from USGS Mesozoic locality D 1940; plaster cast of the lectotype,.

*Dimensions*

| Specimen | h | l | H | L | s | α | δ | hmax |
|---|---|---|---|---|---|---|---|---|
| Holotype | 56.5 | 45.5 | 44.0 | 52.0 | 29.5 | 42 | 108 | 82 (LV) |
| USNM 507539 | 69.0 | 58.0 | 55.5 | 65.0 | 39.0 | 50 | 110 | 70 (RV) [bi-valved] |
| USNM 507531 | 56.0 | 42.0 | 37.2 | 54.3 | 38.0 | 38 | 113 | 71.5 (RV) [bi-valved |
| USNM 507532 | 46.0 | 38.0 | 44.4 | 33.5 | — | 42 | 110 | 50 (RV) [bi-valved] |
| USNM 507536 | 56.0 | 43.0 | 41.0 | 55.0 | 33.5 | 38 | 103 | 59 (RV) [bi-valved] |
| USNM 507537 | 56.4 | 55.4 | 50.5 | 54.5 | 36.5 | 46 | 114 | 55.5 (RV) [bi-valved] |
| USNM 507724 | 63.0 | 57.0 | 50.0 | 559.5 | — | 40 | 103 | 94 |

**Description**: Small to medium sized for genus, inequilateral, sub-equivalve, with LV slightly larger than RV. Shell markedly oblique, with inclination angle between 40 and 50°. Shell sub-triangular in outline, moderately to strongly inflated, with maximum inflation dorso-central. Terminal umbonal region moderately to strongly massive, ranging high above hinge line, curved dorsally, with beak terminus, pointed ventrally. Hinge line straight, moderately long. Anterior margin long, broadly convex, slightly concave below umbo, passing into rounded ventral margin and straight posterior margin. Anterior face steep, high. Posterior auricle small to moderate sized and, in juvenile stages, distinct from disc. In adult stage, the posterior auricle merges with disc.

Ornament composed of weak or almost absent irregularly spaced ribs and irregular very low, indistinct rugae. Some specimens virtually smooth.

**Remarks**: Based on its high obliquity, almost smooth surface as well as massive umbonal region which projects substantially above the hinge line, "*I.*" *tenuilineatus* HALL & MEEK, 1856 has a very characteristic morphology. Some specimens with more massive umbonal region resemble *Sphaeroceramus sarumensis* (WOODS, 1912). The latter species, however, is a geniculated form, with relatively high juvenile obliquity, being almost orthocline as adult.

"*I.*" *tenuilineatus* varies in the shape of umbonal region and obliquity, ranging from a relatively slender, oblique morphotype, as represented by the lectotype (Pl. VIII, fig. 4), through oblique forms possessing a relatively massive umbonal region (e.g. Pl. X, fig. 1, 5), to less oblique but with slender umbo (Pl. X, fig. 2).

USNM 507559, a relatively large specimen from USGS Mesozoic locality D 1940 (Pl. XIII, fig. 4), differs in its more massive appearance and distinctly higher l/h ratio. It closely resembles some specimens of "*I.*" *pierrensis* sp. nov. and may be included into synonymy of this latter species.

WHITFIELD's (1880, pl. 9, figs 12-13; illustrated herein in Pl. XXXVII, fig. 6) concept of "*I.*" *tenuilineatus* HALL & MEEK is clearly distinct. In contrast to HALL & MEEK's type, WHITFIELD's specimen is distinctly elongated posteriorly, resembling the Early-Middle Campanian cataceramids, such as *C. subcompressus* (MEEK & HAYDEN) or Early Maastrichtian *C.? barabini* (MORTON, 1834). The figure in WHITFIELD is slightly misleading, suggesting a massive umbo, projecting markedly above the hinge line. This results from the specimen's strong inflation which, when viewed from the juvenile side, possesses an indistinct umbo, which only slightly projects above the hinge line.

**Occurrence**: MEEK's (1876a, pl. 12, fig. 6) type comes from the Great Bend of the Missouri River, so it may come from the Gregory Member of the Pierre Shale, which corresponds to the *Baculites gregoryensis* and *Baculites scotti* Zones, of the topmost Middle Campanian. The more precisely dated specimens used here are from the upper *B. gregoryensis* Zone and from the *B. scotti* Zone. Endemic to the Western Interior.

### "*Inoceramus*" *convexus* HALL & MEEK, 1856
### Pl. XXXV, fig. 2

1856. *Inoceramus convexus* HALL & MEEK, p. 386, pl. 2, fig. 2.

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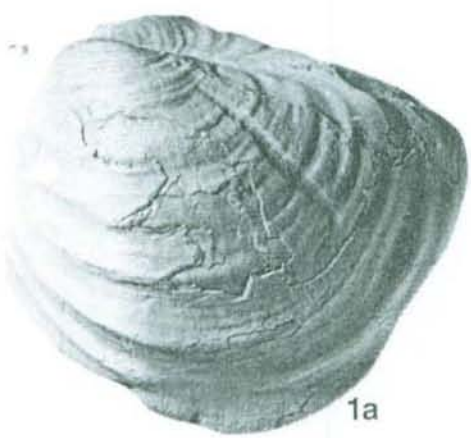
Plate XXXIV

Fig. 1: "*Inoceramus*" *redbirdensis* sp. nov.; 1 – USNM 507656 from USGS Mesozoic locality D 1961; *Baculites eliasi* Zone; uppermost Campanian.

Fig. 2-5: "*Inoceramus*" *wyomingensis* sp. nov.; 2 – USNM 507736 from USGS Mesozoic locality 6217, 3 – USNM 507727 from USGS Mesozoic locality D 13994, 4 – USNM 507726 from USGS Mesozoic locality D 13994, 5 – USNM 507735 from USGS Mesozoic locality 6217; *Baculites eliasi* Zone; uppermost Campanian.

All figures are in natural size



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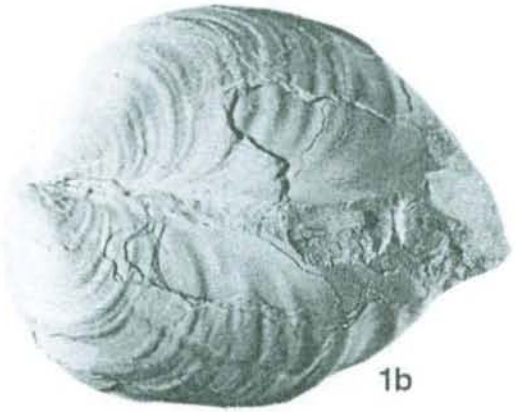

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1876a. *Inoceramus convexus* HALL & MEEK. - MEEK, p. 51, pl. 12, fig. 5.
non 1913. *Inoceramus convexus* HALL & MEEK. - BÖSE, p. 34, pl. 3, figs 3-5.
? 1959. *Inoceramus convexus* HALL & MEEK. - DOBROV & PAVLOVA, p. 155, pl. 21, fig. 1.
non 1962. *Inoceramus convexus* HALL & MEEK. - JOLKICEV, p. 140, pl. 6, fig. 1.
non 1963. *Inoceramus convexus* HALL & MEEK. - TSAGARELI, p. 101, pl. 6, fig. 3.
? 1997. *Inoceramus convexus* HALL & MEEK. - ATABEKIAN, p. 68, pl. 27, fig. 3.

**Type**: The holotype, by monotypy, is AMNH 9357/1, the original to HALL & MEEK (1854, pl. 2, fig. 2; reillustrated herein in Pl. XXXV, fig. 2). The specimen comes from the Gregory Member of the Pierre Shale of the Great Bend of the Missouri, and probably corresponds to *Baculites gregoryensis – Baculites scotti* Zones of the topmost Middle Campanian.

*Dimensions*

| Specimen | h | l | H | L | s | α | δ | hmax |
|---|---|---|---|---|---|---|---|---|
| AMNH 9357/1(Holotype) | 62.0 | 62.0 | 54.0 | 67.0 | 44.5 | 125 | 43 | 80 (LV) |

**Description**: Medium-sized, inequilateral, moderately inflated species. Valves posteriorly elongated, with hinge line long, straight. Anterior margin short, straight, at the umbonal region slightly concave. Ventral margin broadly convex, rounded, passing into rounded posterior margin. Umbonal region projecting above hinge line. Posterior auricle very small, narrow, elongated parallel to hinge line. Shell ornamented with irregular, rounded concentric rugae, moderately well developed in its middle part; in umbonal region and ventrally shell becomes smooth. Sharp-edged growth lines prominent ventrally.

**Remarks**: The species is known exclusively from its type specimen. Specimen USNM 507559 from USGS D 1940 show some resemblance but differs in much weaker ornament. However, the holotype's external prismatic shell layer is not preserved, thus its original ornament could have been more pronounced.

It is interesting that this very poorly known species is among the most commonly cited Campanian "American" species in Europe (see synonymy). In most cases, these European taxa are clearly other species. Others, such as that reported by DOBROV & PAVLOVA's (1959) or recently published by ATABEKIAN (1997), display close morphological similarity.

**Occurrence**: MEEK's type (1876a, pl. 13, fig. 2) comes from the Great Bend of the Missouri River, and according to ammonite data comes from the Gregory Member of the Pierre Shale, which encompasses the uppermost *Baculites gregoryensis* and *Baculites scotti* Zones.

### *"Inoceramus" convexiformis* sp. nov.
### Pl. XXV, fig. 1

**Type**: The holotype is USNM 507652 (Pl. XXV, fig. 1) from the USGS Mesozoic locality 16213; *Baculites reesidei* Zone.

**Derivation of the name**: Because of its resemblance to *Inoceramus convexus* HALL & MEEK, 1854.

**Material**: Single specimen: USNM 507652, from USGS Mesozoic locality 16213, from the *Baculites reesidei* Zone of the upper Upper Campanian.

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Plate XXXV

Fig. 1: *Cataceramus? barabini* (MORTON, 1834); USNM 507667 from USGS Mesozoic locality D 1048, *Baculites baculus* Zone; lowest Maastrichtian.

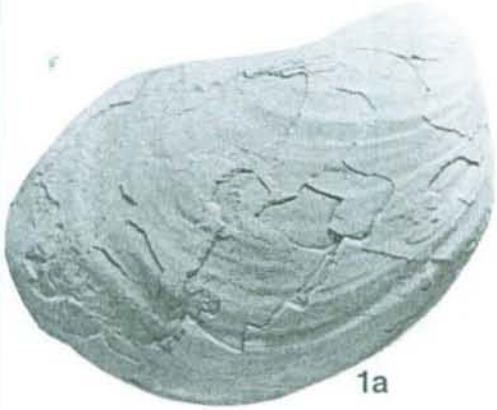
Fig. 2: *"Inoceramus" convexus* HALL & MEEK, 1854; AMNH 9357/1; holotype, original of HALL & MEEK (1854, pl. 2, fig. 2); Gregory Member of the Pierre Shale of the Great Bend of the Missouri, *Baculites gregoryensis – B. scotti* Zones; topmost Middle Campanian

Fig. 3: *"Inoceramus" vanuxemi* MEEK & HAYDEN, 1860; USNM 483, holotype; original to MEEK (1876, pl. 14, fig. 2); Upper Campanian of Sage Creek, South Dakota, probably *Baculites compressus* Zone; middle Upper Campanian

Fig. 4: *"Inoceramus" sublaevis* HALL & MEEK, 1856; lectotype; original to HALL & MEEK (1856, pl. 2, fig. 1), Great Bend of the Missouri River, South Dakota, *Baculites gregoryensis* or *Baculites scotti* Zones; topmost Middle Campanian

Fig. 5: *"Inoceramus" balchii* MEEK & HAYDEN, 1860, USNM 484, holotype; original to MEEK (1876, p. 56, pl. 15, fig. 1); Yellowstone River, Montana, 150 miles above its mouth, from the *Baculites grandis* Zone; Lower Maastrichtian.

All figure are in natural size



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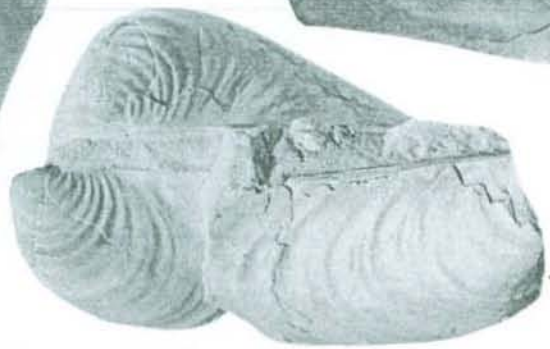

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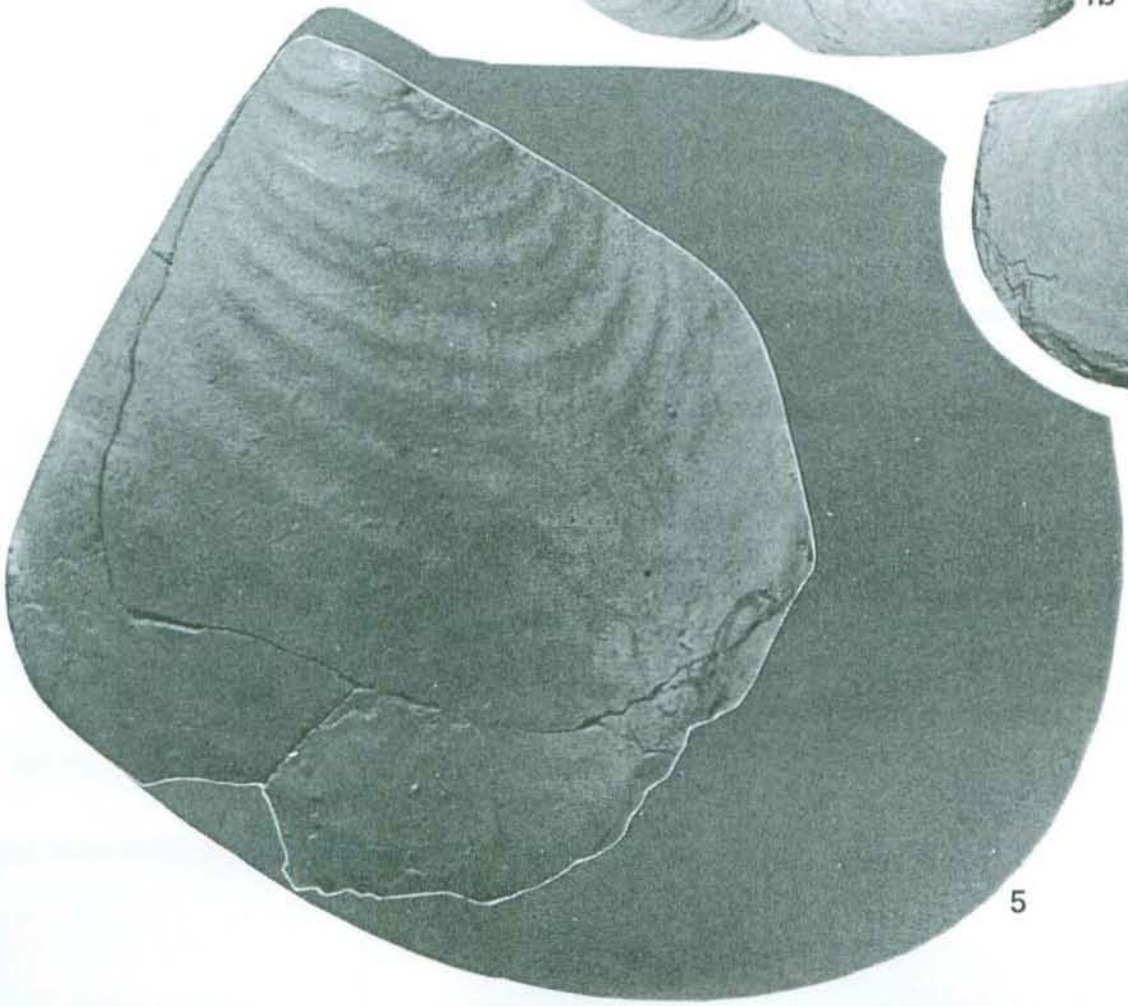

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4

**Diagnosis**: Medium-sized species with strongly inflated and obliquely oriented, globose-shaped, regularly rugate juvenile stage followed by moderately convex irregularly rugate adult stage.

**Description**: Medium-sized, inequilateral, prosocline species, distinctly geniculated. Juvenile stage globose-shaped, elongated postero-ventrally, with umbo projecting above hinge line. Adult stage flat, with the same obliquity. Anterior margin relatively short, passing into broadly rounded antero-ventral margin, and thence into narrowly rounded poster-ventral one. Hinge line long straight. Posterior auricle relatively large; in umbonal region distinct from disc.

Juvenile stage ornamented with regular, closely spaced, rounded rugae. Adult stage less regularly ornamented with rugae well developed only on the anterior part.

**Remarks**: In general outline "*Inoceramus*" *convexiformis* resembles "*Inoceramus*" *tenuilineatus*. It differs from the latter by antero-ventral shell elongation and the type of ornament; "*I.*" *tenuilineatus* is almost smooth, whereas "*I.*" *convexiformis* possesses quite regular in juvenile and subregular rugae in adult. Moreover, the latter species has less antero-dorsally elongated juvenile stage with less distinct projection of the umbonal part above the hinge line. Furthermore, its posterior auricle is less distinct from the disc. Both "*I.*" *tenuilineatus* and "*I.*" *convexus* are much weaker ornamented in juvenile stage.

**Occurrence**: In the Western Interior the only specimen comes from the *Baculites reesidei* Zone. The species is known from the *Nostoceras hyatti* Zone of the Vistula section, Central Poland.

### The group of "*Inoceramus*" *scotti*

We refer medium- to weakly inflated, large-sized forms, with moderate to small obliquity and with weak, subregular ornament to the *scotti* group. We include: "*I.*" *scotti* sp. nov., "*I.*" *pierrensis* sp. nov., "*I.*" *nebrascensis* OWEN, 1852, "*I.*" *balchiformis* sp. nov., and "*I.*" *balchii* MEEK & HAYDEN, 1860 within this plexus.

### "*Inoceramus*" *scotti* sp. nov.
### Pl. IX, figs 1-3

**Type**: The holotype is USNM 507529 (Pl. IX, fig. 2) from Tom Hollow, Pueblo County; from the ferruginous concretions in the Pierre Shale, *Baculites scotti* Zone. USNM 507540 and ?USNM 507541 are paratypes.

**Derivation of name**: After G.R. SCOTT, retired US Geological Survey geologist, collector of numerous inoceramid collections described here.

**Material**: USNM 507529 from USGS Mesozoic locality D1520; USNM 507540 and ?USNM 507541, both from USGS Mesozoic locality D1574; USNM 507733 from USGS Mesozoic locality D1923.

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Plate XXXVI

Fig. 1: *Inoceramus succiensis* WHITEAVES, 1879; USGS 1348, original of *Inoceramus crippsi* var. *subundatus* in MEEK (1876b, pl. 3, fig. 3); Sucia Islands, Canada; ?Middle Campanian.

Fig. 2, 4, 6-7: *Cataceramus? barabini* (MORTON, 1834); 2 – USGS 477A, original of *Inoceramus Cripsii*? var. *barabini* in MEEK (1876a, pl. 13, fig. 1a), 4 – USGS 477B, original of *Inoceramus Cripsii*? var. *barabini* in MEEK (1876a, pl. 13, fig. 1b-c); 6-7 – two unillustrated specimens from the original MEEK's collection.

Fig. 5: *Cataceramus subundatus* (MEEK, 1861), USNM 126, paratype, unillustrated specimen, from the original MEEK's collection; Sucia Islands, Canada; ?Middle Campanian.

Fig. 3: *Cataceramus subcompressus* (MEEK & HAYDEN 1860); USNM 4301, holotype; original of *Inoceramus Cripsii* var. *subcompressus* in MEEK (1876, pl. 38, fig. 2bis), mouth of the Judith River, Montana, *Scaphites hippocrepis* or *Baculites asperiformis* Zones; upper Lower Campanian or lower Middle Campanian.

Fig. 8: *Cataceramus? subcircularis* (MEEK, 1876); USNM 479, holotype; the original of *Inoceramus proximus* var. *subcircularis* in MEEK (1876, p. 12, fig. 2); Yellowstone River, Montana about 150 miles above its mouth; most probably lower Maastrichtian.

Fig. 9-10: "*Inoceramus*" *sagensis* OWEN, 1852, holotype, original of OWEN's (1852, p. 582, pl. 7, fig. 3) specimen, USNM 20246, Upper Cretaceous of Pierre Shale, Sage Creek, South Dakota; *Baculites compressus* Zone; middle Upper Campanian.

All figures are x 0.95


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*Dimensions*

| Specimen | h | l | H | L | s | α | δ | hmax |
|---|---|---|---|---|---|---|---|---|
| USNM 507529 | 102.0 | 96.0 | — | — | — | 65 | 115 | 18 |
| USNM 507540 | 75.6 | 75.0 | 71.0 | 70.5 | 36.5 | 62 | 120 | 110 |
| USNM 507541 | 70.5 | 66.0 | 64.0 | 66.5 | 49.2 | 54 | 115 | 89 |

**Diagnosis**: Moderate to large-sized, weakly inflated, inequilateral species. Valves moderately oblique, ventrally elongated, with suboval outline and subregular ornament composed of rounded, regularly spaced rugae.

**Description**: Medium- to large-sized species, inequilateral, ?equivalved, weakly inflated, prosocline. Disc axially elongated, passing continuously into small, indistinct posterior auricle. Anterior margin relatively long, weakly convex, slightly concave just below beak. Beak small, curved anteriorly, projecting distinctly above hinge line, passing into regularly rounded ventral margin and thence into almost straight or slightly convex posterior margin. Hinge line relatively short, straight.

Ornament composed of regularly spaced, symmetrical, rounded rugae, best developed in the central disc.

**Remarks**: Distinct ventral shell elongation, with very low obliquity and very regular ornament, composed of symmetrical, rounded rugae, as well as the lack of well-developed posterior auricle are among the primary morphologic features of this species. Juvenile specimens may be very similar to "*Inoceramus*" *gandjaensis* ALIEV, 1956, as demonstrated by USNM 507541 (Pl. IX, fig. 3). Despite the similarity in overall appearance, "*I.*" *scotti* differs from *Inoceramus sagensis* OWEN in the development of a posterior auricle and in the growth axis, which in OWEN's species is curved anteriorly, instead of straight as in "*I.*" *scotti*. In valve outline "*I.*" *scotti* sp. nov. closely resembles "*Inoceramus*" *pierrensis* sp. nov. In contrast to the latter species, which is almost smooth, "*I.*" *scotti* possesses quite regular ornament.

**Occurrence**: Known exclusively from the Western Interior *Baculites scotti* Zone.

### "*Inoceramus*" *pierrensis* sp. nov.
### Pl. XII; Pl. XIV, figs 1, 3, 5; Pl. XV, fig. 4; Pl. XVI, fig. 1

1896. *Inoceramus sagensis* OWEN. - GILBERT, pl. 56, fig. 2.

**Type**: The holotype is USNM 507740 (Pl. XIV, fig. 1) from USGS Mesozoic locality D1923, from the *Baculites scotti* ammonite Zone of the Red Bird section, Wyoming (see GILL & COBBAN, 1966). USNM 507560, USNM 507562 (Pl. XIV, fig. 3), USNM 507563 (Pl. XIV, fig. 5), USNM 507566 (Pl. XII), USNM 507568 (Pl. XVI, fig. 1), USNM 507569, USNM 507576 and USNM 507578 (Pl. XV, fig. 4) are paratypes.

**Derivation of the name**: Named for the Pierre Shale, the primary formation studied in this work.

**Material**: USNM 507560 and USNM 507561 from USGS Mesozoic locality D 1498; USNM 507562 from USGS Mesozoic locality D 1048; USNM 507563, USNM 507566 from USGS Mesozoic locality D3789; USNM 507568, USNM 507569, USNM 507576, USNM 507578, all from USGS Mesozoic locality D79; USNM 507740 from USGS Mesozoic locality D1923.

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Plate XXXVII

Fig. 1: *Cataceramus? palliseri* (DOUGLAS, 1942) or *Cataceramus? subcircularis* (MEEK, 1876a); USNM 12296A, original of *Inoceramus vanuxemi* MEEK & HAYDEN, 1860, in WHITFIELD (1880, pl. 7, fig. 8; pl. 8, fig. 4).

Fig. 2: *Cataceramus? subcircularis* (MEEK, 1876a); USNM 12296B, original of *Inoceramus vanuxemi* MEEK & HAYDEN, 1860, in WHITFIELD (1880, pl. 7, fig. 9; pl. 8, fig. 5).

Fig. 3: "*Inoceramus*" *vanuxemi* MEEK & HAYDEN, 1860; USNM 12296C, original of *I. vanuxemi*, var.? in WHITFIELD (1880, pl. 7, fig. 10); *Baculites compressus* Zone; Middle Campanian.

Fig. 4: "*Inoceramus*" *whitfieldi* sp. nov.; USNM 12323, original of *Endocostea sulcata* ROEMER in WHITFIELD (1880, pl. 10, fig. 6); .

Fig. 5: *Inoceramus* sp.; USNM 12275, original of *Inoceramus simpsoni*? MEEK, 1877 in WHITFIELD (1880, pl. 9, fig. 9).

Fig. 6: "*Inoceramus*" sp.; USNM 12314, original of *Inoceramus tenuilineatus* HALL & MEEK, 1856, in WHITFIELD (1880, pl. 9, fig. 12).

Fig. 7: "*Inoceramus balchii* MEEK & HAYDEN, 1860; USNM 12313, original of *Inoceramus sagensis* OWEN, 1852, in WHITFIELD (1880, pl. 7, fig. 12).

Fig. 8: "*Inoceramus*" sp.; USNM 12320, original of *Inoceramus simpsoni* MEEK, 1877, in WHITFIELD (1880, pl. 8, fig. 1).

Fig. 9: *Mytiloides* sp.; USNM 12285, original of *Inoceramus altus* MEEK & HAYDEN, 1860, in WHITFIELD (1880, pl. 9, fig. 11); Turonian of Black Hills area.


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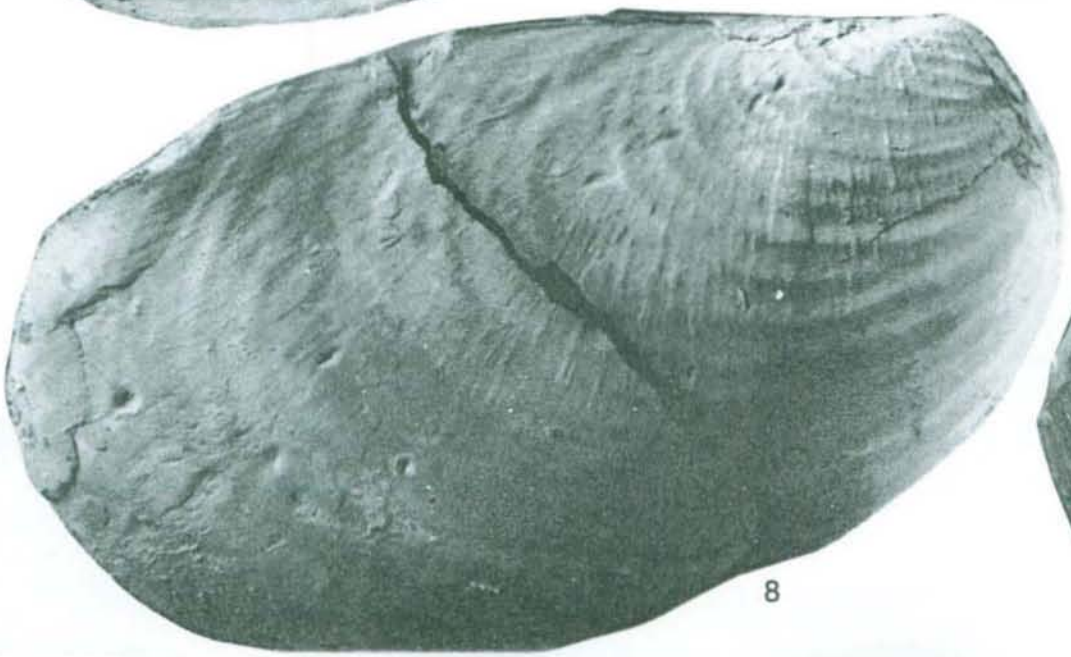
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*Dimensions*

| Specimen | h | l | H | L | s | α | δ | hmax |
|---|---|---|---|---|---|---|---|---|
| USNM 507560 | 57.0 | 51.0 | 45.4 | 54.5 | — | 115 | 50 | 87(LV) |
| USNM 507568 | 82.0 | 71.5 | 69.0 | 71.0 | 39.4 | 125 | 48 | 190(LV) |
| USNM 507576 | 56.0 | 48.0 | 47.0 | 52.5 | 31.5 | 120 | 46 | 102(RV) |
| USNM 507740 | 60.8 | 54.5 | 54.7 | 58.0 | 33.5 | 122 | 55 | 86.5 (bi-valved) |

**Diagnosis**: Large-sized, weakly inflated, ventrally elongated species, with weakly separated, relatively small posterior auricle, and long, slightly convex anterior margin. Valves weakly ornamented or completely smooth.

**Description**: Medium- to large-sized, prosocline, weakly inflated species, with dorsal maximum inflation. Valves equivalve, ventrally elongated, moderately inequilateral, with long, weakly convex anterior margin, slightly concave near umbo. Ventral margin rounded, passing into long, slightly convex posterior margin. Hinge line straight, relatively short. Beak small, projecting slightly above hinge line, curved antero-dorsally. Posterior auricle very small, continuous with disc.

Shell weakly ornamented with irregular rugae, widely spaced in ventral part; sometimes completely smooth.

**Remarks**: "*I.*" *pierrensis* displays moderate variability with respect to valve inflation and surface ornament. It varies from almost smooth, as in USNM 507569 and USNM 507563, to moderately rugate forms, with rugae developed primarily in the juvenile stage (e.g., USNM 507578 or USNM 507566 – see Pl. XV, fig. 4; pl. XII).

"*I.*" *balchii* MEEK & HAYDEN, 1860, is morphologically very similar to "*I.*" *pierrensis* sp. nov., but the latter taxon differs in less regular and less well-developed ornament, stronger valve inflation, and in convex anterior margin, which in the former species is straight to slightly concave. Juvenile parts of "*I.*" *balchii* bear quite regular, low concentric rugae, which, though weaker in the axial portion of the valves, are well-developed in anterior and posterior parts of the shell.

A juvenile of "*I.*" *pierrensis* sp. nov. may represent HALL & MEEK's "*I.*" *sublaevis*.

**Occurrence**: The species is known only from the Western Interior, ranging from *Baculites scotti* through the *Exiteloceras jenneyi* Zones.

## "*Inoceramus*" *nebrascensis* OWEN, 1852
## Pl. XV, fig. 1; Pl. XVI, fig. 2; Pl. XX, fig. 1; Pl. XXXVIII, fig. 4

1852. *Inoceramus Nebrascensis* (N.S.) OWEN, p. 582, pl. 8A, fig. 1.

non 1876a. *Inoceramus Sagensis* var. *Nebrascensis* OWEN. - MEEK, p. 52, pl. 13, fig. 2. [=*Inoceramus sagensis* OWEN, 1852]

non 1963. *Inoceramus nebrascensis* OWEN. - TSAGARELI, p. 98, pl. 4, fig. 4 [=?*Inoceramus sagensis* OWEN, 1852].

1978. *Inoceramus pteroides pyrenaicus* SORNAY *in* SORNAY & BILOTTE, p. 32 (pars), pl. 4, fig 1 [?non pl. 2, fig. 1].

non 1982. *Inoceramus* aff. *pteroides pyrenaicus* SORNAY. - SORNAY, p. 10, pl. 3, fig. 4.

**Type**: By monotypy the holotype is USNM 20247, OWEN's original (1852, pl. 8A, fig. 1) from the Campanian of Sage Creek, Pennington County, South Dakota.

**Material**: USNM 507567, and USNM 507586 from USGS Mesozoic locality D79; the type of the species; USNM 507580 from USGS Mesozoic locality D3713 and USNM 507581 from USGS Mesozoic locality D79.

*Dimensions*

| Specimen | h | l | H | L | s | α | δ | hmax |
|---|---|---|---|---|---|---|---|---|
| Holotype | 95.5 | — | 71.5 | 96.0 | 62 | — | 40 | — |
| USNM 507567 | 121.0 | 86.0 | 79.5 | 110.0 | 84 | 110 | 35 | 185 |

**Description**: Moderate to large sized for genus, inequilateral, ?equivalved. Valves trapezoidal in outline, weakly to moderately inflated; some specimens with apparent geniculation. Posterior auricle relatively small, weakly separated from disc. Growth axis almost straight, with δ

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Plate XXXVIII

Fig. 1: "*Inoceramus*" *maclearni* DOUGLAS, 1942; USNM 507685 from USGS Mesozoic locality D 1048; *B. baculus* Zone; lowest Maastrichtian.

Fig. 2, 6: "*Inoceramus*" *saskatchewanensis* WARREN, 1934; cotypes: 2 - NMC 8742a, 6 – NMC 8742; both from Bearpaw Formation: ?*Baculites compressus* Zone; ?Upper Campanian.

Fig. 3, 5: "*Inoceramus*" *maclearni* DOUGLAS, 1942; 3 – GSC 8926, holotype of *Inoceramus mcshaniensis* DOUGLAS (1942, pl. 2, fig. 2); 5 – GSC 8925, holotype of *Inoceramus maclearni* DOUGLAS (1942, pl. 2, fig. 1); *B. reesidei* Zone; upper Upper Campanian.

Fig. 4: "*Inoceramus*" *nebrascensis* OWEN, 1852; USNM 20247, holotype, original of OWEN (1852, pl. 8A, fig. 1), Sage Creek, Badlands National Park, South Dakota; ?*Baculites compressus* Zone; ?Upper Campanian.

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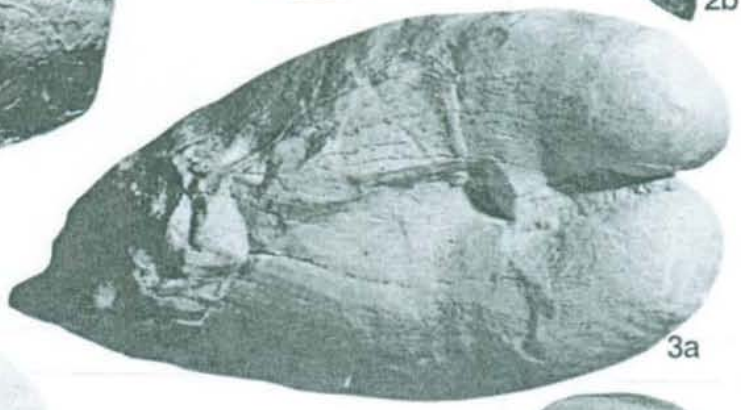
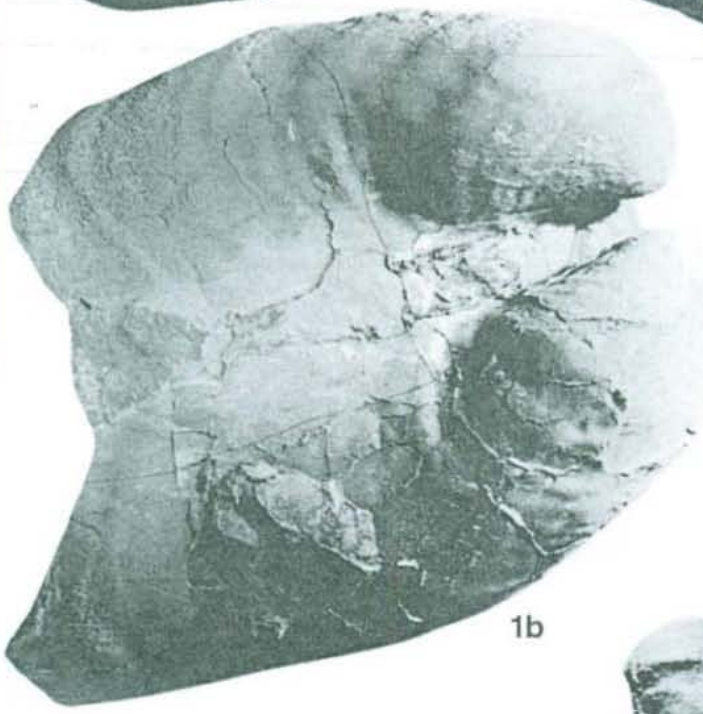


3a



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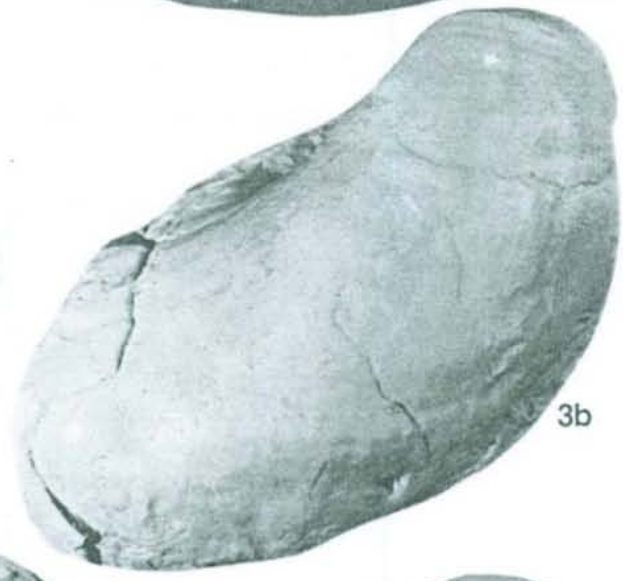

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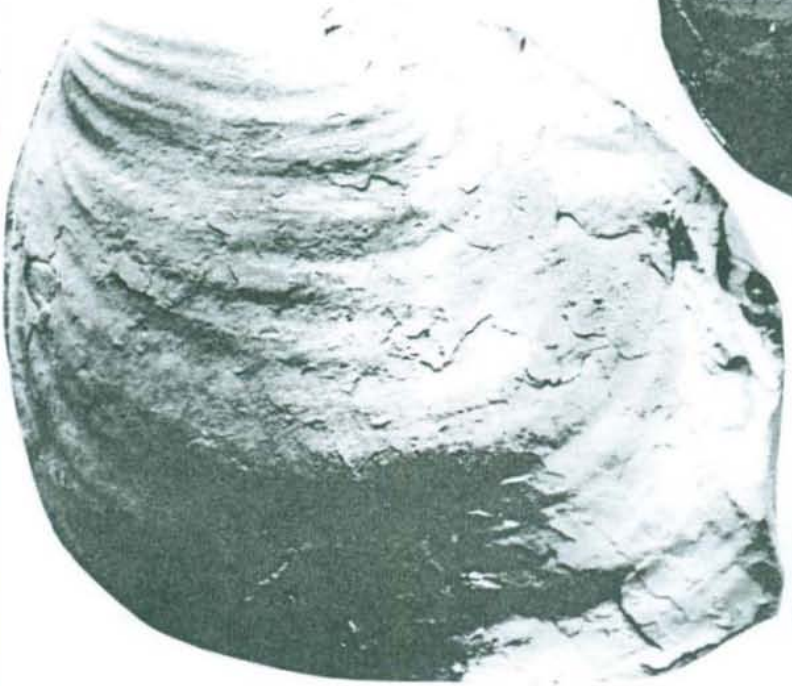

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5b

values below 40° (relatively oblique form). Anterior margin moderately long, weakly convex or straight, passing into broadly convex ventral and posterior margins. Hinge line straight, long. Umbo projecting above hinge line.
Shells ornamented with sub- to irregular rugae; in adult stage shells almost smooth.

**Remarks**: The illustration in OWEN (1852, pl. 8A, fig. 1) is almost perfect (compare with its photographic illustration herein – Pl. XXXVIII, fig. 4). As in the case of "*Inoceramus*" *sagensis*, however, the illustration is a mirror image and the specimen is actually the LV, not the RV. The RV is not preserved; some adult fragments attached to the RV valve belong probably to another specimen.
In contrast to MEEK's (1876a) assessment, the types of OWEN's "*I.*" *nebrascensis* and of "*I.*" *sagensis* differ considerably and should be retained as distinct species. In comparison with "*I.*" *sagensis*, "*I.*" *nebrascensis* differs in its distinct posterior elongation (with higher l/h ratio), lower obliquity and, moreover, weaker and less regular ornament.
*Inoceramus pteroides pyrenaicus* described from the Campanian of Spain by SORNAY (*in* SORNAY & BILOTTE, 1978, p. 32, pl. 4, fig. 1) is very similar and most probably conspecific with "*I.*" *nebrascensis*. This is particularly true of the holotype, whereas the additional specimen illustrated by SORNAY (*in* SORNAY & BILOTTE, 1978, pl. 2, fig. 1) differs substantially from the type in its ornamentation; it consists of widely spaced, narrow rugae, with very wide interspaces, covered by distinct, raised growth lines. Thus this second specimen may represent a different species although the range of ornament variability in OWEN's species is virtually unknown and consequently no definitive statement can currently be made. Additionally, a remarkably different specimen is SORNAY's *I. pteroides pyrenaicus* from the Upper Campanian of Belgium (SORNAY, 1982, pl. 3, fig. 4). Although SORNAY left it in open nomenclature because of its incomplete preservation, this specimen is clearly less oblique and possesses a much different type of ornament.
The illustrated specimen of "*Inoceramus*" *nebrascensis* OWEN in TSAGARELI (1963, pl. 4, fig. 4) is much less oblique and possesses quite regular ornament and belongs to "*Inoceramus*" *sagensis* OWEN.

**Occurrence**: The type specimen comes from Sage Creek (?*B. compressus* Zone); the species is known from the lower Upper Campanian (*E. jenneyi* Zone through ?*B. compressus* Zone) of the Western Interior. Known from the Upper Campanian (with no further refined stratigraphic information) of Europe (northern Spain).

### "*Inoceramus*" *balchiformis* sp. nov.
### Pl. XXV, figs 2, 5; Pl. XXX

**Type**: The holotype is USNM 507622, from USGS Mesozoic locality D372 (Pl. XXV, fig. 2), from the *B. reesidei* Zone of Colorado, US Western Interior.

**Derivation of the name**: Because of its resemblance to "*Inoceramus*" *balchii* MEEK & HAYDEN, 1860.

**Material**: USNM 507621 from USGS Mesozoic locality 16215; USNM 507622, from USGS Mesozoic locality D372; USNM 507623 from USGS Mesozoic locality D2719.

*Dimensions*

| Specimen | h | l | H | L | s | α | δ | hmax |
|---|---|---|---|---|---|---|---|---|
| USNM 507622 | 71.5 | 63.0 | 58.5 | 63.0 | 35.0 | 129 | 50 | 103 (RV) |

**Description**: Medium- to large-sized, prosocline, equivalve species. Valves inequilateral, weakly inflated, with maximum inflation in umbonal region. Beak small, pointed anteriorly, projecting slightly above hingeline.

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Plate XXXIX

Fig. 1-2, 7-8, 10: "*Inoceramus*" *incurvus* MEEK & HAYDEN, 1856; 1 – USNM 507681 from the USGS Mesozoic locality D 877; 2 – USNM 482, paratype; 7 – YPM 191003, from Glendive section; 8 – USNM 507686 and 10 – USNM 507695, from USGS Mesozoic locality D 877; all from *Baculites baculus* Zone; lowest Maastrichtian.

Fig. 3, 6: *Cataceramus? subcircularis* (MEEK, 1876a); 3 – USNM 507680 from USGS Mesozoic locality D 1048, 6 – YPM 191004, from the Glendive section; *Baculites baculus* Zone; lowest Maastrichtian.

Fig. 4-5: *Cataceramus? barabini* (MORTON, 1834); 4 – USNM 507668 from unknown locality; 5 – USNM 507663 from USGS Mesozoic locality D 1048; *Baculites baculus* Zone; lowest Maastrichtian.

Fig. 9: *Endocostea* sp. [slightly deformed specimen]; USNM 507705 from USGS Mesozoic locality D 434; *Baculites baculus* Zone; lowest Maastrichtian

Besides fig. 8, which is x 0.65, all other figures are in natural size

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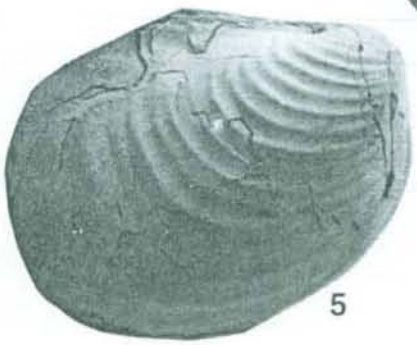

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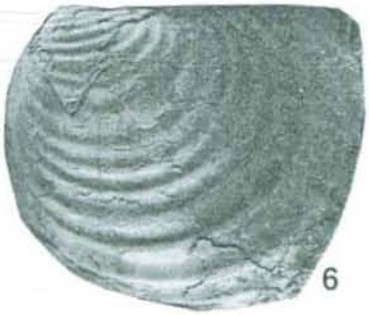

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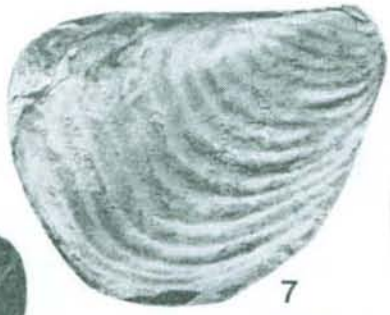

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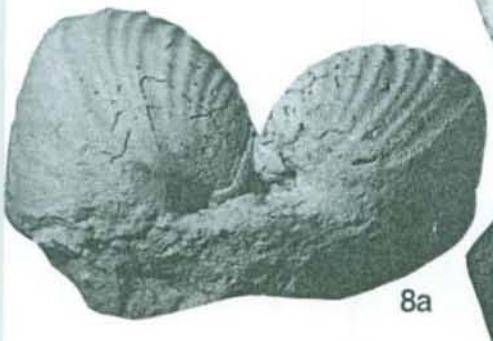

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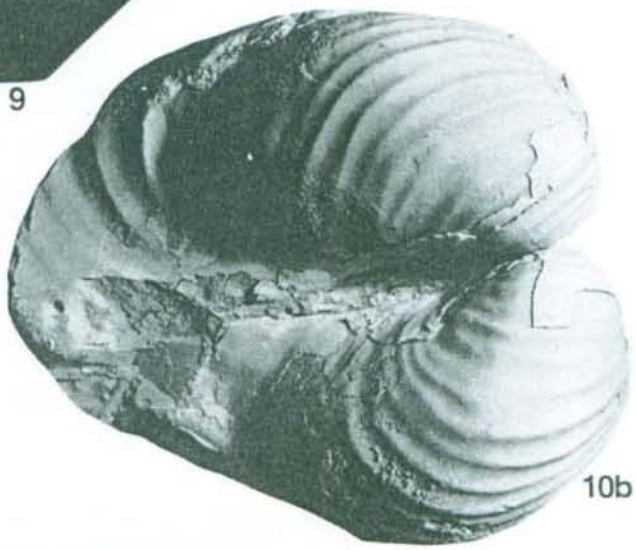

10b

Anterior margin straight, concave near umbo, passing into broad, rounded ventral margin, and thence into weakly convex posterior margin. Hinge line long, straight. Posterior auricle relatively large, not separated from disc.

In juvenile stage shell ornamented with rounded, relatively widely spaced concentric rugae, weakening and finally disappearing ventrally.

**Remarks:** "*I.*" *balchiformis* sp. nov. differs from "*I.*" *balchii* in being less prosocline, less inflated, in the concave anterior margin and in smaller, indistinct umbo which does not project above the hinge line. Morover, "*I.*" *balchiformis* sp. nov. is less elongated posteriorly and its posterior auricle is less distinctly separated from the disc. "*I.*" *balchiformis* is also similar to basal Upper Campanian forms such as "*I.*" *pierrensis* sp. nov. and "*I.*" *scotti* sp. nov.

**Occurrence**: The species is known from the *Baculites reesidei* Zone of the Western Interior and from the topmost Campanian *Nostoceras hyatti* Zone of the Middle Vistula section, Central Poland.

### "*Inoceramus*" *balchii* MEEK & HAYDEN, 1860
### Pl. XXXV, fig. 5; Pl. XXXVII, fig. 7; Pl. XLIV, fig. 1

1860. *Inoceramus Balchii* MEEK & HAYDEN, p. 180.

1876a. *Inoceramus Balchii* MEEK & HAYDEN. - MEEK, p. 56, pl. 15, fig. 1.

? 1880. *Inoceramus sagensis* OWEN. - WHITFIELD, p. 393, pl. 7, fig. 12; pl. 8, fig. 2.

non 1903. *Inoceramus balchii* MEEK & HAYDEN. - JOHNSON, p. 117, pl. 2, fig. 16. [?"*Inoceramus*"*vanuxemi* MEEK & HAYDEN, 1860].

non 1963. *Inoceramus balchi* MEEK & HAYDEN. - TSAGARELI, p. 99, pl. 2, fig. 1.

**Type**: The holotype, by monotypy, is USNM 484, the original to MEEK (1876a, p. 56, pl. 15, fig. 1; reillustrated herein – Pl. XXXV, fig. 5); according to MEEK (1876a, p. 56) the specimen comes from Yellowstone River, 150 miles above its mouth, from the *B. grandis* Zone.

**Material**: USNM 507708, from USGS Mesozoic locality D 1868, *B. grandis* Zone; USNM 507719, USNM 507721, and USNM 507723, all from USGS D 2121, *B. clinolobatus* Zone; UWWG US1 from Weston County, Wyoming (N1/2 sec. 10, T. 42 N., R. 62 W.), *Baculites grandis* Zone.

**Description**: Large to very large species, weakly to moderately inflated, inequilateral, equivalved. Valves subquadrate in outline, prosocline. Anterior margin relatively long, straight to weakly convex anteriorly; weakly concave just below umbo. Ventral and posterior margins broadly rounded. Hinge line straight, long. Umbo usually distinctly projecting above hinge line. Posterior auricle large, extended posteriorly, distinct from disc in the juvenile part.

Juvenile valves ornamented with irregularly spaced, asymmetrical rugae. Axially, rugae have a V-shaped outline, they weaken slightly when passing onto posterior auricle. Adult stage with indistinct, very irregular rugae or completely smooth.

**Remarks**: The holotype is incompletely preserved, with umbonal and postero-dorsal part missing (see Pl. XXXV, fig. 5). Clearly, the specimen was mishandled at some point inasmuch as when MEEK prepared his monograph (1876a), it appears much more complete, with a large portion of dorsum and posterior evidently lost (compare the illustrated type with the figure in MEEK, 1876a, pl. 15, fig. 1). MEEK's figure, as revealed by a comparison to the preserved valve was, to some extent, idealised. This is particularly evident in the manner in which the characteristic narrow bends of rugae (V-shaped outline) in the axial part, appear rounded in MEEK's illustration (1876a, pl. 13, fig. 1). Moreover, the actual specimen

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Plate XL

Fig. 1-4, 7-8: *Endocostea typica* WHITFIELD, 1880; 1 – USNM 12261a, 2 – USNM 12261b, 3 – USNM 12261d, 4 – USNM 12261c [letteral symbols *after* SEITZ 1967]; originals of *Endocostea typica* WHITFIELD *in* WHITFIELD (1880, pl. 9, figs 1-3, 7); Old Woman Fork, Cheyenne River, Wyoming; 7 – USNM 507669 from USGS Mesozoic locality D 1970; 8 – USNM 507752, from USGS Mesozoic locality D 1971, both from the Red Bird section, Wyoming; *Baculites baculus* Zone; lowest Maastrichtian.

Fig. 5: *Cataceramus? barabini* (MORTON, 1834); USNM 12261e [letter symbol after SEITZ 1967]; original of *Endocostea typica* WHITFIELD *in* WHITFIELD (1880, pl. 9, fig. 4); Old Women Fork, Cheyenne River, Wyoming; *Baculites baculus* Zone; lowest Maastrichtian.

Fig. 6: *Endocostea coxi* (REYMENT, 1955); USNM 507709 from old USNM locality 7459, Nacatoch Sands, Texas; Lower Maastrichtian; x 0.9.


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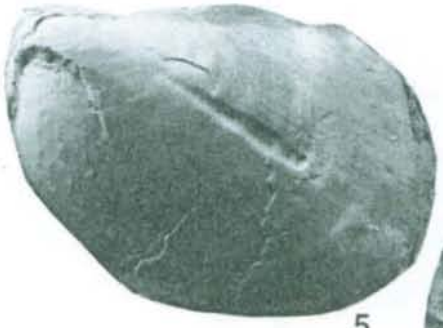
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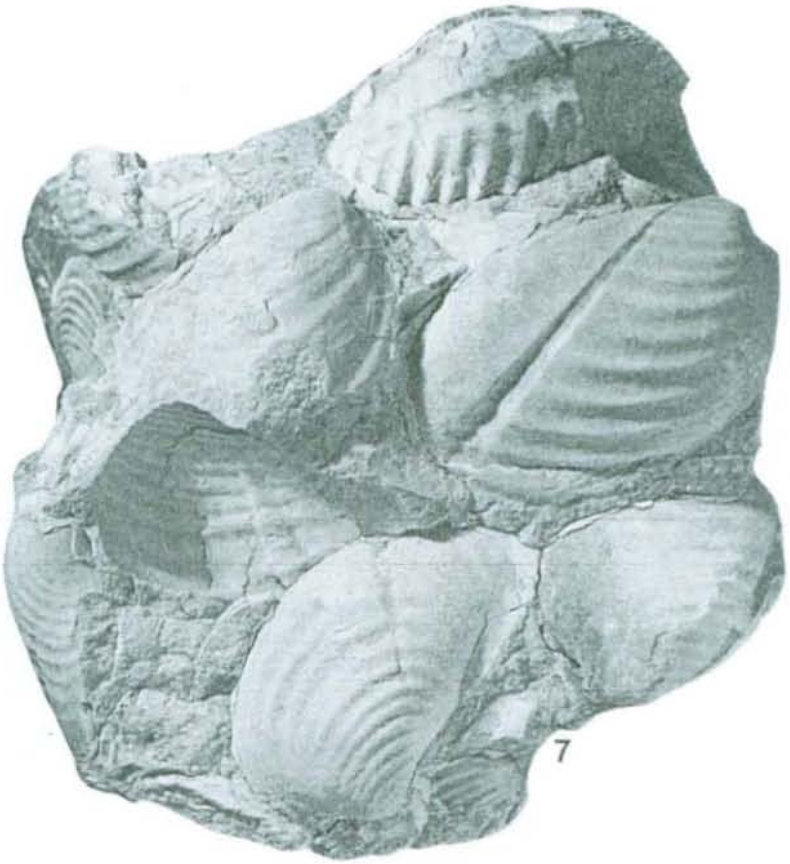
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8

also shows irregular doubling of rugae in the adult stage and distinct asymmetry of the rugae with both features weakly shown or completely omitted in MEEK's illustration.

We refer WHITFIELD's (1880, pl. 7, fig. 12) "*I.*" *sagensis* (photographically represtented in our Pl. XXXVII, fig. 7) to "*Inoceramus*" *balchii*. This distinctly prosocline specimen, with large posterior auricle, long hingeline, and with irregular rugae differs markedly from "*I.*" *sagensis* and closely resembles MEEK & HAYDEN's species.

JOHNSON's (1903, pl. 2, fig. 16) specimen is regularly rugate and rounded in outline. The specimen is quite distinct from "*I.*" *balchii* more closely resembling *Inoceramus vanuxemi* MEEK & HAYDEN, 1860, a taxon rarely described from the Western Interior.

In the material studied, "*Inoceramus*" *balchii* is rather uncommon. Good specimens, such as USNM 507721 (Pl. XLIV, fig. 1), USNM 507719, and USNM 507723, come from the *B. clinolobatus* Zone, from USGS Mesozoic locality D 2121. The specimens at hand are represented by medium-sized representatives of the species, which retain well-developed rugae. The rugae show a very characteristic outline: V-shaped at the growth-axis. This feature is not seen in MEEK's illustration (1876a, pl. 15, fig. 1), but it is obvious on the preserved fragments from the original specimen (see Pl. XXXV, fig. 5).

**Occurrence**: The type comes from the *B. grandis* Zone in the Western Interior. It ranges up to the *B. clinolobatus* Zone in that area. It is also known from the Lower Maastrichtian of the Gulf Coast. "*Inoceramus*" *balchii* is commonly cited in papers from Eastern Europe (e.g. TSAGARELI, 1963; GAMBASHIDZE, 1963ALIEV & KHARITONOV, 1981; ALIEV *et al.*, 1982). None of those illustrated specimens can, however, be referred to the American species.

### The group of "*Inoceramus*" *altus*

The group comprises small- to moderate-sized, weakly to moderately inflated forms, with very regular concentric ornament. All forms have limited obliquity and usually a distinct posterior auricle. We refer "*I.*" *altus* MEEK, "*I.*" *altusiformis* sp. nov., "*I.*" *sagensis* OWEN, and "*I.*" *vanuxemi* MEEK & HAYDEN to this plexus.

### "*Inoceramus*" *altus* MEEK, 1871
### Pl. XXII, figs 1-8; Pl. XXIII, figs 1, 3-5; Pl. XXIV, fig. 1

1871. *Inoceramus altus* MEEK, p. 302.
1876a. *Inoceramus altus* MEEK. - MEEK, p. 43, pl. 14, fig. 1.
non 1880. *Inoceramus altus* MEEK. - WHITFIELD, p. 391, pl. 9, fig. 11[= *Mytiloides* sp.].
1898. *Inoceramus altus* MEEK. - LOGAN, p. 506, pl. 107, fig. 1.

**Type**: The holotype, by original designation, is USNM 12462, the specimen illustrated by MEEK (1876a, pl. 14, fig. 1; reillustrated herein in Pl. XXIV, fig. 1) from near Medicine Bow station, Wyoming, *Baculites compressus* Zone.

**Material**: USNM 507596 from USGS Mesozoic locality D1352; USNM 507599 from USGS Mesozoic locality D1786; USNM 507598 from USGS Mesozoic locali-

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Plate XLI

Fig. 1: *Cataceramus? subcircularis* (MEEK, 1876); 1 - USNM 507732, Ripley Formation, Coon Creek, McNairy County, Tennessee; Lower Maastrichtian.

Fig. 2: ? *Cataceramus? subcircularis* (MEEK, 1876); USNM 507720 from USGS Mesozoic locality D 1042; *Baculites clinolobatus* Zone; upper Lower Maastrichtian.

Fig. 3: *Cataceramus? oviformis* sp. nov.; holotype, USNM 131542; original of *Inoceramus* sp. *in* DANE (1929, pl 25, fig. 1), Nacatoch Sand of the High Bluff on Ouachita River, 1.5 miles north of Arkadelphia, Clark County; Lower Maastrichtian.

Fig. 4: *Trochoceramus nahorianensis* (KOCIUBINSKIJ, 1968); USNM 507741, Nacatoch Sand, Canyon Creek; ?uppermost Campanian.

Fig. 5: *Cataceramus*? *gandjaeformis* sp. nov.; USNM 507647 from USGS Mesozoic locality D 373, *Baculites jenseni* Zone; upper Upper Campanian.

Fig. 6: "*Inoceramus*" *stephensoni* sp. nov.; USNM 76375, original to *Inoceramus vanuxemi* HALL & MEEK *in* STEPHENSON (1941, pl. 13, fig. 4); Nacatoch Sand near Chatfield, Navarro County, Texas; Lower Maastrichtian.

All figures are in natural size

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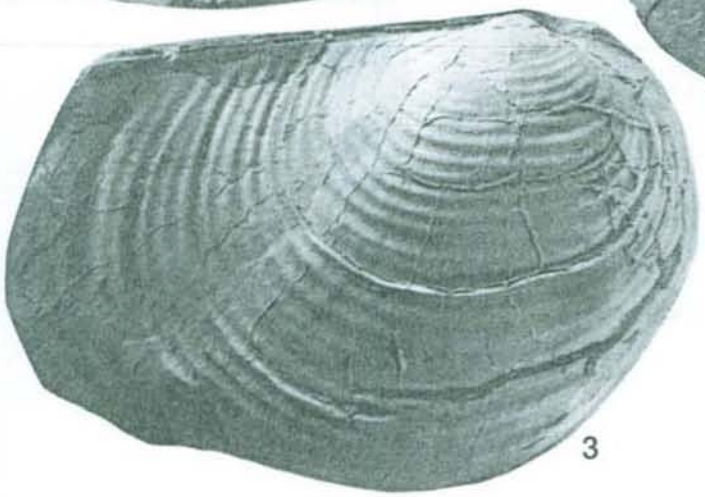

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ty D1351; USGS 23072 and USNM 507600 from USGS Mesozoic locality 23072; type of the species; USNM 507611 from USGS Mesozoic locality 23072; USNM 507613 from USGS Mesozoic locality D1786; USNM 507614, USNM 507615, and USNM 507616 from USGS Mesozoic locality D1351; USNM 507609 and USNM 507610 from USGS Mesozoic locality D2654; USNM 507603, USNM 507604, USNM 507605, USNM 507606, USNM 507608, all from USGS Mesozoic locality D1786; USNM 507618 from USGS Mesozoic locality D2654;

*Dimensions*

| Specimen | h | l | H | L | s | α | δ | l/h | hmax |
|---|---|---|---|---|---|---|---|---|---|
| Holotype | 93.0 | 68.0* | 85.5 | 68.0 | 43.0 | 95 | 58 | 0.73 | 116 (LV) |
| USNM 507597 | 72.0 | 67.0 | 68.5 | 67.0 | 28.5 | 118 | 68 | 0.93 | 80 (RV) |
| USNM 507599 | 77.0 | 66.0 | 68.0 | 69.0 | 34.0 | 115 | 55 | 0.85 | 100 (LV) |
| USNM 507598 | 72.0 | 58.0 | 68.0 | 59.0 | 29.5 | — | 62 | 0.80 | 94 (RV) |
| USNM 507600 | 55.0 | 49.9 | 49.5 | 52.0 | 29.0 | 123 | 63 | 0.90 | 108 (RV) |
| USNM 507596 | 67.0 | 54.0 | 60.0 | 57.0 | 24.5 | 120 | 60 | 0.80 | 92 (RV) |
| USNM 507595 | 90.0 | 74.0 | 82.0 | 76.0 | 39.8 | 115 | 60 | 0.82 | 112 (RV) |
| USNM 507611 | 51.0 | 43.8 | 46.0 | 44.0 | 26.5 | 119 | 60 | 0.85 | — |
| USNM 507613 | 62.0 | 51.2 | 54.7 | 55.0 | 28.0 | 113 | 53 | 0.82 | 77 (LV) |
| USNM 507614 | 55.0 | 45.5 | 50.0 | 47.0 | 26.0 | 113 | — | 0.82 | 57 (RV) |
| USNM 507608 | 51.0 | 43.7 | 47.3 | 42.0 | 23.5 | 110 | 58 | 0.85 | 57 (LV) |
| USNM 507603 | 64.5 | 60.3 | 60.0 | 62.0 | 28.5 | 122 | 58 | 0.93 | 75 (RV) |

**Description**: Moderate to large sized for genus, inequilateral, equivalved. Shell (with growth-axis straight to slightly convex anteriorly) prosocline, with beak terminal, pointed anteriorly, moderately projecting above hinge line. Posterior auricle large extended posteriorly, well separated from disc with distinct auricular sulcus. Hinge line long, straight. Anterior margin broadly convex (its straight character in holotype results from slight deformation). Ventral margin rounded, narrow, passing into long, straight posterior margin. Close to hinge line posterior margin sometimes slightly concave. Shell ornamented with closely and regularly spaced, asymmetrical concentric ribs (with steeper ventral slope). Ribs weaken markedly when they pass onto posterior auricle. It is seen the best on the type specimen. Toward hinge, ribs either run straight or curve posteriorly. Rugae parallel to growth lines.

**Remarks**: It is a very characteristic species, which besides "*I.*" *altusiformis*, differs form all other species occurring in the Upper Campanian. From "*I.*" *altusiformis* it differs in slender outline and in large and better separated posterior auricle. The type of the species (Pl. XXIV, fig. 1) is slightly deformed in the anterior margin, what makes the specimen even more slender than it really is.

In surface ornament "*I.*" *altus* resembles "*Inoceramus*" *vanuxemi* MEEK & HAYDEN, 1860 (see pl. XXXV, fig. 3). The latter species is less oblique, less inflated and its ornament seems to be more regular. Laterally compressed specimens may be very similar.

The specimen referred to "*Inoceramus*" *altus* and illustrated by WHITFIELD (1880, pl. 9, fig. 11) represents an Upper Turonian *Mytiloides* species. The actual specimen differs considerably from WHITFIELD's sketch (see illustration herein in Pl. XXXVII, fig. 9) being markedly more inflated, axially elongated, relatively small form, orthocline, with weakly separated posterior auricle.

**Occurrence**: The species is known from US Western Interior from the *Didymoceras cheyennense*, *Baculites compressus*, and *Baculites cuneatus* Zones. Outside the Western Interior, the species is almost unknown. To date, the only record comes from the middle part of the Piotrawin quarry, Upper Campanian of the Central Poland Vistula section, *Nostoceras hyatti* ammonite Zone (WALASZCZYK, in prep.).

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Plate XLII

Fig. 1: *Cataceramus? subcircularis* (MEEK, 1876); USNM 507714; from Gulf Coast, locality unknown; ?Lower Maastrichtian.

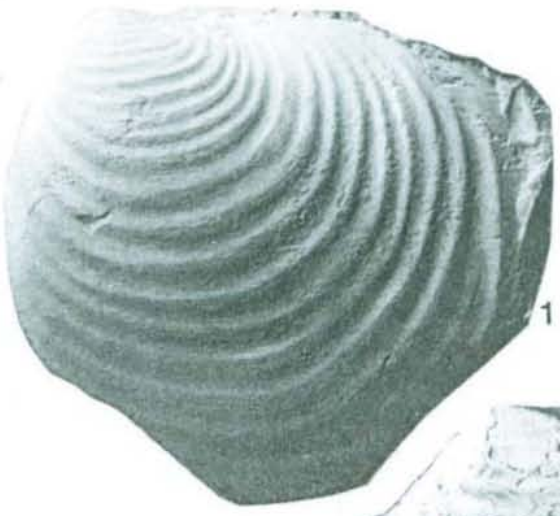
Fig. 2, 11: *Cataceramus? glendivensis* sp. nov.; 2 – YPM 191001, holotype; 11 – YPM 191002, paratype both from Glendive section, Montana; upper *Baculites baculus* Zone; lower Lower Maastrichtian.

Fig. 3-4, 6-9: *Trochoceramus radiosus* (QUAAS, 1902); 3 – USNM 507703, from the *B. grandis* Zone; 4, 6-9 – all from Weston County, Wyoming (N1/2 sec. 10, T. 42 N., R. 62 W.), *Baculites grandis* Zone; lower Lower Maastrichtian..

Fig. 5: "*Inoceramus*" *stephensoni* sp. nov.; YPM 191005, from Weston County, Wyoming (N1/2 sec. 10, T. 42 N., R. 62 W.), *Baculites grandis* Zone; lower Lower Maastrichtian.

Fig. 10: *Trochoceramus* sp.; USNM 507718; from the Ripley Formation along Coon Creek, McNairy County, Tennessee; ? uppermost Campanian.

All figures are in natural size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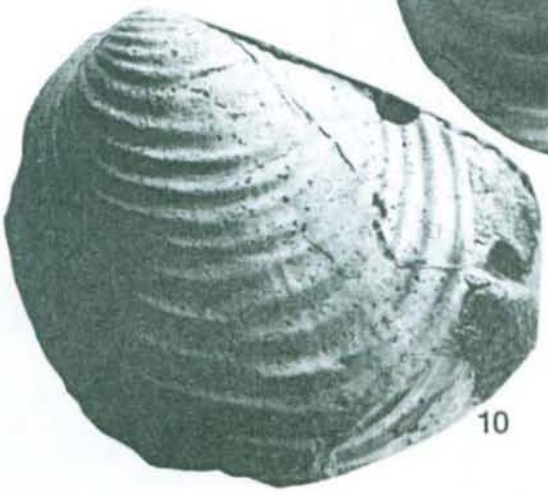
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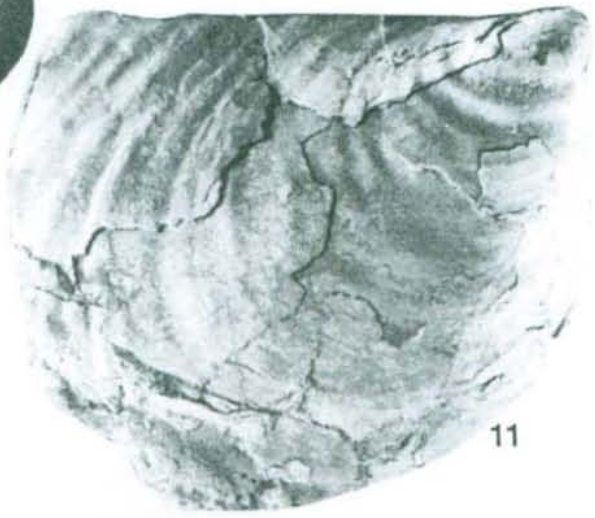
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### *"Inoceramus" altusiformis* sp. nov.
### Pl. XXIII, figs 2, 6-8

1941. *Inoceramus vanuxemi* MEEK & HAYDEN?. - STEPHENSON, p. 99 (pars), pl. 13, fig. 1.

**Type**: The holotype is USNM 507612, from USGS Mesozoic locality D1786, *Baculites compressus* Zone; USNM 507592 and USNM 507601, unknown locality, and USNM 507587, USNM 507588, and USNM 507589, from USGS Mesozoic locality 16732 are paratypes.

**Material**: USNM 507592, USNM 507601, locality unknown; USNM 507587, USNM 507588, and USNM 507589, from USGS Mesozoic locality 16732; USNM 507612 from USGS Mesozoic locality D1786; USNM 76373, original of *I. vanuxemi* MEEK & HAYDEN of STEPHENSON (1941, pl. 13, fig. 1) (pl. XXIII, fig. 7).

*Dimensions*

| Specimen | h | l | H | L | s | α | δ | l/h | hmax |
|---|---|---|---|---|---|---|---|---|---|
| USNM 507592 | 83.0 | 84.5 | 79.0 | 85.0 | 35.0 | 133 | 65 | 1.02 | 120 (LV) |
| USNM 507587 | 73.0 | 63.5 | 68.0 | 67.0 | 31.5 | 122 | 57 | 0.87 | 105 (RV) |
| USNM 507588 | 57.0 | 50.0 | 53.0 | 51.5 | 30.0 | 123 | 56 | 0.88 | 83.8 (LV) |
| USNM 507589 | 45.4 | 45.0 | 42.0 | 45.0 | 26.7 | 120 | 50 | 0.99 | 84.3 (RV) |

**Diagnosis**: Medium- to large-sized species almost identical to "*I.*" *altus* but subtriangular outline and in general higher l/h values.

**Description**: Medium- to large-sized, weakly inflated, moderately prosocline species. Anterior margin moderately long, weakly convex, passing into broadly rounded ventral margin and thence into almost straight posterior margin. Hinge line straight, moderately long. Valve outline trapezoidal, with moderate obliquity. Posterior auricle relatively distinct from disc, of moderate size. Umbo projecting distinctly above hinge line.

Ornament composed of regularly spaced rugae, round-topped, weakening slightly when passing onto posterior auricle.

**Remarks**: "*Inoceramus*" *altusiformis* sp. nov. is very similar to "*I.*" *altus* MEEK, 1871, but the disc outline, and higher disc convexity, which is subtriangular to subquadrate in contrast to elongate oval-shape of MEEK's species.

One of the *Inoceramus vanuxemi* MEEK & HAYDEN? specimens from Texas described by STEPHENSON (1941, p. 99, pl. 13, fig. 1) belongs to this species.

**Occurrence**: Known from the *B. compressus* Zone in the US Western Interior, as well as from Texas and the Gulf Coast, probably from an equivalent horizon.

### *"Inoceramus" sagensis* OWEN, 1852
### Pl. XXIV, figs 2-4; Pl. XXXVI, figs 9-10

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 pierrensis* sp. nov.].

1898. *Inoceramus sagensis* var. *nebrascensis* OWEN. - LOGAN, p. 506, pl. 109, fig. 2.

non 1913. *Inoceramus* cf. *Sagensis* OWEN. - BÖSE, pl. 3, fig. 6.

1959. *Inoceramus sagensis* OWEN. - DOBROV & PAVLOVA, p. 155 (pars), pl. 22, fig. 3

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Plate XLIII

Fig. 1-2: *Trochoceramus tenuiplicatus* (TZANKOV, 1981); 1 – USNM 449225, original to *Inoceramus regularis* D'ORBIGNY in COBBAN & KENNEDY (1993, pl. 1, fig. 22), *Nostoceras alternatum* Zone, south-western Arkansas; 2 – USNM 76374, original to *Inoceramus vanuxemi* MEEK & HAYDEN? in STEPHENSON (1941, pl. 13, fig. 3), Nacatoch Sand, Navarro County, Texas.

Fig. 3-5: *Trochoceramus radiosus* (QUAAS, 1902); 3 – USNM 507704, 4 – USNM 507702, 5 – USNM 507715; Weston County, Wyoming (N1/2 sec. 10, T. 42 N., R. 62 W.), *Baculites grandis* Zone; lower Lower Maastrichtian.

Fig. 6: *Cataceramus? subcircularis* (MEEK, 1876); USNM 449227, original to *Inoceramus regularis* D'ORBIGNY in COBBAN & KENNEDY (1993, pl. 1, fig. 17); *Nostoceras alternatum* Zone, south-western Arkansas.

Fig. 7-9: *Trochoceramus* sp.; 7 – USNM 507717, 8 – USNM 507716; USGS 13543, loose specimen from base of high bluff on Ouachita River, 1.5 miles above Arkansas, Nacatoch Sands; 9 – USNM 507750 from the Ripley Formation, Coon Creek, McNairy County, Tennessee; ?uppermost Campanian.

All figures are in natural size

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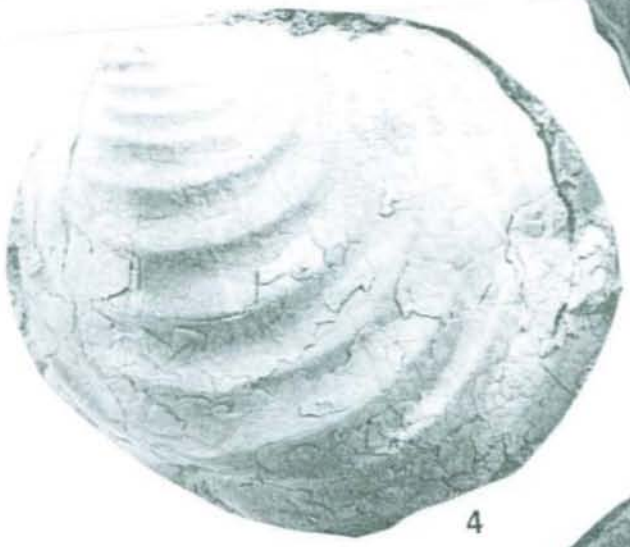

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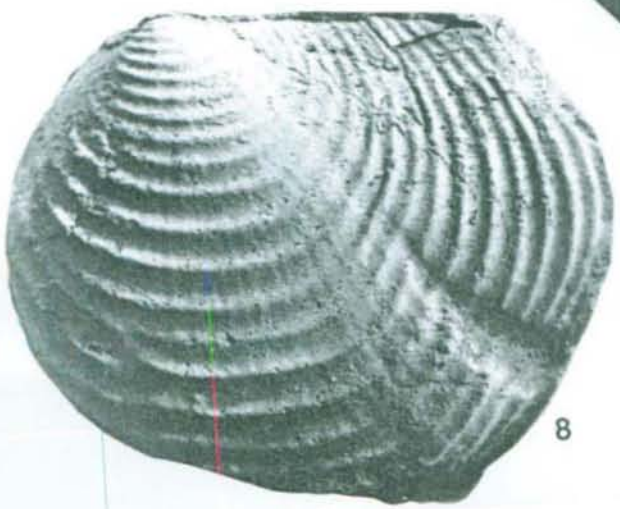

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[non pl. 23, fig. 5 = ?"*Inoceramus*" *nebrascensis* OWEN].

? 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* MEEK. - SOBOLEVA, p. 148, pl. 4, fig. 1.

1970. *Inoceramus djusaliensis* SOBOLEVA, p. 151, pl. 5, fig. 1; pl. 7, fig. 1

1970. *Inoceramus convexus* HALL & MEEK. - 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. - KOCIUBYNSKIJ, p. 85, pl. 24, fig. 2.

1974. *Inoceramus armenicus* ATABEKIAN, p. 217, pl. 111, fig. 1.

non 1974. *Inoceramus sagensis* OWEN. - ATABEKIAN, p. 217, pl. 111, fig. 2; pl. 112, fig. 1.

**Type**: The holotype, by monotypy, is OWEN's (1852, p. 582, pl. 7, fig. 3) specimen, USNM 20246, Upper Cretaceous, Sage Creek, Pennington County, South Dakota.

**Material**: USNM 507590 from USGS Mesozoic locality 23072; USNM 507591 and USNM 507593, locality unknown; USNM 507602 from USGS Mesozoic locality D1598; USNM 507607 from USGS Mesozoic locality D1786; USNM 507617 from USGS Mesozoic locality 23072; USNM 507619, locality unknown; USNM 507751, from USGS Mesozoic locality D 786, from the *compressus* Zone; USNM 20246, the holotype.

*Dimensions*

| Specimen | h | l | H | L | s | α | δ | hmax |
|---|---|---|---|---|---|---|---|---|
| Holotype | 55.5 | — | 50.0 | 50.0 | 31.0 | — | 58 | 97 |
| USNM 507591 | 102.0 | 88.5 | 86.0 | 95.0 | 66.5 | 123 | 55 | 159(RV) |

**Description**: Medium-sized, inequilateral, equivalved species, moderately inflated, prosocline. Umbo weakly inflated, with beak projecting moderately above hinge line. Anterior margin relatively long, widely convex, passing into rounded ventral margin and weakly convex posterior margin. Hinge line moderately long, straight. Growth axis straight to weakly convex anteriorly. Posterior auricle relatively small, weakly separated from disc. Disc moderately inflated with maximum inflation dorso-central.

Surface ornamented with subregularly spaced, round-topped rugae. Rugae most prominent over disc, weakening toward anterior and posterior margins.

**Remarks**: OWEN's specimen of "*I.*" *sagensis* is a bivalved specimen. The valve illustrated originally by OWEN is, however, the LV and not RV as shown in OWEN's figure (1852, pl. 7, fig. 3); it is a mirror image, similarly to "*I.*" *nebrascensis* OWEN, 1952.

MEEK (1876a, p. 53) synonymised "*I.*" *sagensis* OWEN with the second OWEN's (1852) species "*I.*" *nebrascensis*. Both species markedly differ, however, in their shell outline and type of ornament, and should be retained as distinct species. "*I.*" *nebrascensis* is more elongated posteriorly, whereas "*I.*" *sagensis* OWEN is distinctly less oblique (δ averages 55 in "*I.*" *sagensis* whereas it averages 36 in "*I.*" *nebrascensis*). The latter species is also more subquadrate in outline. *I. sagensis* var. *nebrascensis* of MEEK (1876a, pl. 13, fig. 2) is conspecific with "*I.*" *sagensis*.

"*Inoceramus*" *sagensis* of WHITFIELD (1880, pl. 7, fig. 12; reillustrated herein in Pl. XXXVII, fig. 7), from the Cheyenne River, near Rapid Creek (Black Hills, South Dakota), differs from OWEN's type in its ornament which consists of sharp-edged, widely spaced rugae, with broad, flat-floored interspaces. Moreover, it possesses a relatively longer hinge line, and contains a distinctly more dorsally projecting umbo.

The specimen of "*I.*" *sagensis* illustrated by GILBERT (1896, pl. 66, fig. 2), from the ?Lower Maastrichtian of

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Plate XLIV

Fig. 1: "*Inoceramus*" *balchii* MEEK & HAYDEN, 1860; 1 – USNM 507720 from USGS Mesozoic locality D 1042, *Baculites clinolobtaus* Zone; middle Lower Maastrichtian.

Fig. 2, 4: *Cataceramus? glendivensis* sp. nov.; 2 – USNM 507649, 4 – USNM 507650, both from Weston County, Wyoming (N1/2 sec. 10, T. 42 N., R. 62 W.), *Baculites grandis* Zone; lower Lower Maastrichtian.

Fig. 3: "*Inoceramus*" *stephensoni* sp. nov.; USNM 507487, from the Weston County, Wyoming (N1/2 sec. 10, T. 42 N., R. 62 W.), *Baculites grandis* Zone; lower Lower Maastrichtian.

Fig. 5: *Cataceramus? subcircularis* (MEEK, 1876); USNM 507651, from the Weston County, Wyoming (N1/2 sec. 10, T. 42 N., R. 62 W.), *Baculites grandis* Zone; lower Lower Maastrichtian.

All figures are in natural

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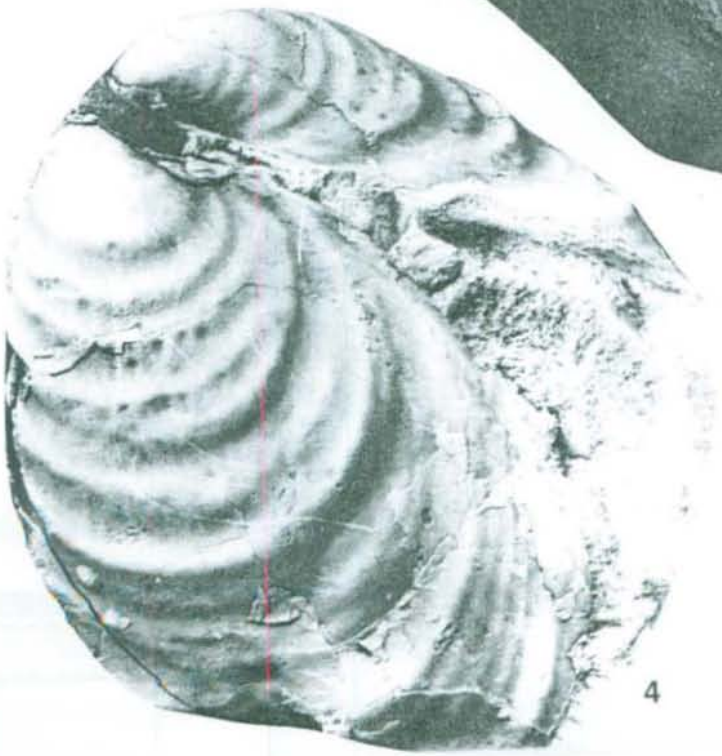

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eastern Colorado, differs from OWEN's type in their straight anterior margin and ornament. It belongs within our newly described "*Inoceramus*" *pierrensis*.

Although none of the specimens from New Jersey, illustrated and referred to *Inoceramus sagensis* by WHITFIELD (1885, pl. 14, fig. 15; pl. 15, figs 1-2), is sufficiently preserved to allow a definitive determination, they differ from the type and from Western Interior specimens in their ornament, and most probably represent a different species.

"*Inoceramus*" *sagensis* OWEN is inevitably one of the best represented, and the most commonly cited, North American Campanian species in Europe, although most of the specimens referred to it represent other species. To some extent, this reflects the acceptance of MEEK's concept of OWEN's species, i.e., broadening the concept to include "*I.*" *nebrascensis*.

*Inoceramus armenicus* described by ATABEKIAN (1974, p. 217, pl. 111, fig. 1) from the Campanian of Caucasus is conspecific with "*Inoceramus*" *sagensis*. This moderately oblique, ovate species possesses umbone projecting above the hinge line and quite regular juvenile ornament, which becomes less distinct ventrally. It is almost identical to OWEN's type. Instead, his *I. sagensis* (see ATABEKIAN 1974, p. 217, pl. 111, fig. 2 and pl. 112, fig. 1) resembles "*I.*" *nebrascensis* OWEN, 1852.

A large collection of "*I.*" *sagensis* was illustrated by SOBOLEVA (1970) from the Kyzyl-Kum area in western Central Asia. Although she referred many of the specimens to other species (see synonymy), including two new taxa, *Inoceramus djusaliensis* and *I. karakatensis*, all of them display the characteristics of OWEN's species. One very interesting aspect of this material was published a decade later by ZONOVA (1980). She showed that at least SOBOLEVA's (1970) *I. djusaliensis* has a distinct ligamentat, not divided into resilifers and interresilifer areas as is typical of most inoceramids, but represented by a uniform, tube-like structure, like that found in the Maastrichtian *Inoceramus*-like genus *Tenuipteria*. This type of ligament was recently recognised to be relatively common in the Lower Maastrichtian inoceramids described from the Arabian Peninsula (MORRIS, 1995). Similarly, numerous specimens from the topmost Campanian of the *Nostoceras hyatti* Zone from the Vistula section are characterised by this ligament type (WALASZCZYK, in prep.). It may appear that true inoceramids are much closer to representatives of the genus *Tenuipteria* than hitherto assumed. The tube-like ligament may appear to be of great importance in determining the pattern of inoceramid evolution, the relationship between true inoceramids and the enigmatic genus *Tenuipteria*, as well as in refining the biostratigraphic potential of Campanian and Lower Maastrichtian inoceramids.

**Occurrence**: US Western Interior: the *Baculites compressus* Zone. Known from the Upper Campanian of Europe and Western Central Asia, but without more precise stratigraphic location.

### "*Inoceramus*" *vanuxemi* MEEK & HAYDEN, 1860
### Pl. XXXV, fig. 3; Pl. XXXVII, fig. 3

1860. *Inoceramus Vanuxemi* MEEK & HAYDEN, p. 180.
1876a. *Inoceramus Vanuxemi* MEEK & HAYDEN. - MEEK, p. 57, pl. 14, fig. 2.
non 1880. *Inoceramus vanuxemi* MEEK & 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.
non 1941. *Inoceramus vanuxemi* MEEK & HAYDEN?. - STEPHENSON, p. 99, pl. 13, figs 1-4.
non 1961. *Inoceramus* sp. ex gr. *vanuxemi* MEEK & HAYDEN. - SORNAY, pl. 2, fig. 4.

**Type**: The holotype, by original designation is USNM 483 from the Upper Campanian of Sage Creek (probably *Baculites compressus* Zone), Pennington County, South Dakota.

**Material**: The type of the species and a single specimen from the collection in Tampa, are most probably from the *Baculites compressus* Zone.

*Dimensions*

| Specimen | h | l | H | L | s | α | δ | hmax |
|---|---|---|---|---|---|---|---|---|
| Holotype | 62.0 | 61.0 | 59.5 | 59.5 | 28.5 | 130 | 63 | 117(LV) |

**Description**: The holotype is a large-sized, almost flat, orthocline species. Anterior part is not preserved but the ornament orientation suggests the presence of a long, weakly inflated anterior margin, passing into a rounded ventral margin and then into a weakly convex posterior margin. The beak is small, indistinct, projecting very slightly above the hinge line. The latter is straight, moderately long. Posterior auricle moderately large, separated from the disc only in the umbonal part, in adult stage passing continuously into disc. The growth axis is straight.

The shell ornamented with very regular, subsymmetrical commarginal rugae, with interspaces wider than rugae, increasing gradually ventralward.

**Remarks**: The species is very poorly represented in the material studied, and only a single specimen of those published actually belong to MEEK & HAYDEN's species.

Three specimens were illustrated and referred to "*I.*" *vanuxemi* by WHITFIELD (1880, pl. 7, figs 8-10), with one referred to a new variety (his pl. 7, fig. 10). The specimens illustrated in his figures 8 and 9 (illustrated herein in Pl. XXXVII, figs 1-2) are posteriorly elongated, regularly ornamented forms which should probably be

referred to *Cataceramus? palliseri* (DOUGLAS). The third of his specimens (illustrated herein in pl. XXXVII, fig. 3) is an orthocline, ventrally elongated morphotype, which resembles "*I.*" *vanuxemi* in outline. It differs only slightly in ornament, but we have too few specimens at hand to see the range of infraspecific variability of "*I.*" *vanuxemi* in this respect. This specimen, referred by WHITFIELD to a new variety is included herein into synonymy with "*I.*" *vanuxemi*.

A range of Upper Campanian and Lower Maastrichtian forms from Texas were referred to "*Inoceramus*" *vanuxemi* by STEPHENSON (1941, pl. 13, figs 1-4). The illustrated forms represent quite different taxa with none of them referrable to MEEK & HAYDEN's species. The smaller specimen, USNM 76374 (STEPHENSON's pl. 13, fig. 2), is regularly ornamented, moderately oblique form, which may represent *C.? subcircularis* (MEEK) or *C.? palliseri* (DOUGLAS). The second specimen, USNM 76374 (STEPHENSON's pl. 13, fig. 3; reillustrated herein in Pl. XLIII, fig. 2) has a distinct radial ornament and represents *Trochoceramus tenuiplicatus* (TZANKOV, 1981). USNM 76375, STEPHENSON's third specimen (his pl. 13, fig. 4; reillustrated herein in Pl. XLI, fig. 5), although it possesses a similar juvenile stage as "*I.*" *vanuxemi*, it has a completely different adult stage and represents "*Inoceramus*" *stephensoni* sp. nov. Finally, USNM 76373 (STEPHENSON's pl. 13, fig. 1; reillustrated herein in Pl. XXIII, fig. 7), is characterised by a moderately inflated disc, a distinct posterior auricle, and with low obliquity and very regular, rounded ornament outline is referred here to "*Inoceramus*" *altusiformis* sp. nov.

*Inoceramus* sp. ex gr. *vanuxemi* MEEK & HAYDEN reported from Vonso, Congo, illustrated by SORNAY (1961, pl. 2, fig. 4) is much more oblique, with $\delta = 55°$, than the American species in which $\delta \approx 65°$. The ornament outline, posterior auricle and the anterior margin, however, are very similar between the two. According to ammonite data, SORNAY's species comes from the Upper Santonian/Lower Campanian strata and is thus markedly older stratigraphically than the species discussed.

**Occurrence**: The type and the other specimen are limited to the *Baculites compressus* Zone of the Western Interior. No convincing report outside this area exists.

### "*Inoceramus*" *stephensoni* sp. nov.
### Pl. XLI, fig. 6; Pl. XLII, fig. 5; XLIV, fig. 3

1941. *Inoceramus vanuxemi* MEEK & HAYDEN?. - STEPHENSON, p. 99 (pars), pl. 13, fig. 4 (only).

**Type**: The holotype is USNM 507487 (Pl. XLIV, fig. 3), from the *Baculites grandis* Zone of Weston County, Wyoming.

**Derivation of name**: After Loyd William STEPHENSON, American geologist and paleontologist, who made significant contributions to Cretaceous paleontology and stratigraphy.

**Material**: Numerous specimens in the collections from Glendive, Montana, in Tampa; YPM 191005, USNM 507487, UWWG US2, UWWGUS3, and UWWG US4, all three from the *Baculites grandis* Zone of Weston County, Wyoming (N1/2 sec. 10, T. 42 N., R. 62 W.); original to *Inoceramus vanuxemi* MEEK & HAYDEN? in STEPHENSON (1941, pl. 13, fig. 4; reillustrated herein in pl. XLI, fig. 6).

**Diagnosis**: Medium- to large-sized species, weakly inflated, elongated ventrally. Two differently ornamented growth stages with *Platyceramus*-type geniculation. Juvenile ornament composed of regularly and closely spaced, symmetrical rugae; adult ornament irregular, composed of widely spaced, low rugae, almost flat.

**Description**: Medium- to large-sized species, orthocline or moderately prosocline, weakly inflated with maximum inflation in dorso-central part. Anterior margin relatively long as compared to length of growth axis, trending straight, slightly concave below umbo, passing into long, broadly rounded ventral margin and then into posterior margin. Hinge line long, straight. Beak small, usually only weakly projecting above hinge line. Minimal obliquity, with $\delta$ approximating 70°.

Valves ornamented by two, variablye growth stages; juvenile consists of regularly spaced, symmetrical rugae, with gradual increase of interspaces ventrally, with rounded outline. Adult part virtually smooth, with indistinct, irregular, low rugae, and raised growth lines. No geniculation delimits change from juvenile to adult ornament.

**Remarks**: The low obliquity and occurrence of two, differently ornamented ontogenetic stages, oriented in the same plane, are characteristic of the species. The juvenile stage resembles "*Inoceramus*" *vanuxemi*, from the Upper Campanian *Baculites compressus* Zone, although the latter does not show the change in the ornament and moreover, is less inflated. "*I.*" *altus* and "*I.*" *altusiformis*, both from the middle Upper Campanian are similar. The two latter species possess, however, distinct posterior auricles, and are markedly more oblique. The stratigraphically coeval species, *Inoceramus subcircularis*, which is similar to juvenile "*I.*" *stephensoni*, differs in much higher obliquity.

"*I.*" *stephensoni* represents the same morphotype as some platyceramids, with regularly ornamented juveniles and growth in the same plane in the adult stage, that were common in the Santonian. The best examples of this morphology are: *Platyceramus ahsenensis* (SEITZ), *Pl. cycloides* (WEGNER), or *Pl. rhomboides* (SEITZ) (see SEITZ, 1961). All these forms are, however, stratigraphically much older (>10 Mya), and the existing fossil record suggests a lack of evolutionary continuity. Morphologically, however, the specimens of "*I.*" *stephensoni* could be placed in the variability range for any of these platyceramid species.

Some specimens referred to *Inoceramus* (*Platyceramus*) aff. *cycloides* WEGNER by SEITZ (1970, p. 129, pl. 23, fig. 2 and pl. 28, fig. 1) from Muntigl, Austria – the locality from which *Trochoceramus* material was initially monographed by SEITZ (1970, with revision of FUGGER & KASTNER's [1885] original descriptions) – show similar growth patterns to "*I.*" *stephensoni*. As in our species, the Austrian specimens show a distinctly rugate juvenile stage, followed in the same plane by an almost smooth, growth-line covered, adult stage. Direct comparison, however, is very difficult as the Austrian specimens are markedly deformed and incomplete, but they are very similar and moreover, come from the same stratigraphic interval (the horizon with trochoceramids).

**Occurrence**: Known from the Western Interior and from Texas in the Gulf Coast. The species possibly has a much wider occurrence as suggested by very similar forms reported from Austria (FUGGER & KASTNER, 1885; SEITZ, 1970).

## The group of "*Inoceramus*" *oblongus*

The group comprises – distinctly elongated, massive, moderately to strongly inflated forms. The species included in this plexus are: "*I.*" *oblongus* MEEK, "*I.*" *wyomingensis* sp. nov., and "*I.*" *magniumbonatus* DOUGLAS.

### "*Inoceramus*" *oblongus* MEEK, 1871
### Pl. XXVI, figs 2, 5; Pl. XXVII, figs 1, 3; Pl. XXVIII; Pl. XXXI, fig. 5

1871. *Inoceramus oblongus* MEEK, p. 297.
1879. *Inoceramus oblongus* MEEK. - WHITE, p. 285, pl. 2, fig. 1.

**Type**: The holotype, by original designation of MEEK (according to WHITE, 1879), is the USNM 774, illustrated by WHITE (1879, p. 285, pl. 2, fig. 1; reillustrated herein – Pl. XXXI, fig. 5) which, according to WHITE (1879), comes from the uppermost Campanian approximately 9.5 km south of Fort Collins, Colorado.

**Material**: USNM 507632, from USGS Mesozoic locality D10897; USNM 507641, USNM 507642, USNM 507644, all three from USGS Mesozoic locality D302; USNM 507743 from USNM locality 9974; USNM 507754, and USNM 507755, all from USGS Mesozoic locality D 1466, from the *Baculites reesidei* Zone; USNM 507645 from USGS Mesozoic locality D2805; USNM 507646 from USGS Mesozoic locality D2849.

**Description**: Medium- to large-sized, inequilateral, equivalved, moderately to strongly inflated species. Valves prosocline, subtriangular in outline, strongly elongated posteriorly. Anterior margin relatively short, passing with a distinct break into long to very long antero-ventral margin, and thence into regularly rounded posterior margin. Hinge line long, straight. Posterior margin, narrow, subtriangular, elongated parallel to hinge line. Umbo pointed anteriorly, projecting moderately above hinge line.

Valves with moderate ornament, composed of irregularly spaced, low rugae.

**Remarks**: The typical specimens are moderately inflated (Pl. XXVII, fig. 1, 3; Pl. XXXI, fig. 5). Based on the distinctive transition from the anterior face to the very long antero-ventral margin we referred other more inflated specimens characterised by more prominent ornamentation (Pl. XXVIII) to the species. We also referred a series of small, weakly to moderately inflated, distinctly oblique specimens (Pl. XXVI, fig. 2, 5; Pl. XXVII, fig. 1), regarded here as juveniles, to "*I.*" *oblongus*. These specimens resemble Middle Campanian *Cataceramus? agdjakendsis* (ALIEV) (see Pl. VII, fig. 5, 7, 10) or *Inoceramus ellipticus* GIERS, and it is possible that earlier reports of these two species from the high Campanian, such as *Inoceramus balticus ellipticus* GIERS reported by DHONDT (1993, pl. 6, fig. 1) from the Upper Campanian of Tercis, SW France, should be referred to "*I.*" *oblongus* as well.

**Occurrence**: Convincing specimens are known exclusively from the *Baculites reesidei* Zone, Western Interior. Possibly present in the uppermost Campanian of Europe.

### "*Inoceramus*" *wyomingensis* sp. nov.
### Pl. XXXIV, figs 2-5

**Type**: The holotype is a bivalved specimen, USNM 507735 (Pl. XXXIV, fig. 5), from the Lewis Shale in Natrona County, Wyoming, locality 29 (USGS locality 6217); possibly *Baculites eliasi* Zone. USNM 507736, from the same locality, and USNM 507727and USNM 507726, from locality 10 (USGS Mesozoic locality D13994), are paratypes.

**Derivation of the name**: From the state of Wyoming, United States.

**Material**: USNM 507726 and USNM 507727 from USGS Mesozoic locality D 13994; USNM 507735 and USNM 507736 from USGS Mesozoic locality 6217; all specimens from the *Baculites eliasi* Zone.

**Diagnosis**: Medium- to large-sized species with strong posterior elongation of valves and strongly elongated concentric rugae parallel to hinge line.

**Description**: Medium- to large-sized, equivalved, strongly inequilateral, prosocline species. Hinge line straight, very long. Anterior margin relatively short, rounded, trending into very long, broadly rounded ventral margin. Posterior margin short, slightly convex. Growth axis weakly anteriorly convex. Beak small, projecting slightly above hinge line. Umbonal part massive, relatively large. Posterior auricle small, indistinct, weakly separated from disc.

Shell ornamented with subregularly spaced, rounded rugae, well developed only in juvenile part of shell. Adult shell smooth or with irregularly spaced, low, indistinct rugae. In ventral part rugae markedly elongated, parallel to hinge line.

**Remarks**: Some elongated specimens of "*Inoceramus*" *oblongus* MEEK are similar to "*I.*" *wyomingensis* sp. nov. MEEK's species does not show, however, the characteristic rugae outline on the main part of the disc trending parallel to the hinge line. However, both species clearly belong to the same morphological group. *Inoceramus* (*Selenoceramus*) *ghadamesensis* described from the Lower Maastrichtian of Libya (TRÖGER & RÖHLICH, 1981, p. 170) is very similar to our species. This is particularly true of the specimens with weak geniculation (e.g. TRÖGER & RÖCHLICH, 1981, pl. 1, figs 1-6).

**Occurrence**: Known exclusively from the *Baculites eliasi* Zone of the Western Interior.

### "*Inoceramus*" *magniumbonatus* DOUGLAS, 1942
### Pl. XXIX; Pl. XXXI, fig. 2; Pl. XXXII, figs 1, 4-5

1942. *Inoceramus barabini* var. *magniumbonatus* DOUGLAS, p. 63, pl. 1, fig. 1.
? 1962. *Inoceramus barabini* aff. var. *magniumbonatus* DOUGLAS. - JOLKICEV, p. 142, pl. 5, fig. 1
? 1981. *Inoceramus borilensis* JOLKICEV. - TZANKOV, p. 91, pl. 40, fig. 1.

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

**Material**: USNM 507636 from USGS Mesozoic locality D1466; USNM 507637 from USGS Mesozoic locality D1924; USNM 507638, USNM 507640, and USNM 507749, from USNM locality 9974; USNM 507643 from USGS Mesozoic locality D302; USNM 507753 from USGS Mesozoic locality D1466; type of the species.

**Description**: Large-sized, prosocline, inequilateral, equivalve species. Valves strongly inflated due to geniculation. Juvenile stage moderately to strongly inflated, trapezoidal in outline. Beak and umbonal region distinctly projecting above long, straight hinge line. Anterior margin relatively short, weakly convex anteriorly, slightly concave below umbo, passing into long, broadly convex ventral margin. Posterior margin rounded. Posterior auricle narrow, elongated parallel to hinge line. Geniculation sharp to more rounded, with very large juvenile stage, and usually smaller adult stage.

Juvenile shell ornamented with strong, widely spaced rugae, slightly asymmetrical, with very broad interspaces. Adult stage with irregular, indistinct rugae or smooth.

**Description of the holotype**: The holotype is a large, bivalved specimen ($h_{max}$ = 125 mm), with the LV very incomplete and devoid of ornament. The RV is much better preserved, although it also lacks the postero-dorsal part of the valve. Due to geniculation at 98 mm axial length, the specimen is highly inflated. The geniculation is readily apparent in DOUGLAS' (1942, pl. 1, fig. 1) photograph due to the valve's orientation. It depicts a relatively high, smooth adult stage visible. Juvenile stage moderately inflated, highly oblique ($\delta_{max}$ = 37°), with the beak located anteriorly and projecting distinctly (about 5 mm) above the hinge line. Hinge line very long (in juvenile stage = 56 mm). The anterior margin is relatively short, almost straight, with concave portion just below the beak. The juvenile stage is covered with strong and widely spaced rugae, with very broad interspaces. The postero-dorsal part of the juvenile surface is not preserved. The geniculation well developed. The adult stage high and almost smooth.

**Remarks**: The species is characterised by its strong posterior elongation, high inflation, and strong, widely spaced rugae. The variability is confined to differences in the geniculation. Forms with distinct geniculation have a moderately inflated juvenile stage and a distinct change in ornament, as represented by the holotype (Pl. XXXI, fig. 2) and USNM 507638 (Pl. XXXII, fig. 1). The specimens not distinctly geniculated are uniformly inflated and do not show any specific point of ornament change (Pl. XXXII, fig. 4-5).

**Occurrence**: "*Inoceramus*" *magniumbonatus* DOUGLAS is common in the *Baculites reesidei* Zone of the Western Interior. It is also known from the uppermost Campanian *Nostoceras hyatti* Zone of the Vistula section, central Poland.

## The group of "*Inoceramus*" *incurvus*

The group comprises species with three distinct ontogenetic stages: the juvenile, the neck and the adult stages, all from the topmost Campanian and Lower Maastrichtian. Forms included in this plexus are: "*I.*" *incurvus* MEEK & HAYDEN, "*I.*" *mclearni* DOUGLAS, and "*I.*" *furnivali* DOUGLAS.

### "*Inoceramus*" *incurvus* MEEK & HAYDEN, 1856
### Pl. XXXIX, figs 1-2, 7-8, 10

1856. *Inoceramus incurvus* MEEK & HAYDEN, p. 277.
1876a. *Inoceramus incurvus* MEEK & HAYDEN. - MEEK, p. 61, pl. 12, fig. 4.
1898. *Inoceramus incurvus* MEEK & HAYDEN. - LOGAN, p. 505.
?1996. "*Inoceramus*" ex gr. *impressus* D'ORBIGNY. - WALASZCZYK *et al.*, pl. 4, fig. 1.

**Type**: The holotype, by original designation is the specimen illustrated by MEEK (1876a, pl. 12, fig. 4) from Little Bear's Village, South Dakota, between Fort Pierre and Fort Clark, Lower Maastrichtian.

**Material**: USNM 507681, USNM 507682, USNM 507683, USNM 507684, USNM 507686, USNM 507689, USNM 507690, USNM 507691, USNM 507692, USNM 507693, USNM 507694, USNM 507695, USNM 507696, USNM 507697, USNM 507700, USNM 507701, USNM 507725; all from USGS Mesozoic locality D 877; USNM 507698 and USNM 507699 from USGS Mesozoic locality D 2386; YPM 191003 and numerous unregistered specimens from collections of Tampa University from Glendive.

*Dimensions*

| Specimen | h | l | H | L | s | α | δ | hmax |
|---|---|---|---|---|---|---|---|---|
| USNM 507681 | 59.5 | 37.0 | 39.0 | 57.5 | 40.0 | 110 | 40 | 59.5 (RV) |
| USNM 507682 | 46.0 | 35.0 | 30.5 | 45.5 | 30.0 | 107 | 33 | 55 (LV) |
| USNM 507684 | 49.0 | 33.0 | 34.0 | 48.0 | 34.0 | 112 | 36 | 63 (RV) |
| USNM 507687 | 44.0 | 34.5 | 34.0 | 43.0 | 27.0 | 112 | 37 | 58 (RV) |
| USNM 507686 | 44.5 | 30.5 | 32.5 | 43.0 | 30.0 | 110 | 33 | 44.5(LV) |
| USNM 507725 | 48.0 | 35.0 | 36.0 | 47.0 | 28.5 | 105 | 35 | 53 (RV) |
| USNM 507688 | 50.5 | 40.5 | 38.5 | 51.0 | 31.0 | 115 | 40 | 60 (RV) |
| USNM 507689 | 44.5 | 37.0 | 33.0 | 44.0 | 32.0 | 100 | 33 | 51 (LV) |
| USNM 507690 | 51.0 | 43.0 | 39.0 | 56.0 | 35.0 | 115 | 37 | 80 (RV) |
| USNM 507691 | 38.0 | 32.0 | 26.5 | 38.0 | 27.5 | 110 | 33 | (RV) |
| USNM 507692 | 50.5 | 42.0 | 35.5 | 53.0 | 34.0 | 117 | 40 | 64 (RV) |
| UNSM 507694 | 57.0 | 42.0 | 39.0 | 59.0 | 36.0 | 107 | 36 | 70 (RV) |
| UNSM 507696 | 34.0 | 23.5 | 21.5 | 34.5 | 21.0 | 105 | 30 | 38 (LV) |
| USNM 507697 | 47.0 | 34.0 | 32.5 | 47.5 | 28.5 | 103 | 35 | 51 (RV) |

**Description**: Small- to medium sized, inequilateral, equivalved species. Valves with three distinct ontogenetic stages: juvenile, adult, and gerontic, each separated by distinct geniculations. Juvenile stage of small to moderate size, moderately to strongly inflated, elongated toward postero-ventral margin. Beak curved strongly antero-dorsally, projecting markedly above hinge line. Hinge line straight, relatively long. Posterior auricle of moderate size, distinct from disc. Disc with more or less well-developed, axially positioned radial sulcus. Anterior margin short, convex, passing into long, broadly convex antero-ventral margin. Postero-ventral margin rounded, straight or slightly concave at axial sulcus. Posterior margin straight or slightly convex posteriorly. Juvenile-adult stage transition marked by a well-developed positive geniculation. In posterior and postero-ventral parts adult stage almost perpendicular to juvenile one, in antero-ventral part transition is marked by a slight incision.

Gerontic stage is the largest part of shell. In posterior part and postero-ventral parts gerontic stage abuts the adult stage with a distinct (up to 90°) negative geniculation. Geniculation not observed in anterior and antero-ventral parts.

Ornament well developed only in juvenile part, where it is composed of regular to sub-regular, sharp-edged, asymmetrical rugae, with steeper ventral margins. In adult and gerontic stages, ornament poorly developed, composed of irregular ribs and low, irregular rugae.

**Remarks**: As demonstrated by some of the specimens illustrated here (Pl. XXXIX, fig. 8, 10) as well as by many unregistered specimens from both collection D877 in the US Geological Survey, Denver as well as the collections of the University of South Florida, both the holotype and one of the paratypes (illustrated herein – Pl. XXXIX, fig. 2) represent incomplete specimens with solely the juvenile stages preserved. When preserved, the adult and gerontic stages are usually represented by their less characteristic anterior parts. This led to MEEK's mistaken concept of this species as represented by small, highly inflated, almost spherical, forms. As demonstrated by completely preserved specimens (e.g., Pl. XXXIX, fig. 8, 10) this is, however, not the case. The species possesses a highly posteriorly elongated adult stage, representing the same morphotype as "*I.*" *mclearni*, "*I.*" *mcshaniensis*, and "*I.*" *furnivali*. "*I.*" *mclearni* and "*I.*" *mcshaniensis* are most likely conspecific, and it is highly probable that they are also conspecific with "*I.*" *incurvus*. However, their juvenile stages are too poorly preserved (these are internal moulds) to allow for a definitive evaluation. "*I.*" *furnivali* is distinctly larger and its juvenile part, also not particularly well preserved, is very difficult to compare with juveniles of "*I.*" *incurvus*.

"*Inoceramus*" ex gr. *impressus* D'ORBIGNY, described from Aimaki section (Daghestanian Caucasus) by WALASZCZYK *et al.* (1996, pl. 4, fig. 1) should probably be referred to *Inoceramus incurvus*. It possesses a distinct radial sulcus and ornament very similar to the American specimens. Similar to most of the material studied here, it is represented solely by a juvenile stage. USNM 507705, from the *Baculites baculus* Zone of USGS Mesozoic locality D 434 (Pl. XXXIX, fig. 9), although it is probably slightly deformed, is very similar to "*I.*" *incurvus*.

**Occurrence**: *Inoceramus incurvus* is a dominant form in the lower *Baculites baculus* Zone in the Western Interior.

### *"Inoceramus" mclearni* DOUGLAS, 1942
### Pl. XXXVIII, figs 1, 3, 5

1942. *Inoceramus mclearni* DOUGLAS, p. 60, pl. 2, fig. 1.

1942. *Inoceramus mcshaniensis* DOUGLAS, p. 61, pl. 2, fig. 2.

**Type**: The holotype, by original designation, is GSC 8925 illustrated by DOUGLAS (1942, pl. 2, fig. 1; reillustrated herein in Pl. XXXVIII, fig. 5), from the uppermost Campanian exposed along McShane Creek, Saskatchewan, Canada, about 140 m below the top of the Bearpaw Formation.

**Material**: USNM 507685 from USGS Mesozoic locality D 1048 of the *Baculites baculus* Zone; GSC 8925 and GSC 8926, DOUGLAS' types of "*Inoceramus*" *mclearni* and "*I.*" *mcshaniensis*, respectively.

**Description**: The type of the species is a bivalved specimen, moderately large, with adult length aproximately 60 mm. It is distinctly geniculated, with small, weakly inflated juvenile stage, 26 mm long, perpendicular adult stage, and gerontic stage elongated postero-ventrally. Beak small, indistinct, not projecting above the hinge line. Anterior margin straight, relatively long, passing into broadly convex antero-ventral margin, and then into rounded posterior margin. The shell is almost smooth, with low, indistinct, irregularly spaced rugae in adult stage. The transition between the juvenile and adult stages delimited by a narrow furrow, which probably represents deformation rather than an original morphological character.

**Remarks**: As in "*Inoceramus*" *furnivali*, "*I.*" *mclearni* DOUGLAS also represents the *incurvus*-type morphology, with three ontogenetic stages and the general posterior shell elongation, particularly in the gerontic stage. "*I.*" *mcshaniensis*, described by DOUGLAS from the same locality and at least partially from the same stratigraphic position, is conspecific with "*I.*" *mclearni*. As in "*I.*" *mclearni*, "*I.*" *mcshaniensis* (reillustrated in Pl. XXXVIII, fig. 3) possesses three distinct ontogenetic stages, smooth shell surface and postero-ventral gerontic elongation. Some differences between these two species, mentioned by DOUGLAS (1942, p. 61) result from the larger size of the juvenile stage in the type of "*I.*" *mcshaniensis* as well as from its slight deformation.

**Occurrence**: The type comes from the uppermost Campanian, probably *Baculites reesidei* Zone; USNM 507685 is from the *Baculites baculus* Zone.

### *"Inoceramus" furnivali* DOUGLAS, 1942 Pl. XXV, fig. 4; Pl. XXVI, fig. 4

1942. *Inoceramus furnivali* DOUGLAS, p. 62, pl. 3.

**Type**: The holotype, by original designation, is GSC 8927, illustrated by DOUGLAS (1942, pl. 3; and reillustrated in Pl. XXV, fig. 4; Pl. XXVI, fig. 5), from the uppermost Campanian exposed along Boxelder Creek, Saskatchewan, Canada, about 190 m below the top of the Bearpaw Formation.

**Description**: The species is represented exclusively by its holotype, studied herein based on a plaster cast. The type is a bivalved, huge (L = 240 mm) specimen lacking the antero-ventral part. It possesses two geniculations and strong posterior valve elongation. The juvenile stage, about 80 mm long, is moderately inflated, with maximum inflation anterior-dorsally, prosocline, with the beak curved antero-dorsally. The hinge line is long and straight. The shell surface is almost smooth. It is, however, an internal mould and the actual outer shell surface could have been rugate. Adult stage in anterior and antero-ventral parts growths perpendicularly to the juvenile one. In posterior part, the geniculation angle is approximately 40-50°. Adult stage again strongly elongated posteriorly. Adult and gerontic stages with irregular, widely spaced, low rugae.

**Remarks**: "*Inoceramus*" *furnivali* DOUGLAS represents the "*Inoceramus*" *incurvus*-type morphology and closely resembles the larger specimens of this species. It is, however, markedly larger. Moreover, it does not have the details of juvenile ornament preserved, and consequently an unequivocal comparison is impossible. In addition, the type of "*I.*" *furnivali* comes from an older stratigraphic interval (*Baculites reesidei* Zone) than "*Inoceramus*" *incurvus*, which seems to be limited to the lower (but not lowermost) Maastrichtian.

**Occurrence**: The type comes from the uppermost Campanian, probably *Baculites reesidei* Zone. KAUFFMAN *et al.* (1994) report the taxon from an interval spanning the *Baculites reesidei* of the uppermost Campanian through the *Baculites baculus* ammonite Zones of the lowermost Maastrichtian.

### Comments on "*Inoceramus*" *sublaevis* HALL & MEEK, 1856 (Pl. XXXV, fig. 4), and "*Inoceramus*" *saskatchewanensis* WARREN, 1934 (Pl. XXXVIII, figs 2, 6)

Both "*I.*" *sublaevis* HALL & MEEK, and "*I.*" *saskatchewanensis* WARREN are described on the basis of insufficiently preserved material for their unequivocal identification, thus representing *nomina dubia*. In the case of "*I.*" *sublaevis*, HALL & MEEK's name is, moreover, a junior homonym.

### *"Inoceramus" sublaevis* HALL & MEEK, 1856 [Pl. XXXV, fig. 4]

1856. *Inoceramus sublaevis* HALL & MEEK, p. 386, pl. 2, fig. 1. [Pl. XXXV, fig. 4]
1876a. *Inoceramus sublaevis* HALL & MEEK. - MEEK, p. 58, pl. 12, fig. 1.
1880. *Inoceramus sublaevis* HALL & MEEK. - WHITFIELD, p. 393, pl. 10, figs 1-3.

**Type**: The lectotype, here designated, is AMNH original to HALL & MEEK (1856, pl. 2, fig. 1), from the Great Bend of the Missouri River, South Dakota, dated to the *Baculites gregoryensis* or *Baculites scotti* Zones of the uppermost Middle Campanian.

*Dimensions*

| Specimen | h | l | H | L | s | α | δ | hmax |
|---|---|---|---|---|---|---|---|---|
| Lectotype | 47.0 | — | 39.4 | 48.0 | 28.3 | 130 | 45 | 47 |

**Description and remarks**: The lectotype is represented by a juvenile RV. It is weakly inflated, prosocline, moderately oblique specimen. Umbone pointed, projected above hinge line. Anterior margin weakly convex, mod-

erately long, passing into broadly convex ventral margin. Posterior margin long, weakly convex. Hinge line straight, long. Posterior auricle elongated, triangular, distinct from disc. Ornament very weak with virutally smooth shell. Some indistinct and irregular rugae visible on the ventral part.

"*Inoceramus*" *sublaevis* HALL & MEEK, 1856, represents a *nomen dubium*, as its type, as well as any other specimen subsequently referred to this species, do not allow for its unequivocal application to any of the recognised species; it is represented by juvenile part only and fits the characteristic of at least three stratigraphically coeval species: "*Inoceramus*" *nebrascensis* OWEN, 1852, "*I.*" *scotti* sp. nov., and "*I.*" *pertenuiformis* sp. nov. Moreover, the name *sublaevis* was a homonym at the time of its introduction by HALL & MEEK (1856) as it was used already by MÜNSTER (mentioned in GOLDFUSS, 1836, p. 117).

**Occurrence**: The type, according to HALL & MEEK (1856) and MEEK (1876a, p. 59) came from the Great Bend of the Missouri River. Therefore, it may come from the Gregory Member of the Pierre Shale, which corresponds to the *Baculites gregoryensis* and *Baculites scotti* Zones, of the topmost Middle Campanian.

### "*Inoceramus*" *saskatchewanensis* WARREN, 1934, pl. 3, figs 10-12 [Pl. XXXVIII, fig. 2, 6]

**Description and remarks**: Both of WARREN's types, from the National History Museum of Canada, are represented by small-sized (with h below 30 mm), single-valved internal moulds (see Pl. XXXVIII, fig. 2, 6). Their surfaces are almost smooth, with weakly developed rugae. Shells are moderately inflated, with small indistinct beaks, projecting only slightly above relatively long and straight hinge line. Posterior auricle relatively large but is not distinctly separated from disc.

Both specimens are indistinguishable from juvenile stages of numerous Upper Campanian forms, representing such variable morphotypes as "*Inoceramus*" *nebrascensis*, "*Inoceramus*" *pierrensis*, or "*Inoceramus*" *mclearni*. Unless further material from the type locality is provided, showing that the complete form is different from all earlier distinguished taxa, "*I.*" *saskatchewanensis* WARREN is a *nomen dubium*.

**Occurrence**: WARREN's type came from the Belly River Sands at Outlook, in Saskatchewan, Canada. KAUFFMAN *et al.* (1994) reports the species from the upper Middle Campanian (*Baculites gregoryensis* through *Baculites scotti* Zones).

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