

Inoceramidae from the Campanian (Upper Cretaceous) of the Gschliefgraben (Ultrahelvetic; Austria)

by

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Contents

Abstract, Zusammenfassung	41
Introduction	41
Systematic Palaeontology	42
Conclusion	50
References	52

Abstract

Twelve taxa of Inoceramidae are described from the Late Campanian through Early Maastrichtian of the Gschliefgraben (Ultrahelvetic, Upper Austria): *Cataceramus balticus balticus* (BÖHM), *Cataceramus balticus ellipticus* (GIERS), *Cataceramus balticus* aff. *haldemensis* (GIERS), *Cataceramus balticus* (BÖHM) subsp. indet., *Endocostea impressa* (D'ORBIGNY), *Inoceramus regularis* D'ORBIGNY, *Inoceramus* cf. *borilensis* JOLKIČEV, *Inoceramus* aff. *bererensis* SORNAY, *Inoceramus sagensis* OWEN, *Cordiceramus* ? aff. *heberti* (FALLOT), *Cremnoceramus* aff. *inconstans* WOODS and *Cremnoceramus sarumensis* (WOODS sensu SORNAY 1982). The material is from a permanently active mudflow area. The sequence was compiled by KENNEDY & SUMMESBERGER (1984) after PREY (1983). The diverse fauna indicates a Late Campanian through (?) Early Maastrichtian age.

Zusammenfassung

Zwölf Taxa Inoceramidae werden aus dem Obercampan bis (?) tiefsten Untermaastricht des Gschliefgrabens (Ultrahelvetikum; Oberösterreich) beschrieben: *Cataceramus balticus balticus* (BÖHM), *Cataceramus balticus ellipticus* (GIERS), *Cataceramus balticus* aff. *haldemensis* (GIERS), *Cataceramus balticus* (BÖHM)

subsp. indet., *Endocostea impressa* (D'ORBIGNY), *Inoceramus regularis* D'ORBIGNY, *Inoceramus* cf. *borilensis* JOLKIČEV, *Inoceramus* aff. *bererensis* SORNAY, *Inoceramus sagensis* OWEN, *Cordiceramus* ? aff. *heberti* (FALLOT), *Cremnoceramus* aff. *inconstans* WOODS und *Cremnoceramus sarumensis* (WOODS sensu SORNAY 1982). Das Material stammt aus einem dauernd aktiven Murenstrom. Die kompilierte lithostratigraphische Abfolge (KENNEDY & SUMMESBERGER, 1984) beruht daher vor allem auf der Interpretation des Fossilinhaltes (PREY 1983).

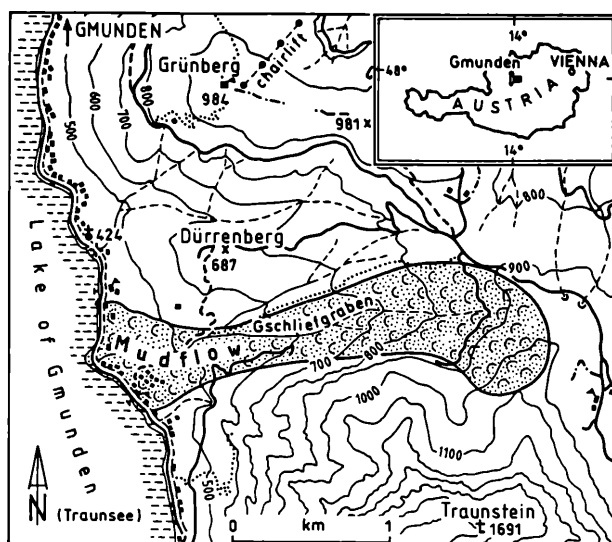


Figure 1: Sketchmap of the Gschliefgraben area.

Introduction

The only inoceramid taxon mentioned in the previous literature (PREY 1983) from the Gschliefgraben is *Inoceramus salisburgensis*. We cannot confirm this identification. *I. salisburgensis* FUGGER & KASTNER is not present in PREY's field collection, which is stored in the collections of the Museum of Natural History in Vienna. A second collection of Inoceramidae was donated (1976) to the NHMW by Prof. Norbert VAVRA (PIUW). The bulk of the fauna was collected by the authors. The description given below is a contribution

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to an integrated documentation of the fossil content of the Late Campanian of the Gschliefgraben. Most of the contributions are presented in this volume.

Abbreviations

- NHMW Naturhistorisches Museum Wien
- GIBF Geologisches Institut Bergakademie Freiberg (Technische Universität)/Sachsen
- ISNB Institut Royal des Sciences Naturelles de Belgique
- MNHNP Muséum National d'Histoire Naturelle, Paris
- SK Skoumal private collection, Vienna
- GSLT Geological Survey of Libya, Tripoli
- USNM United States National Museum Washington
- PIUW Paläontologisches Institut Universität Wien

Systematic Palaeontology

Class Bivalvia
Supraorder Pteriomorpha BEURLIN 1944
Order Pterioidea NEWELL 1965
Family Inoceramidae GIEBEL 1852

Genus *Cataceramus* HEINZ 1932

Type species *Inoceramus goldfussianus* D'ORBIGNY (= *Inoceramus balticus* BÖHM, 1907) by original designation of Cox, 1969: N 315.

Cataceramus balticus balticus (BÖHM)
(Pl. 4, Figs. 1, 2; Text-fig. 2)

Synonymy:

- 1907 *Inoceramus balticus* J. BÖHM: 113.
- 1909 *Inoceramus balticus* J. BÖHM; J. BÖHM: 47; pl. 11, fig. 1.
- 1964 *Inoceramus balticus balticus* J. BÖHM; GIERS: 238–239; pl.1, figs. 2–4.
- 1967 *Inoceramus (Endocostea) balticus* J. BÖHM; SEITZ: 67–72; pl. 6, figs. 1, 2; pl. 8, figs. 1, 2; pl. 10, fig. 1; pl. 12, figs. 1, 2.
- 1993 *Endocostea baltica baltica* (J. BÖHM, 1907); DHONDT: 221, pl. 4, fig. 3.
- 1997 *Cataceramus balticus* (BÖHM, 1907); WALASZCZYK: 18; pl. 12, figs. 1–5 (with additional synonymy).

Material: Internal moulds of two right valves (NHMW 1979/2076/46, NHMW 1979/2076/37) and one left valve (GIBF 1994/4a).

Preservation Incomplete. Portions of the wings, the anterior auricles and the ventral margins are missing. NHMW 1979/2076/46 is completely flattened by compaction.

Description: Valve medium-sized, elongated subquadrate. Thick beak projecting to the hinge line. The umbonal pole is slightly turned to the anterior margin. Anterior margin at the beak concave. Genuculations with a change in the distances between the undulations (ribs) were observed at H = 10.5 mm (NHMW 1979/2076/37) and H = 75.5 mm (NHMW 1979/2076/46). Total angles: 93–105° (GIERS 1964, 238: 98°). The undulations are topounded to sharp due to compaction.

The H/L- and Vo/L-ratios are similar to those of the holotype and specimen IG 6312 (MNHNP). Geographic distribution: Widespread; E-, W- and S-Europe, Asia, N- and S-America (Brasil).

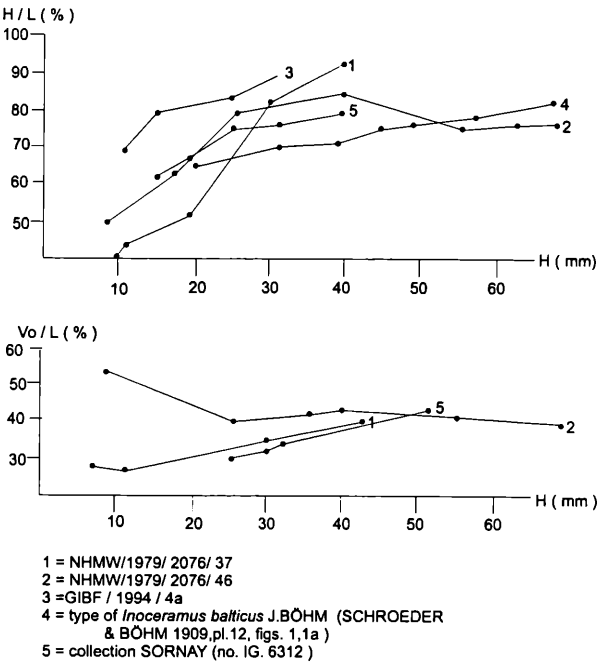


Figure 2: Diagram showing H/L and Vo/L ratios of *Cataceramus balticus balticus* (J. BÖHM).

Distance from UP	1	2	3
10–30 mm	–	–	–
30–50 mm	4.73 mm	6.0 mm	5.5 mm
50–70 mm	–	1.1 mm	–

Table 1. Average undulation intervals (DU) in different distances from the umbilical pole (UP); 1 = NHMW 1979/2076/37, 2 = NHMW 1979/2076/46, 3 = IG 6312 (MNHNP).

Stratigraphic distribution: After GIERS (1964, table 1) *Cataceramus balticus balticus* is a long ranging subspecies appearing in the uppermost Santonian and ranging through the Early Campanian, disappearing in the Late Campanian *Polyplocum* Zone. According to TRÖGER (1989; Text-fig. 5) it occurs in Inoceramid-zones 29–32.

Cataceramus balticus ellipticus (GIERS)
(Text-figs. 3, 4)

- 1964 *Inoceramus balticus ellipticus* GIERS: 244–245; pl. 2, figs. 3, 4
- 1993 *Endocostea baltica elliptica* (GIERS, 1964); DHONDT: 223, pl. 6, fig. 1; text-fig. 6
- 1997 *Inoceramus ellipticus* GIERS, 1964; WALASZCZYK: 39; pl. 23, figs. 1–7; pl. 24, figs. 1–5; pl. 25, figs. 1, 4.

Material: Two internal moulds of right valves without shell (NHMW 1979/2076/34, NHMW 1979/z/160/5); additional fragments from the Gschliefgraben.

P r e s e r v a t i o n : Incomplete. Portions of the wings (posterior auricle) and the ventral margins are absent. Flattened by compaction, with radial cracks.

D e s c r i p t i o n Valve small to medium-sized, shape elongated oval. Small beak slightly turned to the anterior margin and separated from the wing. Anterior auricles are missing. Total angles: 102°,105°. Angle of

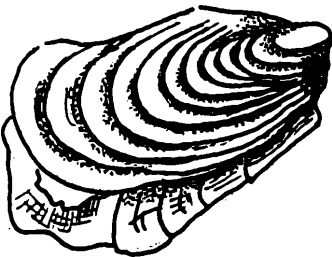


Figure 3:
Cataceramus balticus ellipticus (GIERS); NHMW 1979/2076/34; Gschliefgraben near Gmunden; x 1.

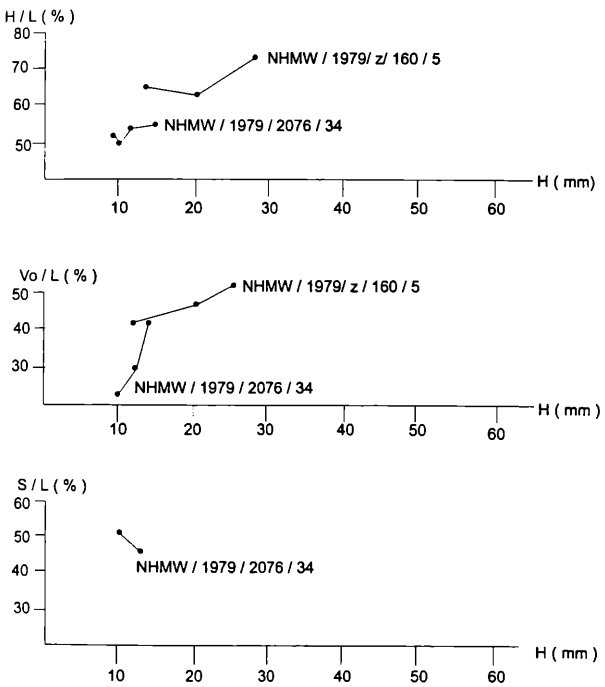


Figure 4: Diagram showing H/L-, Vo/L- and S/L- ratios at *Cataceramus balticus ellipticus* (GIERS).

inclination (growth axis): 25–30°. Geniculations were observed at H=21 mm (NHMW 1979/2076/34) and H=20.2 mm (NHMW 1997/z/160/5). At the geniculations there is a sudden change in the intervals of the undulations (ribs). Distance between the undulations on the umbonal region (10–30 mm from UP): 2–4 mm.

D i s c u s s i o n WALASZCZYK (1997:40) quoted DHONDT’s *Endocostea baltica elliptica* (GIERS) with some doubt concerning the ornament.

Geographic distribution: W- Europe, Münsterland (GIERS 1964), France (HANCOCK et al. 1993).

Stratigraphic distribution: According to GIERS (1964: 244) *Cataceramus balticus ellipticus* (GIERS) occurs in

	NHMW 1979/2076/34		NHMW 1997/z/160/5		
Distance from UP	H/L	Vo/L	S/L	H/L	Vo/L
10–30 mm	54.6	39.6	48.0	68.0	50.0

Table 2. Average H/L- , Vo/L - and S/L - ratios of *Cataceramus balticus ellipticus* (GIERS) from the Gschliefgraben.

the Vorhelmer Schichten, representing the upper part of the early Late Campanian. After WALASZCZYK (1997) it appears in the zone of *Cataceramus balticus beckuensis* (GIERS), which is earliest Late Campanian in age.

***Cataceramus balticus* aff. *haldemensis* (GIERS)**
(Pl. 3, Fig. 4; Text-fig. 5)

C o m p a r e :

- 1932 *Cataceramus haldemensis* HEINZ (nomen nudum): 15
- * 1964 *Inoceramus balticus haldemensis* GIERS: 243–244; pl. 2, fig. 2
- 1967 *Inoceramus (Endocostea) balticus haldemensis* GIERS; SEITZ: 75; pl. 2, fig. 2.
- * 1982 *Inoceramus balticus haldemensis* GIERS; TRÖGER & RÖHLICH:101–111; 9 figs., 1 pl.
- * 1992 *Inoceramus balticus haldemensis* GIERS; TRÖGER & RÖHLICH: 1363–1365; text-figs. 4–7; pl. 1, figs. 1–8.
- 1997 *Inoceramus haldemensis* GIERS; WALASZCZYK: p. 40; pl. 30, figs. 1, ?3, 5.

M a t e r i a l : Five internal moulds: 2 right valves (GIBF 1995/1, NHMW 1997/160/4), 2 left valves (GIBF 1995/2, GIBF 1995/6), 1 bivalved (SK/B/GG/1997/4).

D e s c r i p t i o n Medium-sized, equivalve, inequilateral. Shape axe-like (SK/B/GG/1997/4, GIBF 1995 /1). The other specimens are higher (H/L-ratio > 100, see text-fig 5). Beak in terminal position. Umbonal region slightly prosogyrate and thrustured over the hinge line. Anterior auricle is missing. Anterior margin convex. Undulations (concentric ribs) toprounded. The undulations are turned to the beak on the wing. Undulations sometimes bifurcated. Geniculations were observed in different growth stages. Total angles between 110–150°.

R e m a r k s The H/L- and Vo/L- ratios (text-fig. 3) are comparable with those of a specimen from the Late Campanian of Libya (GSLT/1385-III-C–5/5).

Distance from UP	1	2	3	4
10–30 mm	3.48 mm	3.12 mm	–	3.0 mm
30–50 mm	5.00 mm	10.00 mm	–	3.53 mm
50–70 mm	11.00 mm	–	–	–

Table 3. Average undulation intervals (DU) in different distances from the umbonal pole (UP). 1 GIBF 1995/4, 2 SK/B/GG/1997/4, 3 GIBF 1995/1, 4 GIBF 1995/6

Geographical distribution: W- and E-Europe, N-Africa.

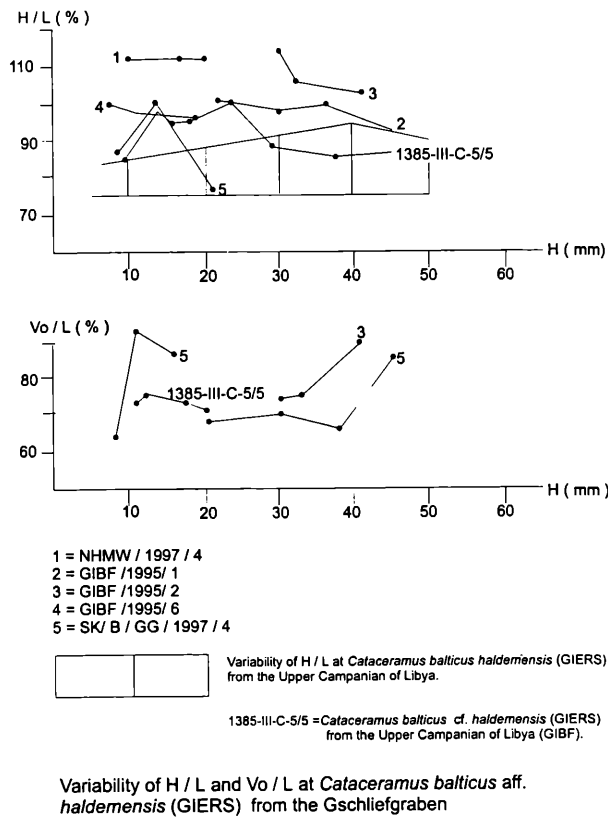


Figure 5: Diagram showing H/L and VO/L-ratios at *Cataceramus balticus* aff. *haldemensis* (GIERS).

Stratigraphic distribution: After GIERS (1994: 243) *I. balticus haldemensis* appears in the „Obere Vorhelmer Schichten“, representing the *Vari* Zone of the Late Campanian, and extends into the *Polyplocum* Zone. After WALASZCZYK (1997) it occurs in the Late Campanian *C. haldemensis* Zone, which is more or less identical with the *Polyplocum* Zone of the traditional Campanian zonation.

***Cataceramus balticus* (BÖHM) subsp. indet.**
(Pl. 3, Fig. 2; Pl. 4, fig. 3; Text-fig. 6)

Material: Internal moulds of four right valves (NHMW 1979/2076/24, SK/B/GG/ 1997/1, GIBF 1995/7, NHMW 1979/2077/5), two left valves (SK/B/GG/1997/2, NHMW 1979/2077/5) and one bivalved specimen (NHMW 1979/2076/28) from the Gschliefgraben.

Preservation: The bivalved specimen is completely flattened by compaction. The other specimens are slightly deformed, showing radial cracks.

Description: Shell medium-sized, equi-valve, inequilateral. Shape elongated oval. Beak distinctly separated from the wing, erected. Umbonal pole slightly prosogyrate. Anterior margin convex. Total angle: 120–125°. Undulations (concentric ribs) staircase shaped to topounded. Growth lines and undulations are bent to the umbonal pole on the wing. Anterior auricle is

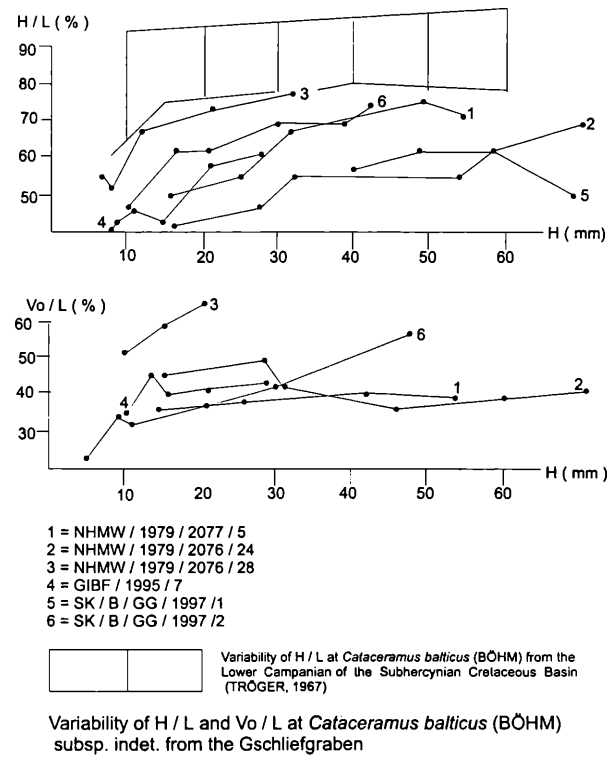


Figure 6: Diagram showing H/L- and Vo/L- ratios of *Cataceramus balticus* (J. BÖHM) al from the Gschliefgraben.

Distance from UP	1	2	3
10–30 mm	–	2.53 mm	6.00 mm
30–50 mm	9.25 mm	–	–
50–70 mm	11.40 mm	–	–

Table 4. Average undulation intervals (DU) of *C. balticus* subsp. indet. at different distances from the umbonal pole (UP) from Gschliefgraben specimens: 1 = NHMW 1979/2076/24, 2 = NHMW 1979/2076/28, 3 = GIBF 1995/7.

Distance from UP	1	2	3
10–30 mm	4.87 mm	2.76 mm	–
30–50 mm	5.00 mm	5.70 mm	5.10 mm
50–70 mm	–	–	–

Table 5. Average undulation intervals (DU) of *C. balticus* subsp. indet. at different distances from the umbonal pole (UP) from Wentneralm I locality in Gams (SUMMESBERGER et al. 1999): 1 = NHMW 1997/z /158/1, 2 = NHMW 1997/z/158/3, 3 = NHMW 1997/z /158/8.

missing. Geniculations were observed in: GIBF 1995/7, SK/B/GG/1997/2 and NHMW 1979/2076/24.

NHMW 1979/2076/28 agrees with the specimens from Gams concerning the undulation intervals. The intervals are greater in the other Gschliefgraben specimens.

Remarks Concerning the shape and the H/L- ratios there are distinct differences between *C. balticus* subsp. indet. and *C. balticus balticus* (J. BÖHM) including *C. balticus haldemensis* (GIERS) (Text-figs. 2, 5).

The shape, development of the umbonal region and the total angle of *C. balticus marcki* (GIERS) are comparable. In contrast to *Cataceramus balticus* (J. BÖHM) subsp. indet. in *Cataceramus balticus marcki* (GIERS) the H/L-ratio strongly increases (170-180 %). Stratigraphic distribution: *Cataceramus balticus* ssp. is a long-ranging species: *Cataceramus balticus marcki* (GIERS) occurs from latest Santonian to the earliest Late Campanian *Polyplacum* Zone.

Genus *Endocostea* WHITFIELD 1880

Type species *Inoceramus (Endocostea) typicus* WHITFIELD.

Endocostea impressa (D'ORBIGNY)

(Pl. 2, Figs. 1, 3, 5, 6; Text-figs. 7 a, b; 8)

- 1845 *Inoceramus impressus* D'ORBIGNY: 515; pl. 409.
- * 1957 *Inoceramus impressus* D'ORBIGNY; SORNAY: figs. 4, 5.

According to SORNAY (1957) the lectotype of *Endocostea impressa* (D'ORBIGNY) is no. 7592 A in D'ORBIGNY's collection (SORNAY, 1957, fig. 4).

Material Three specimens from the Gschliefgraben are available to us: One bivalved (NHMW 1979/2076/25/1,2), one right (SK/B/GG/1997/3) and one left valve (NHMW 1979/2076/30). Two internal moulds of right valves (NHMW 1997z158/0009, 0011) from

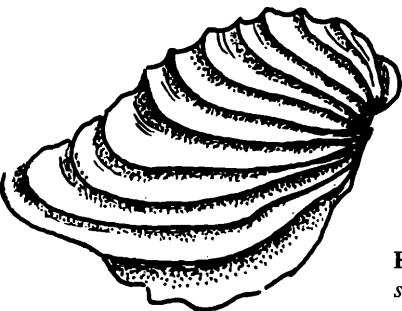
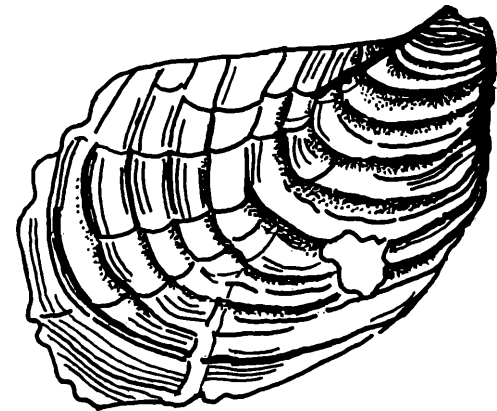
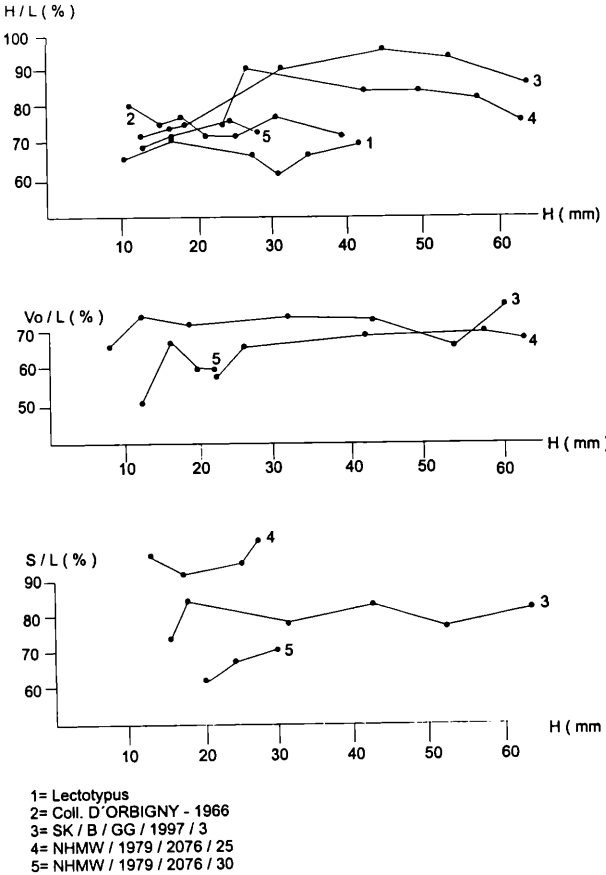


Figure 7a: *Endocostea impressa* (D'ORBIGNY) not deformed umbonal region;

NHMW 1979/2076/25/2; x 1.



7b: *Endocostea impressa* (D'ORBIGNY) with radial cracks caused by compaction; SK/B/GG/1997/3, both from Gschliefgraben; x 1.



Variability of H / L , Vo / L and S / L at *Endocostea impressa* (D'ORBIGNY) from the Gschliefgraben (no. 3-5) .

Figure 8: Diagram showing H/L- and VO/L- ratios at *Endocostea impressa* (D'ORBIGNY) from the Gschliefgraben and of *Endocostea* aff. *impressa* (D'ORBIGNY) from Wentneralm, Gams/Steiermark.

the Wentneralm I at Gams (SUMMESBERGER, WAGREICH, TRÖGER & JAGT 1999) are ancestral to the present species.

Preservation: All internal moulds are incomplete. Parts of the wings and the ventral margins are missing.

Distance from UP	1	2	3	4
10–30 mm	3.73 mm	3.16 mm	3.26 mm	3.60 mm
30–50 mm	4.55 mm	–	5.87 mm	–
50–70 mm	3.61 mm	–	5.20 mm	–

Table 6. Average undulation intervals (DU) of *E. impressa* from Gschliefgraben at different distances from UP. 1 = NHMW 1979/2076/25, 2 = NHMW 1979/2076/30, 3 = SK/B/GG/1997/3, 4 = 7592A (MNHN, collection D'ORBIGNY).

Description: Medium-sized, inequilateral. Shape elongated subquadrate. Beak vaulted, distinctly separated from the wing, prosogyrate. Hinge line straight. Anterior margin slightly concave at the umbonal region. Undulations (concentric ribs) following the shape outline, topounded. The undulations are bent to the umbonal pole (angle 115–120°).

The course of the H/L-, Vo/L- and S/L-ratios (Text-fig. 8) of specimens from the Gschliefgraben and Gams are similar, but they do not agree completely. No. 1966 from the collection of D'ORBIGNY (lectotype) has an intermediate position. Total angle: 92–110° (lectotype: 102°).

Remarks: The specimens from the Gschliefgraben and Wentneralm I (Gams) differ slightly in H/L- and Vo/L-ratios (see Text-fig. 8). The specimens from the Gschliefgraben agree with no. 1966 in D'ORBIGNY's collection of Early Maastrichtian age.

Geographic distribution: W- and E- Europe, N-Africa. Stratigraphic distribution: Early Late Campanian (GIERS 1964) to earliest Maastrichtian (SORNAY 1957). According to WALASZCZYK (1997) Late Campanian through Early Maastrichtian, (?) Late Maastrichtian.

Genus *Inoceramus* J. SOWERBY 1814

Type species *Inoceramus cuvieri* SOWERBY by subsequent designation of Cox (1969: N 315).

Inoceramus regularis D'ORBIGNY
(Pl. 2, Fig. 2; Text-fig. 9)

- 1845 *Inoceramus regularis* D'ORBIGNY: 517, pl. 410
- * 1962 *Inoceramus regularis* D'ORBIGNY; SORNAY: pl. 7, fig. 3
- * 1964 *Inoceramus regularis* D'ORBIGNY; GIERS: 247–248; pl. 3, fig. 3
- * 1976 *Inoceramus regularis* D'ORBIGNY; SORNAY: 7–8; pl. 2, fig. 3; pl. 3, figs. 3–4; text-fig. 4.

Following HEINZ (in sched.) SORNAY (1976: 7–8) designated no. 7594 in D'ORBIGNY's collection as lectotype (SORNAY 1962: pl.1, fig. 3).

Material: A single internal mould of a right valve (NHMW 1979/2076/39) from the Gschliefgraben.

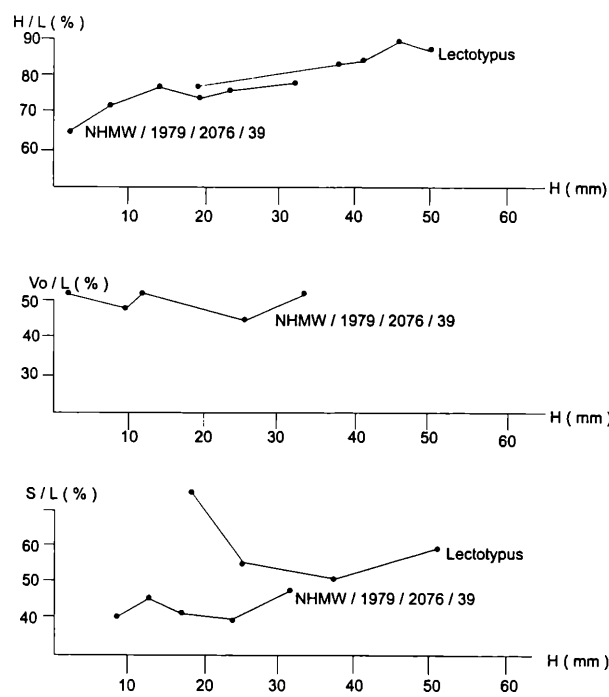
Preservation: Incomplete. Parts of the wing and the anterior margin are missing.

Description: Medium-sized, inequilateral, shape nearly cycloid. Flat with convex anterior margin. Prosogyrate. The umbonal pole projects somewhat above the straight hinge line. Undulations (concentric ribs) topounded. Average distance between the undulations at 10–30 mm distance from the umbonal pole: 3.5 mm. Total angle: 120°. Text-fig. 9 shows H/L-, S/L- and Vo/L-ratios.

Remarks: The present specimen corresponds on all features with the lectotype of *Inoceramus regularis* D'ORBIGNY.

Geographic distribution: Europe, Madagascar (NODA & KANIE 1978 a,b), N-America (KAUFFMAN et al. 1993), N-Africa (TRÖGER & RÖHLICH 1992).

Stratigraphic distribution: Late Senonian after SORNAY (1962); Late Campanian after NODA & KANIE (1978 a, b), early Late Campanian after GIERS (1964).



Inoceramus regularis D'ORBIGNY from the Gschliefgraben.

Figure 9: Diagram showing H/L-, Vo/L- and S/L-ratios at *Inoceramus regularis* D'ORBIGNY from the Gschliefgraben.

Distances from UP	
	NHMW 1979/2077/3
10–30 mm	–
30–50 mm	3.5 mm
50–70 mm	5.0 mm
over 70 mm	11.5 mm

Table 7. Average undulation intervals of *Inoceramus* cf. *borilensis* JOLKIČEV (NHMW 1979/2077/3) from the Gschliefgraben.

Distance from UP	H/L	Vo/L
10–30 mm	44.9 mm	32.7 mm
30–50 mm	66.3 mm	46.75 mm

Table 8. Average H/L- and Vo/L- ratios of *Inoceramus* cf. *borilensis* JOLKIČEV (NHMW 1979/2077/3) from the Gschliefgraben.

Inoceramus cf. *borilensis* JOLKIČEV
(Text-figs. 10, 11)

Compare:

- 1962 *Inoceramus borilensis* JOLKIČEV: 1952–1954; pl. 7, figs. 1a, 1b
- 1993 „*Inoceramus*“ *borilensis* JOLKIČEV; DHONDT: 215; pl. 1, fig.1; pl. 3, fig. 2a, b; text-fig. 3a, b
- 1993 „*Inoceramus*“ cf. *borilensis* JOLKIČEV; DHONDT: 216; pl. 4, fig. 1; text-fig. 2a, b, c.

Material: Two internal moulds are at our disposal: NHMW 1979/2077/3, a left valve from the Gschliefgraben and NHMW 1998/96/1 from Tonionböden (Steiermark).

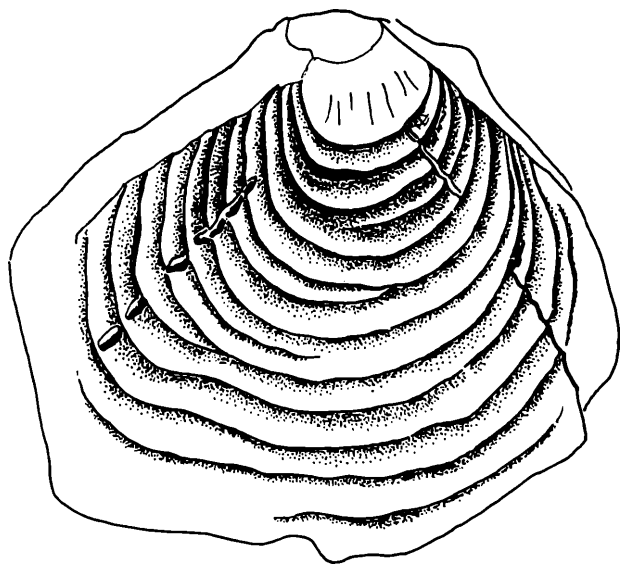


Figure 10: *Inoceramus* cf. *borilensis* JOLKIČEV with geniculation. NHMW1979/2077/3; Gschliefgraben; x 1.

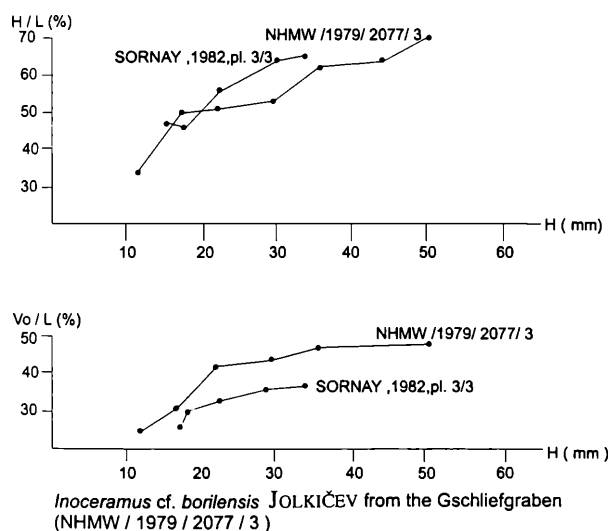


Figure 11: Diagram showing H/L and Vo/L- ratios at *Inoceramus* cf. *borilensis* JOLKIČEV.

Preservation: Highly incomplete. Only the beaks are preserved in both cases. Shell missing.

Description: The umbonal part is strongly erect and separated from the wing, slightly deformed by compaction. Strongly prosogyrate. In NHMW 1979/2076/3 there is a geniculation, which is associated with an increase in the undulation distances. Total angle: 105°.

Remarks An exact identification of the specimens from Austria is not possible. In both cases the shell is missing; this feature is very important for the examination of *Inoceramus borilensis* JOLKIČEV according to JOLKIČEV (1962). The specimens of Austria are comparable with *Inoceramus borilensis* JOLKIČEV from Houthalen determined by SORNAY (1982) and depos-

ited in the collection SORNAY under no. 10222 in Brussels (ISNB).

Occurrence: W- Europe (Belgium, France), E- Europe (Bulgaria), Gschliefgraben.

Stratigraphic distribution Maastrichtian (holotype – Bulgaria). Late Campanian *Nostoceras hyatti* Zone (Tercis/SW France). Early Maastrichtian *Pachydiscus epiplectus* Zone („*Inoceramus*“ cf. *borilensis*; Tercis/SW France).

***Inoceramus* aff. *bererensis* SORNAY**
(Pl. 3, Fig. 1; Text-figs. 12–13)

1975 *Inoceramus bererensis* SORNAY: 11–13; pl. 2, fig. 3; pl. 5, fig. 2; plate 6, fig. 1; Text-figs. 5–6.

Material Two internal moulds of one left (NHMW 1979/2076/44) and one right (SK/B/GG/1997/5) valve.

Preservation: Incomplete. Ventral margins and large parts of the wings are missing. SK/B/GG/1997/5 is highly deformed by compaction. The umbonal part is thrust over the anterior margin.

Description Medium-sized to tall, shape elongated oval. Umbonal part is distinctly separated from the wing. Umbonal pole projecting above the hinge line. Hinge line straight to slightly convex. Geniculation at $H_a = 98$ mm (NHMW 1979/2076/44). At the hinge line the undulations are bent to the umbonal pole. Total angle: 100°; wing angle: 43°. Undulations flat rounded (Anwachsstreifen sensu HEINZ 1928). The growth axis is increasing from 40° to 60° – prosocline. Thickness of the shell 0.8–1.5 mm.

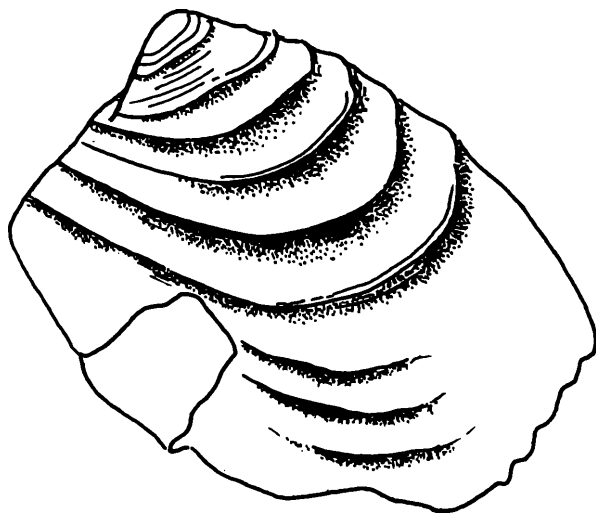


Figure 12: *Inoceramus* aff. *bererensis* SORNAY, SK/B/GG/1997/5 umbonal part thrust over the hinge line (compaction); x 1.

Remarks Shape more elongated than in *Inoceramus bererensis* SORNAY. The Na/Ha-ratio in *Inoceramus bererensis* SORNAY is between 80–90 in contrast to *I.* aff. *bererensis* SORNAY (text-fig. 13). *Inoceramus* aff. *bererensis* SORNAY (NODA & KANIE 1978 a; pl.1,

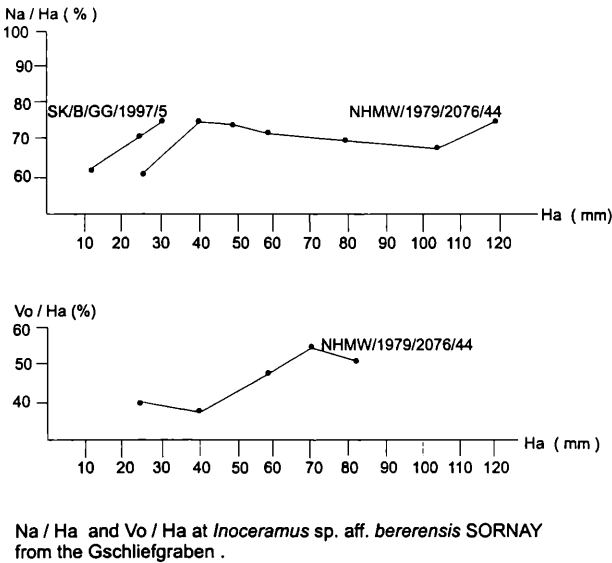


Figure 13: Diagram showing Na/Ha-, Vo/Ha-ratios and WA growth axis at *Inoceramus* aff. *bererensis* SORNAY.

Distance from UP	1	2
10–30 mm	–	–
30–50 mm	9.25 mm	6.50 mm
50–70 mm	13.00 mm	–

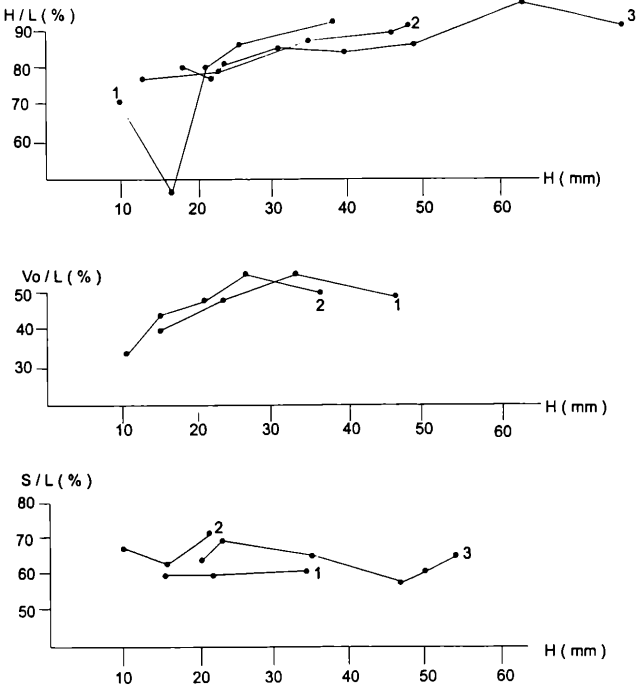
Table 9. Average undulation intervals (DU) of *Inoceramus* aff. *bererensis* SORNAY in different distances from the umbonal pole (UP). 1 = NHMW 1979/2076 / 44; 2 = SK/B / GG/1997/5.

fig. 3) is comparable but has an anterior auricle. In *Inoceramus* aff. *bererensis* SORNAY (TRÖGER & RÖHLICH 1992) the course of the undulations is more cycloid. Geographic distribution: Madagascar (SORNAY 1975), N-Africa (TRÖGER & RÖHLICH 1992). Stratigraphic distribution: Middle Campanian (SORNAY 1975).

Inoceramus sagensis OWEN 1852
(Pl. 2, Fig. 4; Text-fig. 14)

- 1852 *Inoceramus sagensis* OWEN: 582 ; pl. 7, fig. 3
* 1876 *Inoceramus sagensis* OWEN var. *nebrascensis* OWEN-MEEK: 52; pl. 13, figs. 2a, b.
1959 *Inoceramus sagensis* OWEN; DOBROV & PAVLOVA :155; pl. 22, fig. 3; pl. 23, fig. 5.

Material Three internal moulds (one left = NHMW 1979/2076/26; two right ones = NHMW 1979/2076/33, NHMW 1979/2077/2/1) from the Gschliefgraben.
Preservation: Incomplete. Parts of the wing and of the ventral margin are missing. Slightly deformed by compaction.
Description: Medium to tall in size, shape elongated subquadratic .The vaulted beak is distinctly separated from the wing. Umbonal pole prosogyrate. Total angle 120°. Anterior margin distinctly concave. Thick-



1 = NHMW / 1979 / 2076 / 33 (Gschliefgraben)
2 = NHMW / 1979 / 2076 / 26 (Gschliefgraben)
3 = US N.M. 485 (USA)
Variability of H / L , Vo / L and S / L at *Inoceramus sagensis* OWEN.

Figure 14: Diagram showing H/L-, Vo/L- and S/L- ratios at *Inoceramus sagensis* OWEN.

Distance from UP	1	2
10–30 mm	2.52 mm	3.33 mm
30–50 mm	4.20 mm	5.28 mm
50–70 mm	–	5.63 mm

Table 10. Average undulation intervals (DU) at different distances from the umbonal pole (UP) in NHMW 1979/2076/ 33 (1) and *Inoceramus sagensis* var. *nebrascensis* OWEN (2 USNM 485).

ness of shell: 1.5 mm. The interior moulds bear radial striae.
Remarks The changes of the H/L- , Vo/L- and S/ L- ratios are shown in text-fig. 14. They are comparable with the corresponding ratios of USNM no. 485 from the Fort Pierre Group. One part of an umbonal region was determined as *Inoceramus* aff. *sagensis* OWEN (NHMW 1979/2077/2, 1).
Geographic distribution: Caucasus, Crimea, N- Ame- rica (DOBROV & PAVLOVA [in:] MOSKVIN 1959); Gschliefgraben.
Stratigraphic distribution: Late Campanian to Early Maastrichtian (DOBROV & PAVLOVA [in:] MOSKVIN 1959).

Genus *Cordiceramus* HEINZ 1932

Type species: *Inoceramus cordiformis* J. SOWERBY, 1823.

***Cordiceramus* ? aff. *heberti* (FALLOT)**

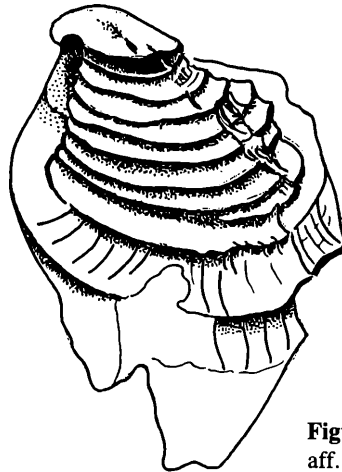
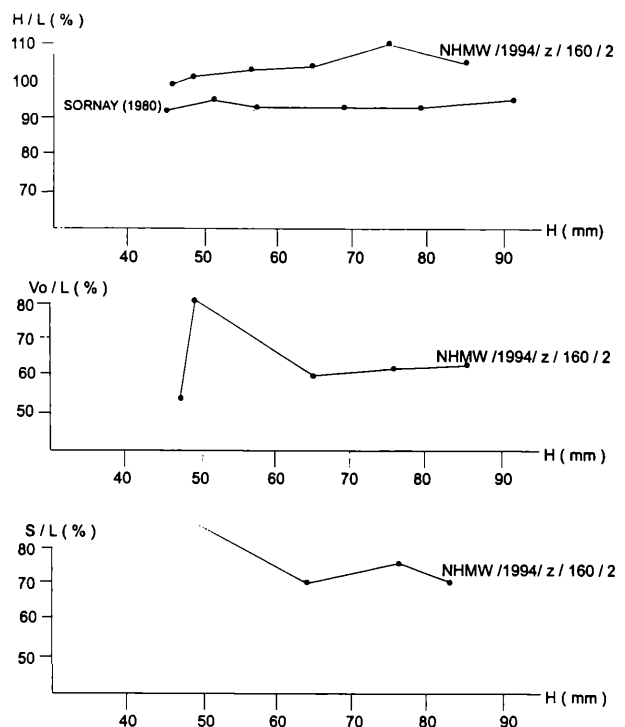
(Pl. 1, Fig. 2 ; Text-figs. 15, 16)

* 1885 *Inoceramus heberti* FALLOT: 249; pl. 7, fig. 11968 *Inoceramus (Cordiceramus) heberti* FALLOT - SORNAY: 41; pl. 4, fig. 5.

The lectotype was designated by SORNAY (1968:41).

Material Internal moulds of two valves (NHMW 1997/z/160/2, SK/B/GG/1997/6).**Preservation:** Incomplete. Flattened by compaction, with radial cracks. The umbonal region of SK/B/GG/6 is missing.**Description:** Medium to large in size. Shape cycloid, flat. Umbo less prominent, not distinctly separated from the wing. Total angle: 120°. Undulations toprounded, sometimes sharp (compaction). Course of the undulations pentagonal subquadratic (e.g. SK/B/GG/1997/6). At the hinge line the undulations are bent to the umbonal pole (angle: 110–120°).Anterior margin slightly concave. Growth axis: 45–58°, slightly prosocline. H/L- ratio (text-fig. 15) similar to the lectotype. SK/B/GG/1997/6 bears an *Endocostea* scar (Text-fig. 15).

Distance from UP	1	2
10–30 mm	—	—
30–50 mm	6.33 mm	5.25 mm
50–70 mm	7.03 mm	8.16 mm
70–90 mm	8.85 mm	9.00 mm

Table 11. Average undulation intervals of NHMW z/160/2 (1) in relation to the lectotype of *Cordiceramus heberti* FALLOT (2).**Remarks** In *Cordiceramus heberti* (FALLOT) the course of the undulations is pentagonal. The undulation distances are greater in the gerontic stages. The Gschliefgraben specimens may be compared with the Late Campanian *Inoceramus* aff. *heberti* FALLOT from Libya (TRÖGER & RÖHLICH, 1992).**Geographic distribution:** W-Europe / Hautes Alpes), Spain (GALLEMI et al., 1993), N-Africa (TRÖGER & RÖHLICH, 1992).**Stratigraphic distribution:** Late Campanian (SORNAY 1968, TRÖGER & RÖHLICH 1992).**Genus** *Cremnoceramus* COX 1969 (non HEINZ 1932)**Type species:** *Inoceramus inconstans* WOODS 1912**Discussion** The genus *Sphaeroceramus* was established by HEINZ (1932) without formal description and illustration. According to HEINZ the type specimen of text-fig. 48 in WOODS (1910–1912) should be chosen as the genotype, described as *Inoceramus inconstans* WOODS (unknown locality, Upper Chalk, unknown horizon). This specimen was renamed *Sphaer-***Figure 15:** *Cordiceramus* ? sp. aff. *heberti* (FALLOT) with *Endocostea* scar- SK/B/GG/1997/6; Gschliefgraben; x 1.**Figure 16:** Diagram showing H/L-, Vo/L- and S/L-ratios at *Cordiceramus* sp. aff. *heberti* (FALLOT) from the Gschliefgraben in comparison with H/L at the lectotype (SORNAY 1980)**Figure 16:** Diagram showing H/L-, Vo/L- and S/L-ratios at *Cordiceramus* ? aff. *heberti* (FALLOT)*oceramus pilula* HEINZ, 1932. WALASZCZYK (1997) used the name *Sphaeroceramus*. He gave a short description of the genus. The type species according to WALASZCZYK is *Inoceramus subsarumensis* RENNGARTEN 1926 = *Sphaeroceramus pilula* HEINZ. Species of the genus *Sphaeroceramus* are *Sph. sarumensis* (WOODS) and *Sph. subsarumensis* (RENNGARTEN). According to COX in MOORE & TEICHERT (1969) *Sphaeroceramus* is a synonym of *Cremnoceramus* COX 1969. We follow COX in this paper.

Cremnoceramus sarumensis (WOODS)
sensu SORNAY 1982
(Pl.1, Fig. 1, Pl. 4, Fig. 4)

Lectotype: The original of WOODS (1912, pl. 52, fig. 2a, b) designated by WALASZCZYK (1997), BMNH collection BLACKMORE.

- 1911 *Inoceramus incostans sarumensis* WOODS: 293; pl. 52, figs. 2, 3
* 1982 *Inoceramus sarumensis* WOODS - SORNAY : pl. 2, fig. 2
1997 *Sphaeroceramus sarumensis* (WOODS, 1912); WALASZCZYK: 31; pl. 1, figs. 1–2, 5; pls. 21–22.

Material Internal mould of a single left valve (NHMW 1997/z/160/1) and a bivalved but incompletely preserved specimen (NHMW 1997/z/160/1).
Preservation: Incomplete. Parts of the wings and of the ventral margins, highly deformed by compression, are missing.
Description: Large, inequilateral. The beaks are weakly involute, prosogyrate. Anterior margin concave. The undulations are rounded and staircase-shaped.

Distance from UP	H / L	Vo / L	DU
10–30 mm	45.9	47.3	2.74 mm

Table 12. Average ratios H/L, Vo/L and average distances (DU) of the undulations in *Cremnoceramus sarumensis* (WOODS) from the Gschliefgraben. NHMW 1997/z /160/1 at 10–30mm distance from the umbonal pole (UP).

Remarks: Concerning the involute character of the umbonal pole the specimens are completely comparable with *Cremnoceramus sarumensis* (WOODS) from the Campanian of Belgium (charbonnage Zolder/charbonnage Limbourg), described by SORNAY (1982).
Stratigraphic distribution: Early Campanian (WOODS 1911) – Smectite de Herve (Campanian – SORNAY 1982). After WALASZCZYK (1997) *S. sarumensis* occurs in the Early Campanian and early Late Campanian of Germany and does not occur in the higher Late Campanian *Polyplocum* Zone respectively *Haldemensis* Zone sensu WALASZCZYK (1997) of the Vistula valley and Westphalia.

Cremnoceramus ? aff. *inconstans* (WOODS)
(Pl. 4, Fig. 5)

Material: A single right valve (NHMW 1979/2077/4) from the Gschliefgraben.
Preservation: Incomplete internal mould with adherent shell and radial cracks, flattened by compaction. The ventral margin, large parts of the wing and the umbonal pole are missing. The umbonal region is highly crushed.
Description: Medium to tall in size, inequilateral. Prominent beak is projecting over the hinge line. Beak not distinctly separated from the wing. Anterior margin convex.

Undulations (concentric ribs) rounded. Growth lines cut the undulations at an acute angle (HEINZ, 1932 : 23, footnote – Anwachsschnittreifen). Distance between the growth lines 0.5–1.5 mm. Thickness of the shell 0.8–1 mm.

Distance from UP	DU
10–30 mm	6.5 mm
30–50 mm	12.0 mm
50–70 mm	15.1 mm
70–90 mm	19.5 mm

Table 13. Average undulation intervals (DU) in different distances from the umbonal pole (UP); NHMW 1979/2077/4 from the Gschliefgraben.

Distance from UP	H/L	Vo/L
10–30 mm	45.0 mm	45.5 mm
30–50 mm	57.9 mm	44.8 mm
50–70 mm	65.9 mm	57.6 mm

Table 14. Average ratios H/L and Vo/L at 10–70 mm distance from the umbonal pole (UP); NHMW 1979/2077/4 from the Gschliefgraben.

Remarks: The shape, the erect beak region and the distance between the undulations indicate that the specimen is a member of the *Cremnoceramus inconstans* group. The specimen differs from all described species by the „Anwachsschnittreifen“.

Conclusion

The diverse Inoceramid fauna indicates Late Campanian through Early Maastrichtian (Tab. 15). This is in accordance with nannoplankton ages (CC22b – CC23c; WAGREICH, 1999, this volume), ammonites (KENNEDY & SUMMESBERGER, 1999, this volume) and Echinodermata (JAGT, 1999, this volume). In terms of ammonite zones the age is from *Phaleratum* to *Polyplocum* Zone. The bulk of the Inoceramids seems to be from the *Haldemensis* Zone (= *Polyplocum* Z.). Early Maastrichtian age cannot be excluded by Inoceramids. A complete list of fossils present in the Late Cretaceous Gschliefgraben locality is given by KENNEDY & SUMMESBERGER, 1999 (this volume).

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Chronostratigraphy	Biostratigraphy NW Germany	Inoceramid assemblage zones	IZ	Range of Gschliefgraben Inoceramids
EARLY MAASTRICHTIAN	Lanceolata Zone			
	Grimmensis/Granulosus Zone			
	Langei Zone			
LATE CAMPANIAN	Polyplacum Zone	Cat. haldemensis Zone	33	
	Vulgaris Zone	Unnamed Zone		
	Basiplana/Spinger Zone	Cat. vorhelmenis Z. - Inoc. agdjakensis Z.	32	
	Conica/Mucronata Zone	Cat. beckunensis Zone	31	
	Gracilis/Mucronata Zone			
EARLY CAMPANIAN	Conica/Gracilis Zone			
	Papillosa Zone	Sph. sarunensis Zone -	30	
	Senonensis Zone	Cat. dariensis Zone		
	Pilula/Senonensis Zone			
	Pilula Zone			
LATE SANTONIAN	Lingua/Quadrata Zone			
	Granulataquadrata Zone			
	Marsupites/Granulata Zone			
		Sphe. - Sphenoceramus Sph. - Sphaeroceramus Cat. - Cataceramus	29	
		Inoceramid zones after WALASZCZYK (1997), IZ Inoceramid zones after TrÖGER (1989), TrÖGER et al. (this work).		
Biostratigraphical range of the Gschliefgraben on the NW German biostratigraphical zonal scheme including the Subhercynian Cretaceous and the Münsterland Basin according to CHRISTENSEN (1988, 1997), ERNST (1964, 1970 b, 1972, 1974), KAUFFMAN et al. (1993), PETRASCHECK (1906), RIEDEL (1931), SCHULZ & SCHMID (1983), SCHULZ (1979), ULBRICH (1971) and unpublished data.				Cataceramus balticus balticus (BOHM) Cataceramus balticus ellipticus (GIERs) Cataceramus balticus aff. haldemensis (GIERs) Cataceramus balticus (BOHM) subsp. indet. Endocostea impressa (D'ORBIGNY) Inoceramus regularis D'ORBIGNY Inoceramus cf. borilensis JOLKČEV Inoceramus sagensis OWEN Crennoceramus sarunensis (WOODS sensu SORNAV 1982)

Table 15. Stratigraphic range of the Gschliefgraben Inoceramidae.

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Plate 1

Fig. 1. *Cremonoceras sarumensis* (WOODS); NHMW 1997/z/160/1;

Fig. 2. *Cordiceras* ? aff. *heberti* (FALLOT); NHMW 1997/z/160/2, completely flattened by compaction, with radial cracks

All from Gschlifgraben ; all x 1

PLATE 1

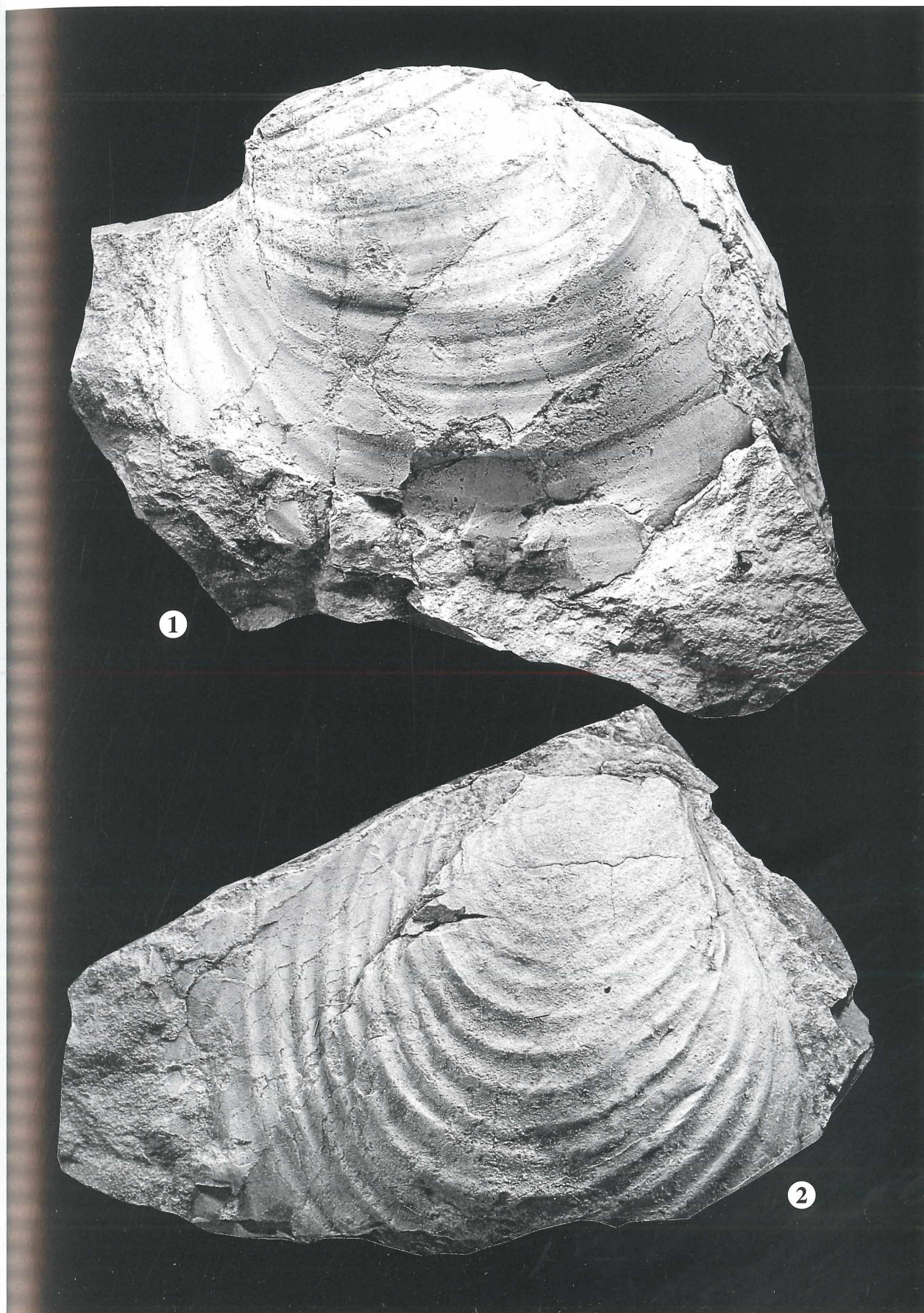


PLATE 2

Fig. 1, 3, 5, 6: *Endocostea impressa* (D'ORBIGNY);

Figs. 1, 3: NHMW 1979/2076/25/1, left valve; Figs. 5, 6: NHMW 2076/25/2; umbonal region of the right valve.

Fig. 2: *Inoceramus regularis* D'ORBIGNY; NHMW 1979/2076/39.

Fig. 4: *Inoceramus sagensis* OWEN; NHMW 1979/2076/26.

All from Gschliefgraben/Gmunden. Fis. 1–5: x 1; Fig. 6: x 2

PLATE 2

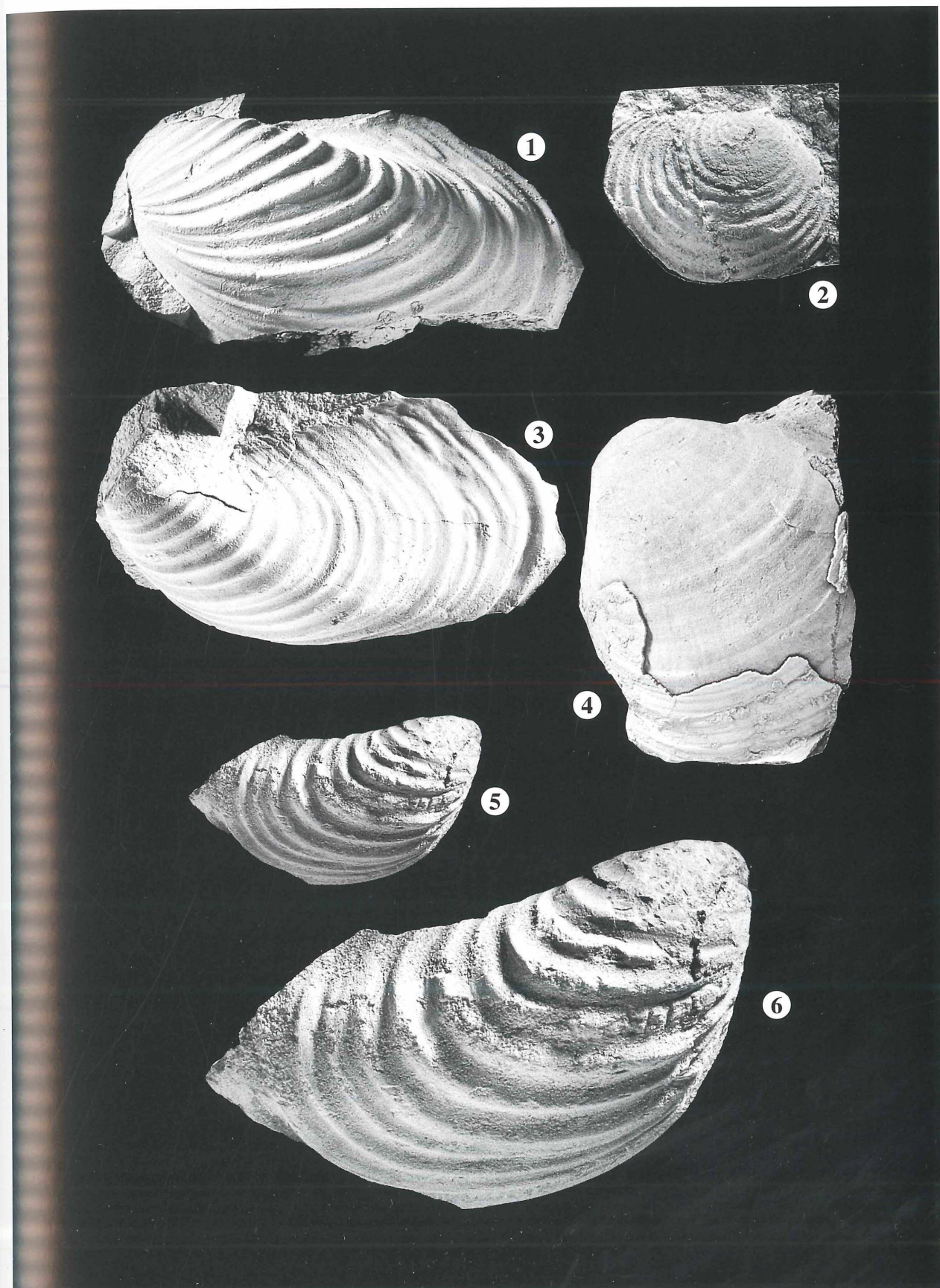


Plate 3

Fig. 1: *Inoceramus* aff. *bererensis* SORNAY; NHMW 1979/2076/44; internal mould of a left valve with adherent shell.

Fig. 2: *Cataceramus balticus* (BÖHM) subsp. indet. with *Endocostea* scar (x); NHMW 1979/2076/24.

Fig. 3, 4: *Cataceramus balticus* aff. *haldemensis* (GIERS); SK/B/GG/1997/4; straight to the growth axis; deformed by compaction.

All from Gschlifgraben. All x 1.

PLATE 3

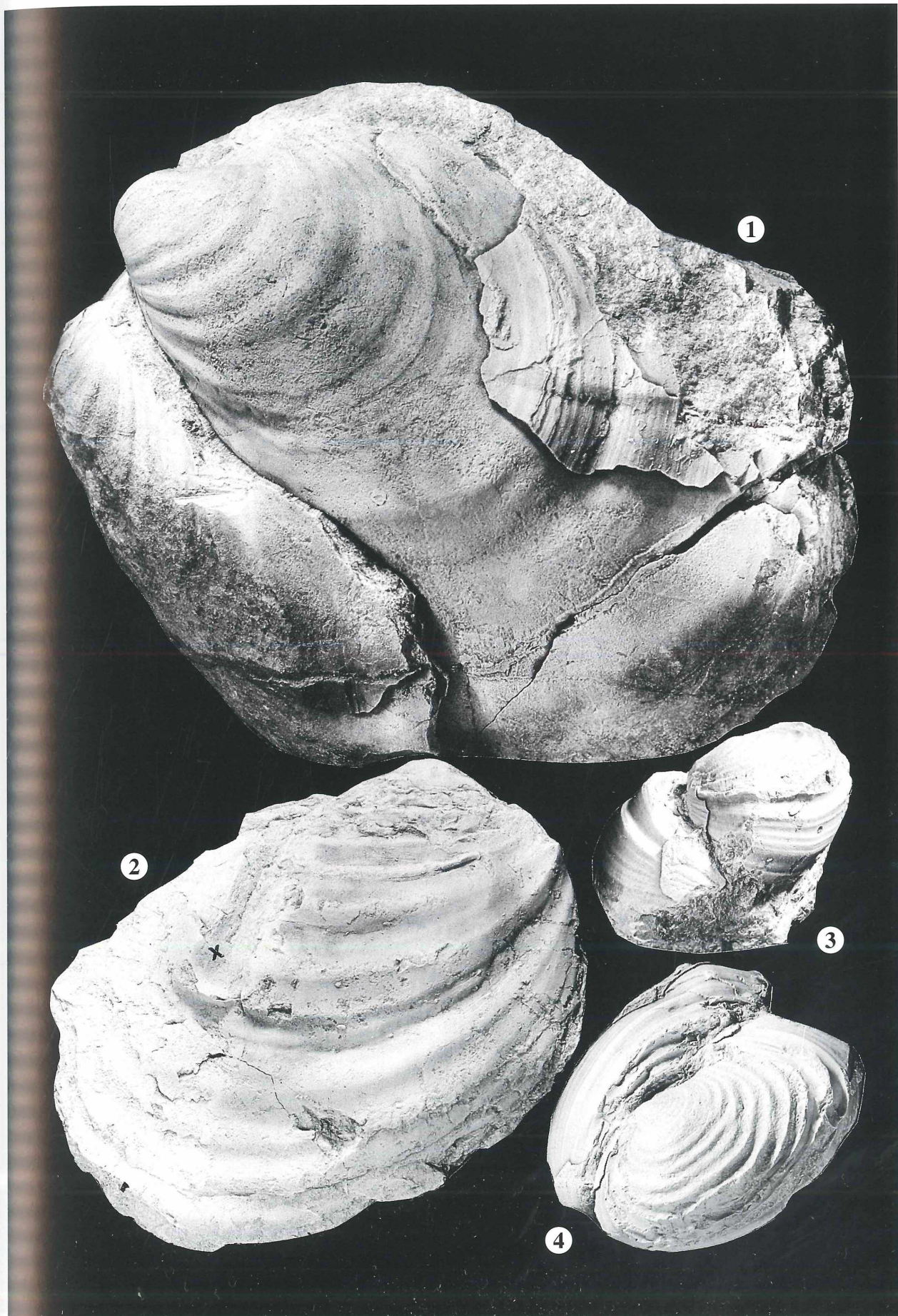
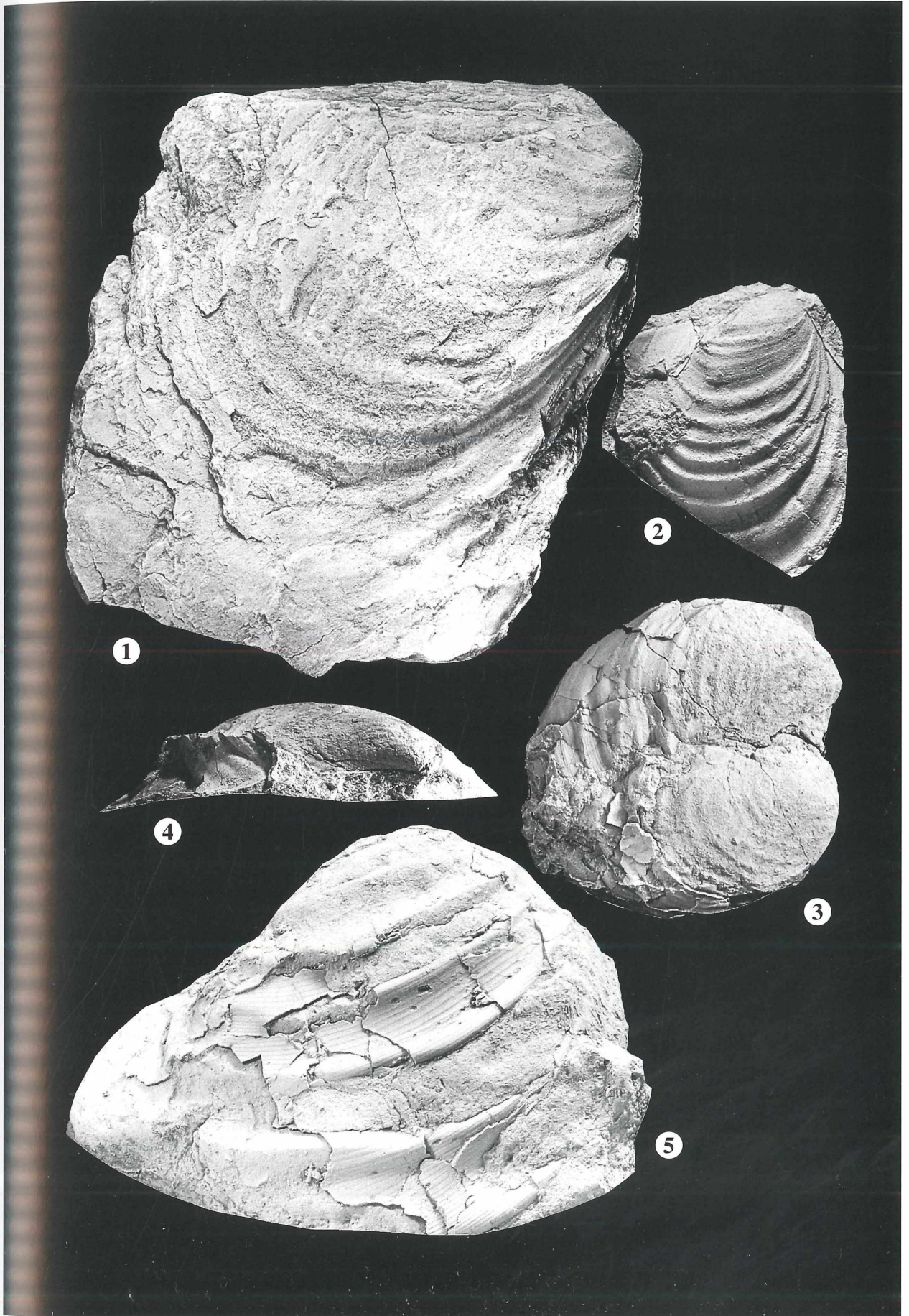


Plate 4

- Fig. 1: *Cataceramus balticus balticus* (J. BÖHM); NHMW 2076/46 ; umbonal region flattened by compaction.
- Fig. 2: *Cataceramus balticus balticus* (J. BÖHM) with geniculation in the umbonal region NHMW 1979/2076/37.
- Fig. 3: *Cataceramus balticus* (J. BÖHM) subsp.indet., bivalved specimen completely flattened by compaction – NHMW 1979/2076/28.
- Fig. 4: *Cremonoceras sarumensis* (WOODS); umbonal region; NHMW 1997/z/160/1.
- Fig. 5: *Cremonoceras* ? aff. *inconstans* WOODS; NHMW 1979/2077/ 4.
- All from Gschliefgraben, all 1 x.

PLATE 4



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