

Early Maastrichtian (Late Cretaceous) Inoceramids from the Piesting Formation (Gosau Group; Austria)

by

TRÖGER, K.-A.¹⁾, SUMMESBERGER, H.²⁾ & WAGREICH, M.³⁾

TRÖGER, K.-A., SUMMESBERGER, H. & WAGREICH, M., 2001. Early Maastrichtian (Late Cretaceous) Inoceramids from the Piesting Formation (Gosau Group; Austria). — Beitr. Paläont., 26:145–167, 14 figs., 3 plates, Wien.

Contents

Abstract, Zusammenfassung	145
1. Introduction	147
2. Systematic Palaeontology	147
3. Stratigraphy of the Piesting Formation in the Neue Welt area	157
4. Maastrichtian inoceramid palaeobiogeography	158
5. Acknowledgements	158
6. References	159
Plates	162

Abstract

Inoceramid bivalves were collected in two closely neighbouring parts of the type section of the newly established Piesting Formation (Gosau Group; see SUMMESBERGER et al., 2002). The lower part of the section at the roadcutting south of Piesting (Lower Austria) yielded *Trochoceras* (?) cf. *dobrovi* (PAVLOVA) and *Trochoceras* cf. *morgani* (SORNAY), proving an uppermost Campanian age, Chron 32N according to palaeomagnetic investigations (SCHOLGER in: SUMMESBERGER et al., 2002). This is endorsed by nannofossils of the nannozones CC18 - CC22.

The Lower Maastrichtian inoceramid fauna from the higher part of the section at the sports area of Piesting contained the following taxa: *Platyceras salisburgensis* (FUGGER & KASTNER), *Platyceras alaeformis* (ZEKELI),

Trochoceras sp. aff. *monticuli* (FUGGER & KASTNER), *Trochoceras* cf. *tenuiplicatus* (TZANKOV), *Trochoceras* sp. aff. *helveticus* (HEINZ), *Inoceramus* sp. aff. *planus* MÜNSTER (sensu WALASZCZYK et al. 1996), *Cataceramus* sp. ex gr. *balticus* (BÖHM), *Cataceramus* ? *glendivensis* WALASZCZYK, COBBAN & HARRIES and *Spyridoceras* cf. *tegulatus* (HAGENOW). The genera *Spyridoceras* and *Trochoceras* predominantly occur in the Lower Maastrichtian. *Pachydiscus neubergicus* (HAUER) and nannofossils of the zone CC24 confirm this stratigraphical interpretation. Palaeomagnetic investigations indicate Chron 31R of the lowermost Maastrichtian.

The inoceramid assemblage of Piesting contains taxa (e.g. *Spyridoceras*) typical of the Northern Temperate Realm sensu KAUFFMAN (1973) co-occurring with species which were first described from the Tethyan Realm (fauna of Muntigl). Species typical for the Southern Temperate Realm are missing.

Zusammenfassung

Zwei nahe benachbarte Profilstrecken der neu definierten Piesting Formation (Gosau Gruppe; siehe SUMMESBERGER et al., 2002) haben zahlreiche Inoceramen geliefert. Der tiefere Profilabschnitt an der Umfahrungsstraße von Piesting (Niederösterreich) gehört mit *Trochoceras* cf. *morgani* (SORNAY) und *T.* (?) cf. *dobrovi* (PAVLOVA) dem höchsten Ober-Campan an. Das Nannoplankton erlaubt eine Einstufung in die Zonen CC18-CC22, die paläomagnetische Untersuchung ergibt Chron 32N (SCHOLGER in: SUMMESBERGER et al. 2002).

Aus dem höheren Profilabschnitt vom Sportplatz Piesting werden folgende Taxa beschrieben: *Platyceras salisburgensis* (FUGGER & KASTNER), *Platyceras alaeformis* (ZEKELI) *Trochoceras* sp. aff. *monticuli* (FUGGER & KASTNER), *Trochoceras* cf. *tenuiplicatus* (TZANKOV), *Trochoceras* sp. aff. *helveticus* (HEINZ), *Inoceramus* sp. aff. *planus* MÜNSTER (sensu WALASZCZYK et al. 1996), *Cataceramus* sp. ex gr. *balticus* (BÖHM), *Cataceramus* ? *glendivensis* WALASZCZYK, COBBAN & HARRIES und *Spyridoceras* cf. *tegulatus* (HAGENOW). Die Gattungen *Trochoceras* und *Spyridoceras* kom-

¹⁾ Karl-Armin TRÖGER, D-09596, Freiberg/Sachsen, Geologisches Institut, Meißer building, Germany. Tel.: ++49 3731 392430; Mail: troeger@geo.tu-freiberg.de.

²⁾ Herbert SUMMESBERGER, mail: herbert.summesberger@nhm-wien.ac.at; A-1014, Wien, Naturhistorisches Museum, Austria.

³⁾ Michael WAGREICH, mail: michael.wagreich@univie.ac.at, A-1090, Wien, Geozentrum der Universität, Austria.

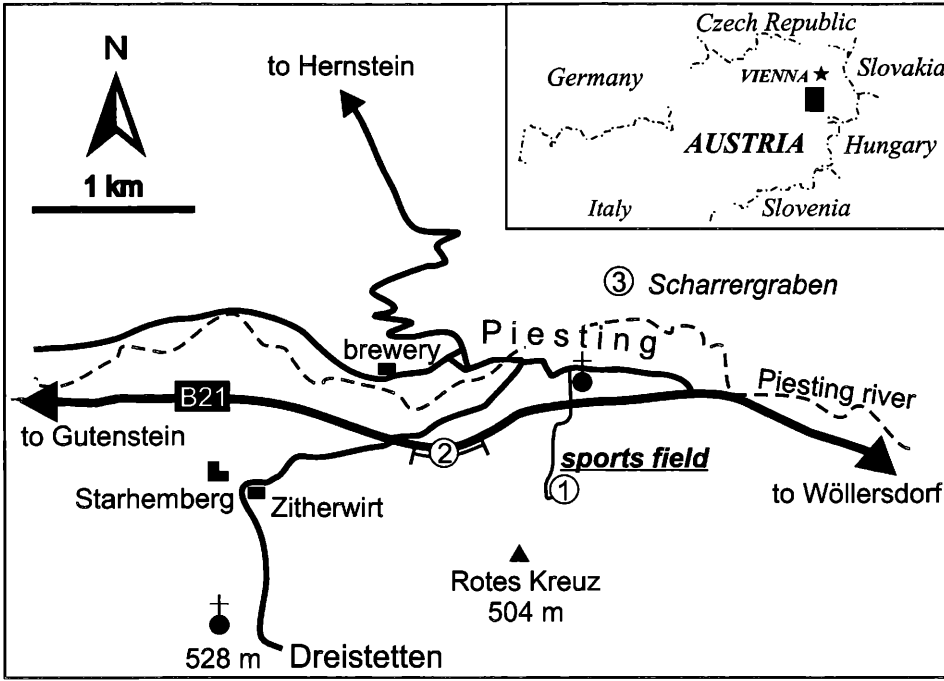


Figure 1: Sketch map of the area around Piesting (Lower Austria) indicating the localities mentioned in the text.

1. Sports field of Piesting.
2. Roadcutting exposures (1996/1998) “Umfahrungsstraße” S of Piesting; 1 and 2 representing the type section of the Piesting Formation.
3. Historic locality “Scharrergraben” N of Piesting famous for its Late Cretaceous corals and rudists.

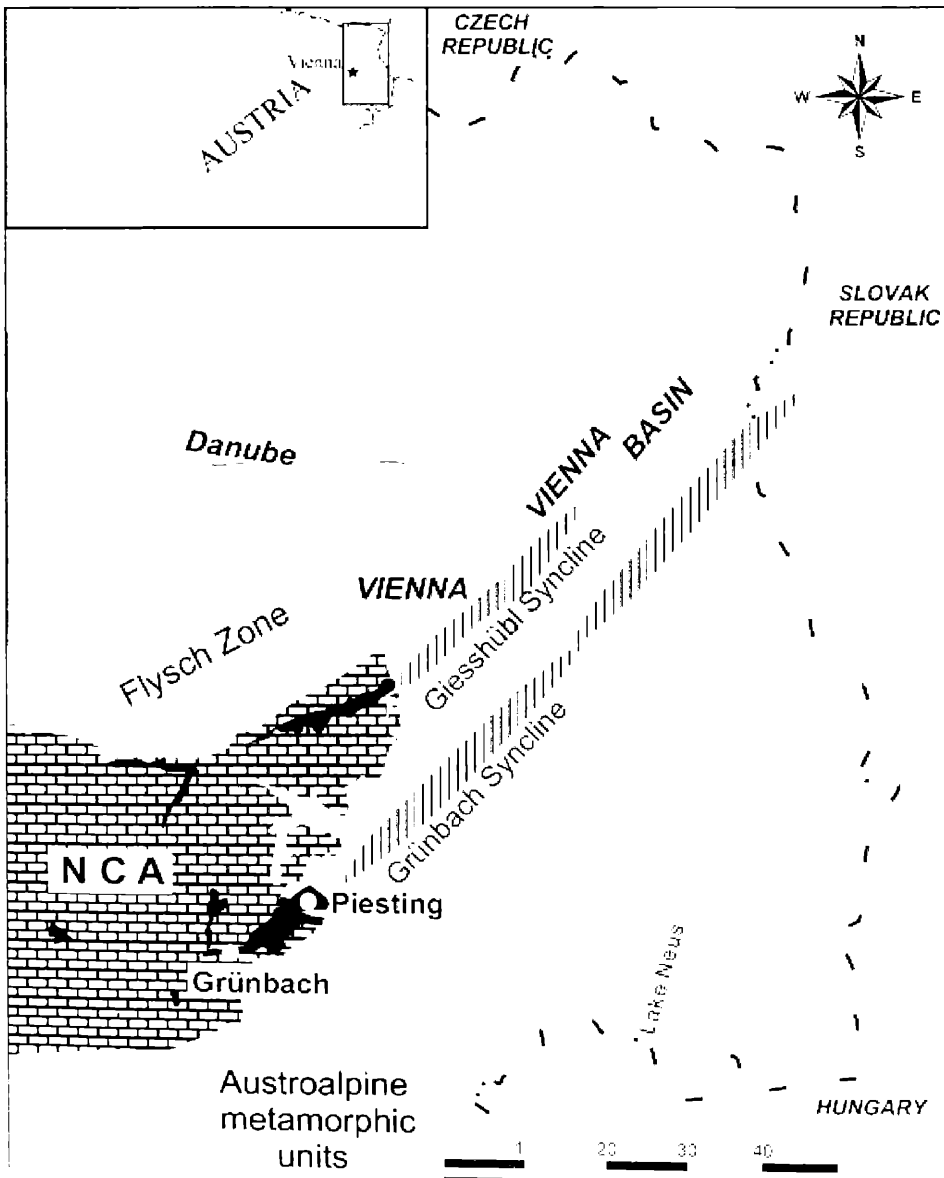


Figure 2: Position of the Grünbach – Neue Welt Cretaceous basin at the eastern border of the Northern Calcareous Alps (black = Upper Cretaceous Gosau Group) and its extension underneath the Neogene Vienna basin. After WAGREICH & MARSCHALKO (1995).

men fast ausschließlich im Untermaastrichtium vor. *Pachydiscus neubergicus* (HAUER), eine Nannoplankton-Fauna der Zone CC24 und die paläomagnetische Datierung des höheren Profilabschnitts (Sportplatz Piesting) (SCHOLGER in: SUMMESBERGER et al., 2002) in Chron 31R bestätigen die Alterseinstufung.

Paläobiogeographische Beziehungen zur nördlichen gemäßigten Zone (sensu KAUFFMAN 1973) werden besonders durch das Auftreten der Gattung *Spyridoceramus* belegt. Ein Teil der Fauna (Fauna von Muntigl - SEITZ 1970) wird erstmals aus dem Tethys-Bereich beschrieben. Typische Vertreter der südlichen gemäßigten Zone fehlen.

1. Introduction

ZITTEL (1866) was the first to describe inoceramids from the the Austrian Gosau Group. He mentioned *Inoceramus Cripsi* MANTELL var. *typica* ZITTEL, *I. Cripsi* MANTELL var. *regularis* D'ORBIGNY, *I. Cripsi* MANTELL var. *alaeformis* ZEKELI, *I. Cripsi* MANTELL var. *decipiens* ZITTEL, *I. latus* MANTELL and *I. cfr. Cuvieri* SOWERBY from the Neue Welt basin in the Northern Calcareous Alps (text-fig. 2). FUGGER & KASTNER (1885) established *Inoceramus salisburgensis* FUGGER & KASTNER and *Inoceramus monticuli* FUGGER & KASTNER occurring in the Flysch of Muntigl and Bergheim near Salzburg. This was later called the "Muntigler Inoceramenfauna" by SEITZ (1970). PETRASCHECK (1906) mentioned *I. salisburgensis* FUGGER & KASTNER from the flysch belt of Leopoldsberg near Vienna. The new genus *Trochoceramus* HEINZ (1932) was established without valid description and figure as a nomen nudum with *Trochoceramus helveticus* HEINZ (1932, p. 19) as type species. SEITZ (1970, p. 112 ff.) reevaluated *Trochoceramus* as a subgenus and gave a description of the subsequently designated holotype of the type species based on a surviving cast when he revised the Muntigl fauna. The type series from the Wang Schichten is lost. The revision of SEITZ revealed the following changes:

Inoceramus latus MANTELL (ZITTEL 1866, pl. 13, fig.7) = *I. (Trochoceramus) aff. helveticus* HEINZ

Inoceramus salisburgensis FUGGER & KASTNER, PETRASCHECK 1906, fig. 3 = *I. (Trochoceramus) aff. monticuli* FUGGER & KASTNER

Inoceramus salisburgensis FUGGER & KASTNER 1885, text-fig. 8 = *I. (Trochoceramus) aff. monticuli* FUGGER & KASTNER

TZANKOV (1981) established the species *Trochoceramus tenuiplicatus* (TZANKOV). Holotype is the original of *Inoceramus salisburgensis* FUGGER & KASTNER sensu PETRASCHECK (1906: 164, text-fig. 3).

Abbreviations:

KBIN TCM – Koninklijk Belgisch Instituut voor Natuurwetenschappen, Brussel

NHMW – Naturhistorisches Museum Wien

GBA – Geologische Bundesanstalt Wien, Austria

For abbreviations of morphological elements see figure 5.

2. Systematic Palaeontology

Class Bivalvia

Supraorder Pteriomorpha BEURLEN 1944

Order Pteroida NEWELL 1965

Family Inoceramidae GIEBEL 1852

Remarks: The inoceramids of Piesting are badly preserved, incomplete internal moulds. They are all more or less deformed by post mortem compaction. Shells are absent in most cases. All specimens are stored in the collections of the Naturhistorisches Museum Wien (NHMW). For symbols and abbreviations see fig. 5. Measurements are in mm.

Genus *Inoceramus* J. SOWERBY 1814

Type species: *Inoceramus cuvieri* SOWERBY 1814 by subsequent designation of COX 1969, p. N315.

Remarks: The ligamental plate of *Inoceramus planus* MÜNSTER and that of the subsequently described taxon are unknown. Therefore we use "*Inoceramus*" (= *Inoceramus sensu lato*)

Inoceramus sp. aff. *planus* MÜNSTER 1836

Plate 1, figs. 2,3; text-fig. 6

Compare:

1835 *Inoceramus planus* MÜNSTER - GOLDFUSS, p. 117, pl. 113, figs. 1a,b.

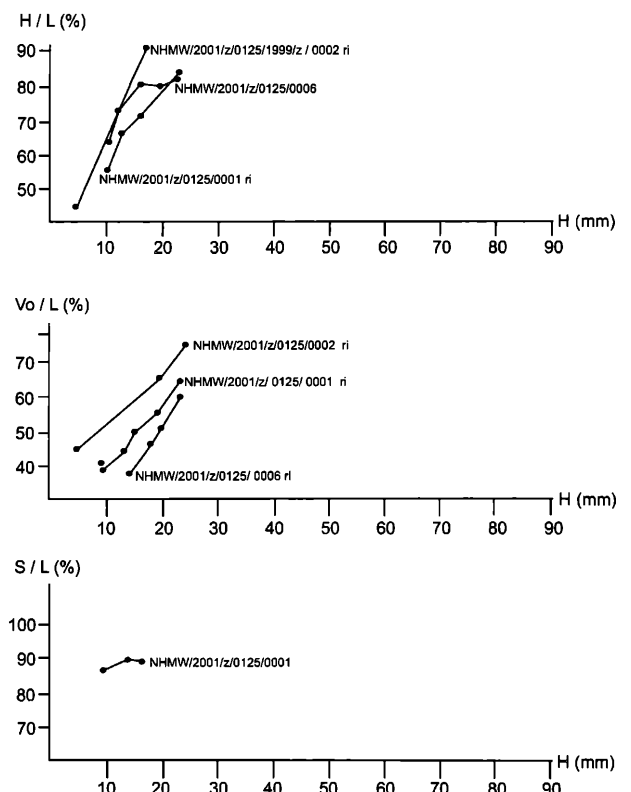


Figure 6: H/L-, Vo/L- and S/L ratio of *Inoceramus* sp. aff. *planus* MÜNSTER from the sports field of Piesting.

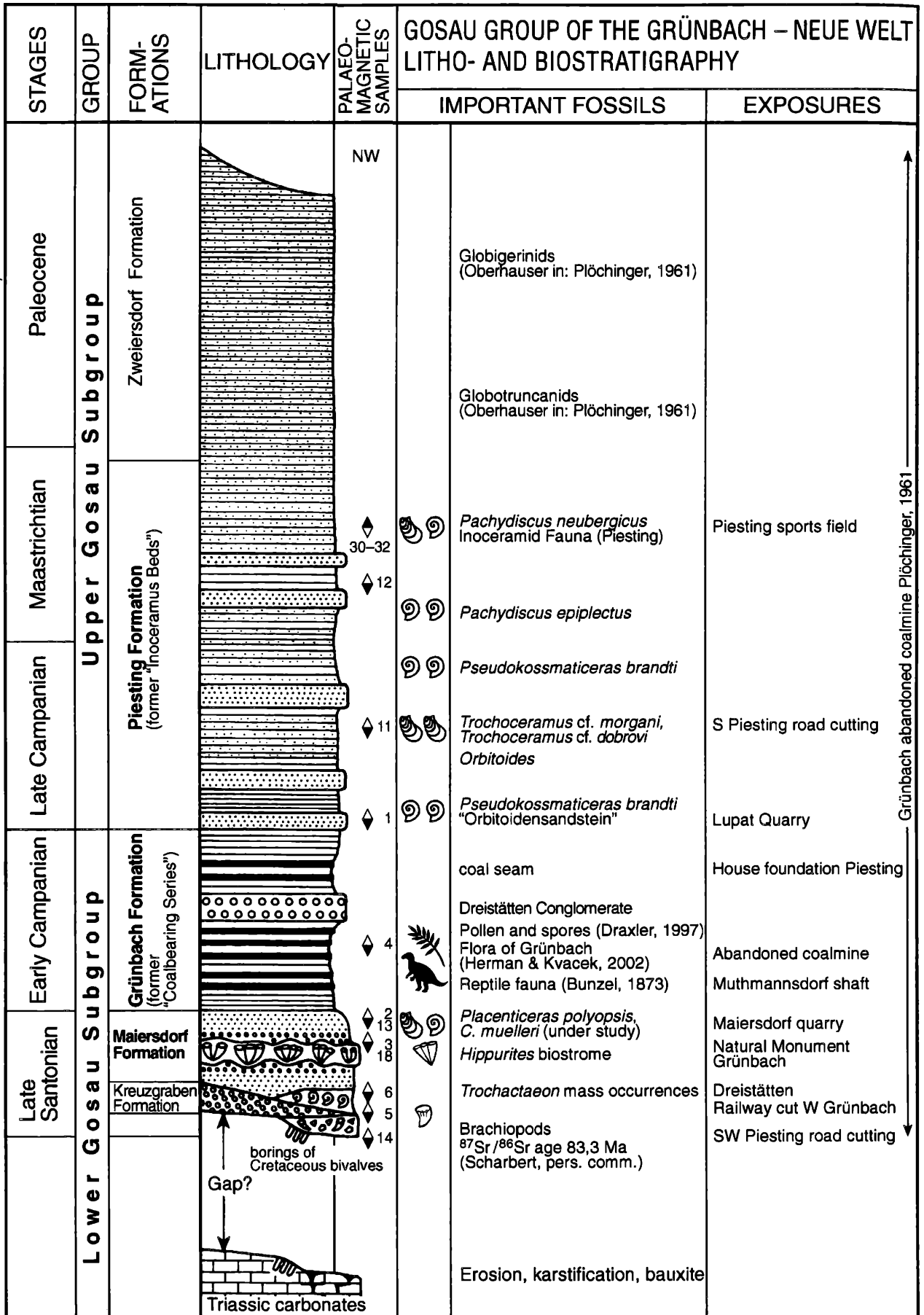


Figure 3: Compiled measured sections of the „Piesting Formation“ (Gosau Group, Neue Welt basin, sports field, Piesting roadcutting, basement excavations; Piesting, Lower Austria (after EGGER et al. 2000).

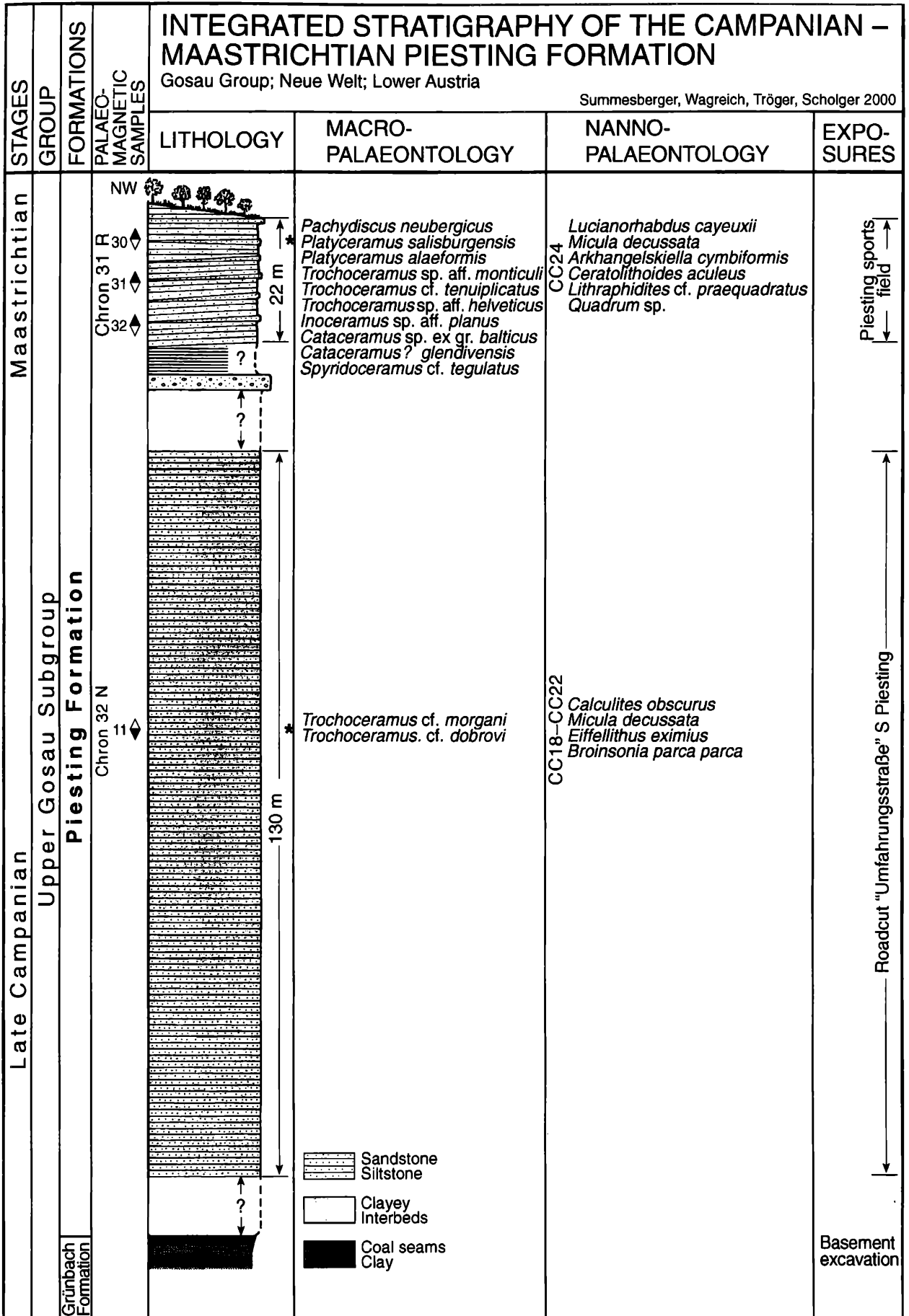


Figure 4: Compiled section of the Gosau Group of the Neue Welt basin (Lower Austria; after EGGER et al. 2000).

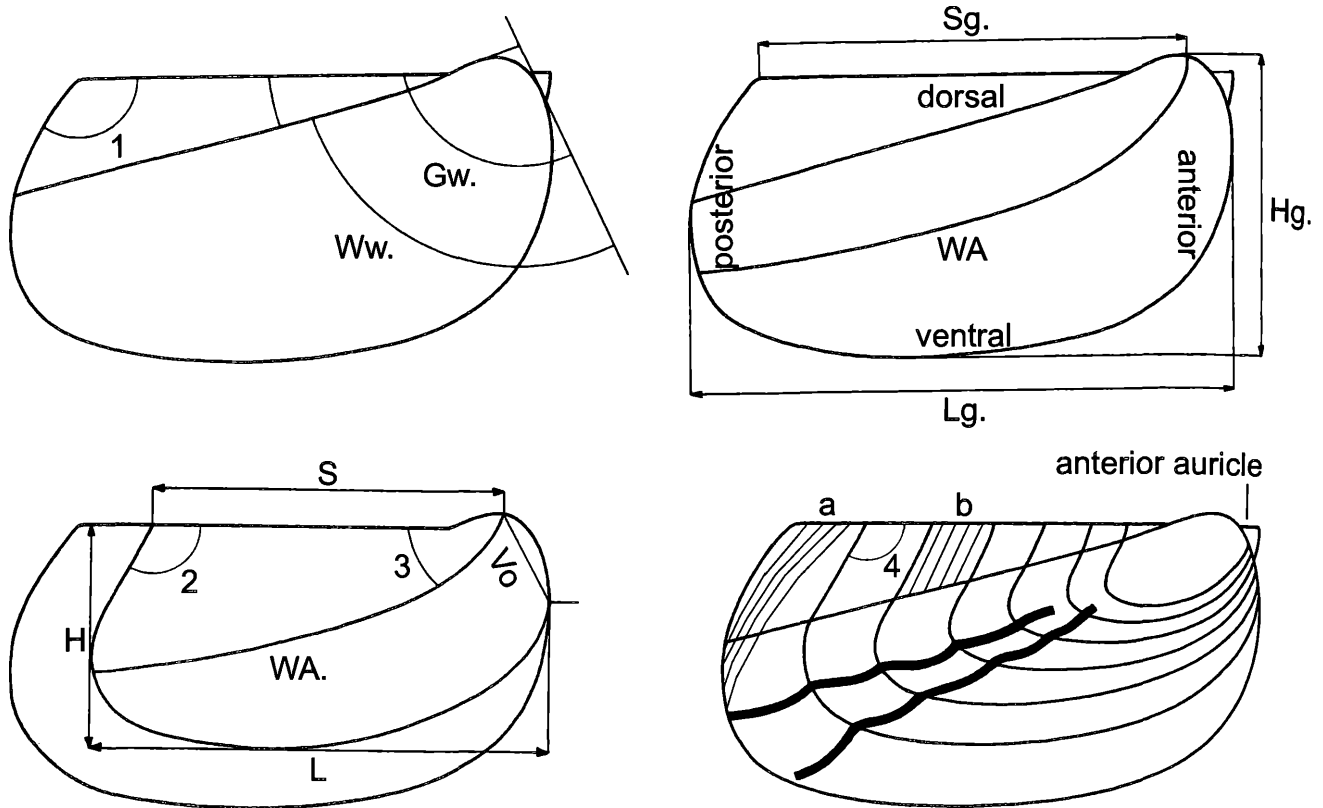


Figure 5: Morphological measurements (external view) in inoceramids with *balticus*-like subcircular and subquadratic shape according to SEITZ (1934), HEINZ (1932), TRÖGER (1969) and HARRIES & KAUFFMAN (1993). Abbreviations: 1 – angle between the hinge line and posterior margin, 2 – angle between hinge line and one undulation, 3 – angle between hinge line and axial length (WA), 4 – angle between hinge line and undulations, Flw. – wing angle, Gw. – angle between the hinge line and the anterior margin, H – height of an undulation, Hg. – height, L – length of an undulation, Lg. – length, S – part of hinge line belonging to the undulation, Sg. – length of the hinge line, Vo – part of the anterior margin belonging to the undulation, WA – growth axis (axial length), Ww. – umbonal angle, lower right corner: ■ – radial ornamentation: ribs (SEITZ), radial folds (HARRIES et al.), concentric ornamentation: ▬ – growth lines (Anwachslinien), — – undulations (SEITZ), a – Anwachsschnittreifen, b – Anwachstreifen (HEINZ).

1993 "*Inoceramus*" aff. *planus* MÜNSTER in GOLDFUSS, 1835; DHONDT, p. 217, pl. 3, figs. 1a,b; text-figs. 3a,b (with synonymy).

1996 "*Inoceramus*" sp. cf. *planus* MÜNSTER; WALASZCZYK et al., pl. 5, fig. 4.

Material: Internal moulds of 4 left valves (NHMW/2001/z/0125/0001, /0125/0002, 0125/0006) from the sports field of Piesting.

Preservation: All specimens are incomplete. Parts of the wing, of the posterior and anterior margin are missing, flattened by post mortem deformation.

Description: Small to medium sized, inequilateral, equivalve (?). Shape nearly ovate. The beak projects slightly over the hinge line and is bent to the anterior margin. The preserved parts of the hinge line are straight. The anterior margin is mainly straight (NHMW/2001/z/0125/0006 – convex – caused by deformation). Gw (Gesamtwinkel = total angle) = 95-110° Growth axis opisthocline. The undulations are rounded to sharp. The latter is caused by deformation. Thickness of the shell: 0.2 mm. The change of the H/L-, Vo/L- and S/L-ratio is shown in fig. 5.

NHMW/2001/z/0125	/0002	/0006	/0001	/0002
D 10-30	3.44	2.81	3.1	4.04

Table 2: Average undulation intervals (AU) in the umbonal region (D = distance from the beak, in mm).

Remarks: The umbonal stage of *Inoceramus* sp. aff. *planus* MÜNSTER is comparable with that of *Inoceramus balticus* BÖHM (e.g. GIERS, 1964, pl. 3, fig. 2). In the subsequent growth stage *I.* sp. aff. *planus* differs by its more elongated undulations (H/L over 80 %; text-fig. 5). The specimens are similar to 435-4 from the Lower Maastrichtian of the Aimaki section figured by WALASZCZYK et al. (1996, pl. 5, fig. 4) and KBIN TCM 10520 from the Upper Campanian of Tercis (DHONDT, 1993, pl. 3, fig. 1 a,b).

Genus *Cataceramus* HEINZ 1932

Type species: *Inoceramus balticus* BÖHM (1909, pl. 11 fig. 2). For the complete discussion of the type species see DHONDT (1993), WALASZCZYK (1997) and WALASZCZYK et al. (2001). For the discussion of a partly assumed synonymy of *Cataceramus* HEINZ, 1932 and *Endocostea*

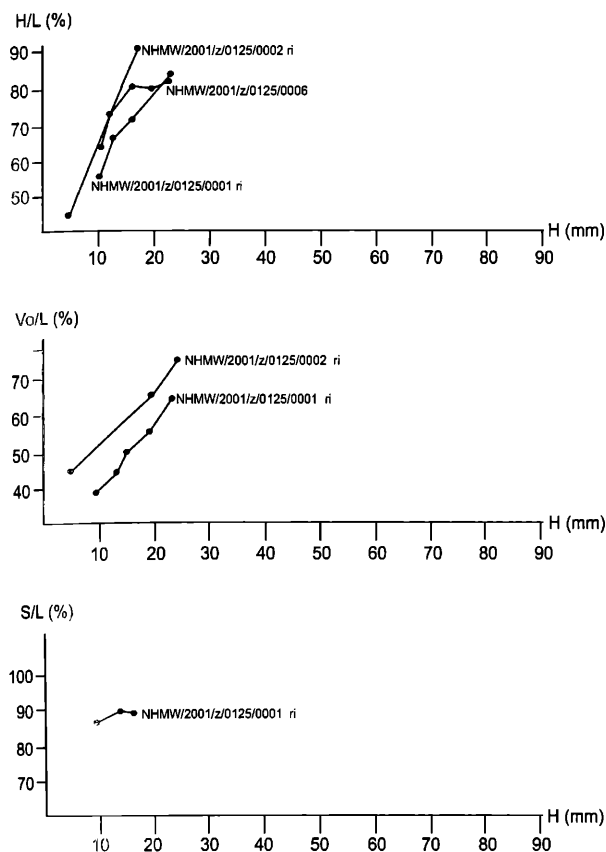


Figure 6: H/L-, Vo/L- and S/L-ratio of *Inoceramus* sp. aff. *planus* MÜNSTER from the sports fields of Piesting.

WHITFIELD (1877) see SEITZ (1967) and WALASZCZYK et al. (2001).

Remarks: The below-mentioned *Cataceramus* ? *glendivensis* WALASZCZYK et al. (2001) was newly established by WALASZCZYK et al. (2001) for an inoceramid species from the lowermost Maastrichtian of the Western Interior Basin of the United States. Dr. WALASZCZYK recognised the affinity of the new established species and two inoceramid specimens of Piesting while visiting the collections of Vienna.

Cataceramus ? *glendivensis* WALASZCZYK, COBBAN & HARRIES (2001)

Plate 1, fig. 1; text-fig. 7

Holotype: By original designation the specimen YPM 191001 of WALASZCZYK et al., pl. XLII, fig. 2.

Locus typicus: Glendive section, Montana (USA)

Stratum typicum: Uppermost part of the Pierre Shale. *Baculites baculus* Zone of Lower Maastrichtian age.

Material: Internal moulds of two left valves (NHMW/2001/z/0125/0011 and /0125/0012).

Preservation: Incomplete. Parts of the wing, of the anterior-, posterior- and ventral margins are missing.

Description: Medium sized. Shape parabolical to elongated parabolical. The strongly domed beak projects over the hinge line, curved and bent to the anterior margin. The anterior margin is convex, immediately at the beak concave. Gw. = 105 - 110°. Growth axis prosocline and convexly curved toward the hinge line. The undulations



Figure 7: *Cataceramus* ? *glendivensis* WALASZCZYK et al. (2001) with curved beak, which is turned to the anterior margin (NHMW/2001/z/0125/0012 from the sports field of Piesting; scale bar = 1 cm).

are pointed. This may be caused by post mortem deformation.

Height (mm)	H/L (%)	Vo/L (%)	S/L (%)
11.5	65.7	54.3	—
17.5	85.4	59.5	—
22.0	88.0	58	62,2
32.5	81.3	42.5	—

Table 2: The H/L-, Vo/L- / S/L - ratios of NHMW/2001/z/0125/0011 (umbonal region). intervals between undulations 3 - 6 mm.

Occurrence: The species is distributed in the upper part of the *Baculites baculus* Zone and in the *Baculites grandis* Zone according to WALASZCZYK et al. (2001). Lower Maastrichtian age Western Interior Basin (USA), Madagascar, Piesting (Austria).

Cataceramus sp. aff. *balticus* (BÖHM1909)

Plate 1, fig. 4

Synonymy. For synonymy of *C. balticus balticus* (BÖHM) see TRÖGER et al. (1999).

Material: Fragments of a left (NHMW/2001/z/0125/0014) and a right valve (NHMW/2001/z/0125/0015) and one of a bivalved specimen (NHMW/2001/z/0125/0013). Both valves of the latter specimen are fixed together at the hinge line.

Preservation: Incomplete and flattened by post mortem deformation. Only the umbonal regions are preserved.

Description: The bivalved specimen consists of the umbonal region of the left valve and the fragment of the umbonal region of the right valve. As far as visible it is inequilateral and medium sized. The beaks arise at the hinge line, not curved. Hinge line at the beak straight. Shape of the undulations rounded to sharp (deformed by post mortem compaction). The intervals between the undulations are increasing from 1.5 mm to 5.8 mm. (H/L at H= 6.5 mm: 50 %; at H= 8.0 mm: 59.3 %).

The umbonal region of the specimen NHMW/2001/z/0125/0015 is similarly shaped but slightly pressed over the hinge line (Hg - incomplete: 14.5 mm; Lg-incomplete:

23.5 mm; Sg.-incomplete:13.5 mm; anterior margin:7.8 mm; Gw. = 124°). The H/L - ratio decreases during ontogeny (H = 64.6 mm: H/L= 64.6%; H = 6.5 mm: H/L = 53.3 %; H = 8.3 mm: H/L = 47.4 %).

Genus *Platyceramus* HEINZ 1932

Type species according to SEITZ (1961, p. 54) is *Inoceramus Mantelli* DE MERCEY (BARROIS 1879, p.454, pl. 4, fig.1).

Platyceramus salisburgensis (FUGGER & KASTNER 1885)
- Pl. 1, fig. 5

Lectotype designated subsequently by SEITZ (1970, p.125) is the original of FUGGER & KASTNER (1885, pl. I).

Synonymy

- 1885 *Inoceramus salisburgensis* n.sp.; FUGGER & KASTNER: 77-79, only pl. I
v.1959 *Inoceramus salisburgensis* FUGGER & KASTNER; DOBROV & PAVLOVA in: MOSKIN: 155, pl.XIX, fig. 2 (non 1).
1970 *Inoceramus (Platyceramus) salisburgensis* FUGGER & KASTNER; SEITZ, pl. 24, fig. 1, pl. 25-27, text-fig. 11.
1977 *Inoceramus salisburgensis* FUGGER & KASTNER; KOTLARZYK et al., pls. I, II.
? 1983 *Inoceramus salisburgensis* FUGGER & KASTNER; PREY, p.102.

Stratum typicum: Aitlengbach Fm. (Flysch) of Upper Campanian through Lower Maastrichtian age (SEITZ,1970)

Locus typicus: Quarry at Muntigl (region Salzburg)

Remarks: The lectotype of *P. salisburgensis* (FUGGER & KASTNER) is a fragment without wing and anterior and posterior margins. It is uncertain whether the fragment belongs to a right or left valve. SEITZ 's (1970, p.126) reconstruction is based on the lectotype from the type locality. Two better preserved paratypes are described and figured by SEITZ (1970, pls. 26, 27). *P. salisburgensis* is a large (height over 50 cm) subcircular species, inequilateral and equivalve. Gw. is over 90° (perhaps 100-110°). The flat beak passes slightly curved from the hinge line to the straight to slightly convex anterior margin. The growth axis is prosocline and slightly curved toward the hinge line. The ornamentation consists of growth lines and flat undulations. Undulations are absent near the ventral margin. The course of the ornamentation at the beak is *balticus*-like. The course of the undulations in the middle part of the valve and near the ventral margin is subcircular. Material: Large fragments are common in the upper parts of the section at the sports field of Piesting. Best preserved are: NHMW/2001/z/0125/0018, 19 and 22, all flattened by post mortem compaction.

Description: NHMW/2001/z/0125/0018 has a length of 141.5 mm and a height of 152 mm. Gw. over 90°. Hinge line is absent. Anterior margin is straight to slightly convex. Undulations especially developed on the umbonal region.

Course of the undulations is subcircular, the intervals from 5.8 to 13.2 mm, near the ventral margin 15 - 30 mm. Shell thickness is 1 - 2.8 mm, in other fragments: 1 - 5.5 mm.

Remarks: The fragments may also belong to the group of the recently described *Inoceramus stephensoni* WALASZCZYK et al. 2001.

Occurrence (text-fig. 14): *P. salisburgensis* (FUGGER & KASTNER) occurs according to SEITZ (1970) in the uppermost Campanian to Lower Maastrichtian of Western, Central and Eastern Europe and Western Asia. The described Campanian specimens from Eastern Europe and Western Asia (PAVLOVA in MOSKVIN 1959) are questionable.

Platyceramus alaeformis (ZEKELI 1852)

Plate 3, fig. 6; text-fig. 8

Lectotype is the original of ZEKELI (pl.1, fig.1) subsequently designated by DHONDT (1993, p 230).

Synonymy

- 1852 *Inoceramus Cripsi* var. *alaeformis* ZEKELI: 102, pl. 1, fig. 1
1866 *Inoceramus Cripsi* var. *alaeformis* ZEKELI; ZITTEL: 97, pl. 14, fig. 5
1993 *Platyceramus alaeformis* (ZEKELI 1852); DHONDT: 230, pl. 5, figs. 2,4; text-fig. 10 a,b. With full synonymy.
? 1993 *Platyceramus* cf. *alaeformis* (ZEKELI 1852); DHONDT: 231.

Material: ZEKELI's and ZITTEL's original material could not be traced in the Vienna collections. One topotype from the "Klause" near Grünbach, similar to that figured by ZITTEL (1866, pl. 14, fig. 1) (GBA, collection WOLF), and two internal moulds of left valves (NHMW/2001/z/0125/0023, 24) from the sports field of Piesting and one from the area of Grünbach were at our disposal.

Preservation: The specimens are incomplete and flattened. Post mortem compaction is proved by radial cracks (NHMW/2001/z/0125/0024) and the pointed shape of the undulations in the specimen from Grünbach. Parts of the wing and the ventral margins are not preserved.

Description: Medium sized, inequilateral. The flat beak is turned to the anterior margin. The beak slightly projects over the hinge line. The anterior margin is convex. The hinge line is straight as far as visible. Gw. = 130-140°, Flw. = 30-40°. The growth axis is straight. The undulations are rounded to pointed. The course of the undulations and growth lines is elongated ovate (L > H). The interval between the undulations slightly increases from the beak to the ventral margin (tab. 3). The angle between hinge line and undulations is 50-70° "Anwachsreifen" are present (text-fig. 5).

D (mm)	125/0024	125/0023	Grünbach
10 - 30	3.65	1.89	2.23
30 - 50	—	4.93	3.16

Table 3: Average interval (AU in mm) between the undulations of *Platyceramus alaeformis* (ZEKELI); D = distance from the beak.

Discussion: The specimen of Grünbach (locality “Klausse”) is similar to the lectotype of *P. alaeformis* (ZEKELI) designated by DHONDT 1993. The specimens of Piesting - designated as *P.cf. alaeformis* (ZEKELI) show small differences in the greater distance of undulations and the course of the undulations. H/L, Vo/L and S/L are similar. May be, that the lower Maastrichtian specimens of Piesting are acquainted with the uppermost Upper Campanian *P. alaeformis* (ZEKELI). WALASZCZYK has redescribed the North American species “*Inoceramus*” *balchii* MEEK & HAYDEN (WALASZCZYK et al. 2001, p.212). He compares the incomplete specimens of Piesting with juvenile stages of “*I.*” *balchii* (= “*I.*” cf. *balchii* MEEK & HAYDEN). Both species are very similar concerning the juvenile stages. A correct identification depends upon complete specimens.

Occurrence: *Platyceramus alaeformis* was originally described by ZEKELI (1852) from the “Region of Wiener

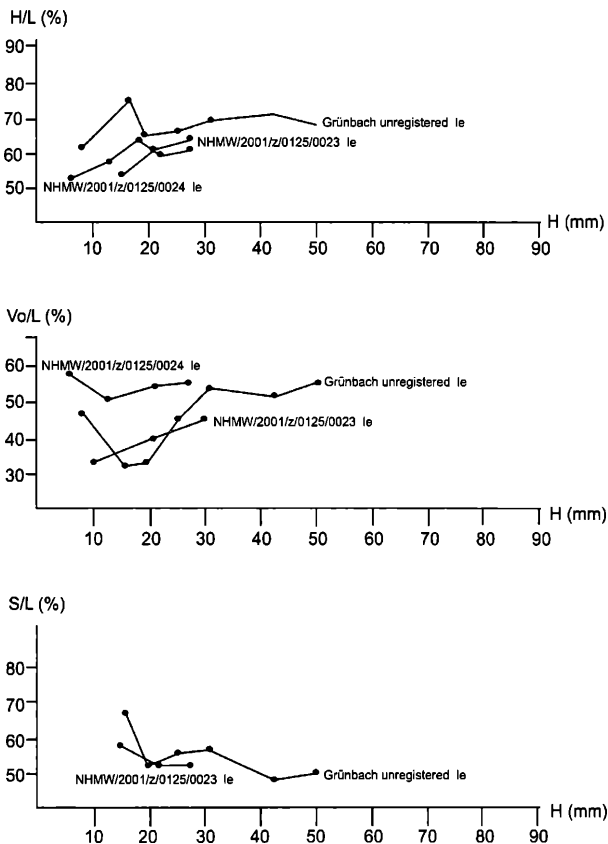


Figure 8: H/L-, Vo/L- and S/L ratio of *Platyceramus alaeformis* (ZEKELI) from the sports field of Piesting and of Grünbach.

Neustadt” We are certain that its type area corresponds with the area of the Piesting Formation (SUMMESBERGER et al., 2000) of the Gosau Group in the Neue Welt basin. The species is quoted from Tercis and from the Petites-Pyrénées, France (DHONDT, 1993, p.231) and with a query from the Spanish Pre-Pyrénées and the Caucasus. Safely dated specimens from Tercis (DHONDT, 1993) are from the Upper Campanian *Hyatti*-Zone. The Austrian specimens from the Piesting area, which is situated within the type area, are dated by co-occurrence with *Pachydiscus neubergicus* (HAUER) from the Lower Maastrichtian *Neubergicus* - Zone.

Genus *Trochoceramus* HEINZ 1932

Type species is *Trochoceramus helveticus* HEINZ by original designation of HEINZ 1932, p.19 (SEITZ 1970, p.112).

Trochoceramus sp. aff. *monticuli* (FUGGER & KASTNER 1885)

Plate 2, figs. 1,2

Lectotype, subsequently designated by SEITZ (1970, p.118) is the original of FUGGER & KASTNER (1885, plate II; collections of the Haus der Natur, Salzburg, 817).

Compare:

1885 *Inoceramus monticuli* n.sp.; FUGGER & KASTNER: 80, pl. II.

1970 *Inoceramus (Trochoceramus) monticuli* FUGGER & KASTNER; SEITZ: 118-119, pl. 17.

Stratum typicum: Altlengbach Fm. (Rhenodanubian Flysch) according to SEITZ (1970) Upper Campanian through Lower Maastrichtian.

Locus typicus: Quarry at Muntigl near Salzburg, Austria
Remarks concerning the lectotype: The lectotype of *T. monticuli* (FUGGER & KASTNER, 1895, pl. II), refigured by SEITZ (1970, plate 17), is a fragment. Beak, hinge line and all margins are missing. Nevertheless SEITZ (1970, p.118-119) gave a description on the basis of the type series, which has been at his disposal. The intervals between the undulations varies from 10 to 17 mm. The undulations are “Anwachsreifen” sensu HEINZ (1928, text-fig. 3) partly turning into “Anwachsschnittreifen” sensu HEINZ (1928, text-fig. 3). The latter are indistinct in the holotype. The ribs are visible only in the middle part of the valve. They are slightly curved and grained at intersections of undulations and ribs. SEITZ (1970, pls.18, 19, 20, 21) pictures several specimens belonging to the group of *T. monticuli* (*T. aff. monticuli*, *T. cf. monticuli*). Material: NHMW/2001/z/0125/0026, 28, two fragments of left valves and one fragment of a right valve (NHMW/2001/z/0125/0027) from the sports field of Piesting were at our disposal.

Description: In NHMW/2001/z/0125/0026 and 28 only the umbonal regions are preserved. Posterior margins, parts of the anterior margins and of the hinge line are missing. NHMW/2001/z/0125/0027 is the middle part of a valve without beak, hinge line and all margins. All specimens are flattened by compaction. The typical ornamentation is visible in NHMW/2001/z/0125/0027 close to the beak: undulations with intervals from 3.4 to 5.8 mm. The ribs are irregularly curved. Their intersections with the undulations are slightly granulated. Close to the ventral margin only growth lines are visible. This change of ornamentation may be caused by a geniculation. NHMW/2001/z/0125/0026 and 28 show *balticus*-like umbonal regions with beaks extending as far as the hinge line. They bear undulations with increasing intervals from 1.5-10.5 mm. Indistinct ribs arise at a distance of 20-30 mm from the beak.

Discussion: The investigated specimens are comparable with those figured by SEITZ (1970, pl. 19, Pl. 20-21; pl. 22, fig. 1).

Occurrence: *I. (Tr.) monticuli* FUGGER & KASTNER was described originally from the Rhenodanubian Flysch (Penninicum) of Muntigl, near Salzburg (Austria). *T. sp. aff. monticuli* is now described from the Upper Austroalpine Gosau Group of the Northern Calcareous Alps. The Lower Maastrichtian age of the latter is given by co-occurrence of *P. neubergicus* (HAUER). The Muntigl occurrence was dated as uppermost Campanian through Lower Maastrichtian (SEITZ 1970, p. 118).

Trochoceramus cf. tenuiplicatus (TZANKOV 1981)

Plate 2, fig. 5; text-fig. 9

1906 *Inoceramus salisburgensis* FUGGER & KASTNER; PETRASCHECK:164, text-fig. 3

v.1970 *Inoceramus (Trochoceramus) aff. salisburgensis* FUGGER & KASTNER; SEITZ: 119- 120, pl. 18, fig. 2

1981 *Inoceramus (Inoceramus) tenuiplicatus* n.sp.; TZANKOV: 85, pl. 30, fig. 1. (with additional synonymy)

Holotype by original designation of TZANKOV (1981, p. 85) is the original of *Inoceramus salisburgensis* FUGGER & KASTNER figured by PETRASCHECK (1906, text-fig. 3) from the Maastrichtian (?) of Leopoldsberg near Vienna, Austria (NHMW/1963/505).

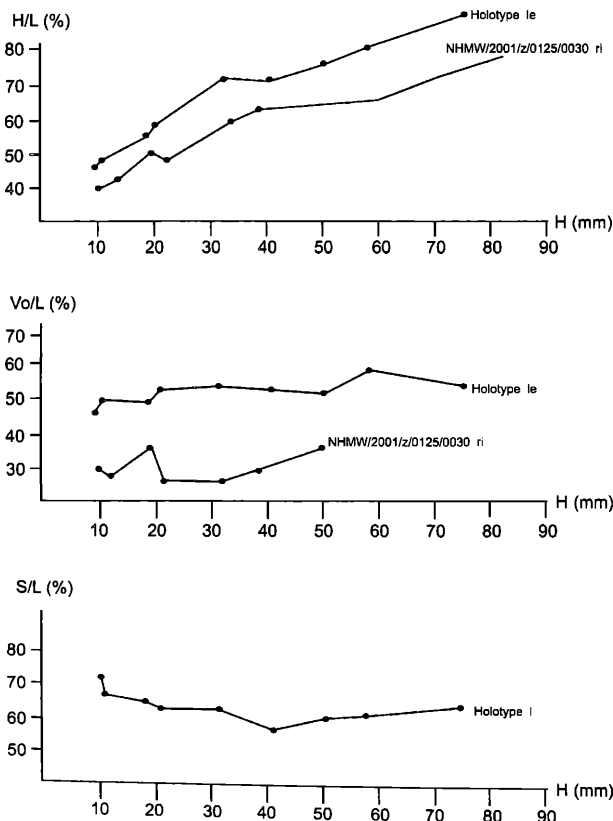


Figure 9: H/L-, Vo/L- and S/L ratio of *Trochoceramus cf. tenuiplicatus* (sports field Piesting) and of the holotype of *Trochoceramus tenuiplicatus* (TZANKOV).

Stratum typicum: Kahlenberg Fm. (Rhenodanubian Flysch) of (?) Maastrichtian age.

Locus typicus: Leopoldsberg near Vienna

Material: NHMW/2001/z/0125/0030 a single internal mould of a right valve from the sports field at Piesting.

Preservation: Incomplete. Wing, posterior and ventral margins are missing. Radial cracks indicate post mortem compaction. The beak is slightly pressed over the anterior margin.

Description: Large sized, inequilateral, perhaps equivalved. *Balticus*-like umbonal region. Anterior margin convex subrounded. Hinge line only partly preserved, straight. Hg. = 129.5 mm (incomplete), Lg = 123.5 mm (incomplete), Vo (anterior margin) = 101.5 mm (nearly complete). Angle between hinge line and anterior margin (Gw.) = 106° (possibly changed by deformation). The ornamentation consists of concentric, sharply-edged undulations (caused by compaction) and radial ribs arising at the beak. They are well developed around the axial region. Rib interval: 1-2.5 mm.

D	Holotype	NHMW/0125/0030
10-30 mm	3.78 mm	5.40 mm
30-50 mm	6.93 mm	7.4 mm
50-70 mm	7.43 mm	—

Table 4: Average undulation intervals in distances (D) from the beak.

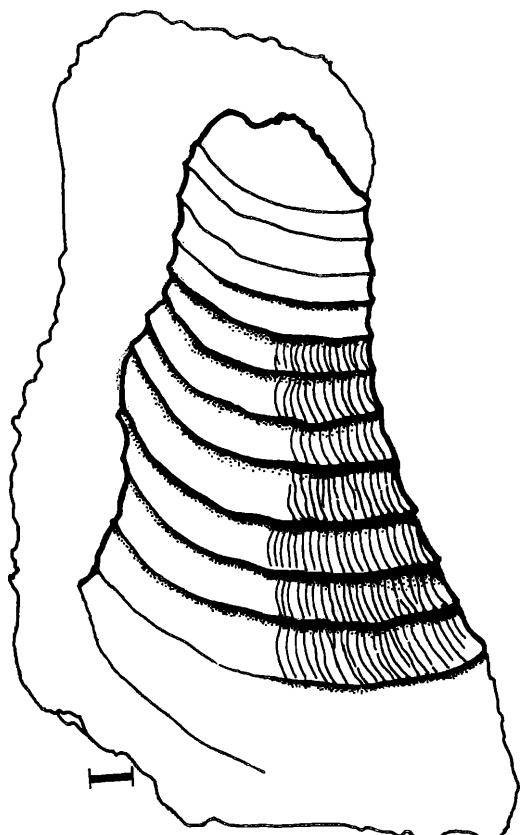


Figure 10: Fragment of *Trochoceramus sp. aff. helveticus* HEINZ (bar scale 1 cm). NHMW/2001/z/0125/0032 from the Lower Maastrichtian of the sports field Piesting.

Remarks: NHMW/2001/z/0125/0030 is comparable with the holotype of *Trochoceramus tenuiplicatus* (TZANKOV) in shape, H/L ratio and the course and type of undulations and ribs. It differs by its smaller Vo/L –ratio and the absence of the "Anwachsschnittreifen" sensu HEINZ (1932) visible in the holotype. This may be caused by the preservation of the former (internal mould without growth lines). WALASZCZYK (pers. comm.) mentioned affinities to specimens of the *Inoceramus balchii* – group, which in contrast lacks radial elements.

Occurrence: *Trochoceramus tenuiplicatus* (TZANKOV) occurs in the Lower Maastrichtian (?) of the Rhenodanubian Flysch of Leopoldsberg near Vienna, in the Lower Maastrichtian of the Nida Trough, south central Poland (WALASZCZYK et al. 1996), Ukraina and of the Gulf Coast of North America (WALASZCZYK et al. 2001).

Trochoceramus sp. aff. *helveticus* (HEINZ 1932)
Plate 3, fig. 1; text-fig. 10

Holotype by subsequent designation of SEITZ (1970) is the original of *Trochoceramus helveticus* HEINZ figured by SEITZ (1970, pl. 14) from Switzerland.

Compare:

1932 *Trochoceramus helveticus* HEINZ, p. 19
1996 *Trochoceramus helveticus* HEINZ; WALASZCZYK et al.: p. 161, pl. 4, figs. 2-3 (with synonymy).

Stratum typicum: Wang beds of Upper Campanian to Maastrichtian age

Locus typicus: N Schrattenfluh, Switzerland

Material: Three fragments (NHMW/2001/z/0125/0031, 32, 33, 34,) from the sports field of Piesting.

Preservation: All specimens are incomplete. Beaks, wings and margins are generally missing. They are all flattened by post mortem deformation.

Description: *Trochoceramus* sp. aff. *helveticus* is a large-sized, inequilateral and flat taxon. The umbonal area of the right valve has *balticus* - like shape. Intervals of the first undulations are 6.5 mm, 8.5 mm, 11.8 mm. The ribs start in 20-30 mm distance from the beak crossing the undulations. Rib-distance is 1.0-1.5 mm. They are irregular and sometimes branched. The undulation intervals on the different fragments vary between 8.8 and 20.5 mm. The ribs covering a great part of all fragments are also irregular and branched. Distances of the ribs 1.0-4.2 mm. The thickness of the partly preserved shell is 0.1-0.5 mm.

Remarks: The shape of beak shape and ribs, which arise within a short distance from the beak, are comparable with those of the holotype, figured by SEITZ (1970, pl. 14). The fragmentary preservation of all specimens from Piesting does not allow an exact determination. Concerning the course of the radial ribs, belonging to the *T. monticuli* – group seems possible (WALASZCZYK, pers. comm.).

Occurrence: Lower Maastrichtian of Switzerland (SEITZ 1970), Lwow (Ukraina), Poland (WALASZCZYK et al., 1996) and Austria.

Trochoceramus sp. aff. *morgani* (SORNAY 1973)
Plate 3, fig. 5

Holotype of *Trochoceramus morgani* (SORNAY) by original designation is the original of SORNAY (1973; pl. 4, fig. 6; text-fig. 5).

Compare:

1973 *Inoceramus (Trochoceramus) morgani* SORNAY: 91-92, pl. 3, figs. 3-4; pl. 4, figs. 2-3.
1996 *Trochoceramus morgani* (SORNAY); WALASZCZYK et al.: 156-157, pl. 2, figs. 1-8.

Stratum typicum: Calcaire à *Baculites* (SORNAY 1973), Maastrichtian

Locus typicus: Picauville (France)

Material: 1 internal mould from the roadcutting of Piesting (NHMW/2001/z/0126/0001).

Preservation: Undeformed internal mould. Incomplete, parts of the beak and of the ventral margin are missing.

Description: Medium sized (Hg = 47.0 mm; Lg. = 72.5 mm; Sg. = 51.5 mm). Inequilateral, equivalve. Shape *balticus* like. Beak not curved, slightly projects over the hinge line. Hinge line straight. Angle between the hinge line and the posterior margin: 120° Gw. = 113°. Flw. = 37°. Anterior margin convex. Undulations staircase - like. Undulation intervals increasing from the beak (2.5 mm) to the ventral margin (6.5 mm). Ratio H/L at H=15.5 mm: 100%, at H = 21.3 mm: 85.2 mm, at H = 30 mm: 85 %. Ratio S/L at H = 15.5: 59.4 %, at H= 21.3 mm: 75.1 %, at H = 30 mm: 73.3 %. The undulations are curved to the beak at the hinge line (angle 2, see text-fig. 5: 110-118°).

Undulations crenellated at the umbonal region. Ribs not clearly visible. Small *Endocostea* scar present.

Remarks: The specimen described differs from *T. morgani* (SORNAY) by the high H/L ratio at the beak and the form of the radial ornamentation. *Trochoceramus* sp. aff. *morgani* (SORNAY) is possibly a Campanian precursor of *Trochoceramus morgani* (SORNAY).

Occurrence: *Trochoceramus morgani* (SORNAY) is recorded from the topmost Lower/?basal Upper Maastrichtian of Zumaya (WARD & KENNEDY 1993), from the upper part of the *Belemnitella junior* Zone and the basal part of the *Belemnella kasimiroviensis* Zone (Upper Maastrichtian; KENNEDY 1986) and from the same stratigraphic level of the Aimaki region (Caucasus; WALASZCZYK et al. 1996). *T. sp. aff. morgani* (SORNAY) occurs in the uppermost Campanian and lowermost Maastrichtian.

Trochoceramus (?) sp. aff. *dobrovi* (PAVLOVA 1955)
Plate 2, figs. 3,4; Plate 3, figs. 3, 4; text-fig. 1

Holotype is the original of *Inoceramus dobrovi* PAVLOVA 1955 (non PAVLOV), housed in the collections of the State University of Moscow under the number 57120 (field No. 71/199) figured by PAVLOVA (1955, pl. 19, fig. 3) according to WALASZCZYK et al (1996).

Compare:

v. 1955 *Inoceramus dobrovi* n.sp. PAVLOVA (thesis, pl.19, fig. 3, p. 243)

1996 "*Inoceramus*" cf. *dobrovi* PAVLOVA; WALASZCZYK et al.: pl.5, fig. 3.

Material: Internal moulds of a right valve (NHMW/2001/z/0126/0002) and a left one (NHMW/2001/z/0126/0003) from the roadcutting at Piesting.

Preservation: Incomplete. Parts of the wings and of the ventral margins are missing. Slightly deformed by post mortem compaction.

Description: Medium sized (NHMW/2001/z/0126/0002: Hg. = 56 mm, Lg. = 55 mm, Sg. = 39,5 mm, Vo. = 29 mm; NHMW/2001/z/0126/0003: Hg. = 52,5 mm, Lg. = 61,2 mm, Sg. = 45 mm). Inequilateral, equivalve, shape subcircular to subquadrate. Beak projecting over the hinge line and bent to the anterior convex margin. Gw. is 130° in NHMW/2001/z/0126/0002, 110° in NHMW/2001/z/0126/0003. Hinge line straight. Angle between the hinge line and the anterior margin (text-fig. 5): 128° Growth axis nearly straight (angles between 65 and 75°). Course of the undulations staircase-like to pointed (caused by post mortem deformation). The undulations are crenellated. Weak ribs are visible near the ventral margin.

D	0126/0002	0126/0003	holotype
10-30	2.66	3.31	3.33
30-50	4.68	3.48	—

Table 5: Average undulation intervals in distances from the beak (Dmm) in NHMW/2001/z/0126/0002,3 and the holotype of *Trochoceramus* (?) *dobrovi* (PAVLOVA).

Remarks: The differences between the holotype and the specimens described are visible on text-fig. 11. Ribs are missing in the holotype. Taking into consideration the shape and the crenellation of the undulations at the specimens of the roadcutting of Piesting are comparable with specimen 454 from the Lower Maastrichtian of the Aimaki section (Caucasus) figured by WALASZCZYK et al. (1996, pl. 5, fig. 4).

Occurrence: Uppermost Campanian and Lower Maastrichtian of the Caucasus (PAVLOVA 1955, WALASZCZYK et al., 1996).

Genus *Spyridoceramus* COX 1969
(ex HEINZ 1932, nomen nudum)

Type species: *Inoceramus tegulatus* HAGENOW (HEINZ 1932, COX 1969)

Spyridoceramus cf. *tegulatus* (HAGENOW 1842)
Plate 1, fig. 6; Plate 3, fig. 2; text-fig. 12

Lectotype: By designation of SPEDEN (1970, p.6) the original of WOLANSKY (1932) (fig. 5, pl. 5).

Compare:

1842 *Inoceramus tegulatus* HAGENOW: 559

1932 *Inoceramus* (*Spyridoceramus*) *tegulatus* HAGENOW;
WOLANSKY: 28-29, ? pl. IV, fig. 5, pl. V, figs. 5-6.

1965 *Inoceramus tegulatus* HAGENOW; NESTLER: 57-58

1983a *Spyridoceramus tegulatus* (HAGENOW); DHONDT: 43

Stratum typicum: Chalk of Lower Maastrichtian age (*occidentalis* or *cimbrica* Zone; STEINICH & NESTLER 1967)

Locus typicus: Rügen (N Germany) without exact location

Material: Internal moulds of three left (NHMW/2001/z/0125/0042, 42a; NHMW/2001/z/0125/0047) and two right valves (NHMW/2001/z/0125/0043,45) from the sports field of Piesting.

Preservation: The specimens are badly preserved and incomplete. Outer parts of the wings and parts of the posterior and ventral margins are missing. The specimens are completely flattened by post mortem deformation.

Description: Small sized (height to 30 mm), equivalve, strongly curved, *Avicula*-like shape. The beak projects above the hinge line and is bent to the convex to straight anterior margin. Hinge line straight but in all cases incomplete. Growth axes prosocline. Small anterior auricles were observed in NHMW/2001/z/0125/0047 and 49 (*Spyridoceramus* sp.). The ornamentation consists of undulations and ribs. Undulation intervals: 2mm. The ribs arise in different distances from the beak and cross the undulations. They are tile-like in most cases. Tubercles

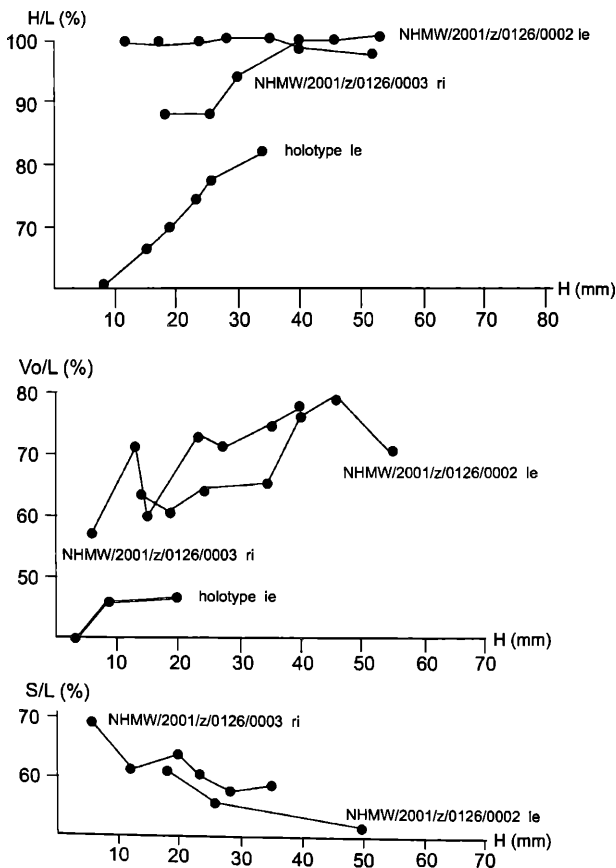


Figure 11: Comparison between the holotype of *Trochoceramus* (?) *dobrovi* (PAVLOVA) and *Trochoceramus* (?) sp. aff. *dobrovi* (PAVLOVA) from the roadcutting at Piesting.

at the intersection of the ribs with the undulations were only observed in the specimen NHMW/2001/z/0125/0043. This is comparable with figure 7 in ODUM, 1922 (*Inoceramus tegulatus* HAGENOW; ODUM 1922, fig.7 = *Tenuipteria geulemensis* (VOGEL) = *Inoceramus tegulatus* DOBROV non HAGENOW according to DHONDT (1983a).

The strong deformations caused by post mortem compaction exclude information concerning the H/L-, Vo/L- and S/L ratios. Angle between the hinge line and the anterior margin (Gw. = Gesamtwinkel) = 70-80° Shell thickness: 0.1- 0.5 mm (mainly 0.1-0.2 mm).

Remarks: SPE DEN (1970) discussed the generic status of the *Inoceramus tegulatus*-Group.

The species *Spyridoceramus tegulatus* (HAGENOW, 1842); *Tenuipteria fibrosa* (MEEK & HAYDEN, 1856) and *Tenuipteria argentea* (CONRAD, 1858) belong to the genus *Tenuipteria* according to SPE DEN (1970). The genus *Spyridoceramus* established by HEINZ (1932) without diagnosis and figures is invalid according to SPE DEN (1970) too. We follow COX (1969) and DHONDT (1983, p. 49), who gave a diagnosis of the genera *Tenuipteria* und *Spyridoceramus* and discussed remarkable differences between the mentioned two genera.

Occurrence: Lower Maastrichtian and basal Upper Maastrichtian (DHONDT, 1983) of the Northern Hemisphere: North America (Western Interior), S Netherlands, N Germany, Caucasus, Kamchatka, Japan; mainly occurring in the *tegulatus/junior* Zone (JAGT et al. 1999).

Spyridoceramus sp.
not figured

Material: Three specimens (NHMW/2001/z /0125/0046, 49, 50).

Description: The preservation of three specimens from the sports field of Piesting is so bad that determination of the species is impossible. Therefore, open nomenclature is used.

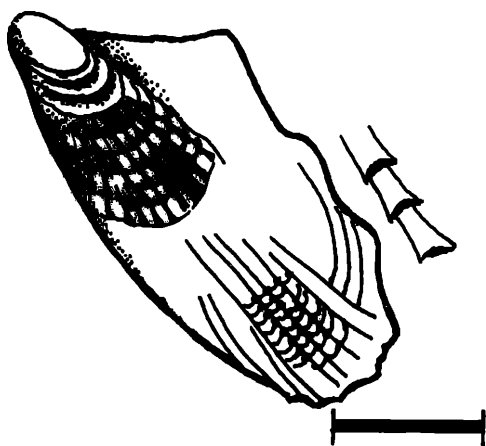


Figure 12: *Spyridoceramus* cf. *tegulatus* (HAGENOW) with tile-like ribs. NHMW/2001/z/0125/0042, from the sports field Piesting (bar scale 1 cm)

3. Stratigraphy of the Piesting Formation in the Neue Welt area

Integrated biostratigraphic investigations using nannoplankton, inoceramids, rare ammonites and palaeomagnetic investigations were carried out to fix the stratigraphic age of the Piesting Formation of the Gosau Group (SUMMESBERGER et al., 2002) with outcrops at the sports field of Piesting and the roadcutting of Piesting (SUMMESBERGER et al., 2002, text-fig.1).

Inoceramids: Biostratigraphical investigations at the Campanian /Maastrichtian boundary and particularly in the Lower Maastrichtian were made by SEITZ (1970), DHONDT (1982, 1983a, 1992, 1993) and WALASZCZYK et al. (1996). SEITZ (1970) proclaimed an Upper Campanian through /Lower Maastrichtian age of the fauna of Muntigl, containing *Platyceramus salisburgensis* (FUGGER & KASTNER), *Trochoceramus monticuli* (FUGGER & KASTNER), *Trochoceramus radiosus* (QUAAS), *Trochoceramus helveticus* (HEINZ) and *Trochoceramus nahorianensis* (KOTSIUBYNSKI). The genera *Trochoceramus* and *Spyridoceramus* are common in the Lower Maastrichtian (DHONDT, 1983, 1983a, 1993; WALASZCZYK et al., 1996). Text-fig. 13 gives an overview of the FOD (first occurrence date) and the LOD (last occurrence date) of the genera *Cataceramus*, *Endocostea*, *Platyceramus*, *Cordiceramus*, *Trochoceramus*, *Spyridoceramus* and *Tenuipteria*. The inoceramid assemblage at the sports field of Piesting consists of a Muntigl fauna accompanied by *Spyridoceramus* cf. *tegulatus* (HAGENOW) and *Platyceramus alaeformis* (ZEKELI). *Platyceramus alaeformis* (ZEKELI) was found in the *Nostoceras hyatti* Zone (DHONDT 1993) of Tercis (proposed section for the Campanian/Maastrichtian boundary). *Spyridoceramus tegulatus* (HAGENOW) is a Lower Maastrichtian form of Northern Europe. *Cataceramus* ? *glendivensis* WALASZCZYK et al. (2001) occurs at the basal Lower Maastrichtian of the Western Interior of the United States (WALASZCZYK et al., 2001). The inoceramid assemblage of the sports field at Piesting therefore indicates a basal Lower Maastrichtian. This is confirmed by the rare co-occurrence of *Pachydiscus neubergicus* (HAUER) in the basal parts of the investigated section.

The inoceramid assemblage of the roadcutting of Piesting consists of two species only: *Trochoceramus* (?) sp. aff. *dobrovi* (PAVLOVA) and *Trochoceramus* sp. aff. *morgani* (SORNAY). Those not clearly determined inoceramid species do not allow a detailed biostratigraphic interpretation in the uppermost Campanian/Early Maastrichtian interval. Concerning the lithostratigraphic position and the inoceramid fauna, an uppermost Campanian age seems likely.

4. Maastrichtian inoceramid palaeobiogeography

KAUFFMAN (1973), after having investigated Cretaceous bivalve assemblages distinguished three different realms

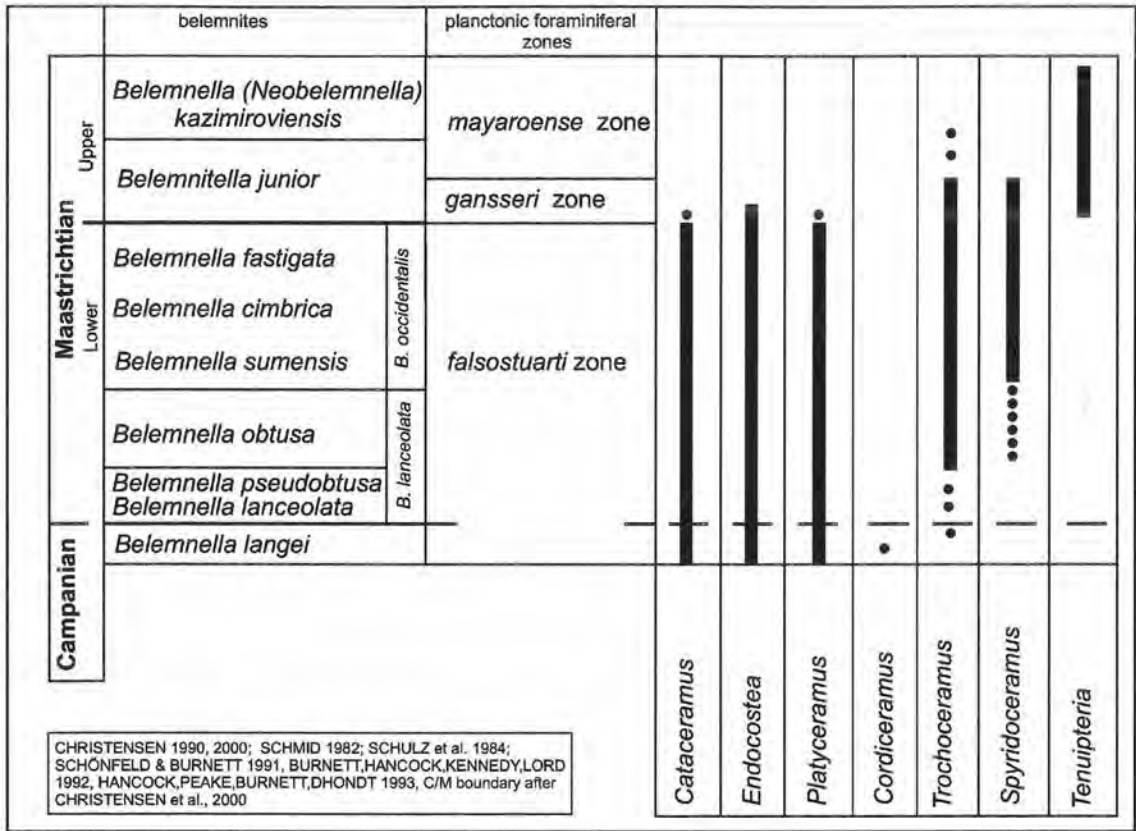


Figure 13: Vertical distribution of inoceramid and inoceramoid genera in the Maastrichtian of Europe.

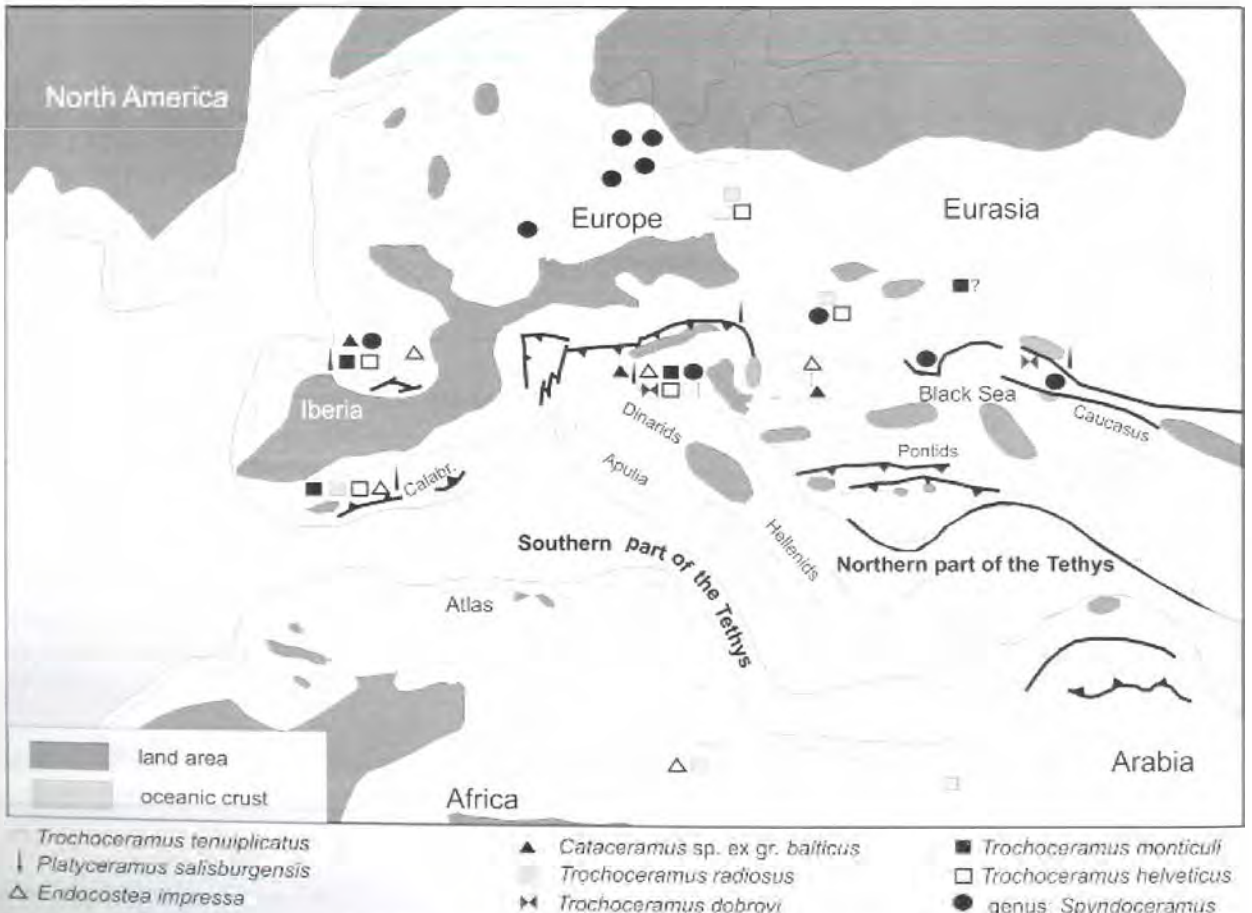


Figure 14: Palaeobiogeography of Early Maastrichtian inoceramids in Eurasia and N Africa.

- the North Temperate Realm, the Tethyan Realm and the South Temperate Realm. Further investigations especially concerning Maastrichtian inoceramid palaeobiogeography were carried out by DHONDT (1982, 1983, 1983a, 1992) and S. VOIGT (1996). The inoceramid assemblage of Piesting fits well into the palaeobiogeographic picture established by the above mentioned authors.

The Maastrichtian inoceramid assemblage of Piesting contains taxa which are widespread in the North Temperate Realm (e.g. *Spyridoceramus*; DHONDT 1992). This genus is accompanied by species originally described from the Northern part of the Tethyan Realm belonging to the fauna of Muntigl (SEITZ 1970), for example *Platyceramus salisburgensis* (FUGGER & KASTNER) and *Trochoceramus monticuli* (FUGGER & KASTNER). Similar assemblages with *Trochoceramus nahorianiensis* (KOTSIUBYNSKIJ) and *Trochoceramus helveticus* (HEINZ) were also found in southwestern France and northern Spain (text-fig. 14). The Lower Maastrichtian inoceramid assemblages in northern Africa, however, are quite different (SORNAY 1968, 1973, 1975; TRÖGER & RÖHLICH 1991). This confirms inoceramid migrations between the North Temperate Realm and the Tethyan Realm during Maastrichtian times. Palaeogeography according to VOIGT (1996). Further used literature: BURNETT et al. (1992), DHONDT (1983, 1992, 1993), GALLEMI et al. (1995), HANCOCK et al. (1993, 1996), JOLKICEV (1962), LOPEZ (1995, 1996), MOSKVIN (1959), NESTLER (1965), SANTAMARIA & LOPEZ (1996), SCHÖNFELD & BURNETT (1991), SCHULZ et al. (1984), SEITZ (1970); SORNAY (1973, 1975), TRÖGER & RÖHLICH (1991); WALASZCZYK et al. (1996), WARD et al. (1991).

5. Acknowledgements

We are greatly indebted to Dr. WALASZCZYK for his remarks and the opportunity to compare the specimens of Piesting with specimens from the USA housed in the collections of the University of Warszawa and for the access to an unpublished paper (WALASZCZYK et al., 2001). We also are grateful for the help of Dr. CERNAJSEK (Austrian Geological Survey, Vienna) for support concerning literature. Dr. EGGER (Austrian Geological Survey, Vienna) provided valuable information on the lithostratigraphy of the Rhenodanubian flysch. Financial support by the IGCP-Projekt 362 "Tethyan and Boreal Cretaceous" is greatly acknowledged by SUMMESBERGER and WAGREICH; TRÖGER is grateful for financial support of the Naturhistorisches Museum Wien. Technician work and photos were done by the staff of the NHMW.

6. References

- BARROIS, C., 1879. Sur quelques espèces nouvelles ou peu connues du terrain crétacé du Nord de France. — Ann. Soc. géol. Nord, **6**:449–487, Lille.
- BURNETT, J.A., HANCOCK, J.M., KENNEDY, W.J. & LORD, A.R., 1992. Macrofossil, planktonic foraminiferal and nannofossil zonation at the Campanian-Maastrichtian boundary. — Newsl. Stratigr., **27**:157–172, Berlin-Stuttgart.
- CHRISTENSEN, W.K., 2000. *Belemnitella schulzi* sp. nov. from the uppermost Campanian and lowest Maastrichtian chalks of northwest Germany and Denmark. — Acta Geologica Polonica, **50**/1:55–66, 3 figs., 1 pl., Warszawa.
- CHRISTENSEN, W.K., HANCOCK, J.M., PEAKE, N.B. & KENNEDY, W.J., 2000. The base of the Maastrichtian. — Bull. Geol. Soc. Denmark, **47**:81–85, Copenhagen.
- COX, L.R., 1969. "Inoceramidae" in: MOORE, R. C. (ed.): Treatise on Invertebrate Paleontology, Part N., 1, Mollusca **6**:N 314–N 321, Kansas.
- DHONDT, A.V., 1982. Bivalvia (Mollusca) from the Maastrichtian of Hemmoor (NW Germany) and their palaeobiogeographical affinities. — Beih. Geol. Jb. A **61**:73–107, 1 fig., 3 tables, 5 pls., Hannover.
- DHONDT, A.V., 1983. Campanian and Maastrichtian Inoceramids: A review. — Zitteliana, **10**:689–701, München.
- DHONDT, A.V., 1983 a. Tegulated Inoceramids and Maastrichtian Biostratigraphy. — Newsl. Stratigr. **12** (1):43–53; 5 figs., 1 tab., Berlin-Stuttgart.
- DHONDT, A.V., 1992. Cretaceous inoceramid biogeography: a review. Paleogeography, Paleoclimatology, Paleoecology, **92**:217–232, Amsterdam.
- DHONDT, A. V., 1993. Upper Cretaceous bivalves from Tercis, Landes, SW France. — Bull. de l'Institut Royal des Sciences Naturelles de Belgique, Sciences de la Terre, **63**:211–259, Brussels.
- DHONDT, A.V., 1999. Upper Maastrichtian bivalve faunas from the Crimea, Maastricht and Mangyshlak. — Bull. de l'Institut Royal des Sciences Naturelles de Belgique, Sciences de la Terre, **69**-Suppl.:55–65, 4 figs., 1 pl., Brussels.
- DOBROV, S.A., 1951. Gruppa *Inocermus caucasicus* n.sp. — *Inoceramus tegulatus* HAG. na severnom Kavkaze. — Sbornik pamiaty akademika a.d. Arkhangelskovo. — Voprosy litologii i stratigrafii SSR:163–172, 2 pls., Moskva.
- EGGER, J., KOLLMANN, H.A., SANDERS, D., SUMMESBERGER, H. & WAGREICH, M., 2000. 6th Internat. Cretaceous Symposium Vienna 2000, Field trip C: Cretaceous of eastern Austria, 56 pp., Vienna.
- FUGGER, E., 1899. Das Salzburger Vorland. — Jahrb. k.k. Geol. Reichsanst., **49**:287–429, 2 pls., 30 text-figs., Wien.
- FUGGER, E. & KASTNER, C., 1885. Naturwissenschaftliche Studien und Beobachtungen aus und über Salzburg. — Die Steinbrüche von Bergheim und Muntigl. — Verl. Hermann Kerber: 62–82, 2 Taf., Salzburg.
- GALLEMI, J., MARTINEZ, R., PONS, J.M., (1983): Coniacian - Maastrichtian of the Tresp Area (South Central Pyrenees). — Newsl. Strat., **12**:1–17.
- GIERS, R., 1964. Die Großfauna der Mukronatenkreide (unteres Obercampan) im östlichen Münsterland. — Fortschr. Geol. Rheinld. u. Westf., **7**:213–294, 8 pls., 10 text-figs., Krefeld.
- GOLDFUSS, A., [unter Mitwirkung Graf Georg zu Münster] 1836. Petrefacta Germaniae. 1833-1841. — Abbildungen und Beschreibungen der Petrefacten Deutschlands

- und der angrenzenden Länder. II. Teil – Inoceramen. — Arnz. & Co., Tab. CVIII-CXIII, Düsseldorf.
- HAGENOW, F. von, 1839. Monographie der Rügen'schen Kreide – Versteinerungen, III. Abtheilung: Mollusken. — Neues Jb. Mineral., 1842:528–575, 9 Taf., Stuttgart.
- HANCOCK, J.M., PEAKE, N.B., BURNETT, J., DHONDT, A.V., KENNEDY, W.J. & STOKES, R.B., 1993. High Cretaceous biostratigraphy at Tercis, south-west France. — Bull. Inst. roy. Sci. nat. Belgique, Sci. de la Terre, **63**:133–148., Brussels.
- HANCOCK, J.M. & GALE, A.S., 1996. The Campanian Stage. In: P.E. RAWSON, A.V. DHONDT, J.M. HANCOCK & W.J. KENNEDY (eds), Proceedings "2nd International Symposium on Cretaceous Stage Boundaries" Brussels 8–16 September 1995. — Bull. Inst. roy. Sci. nat. Belgique, Sciences de la terre, **66**-Supp.:103–109., Brussels.
- HARRIES, P., KAUFFMAN, E.G., CRAMPTON, S.J., BENGTON, P. CECH, S., CRAME, J.A., DHONDT, A.V., ERNST, G., HOLBRECHT, H. LOPEZ, G. MORTIMORE, R., TRÖGER, K.-A., WALASZCZYK, I & WOOD, C.J., 1993. Lower Turonian Euramerican Inoceramidae: A. Morphologic, Taxonomic and Biostratigraphic Overview. — A report from the first workshop on Early Turonian Inoceramids (Oct. 1992, Hamburg, Germany) organized by HILBRECHT, H. and HARRIES, P.J.:1–44, 8 figs., Hamburg.
- HEINZ, R., 1928. Über die bisher wenig beachtete Skulptur der Inoceramen-Schale und ihre stratigraphische Bedeutung. — Mitt. Min.-Geol. Staatsinst. Hamburg, **X**:1–39, 4 pls., Hamburg.
- HEINZ, R., 1932. Aus der neuen Systematik der Inoceramen. Beiträge zur Kenntnis der Inoceramen XIV. — Mitt. Min.-Geol. Staatsinst. Hamburg, **H. XIII**:1–26., Hamburg.
- JAGT, J. W.M., KENNEDY, W.J. & MACHALSKI, M., 1999. Giant scaphitid ammonites from the Maastrichtian of Europe. — Bull. de l'Institut Royal Naturelles de Belgique-Sciences de la Terre, **69**:133–154., Bruxelles.
- JOLKIŠEV, N., 1962. Maastrichtski inocerami v Bulgarija (in Bulgarian and German). — Bulgarska Akademija na Naukite, Geologicheski Institut. Travaux sur la Géologie de Bulgarie, série Paléontologie, **IV**:133–168., Sofia.
- KAUFFMAN, E.G., 1973. Cretaceous Bivalvia. In: Atlas of Palaeobiogeography. (ed. Hallam, A.):353–383. Elsevier Scientific Publishing Company, Amsterdam, London, New York, Tokyo.
- KAUFFMAN, E.G., SAGEMAN, B.B., KIRKLAND, J.I., EDER, W.P., HARRIES, P.J., VILLAMIL, T., 1993. Molluscan Biostratigraphy of the Cretaceous Western Interior Basin, North America. In: Evolution of the Western Interior Basin. (eds.: CALDWELL, W. G. E. and KAUFFMAN, E.G.). — Geol. Association of Canada, Spec. Paper, **39**:397–434., Ottawa.
- KENNEDY, W.J., 1986. The ammonite fauna à *Baculites* (Upper Maastrichtian) of the Contentin Peninsula (Manche, France). — Palaeontology, **29**,1:25–83, 16 pls., London.
- KOTLARCYK, J., MITURA, F. & RAJCHEL, J., 1977. *Inoceramus salisburgensis* z warstw inoceramowych vw rejonie Rybotycz. — Ann. de la Soc. Géol. de Pologne, **XLVII**, 3:371–381, 2 pls., Kraków.
- KOTSUBYNSKIJ, S.P., 1958. Inoceramids of the Cretaceous Deposits of the Volhynian-Podolian Region (Ukrainian language). — Lvivskij Naukovo-Prirodoznavtchij Muzej, Academy of Sciences of the Ukrainian SSR:1–49., Lwow.
- KOTSUBYNSKIJ, S.P., 1968. in PASTERNAK, S.I., GAVRILISHIN, V.I., GINKA, V.A., KOTSUBYNSKIJ, S.P. and SENKOVSKY, J. M.: Stratigrafija i fauna Kreidovich vkladiv sachodu Ukraini (bes Karpat). — Naukova Dumka:272 p., 50 pls., Kiev.
- LOPEZ, G., 1995. Aspectos paleobiogeográficos de los inoceramidos (Bivalvia) del Campaniense y Maastrichtiense de Alava y Navarra. — XI. Jornadas de Paleontología, 26–29 de octubre de 1995:107–111., Barcelona.
- LOPEZ, G., 1996. Aportaciones de los inoceramidos (Bivalvia) al conocimiento del Cretácico superior del valle de Barranca, Navarra. — Príncipe de Viana, Suplemento de Ciencias, Año XVI, No **14/15**:97–124, 2 pls., Navarra.
- MOSKVIN, M. M., [ed.] 1959. Atlas verchnemelovoi fauni severnogo Kavkasa i Krima. (russisch). Gosdarstvennoe nauchno-technitscheskoe isdatelstvo neftjanoi i gornoplivnoi literaturi. Inoceramids (DOBROV, S.A. & PAVLOVA, M.M.):130–165., Moskva.
- NESTLER, H., 1965. Die Rekonstruktion des Lebensraumes der Rügener Schreibkreide-Fauna (Unter-Maastricht) mit Hilfe der Paläoökologie und Paläobiologie. — Geologie, **14**, Beih. **49**:1–147, 52 Abb., 7 Taf., 1 Tab., Berlin.
- ODUM, H., 1922. *Inoceramus tegulatus* v. HAGENOW det danske Skriveridd. — Meddelelser fra Dansk geologisk Forening. **6**,10:3–13, 2 pls., Kobenhavn.
- PAVLOVA, M.M., 1995. Inocerami verchnemelovich otloschenii Dagestana (in Russian). — Thesis Report, Moskva.
- PETRASCHECK, W., 1906. Über Inoceramen aus der Gosau und dem Flysch der Nordalpen. — Jahrb. k.k. Geol. Reichsanstalt, **56**,1:155–167, 6 Taf., Wien.
- PREY, S., 1983. Das Ultrahelvetikum-Fenster des Gschlifgrabens südsüdöstlich von Gmunden (Oberösterreich). — Jahrb. Geol. B.A. **126**/1:95–127, 4 text-figs., 1 geol. map., Wien.
- SANTAMARIA, R. & LOPEZ, G., 1996. Aspectos biostratigraficos de los ammonites e inoceramidos (Bivalvia) de la provincia de Alava. — Revista Espanola de Paleontología, No. Extraordinario:148–159., Madrid.
- SCHÖNFELD, S. & BURNETT, J., 1991. Biostratigraphical correlation of the Campanian-Maastrichtian boundary: Lägerdorf-Hemmoor (northwestern Germany), DSDP Sites 548A, 549, and 551 (eastern North Atlantic) with paleobiogeographical and paleoceanographical implications. — Geol. Mag., **128**:479–503., London.
- SCHULZ, M.-G., ERNST, G., ERNST, H. & SCHMID, F., 1984. Coniacian to Maastrichtian stage boundaries in the standard section for the Upper Cretaceous white chalk of NW Germany (Lägerdorf-Krons Moor-Hemmoor): Definitions and proposals. — Bull. Geol. Soc. Denmark, **33**/1:203–216., Copenhagen.
- SEITZ, O., 1934. Die Variabilität des *Inoceramus labiatus* SCHLOTHEIM. — Jb. Preuß. geol. Landesanst., **55**:429–474, 5 pls., 9 text-figs., Berlin.

- SEITZ, O., 1961. Die Inoceramen des Santon von Nordwestdeutschland. I. Teil (Die Untergattungen *Platyceramus*, *Cladoceramus* und *Cordiceramus*). — Beih. Geol. Jahrb., **46**:186 pp., 15 pls., 39 text-figs., Hannover.
- SEITZ, O. 1970. Die Muntigler Inoceramen-Fauna und ihre Verbreitung im Ober-Campan und Unter-Maastricht. — Beih. Geol. Jahrb., **86**: 106-171, Taf. 14-28, 12 Abb. — Hannover.
- SORNAY, J., 1968. Inocérames Senonien du Sud-Ouest de Madagascar. — Ann. de Paléontologie (Invertébrés), **54**:25–57., Paris.
- SORNAY, J., 1973. Sur les inocérames du Maastrichtian de Madagascar et sur une espèce de la Craie à *Baculites* du NW des la France. — Ann. de Paléontologie, **59**: 83–93., Paris.
- SORNAY, J., 1975. Trois espèces nouvelles d'inocérames du Sénonien de Madagascar. — Ann. de Paléontologie (Invertébrés), **61**:3–13., Paris.
- SORNAY, J. & BILOTTE, M., 1978. Faunes d'inocérames du Campanien et du Maastrichtian des Pyrénées. — Ann. de Paléontologie (Invertébrés), **64** (fasc.1):27–45., Paris.
- SPEDEEN, I.G., 1970. Generic status of the *Inoceramus tegulatus* species group (Bivalvia) of the latest Cretaceous of North America. — Postilla, **145**:1–45., Lower Hutt (New Zealand).
- STEINICH, G. & NESTLER, H., 1967. Unter-Maastricht der Insel Rügen. — Bericht von der Exkursion am 20. Oktober 1965. — Ber. deutsch. Ges. geol. Wiss., A, Geol. Paläont., **12** (5):577–585., Berlin.
- SUMMESBERGER, H., WAGREICH, M., TRÖGER, K.-A. & JAGT, J. W.M., 1999. Integrated biostratigraphy of the Santonian/Campanian Gosau Group of the Gams Area (Upper Cretaceous; Styria, Austria). — Beitr. Paläont. **24**:155–205, 12 pls., Wien.
- SUMMESBERGER, H., WAGREICH, M., TRÖGER, K.-A. & SCHOLGER, R., 2000. Piesting-Formation, Grünbach-Formation und Maiersdorf-Formation – drei neue lithostratigraphische Termini in der Gosau Gruppe (Oberkreide) von Grünbach und der Neuen Welt (Niederösterreich). — Abstract „Austrostrat 2000“, Graz.
- SUMMESBERGER, H., WAGREICH, M., TRÖGER, K.-A. & SCHOLGER, R., 2002. Integrated biostratigraphy of the Campanian-Maastrichtian (Late Cretaceous) Piesting Formation (Northern Calcareous Alps, Gosau Group; Lower Austria). — Proceedings volume, 6th Internat Cretaceous Symposium, Vienna 2000. — Ber. Erdwiss. Kommission Österr. Akad. Wiss., Wien.
- TRÖGER, K.-A., 1969. Zur Paläontologie, Biostratigraphie und faziellen Ausbildung der unteren Oberkreide (Cenoman bis Turon). Teil I: Paläontologie und Biostratigraphie der Inoceramen des Cenomans bis Turons. — Abh. Staatl. Mus. Min. Geol. Dresden, **12**:13–207, 14 pls., Dresden.
- TRÖGER, K.-A. & RÖHLICH, P., 1980. Zur Variabilität und Paläobiogeographie von *Inoceramus (Trochoceramus) ianjonensis* SORNAY aus dem Maastricht von Libyen. — Freiburger Forschungsh., C, **357**:93–103., Leipzig.
- TRÖGER, K.-A. & RÖHLICH, P., 1981. *Inoceramus (Selenoceramus) ghadamesensis* n. sp. from the Upper Cretaceous of Libya. — Vestník Ústřední Ústav geol., **56**:169–175., Praha.
- TRÖGER, K.-A. & RÖHLICH, P., 1991. Campanian - Maastrichtian Inoceramid (Bivalvia) Assemblages from NW-Libya. — In: The Geology of Libya. **IV**:1357–1381 (eds. SALEM, M.J., HAMMUDA, O.S., ELIAGOUBI, B.A.), Elsevier, Amsterdam, London, New York, Tokyo.
- TRÖGER, K.-A., SUMMESBERGER, H. & SKOUMAL, P., 1999. Inoceramidae from the Campanian (Upper Cretaceous) of the Gschlifgraben (Ultraschlieftic; Austria). — Beitr. Paläont. **24**:41–61, 15 text-figs., 4 pls., Wien.
- TZANKOV, V. 1981. Bivalvia — in: TZANKOV, V. (ed.), PAMOUKTCHEV, A., TCHECHMEDJIEVA, V. & MOTEKOVA, N. Les fossiles de Bulgarie, V. Crétacé Supérieur, Grandes Foraminifères, Anthozoaires, Gastéropodes, Bivalvia:73–151., Sofia.
- VOIGT, S., 1996. Paläobiogeographie oberkretazischer Inoceramen und Rudisten. — Ozeanographische und klimatologische Konsequenzen einer neuen Paläogeographie. — Münchner Geowissenschaftliche Abhandlungen. Reihe A, Geologie und Paläontologie, **31**:120, 54 Abb., München.
- WAGREICH, M. & MARSCHALCO, R., 1995. Late Cretaceous to Early Tertiary Palaeogeography of the Western Carpathians (Slovakia) and the Eastern Alps (Austria): implications from heavy mineral data. — Geol. Rdsch. **84**:187–199., Stuttgart.
- WALASZCZYK, I., 1997. Biostratigraphie und Inoceramen des oberen Unter-Campan und unteren Ober-Campan Norddeutschlands. — Geol. u. Paläont. in Westfalen, **49**:111 pp., 21 text-figs., 2 pls., Münster.
- WALASZCZYK, I., COBBAN, W.A. & HARRIES P. J., 2001. Inoceramids and inoceramid biostratigraphy of the Campanian and Maastrichtian of the United States Western Interior Basin. — Revue Paléobiol., **20**(1), Genève.
- WALASZCZYK, I., SMIRNOV, J. P. & TRÖGER, K.-A. 1996. Trochoceramid bivalves (Inoceramidae) from the Lower Maastrichtian (Upper Cretaceous) of Daghestan (Aimaki section, NE Caucasus) and south Central Poland. — Acta Geologica Polonica, **46**,1-2:141–164, 11 figs., 6 pls., Warszawa.
- WARD, P.D. & KENNEDY, W.J. 1993. Maastrichtian ammonites from the Biscay region (France, Spain). — J. Paleont. Soc. Mem., **34**:1–58., Tulsa.
- WARD, P.D., KENNEDY, W.J., MACLEOD, K.G. & MOUNT, J.F., 1991. Ammonite and inoceramid bivalve extinction patterns in Cretaceous/Tertiary boundary sections of the Biscay region (southwestern France, northern Spain). — Geology, **19**:1181–1184, 2 figs., Boulder.
- WOLANSKY, D., 1932. Die Cephalopoden und Lamellibranchiaten der Ober-Kreide Pommerns. — Abh. Geol.-Pal. Inst. Greifswald, H. **IX**:1–72, 5 pls., Greifswald.
- ZEKELI, F., 1852. Das Genus *Inoceramus* und seine Verbreitung in den Gosaugebilden der östlichen Alpen. — Jber. naturw. Verein Halle, **4**(1851):78–105, 1 Taf., Berlin.
- ZITTEL, K.A., 1866. Die Bivalven der Gosaugebilde in den nordöstlichen Alpen. — Denkschr. Kais. Akad. Wiss. math.-nat. Klasse, **25**:194 S., 27 Taf. (105–177, Taf. 1–10, 1. Teil, 1. Hälfte ; 1–122, Taf. 11–27, 1. Teil, 2. Hälfte und 2. Teil), Wien.

PLATE 1

Fig. 1 *Cataceramus* ? *glendivensis* WALASZCZYK et al. (2001), NHMW/2001/z/0125/0011

Fig. 2 Umbonal part of *Inoceramus* sp. aff. *planus* MÜNSTER, NHMW/2001/z/0125/0002

Fig. 3 Umbonal part of *Inoceramus* sp. aff. *planus* MÜNSTER, NHMW/2001/z/0125/0001

Fig. 4 Bivalved umbonal part of *Cataceramus* sp. ex gr. *balticus* (BÖHM), NHMW/2001/z/0125/0013

Fig. 5 Fragment of *Platyceramus salisburgensis* (FUGGER & KASTNER), NHMW/2001/z/0125/0018

Fig. 6 *Spyridoceramus* cf. *tegulatus* (HAGENOW), NHMW/2001/z/0125/0043

All are x 1; all are from the Lower Maastrichtian of Piesting (sports field).

PLATE 1

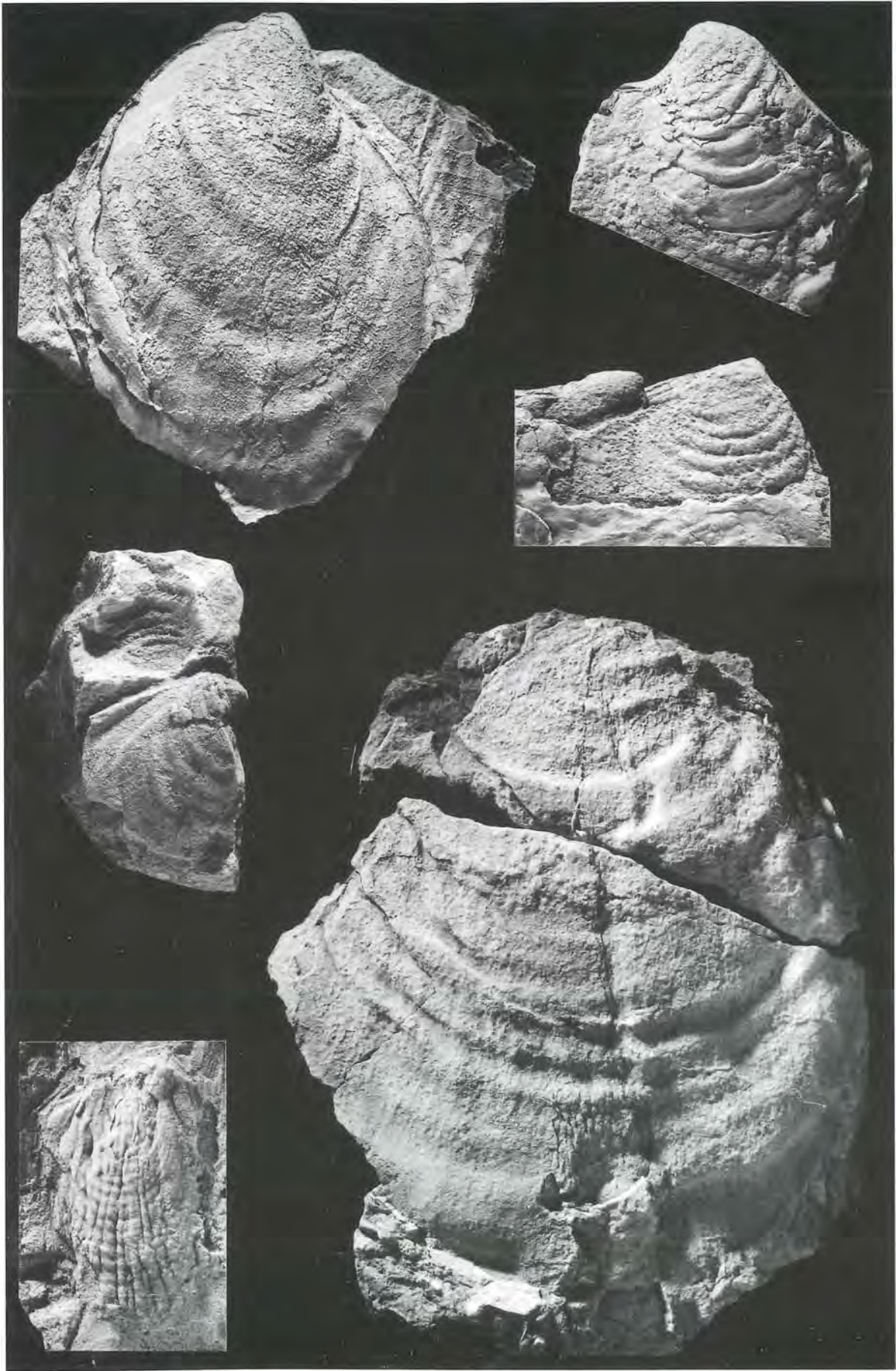


PLATE 2

- Fig. 1 Umbonal part of *Trochoceramus* sp. aff. *monticuli* (FUGGER & KASTNER), NHMW/2001/z/0125/0026; Lower Maastrichtian, Piesting, sports field
- Fig. 2 *Trochoceramus* sp. aff. *monticuli* (FUGGER & KASTNER), NHMW/2001/z/0125/0027; Lower Maastrichtian, Piesting, sports field
- Fig. 3 *Trochoceramus* (?) sp. aff. *dobrovi* (PAVLOVA), NHMW/2001/z/0126/0001; frontal view with crenellated undulations; Upper Campanian, Piesting "Umfahrungsstraße"
- Fig. 4 *Trochoceramus* (?) sp. aff. *dobrovi* (PAVLOVA), NHMW/2001/z/0126/0001; side view with crenellated undulations; Upper Campanian, Piesting "Umfahrungsstraße"
- Fig. 5 *Trochoceramus* cf. *tenuiplicatus* (TZANKOV), NHMW/2001/z/0125/0030; Lower Maastrichtian, Piesting, sports field

All figures are x 1

PLATE 2

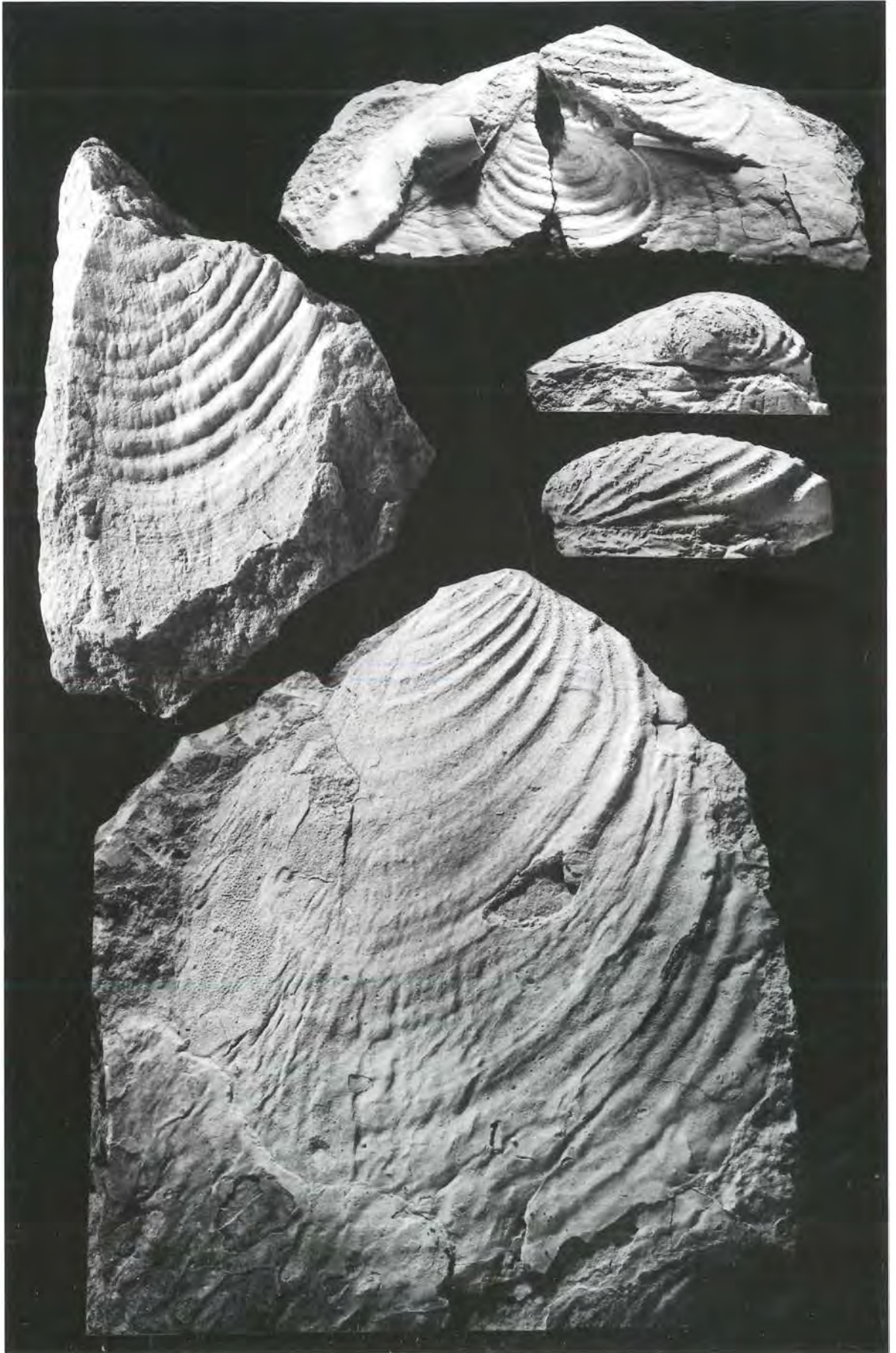


PLATE 3

- Fig. 1 *Trochoceramus* sp. aff. *helveticus* (HEINZ), NHMW/2001/z/0125/0031; x1
Fig. 2 *Spyridoceramus* cf. *tegulatus* (HAGENOW), NHMW/2001/z/0125/0042; x2
Fig. 3 *Trochoceramus* (?) sp. aff. *dobrovi* (PAVLOVA), NHMW/2001/z/0126/0001; x1
Fig. 4 *Trochoceramus* (?) sp. aff. *dobrovi* (PAVLOVA), NHMW/2001/z/0126/0003; x1
Fig. 5 *Trochoceramus* sp. aff. *morgani* (SORNAY), NHMW/2001/z/0126/0002; x1
Fig. 6 *Platyoceramus alaeformis* (ZEKELI), NHMW/2001/z/0125/0023; x1

Figs. 1, 2 and 6 are from the Lower Maastrichtian of Piesting sports field, figs. 3, 4 and 5 are from the Upper Campanian of the roadcutting Umfahungsstraße S Piesting.

PLATE 3

