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Integrated biostratigraphy of the Santonian/Campanian Gosau Group of the Gams Area (Upper Cretaceous; Styria, Austria)

by

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Contents

Abstract

The outcrops Krimpenbach, Wentneralm I and II in the Gosau Group Gams area (Steiermark, Austria; Fig. 1) were sampled and studied for their fossil content and stratigraphic correlation. The Krimpenbach site yielded three inoceramid taxa: *Cordiceramus muelleri* cf. *germanicus* (HEINZ), *Selenoceramus* cf. *inflexus* (BEYENBURG), *Cataceramus balticus* (J. BÖHM) (subsp. indet. and *Cataceramus balticus* cf. *haldemensis* (GIERS) indicating a latest Santonian to earliest Campanian age. This is corroborated by a poor nannoflora indicating a Late Santonian to early Early Campanian age (subzone CC 17b). Wentneralm I yielded inoceramids (four taxa), ammonites (four taxa) and echinoids (three taxa) in a reddish matrix. The age of Wentneralm I with *Hauericeras* cf. *pseudogardeni* (SCHLÜTER), *Pachydiscus (P.)* cf. *launayi*, *Selenoceramus inflexus* (BEYENBURG) and *Sphenoceramus* aff. *angustus* (BEYENBURG) is Early Campanian (*bidorsatum* Zone, *patootensiformis* Zone = inoceramid assemblage Zone 29, CC17–CC19a, *Elevata* Zone). Wentneralm II yielded an inoceramid rich fauna (four taxa), with few ammonites (three taxa) and echinoids (three taxa) in a greenish-grey matrix. *Inoceramus* cf. *bosenbergensis* WALASZCZYK, *Inoceramus planus* MÜNSTER, *Inoceramus* aff. *borilensis* JOLKIČEV, *Cataceramus balticus* cf. *haldemensis* (GIERS) and the ammonites *Pachydiscus (P.) haldemsis* (SCHLÜTER) and *Pachydiscus (P.) tweenianus* (STOLICZKA) indicate a Late Campanian age (*Phaleratum–Polyplocum* Zone, *Vulgaris–Polyplocum* Zone CC19–?CC21, *Elevata-Ventricosa* Zone). A Campanian age for the Wentneralm I and II sections is corroborated by holasteroid and micrasterid echinoids, with records of *Echinocorys* sp. 1, *Echinocorys* sp. 2 (cf. *fonticola* ARNAUD), *Echinocorys* gr. *subglobosa* (GOLDFUSS), *Micraster glyphus* SCHLÜTER and *Micraster* gr. *fastigatus/stolleyi*. However, separation of the latter two species is difficult in the limited material available. Despite these difficulties the assemblage appears to support an Early Campanian age for Wentneralm I and a Late Campanian date for Wentneralm II. The Krimpenbach site yielded no echinoids.

Zusammenfassung

Die Aufschlüsse Krimpenbach, Wentneralm I und II in der Gosau Gruppe von Gams (Steiermark, Österreich) wurden auf ihren Fossilgehalt und ihre stratigraphische Position hin untersucht. Die Fundstelle Krimpenbach lieferte drei Taxa Inoceramen (*Cordiceramus muelleri* cf. *germanicus* (HEINZ), *Selenoceramus* cf. *inflexus* (BEYENBURG), *Cataceramus balticus* (J. BÖHM) subsp. indet. and *Cataceramus balticus* cf. *haldemensis* (GIERS)) aus dem höchsten Santon und basalen Campan in grüngrauer Matrix. Die verarmte Nannoflora weist auf ein Obersanton- bis tiefes Unter-

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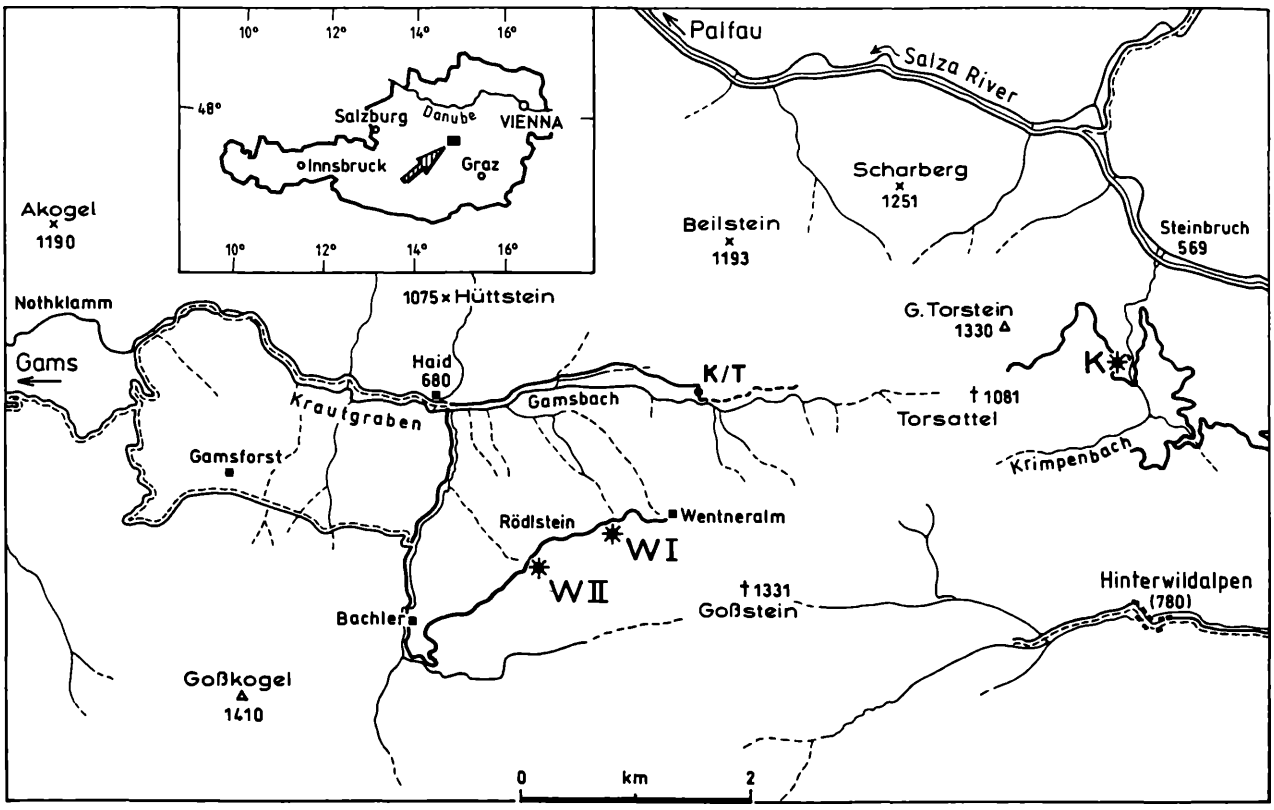


Figure 1: Sketch map of the Gams area with the localities Wentneralm I (W I) and Wentneralm II (W II) and Krimpenbach (K). K/T is the Cretaceous/Palaeogene boundary site of Knappengraben.

campan-Alter (Subzone CC 17b) hin. Wentneralm I enthielt Inoceramen (vier Taxa), Ammoniten (vier Taxa) und Echinoidea (drei Taxa) in einer rötlichen Matrix. Wentneralm I mit *Hauericeras* cf. *pseudogardeni* (SCHLÜTER), *Pachydiscus (P.)* cf. *launayi* und *Selenoceramus inflexus* (BEYENBURG), *Sphenoceramus* aff. *angustus* (BEYENBURG) wird in das untere Untercampan (*Bidorsatum* Zone, *Patootensiformis* Zone = Inoceramen Assemblage Zone 29, CC17–CC19a, *elevata* Zone) eingestuft. Wentneralm II enthielt eine reiche Fauna mit Inoceramen (vier Taxa), Ammoniten (drei Taxa) und Echiniden (drei Taxa) in einer grünlichgrauen Matrix. Mit *Inoceramus* cf. *bosenbergensis* WALASZCZYK, *Inoceramus planus* MÜNSTER, *Inoceramus* aff. *borilensis* JOLKIČEV, *Cataceramus balticus* cf. *haldemensis* (GIERS), *Pachydiscus (P.) tweenianus* (STOLICZKA) und *Pachydiscus (P.) haldemsis* SCHLÜTER) ist Obercampan nachgewiesen (*Phaleratum–Polyplocum* Zone, *Vulgaris–Polyplocum* Zone, CC19–?CC21, *Elevata–Ventricosa*-Zone). Das campane Alter für die Profilabschnitte Wentneralm I und Wentneralm II wird durch holasteroide and micrasteride Echinoidea: *Echinocorys* sp. 1, *Echinocorys* sp. 2 (cf. *fonticola* ARNAUD), *Echinocorys* gr. *subglobosa* (GOLDFUSS), *Micraster glyphus* SCHLÜTER und *Micraster* gr. *fastigatus/stolleyi* gestützt. Trotz der an dem begrenzten Material schwierigen Unterscheidbarkeit der beiden letzten Spezies scheinen die Echinodermenfaunen das untercampane Alter von Wentneralm I und das obercampane Alter von Wentneralm II zu bekräftigen. Die Lokalität Krimpenbach hat keine Echinodermen geliefert.

Introduction

The Gosau Group in the Gams area comprises a Late Turonian to Eocene succession (KOLLMANN 1964; KOLLMANN & SUMMESBERGER 1982; KRISTAN-TOLLMANN & TOLLMANN 1976, SUMMESBERGER & KENNEDY 1996, SUMMESBERGER [in:] SCHULTZ & PAUNOVIĆ 1997). To the south of the Gams area ammonite and inoceramid bearing sediments were found along the forest road from Gamsforst/Bachler to the Wentneralm (Fig. 1). These deposits (Krimpenbach Formation) comprise a southerly neritic facies of the Gams area, subsequently overthrusted towards the northwest onto Eocene turbidites of the basin fill (Zwieselalm Formation). The Late Cretaceous sediments of the Wentneralm area rest unconformably upon Triassic carbonates of the Göller nappe system (lower part of the Aibelmauer slice, KOLLMANN 1964:139) and are overthrusted by Triassic dolomites of the main body of the Aibelmauer slice. Exposures in the Late Cretaceous succession are faulted and tectonically separated due to overthrusting and later strike-slip movements along the Ennstal-Puchberg-Mariazell fault and the Göstling fault (e.g. DECKER et al. 1994, NEMES et al. 1995). A more complete and less deformed neritic succession is known from the Krimpenbach area at the eastern end of the Gams area (KOLLMANN 1964; WAGREICH 1995, Figs. 1, 2).

Field work and collecting was done by WAGREICH and SUMMESBERGER, lithostratigraphy, nanno- and microfossils by WAGREICH, inoceramids by TRÖGER, echinoids by JAGT, ammonites by SUMMESBERGER, who also acted as co-ordinator.

Lithostratigraphy of the Krimpenbach Formation

The Late Cretaceous succession in the Wentneralm and Krimpenbach areas (Fig. 1) starts with red alluvial conglomerates of local origin (Kreuzgraben Formation) passing into a thin interval of grey fan-delta conglomerates and coarse- to medium-grained calcareous sandstones of the Krimpenbach Formation. The coarse-grained part of the succession has a total thickness of up to 50 m. The sandstones contain marine bioclasts (bivalves, red algae, rare foraminifera) and are interpreted as nearshore, storm-influenced and wave-influenced deposits. Large wave ripples were found within these coarse sandstones along the forest road to the west of the Krimpenbach (Fig. 1). No direct biostratigraphic data are available from this succession.
The coarse sandstones normally grade into grey, yellow to red, fine calcareous sandstones to siltstones up to 15 m thick. The fossil site Krimpenbach is situated within this transitional interval from coarse- to fine-grained grey sandstones. Rarely, red calcarenites rest directly upon the Triassic dolomite (e.g. Rödlstein area; Text-fig.1). At the localities Bachler and Krimpenbach layers of rudist shell debris are intercalated, which may be an equivalent to rudist limestones further to the south (Bergstein area; KOLLMANN 1964:101). These bioclastic calcarenites show similarities to fine-grained deposits of the Untersberg Formation southwest of Salzburg (e.g. LEISS, 1988; WAGREICH et al., 1996). The ammonites and inoceramids of locality Wentneralm I were collected from such a red interval. The fauna includes also strongly deformed irregular echinoids. The microfauna is characterized by large agglutinated foraminifera *Lenticulina*, *Gavelinella* and rare planktonic foraminifera. Nannoplankton samples from this interval are very poor. These fine sandstones and siltstones are interpreted as a neritic shelf facies. The high carbon-

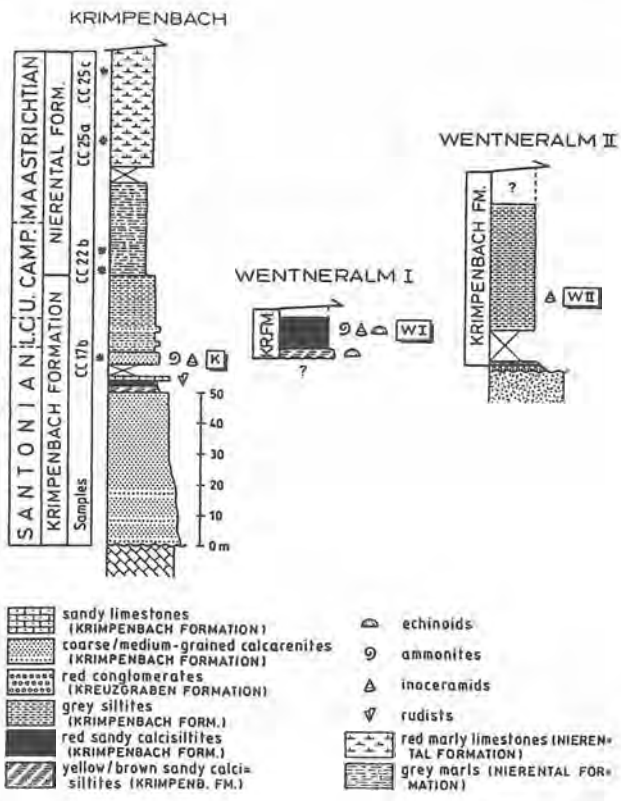


Figure 2: Lithostratigraphic sections of the Late Cretaceous Krimpenbach Formation in the Gams area.

Figure 3: Wentneralm I. View of the outcrop in 1994.

Figure 4:
Wentneralm II. View of the outcrop in 1994.

ate content is a mixture of variable amounts of bioclasts (mostly red algae, echinoderm debris, benthic foraminifera and bryozoans) and a significant terrigenous component, transported into the area by shelf currents with relatively low velocity. Primary stratification was largely destroyed by bioturbation.

Above this red interval, and probably also as a lateral equivalent to it, grey silty to sandy marlstones to marly siltstones are exposed. In the Krimpenbach section they attain a thickness of up to 30 m and are overlain by deep-water marls of the Nierental Formation. In contrast, in the Wentneralm section a second red siltstone interval may be present at the top. Shell layers of inoceramids are a conspicuous feature of the grey marlstone and locality Wentneralm II is situated within this interval. While other macrofossils are very rare, the prominent ichnofauna consists of silicified burrows of *Thalassinoides* and rare large *Zoophycos*, a typical pelagic ichnofossil. The foraminiferal assemblages (p. 171) indicate a deeper, outer neritic depositional environment, based upon the higher diversity of the benthos and higher plankton content. Also the nannoflora (p. 172) is relatively well developed. This grey, outer neritic facies is coeval with the pelagic to deep-water turbiditic Nierental Formation in the "Gams basin" (KOLLMANN 1964:97 ff., WAGREICH & KRENMAYR 1993:72 ff).

Abbreviations

NHMW	Museum of Natural History Vienna
SCHÜ	Ing. Lambert SCHÜSSLER Collection, Leoben
RE	Ruhrland Museum Essen, Germany

Systematic Palaeontology

Phylum Mollusca
Order Ammonoidea ZITTEL 1884
Suborder Ammonitina HYATT 1889
Superfamily Desmoceratacea ZITTEL 1895
Family Desmoceratidae ZITTEL 1895
Subfamily Desmoceratinae ZITTEL 1895

Genus ***Desmophyllites*** SPATH 1929

Type species: *Desmoceras larteti* SEUNES; 1892 by subsequent designation of SPATH (1921).

Desmophyllites sp. indet. juv.
(Pl. 1, Figs. 2, 3)

Material: SCHÜ 71/52 b, a single specimen from Wentneralm I

Description: The minute specimen is deformed into an ellipse (elongate axis 26 mm). The internal mould is preserved in reddish matrix without adherent shell. The specimen is very involute. Due to poor preservation the degree of inflation cannot be observed. With the exception of two constrictions the surface seems to have been smooth.

Discussion: Distortion and small size make identification difficult. Restored shape of the shell and the visible constrictions suggests this specimen to be a juvenile representantative of the genus *Desmophyllites* SPATH.

Occurrence: The known stratigraphical range of the genus (Santonian to Maastrichtian) provides no useful stratigraphical information. Data from associated ammonites and other fossil groups show the site Wentneralm I at Gams to be Early Campanian.

Subfamily Hauericeratinae MATSUMOTO 1938
Genus ***Hauericeras*** DE GROSSOUVRE 1894

Type species *Ammonites pseudogardeni* SCHLÜTER 1872:54, pl. 16, figs. 3–6.

Hauericeras cf. ***pseudogardeni*** (SCHLÜTER 1872)
(Pl. 1, Fig. 1)

Compare

1872 *Ammonites pseudogardeni* SCHLÜTER: 54, pl. 16, figs. 3–6.
1995 *Hauericeras (Hauericeras) pseudogardeni* (SCHLÜTER, 1872); KENNEDY & KAPLAN:18; pls. 1–4; pl. 5, figs. 1, 2 (only); pl. 6, figs. 1, 7; pl. 7, fig. 3 (only) (with synonymy).
1995 *Hauericeras pseudogardeni* (SCHLÜTER, 1872); LOMMERZHEIM: 53; pl. 2, figs. 5, 6 (with additional synonymy).
1997 *Hauericeras (Hauericeras) pseudogardeni* (SCHLÜTER, 1872); KENNEDY & CHRISTENSEN: 85; figs. 5 E, 6.

Lectotype: *Ammonites pseudo-gardeni* SCHLÜTER 1872, pl.16, figs.5,6 by subsequent designation of MATSUMOTO [in:] MATSUMOTO et al. (1990:440).

Material: A single specimen (SCHÜ/71/58) from Wentneralm I in the Gams area.

Description: The specimen is a slightly distorted internal mould of a very large phragmocone, preserved in reddish matrix. The specimen is flattened by post-mortem crushing to a certain degree. A part of the last whorl is restored artificially. The body chamber is absent. The coiling is rather involute, two thirds of the preceding whorl being covered. Due to distortion coiling changes to about 50 % of the preceding whorl on the last portion preserved. The flanks are compressed, the whorl section is lanceolate, the keel is broken away. The umbilicus is shallow, the umbilical wall is steep and apparently has not been vertical originally. The umbilical edge is narrowly rounded. No ribs, tubercles, or constrictions are visible. The absence of constrictions may be due to preservation. Undecipherable fragments of the suture are visible up to the end of the last whorl preserved.

D	Wh	Wb	U	U%
406	165	62	107	26,4

Table 1. Dimensions of *Hauericeras* cf. *pseudogardeni* (SCHLÜTER), SCHÜ 71/58 from Wentneralm I.

Discussion The lectotype of *Hauericeras pseudogardeni* measures 237 mm in diameter. The largest specimen figured by KENNEDY & KAPLAN (1995) had an estimated diameter of 440 mm. The present specimen is even larger, and would have been about 600 mm, inclusive the body chamber. The specimens described by LOMMERZHEIM (1995:53) are much smaller. The absence of constrictions and the difference in size make it difficult to refer SCHÜ 71/58 to one of the high-whorled and apparently closely related species *H. pseudogardeni* (SCHLÜTER), *H. welschi* DE GROSSOUVRE or *H. sulcatum* (KNER). *H. sulcatum* is an Early Maastrichtian species and known from the Ukraine (KENNEDY & SUMMESBERGER 1987:28), Bulgaria (TZANKOV 1982:29) and Poland (BLASZKIEWICZ 1980:41). *H. welschi* occurs in the Santonian (LOMMERZHEIM, 1995:51).

KENNEDY & KAPLAN (1995, p. 18, 20) considered *H. buszi* to be a synonym of *H. pseudogardeni*; however, LOMMERZHEIM (1995:52) treated it as a distinct species ranging from the Santonian to lowest Campanian in the Münster basin (e.g. Olfen, Datteln, Recklinghausen; WEGNER 1905:209).

H. (Gardeniceras) gardeni (BAILY), *H. angustum* (YABE), *H. madagascariense* COLLIGNON, *H. fayoli* DE GROSSOUVRE and *H. rembda* (FORBES) can be distinguished by lower whorl height and wider umbilicus.

Occurrence: The present species was described originally from the Early Campanian of Dülmen (LOMMERZHEIM 1995:54). Co-occurrence with *Placenticeras bidorsatum* (A. ROEMER), *Scaphites binodosus* A. ROEMER (KENNEDY & KAPLAN 1995:20,36, LOMMERZHEIM 1995:54) and the absence of *Marsupites testudinarius* (KENNEDY & KAPLAN 1995:10) confirms the Early Campanian age of the type locality. Data on the the vertical range of *H. pseudogardeni* vary according to the authors. After KENNEDY & KAPLAN 1995 (Fig. 3, p. 20) showed it to range from the Late Santonian *granulata* Zone to the Early Campanian *quadrata* Zone. Contradictory are the authors' statements that *H. pseudogardeni* appears **below** *Marsupites* (p. 20): „an der Basis des Ober-Santon – .... unterhalb der *Marsupites* Total-Range-Zone" and (p. 13): „Ob *Hauericeras (Hauericeras) pseudogardeni* bereits im Ober-Santon einsetzt muß ohne Revision des Originalmaterials fraglich bleiben." LOMMERZHEIM (1995:54) showed *H. pseudogardeni* to appear first a few metres **above** *Marsupites testudinarius* and to be confined to the lower part of the Early Campanian (l.c., Figs. 4–6, 11). Nannostratigraphically the indications given (LOMMERZHEIM 1995) are also contradictory: CC16 in Figs. 5,7 and CC18 in Fig. 10. We provisionally follow the macropalaeontological data based upon several boreholes in the Münsterland basin given by LOMMERZHEIM (l.c.).

Geographical distribution: NW Germany, Sweden and England (MÜLLER & WOLLEMANN 1906; KENNEDY & KAPLAN 1995; LOMMERZHEIM 1995). The occurrence at Gams constitutes the first record from the Tethyan Realm.

Family Pachydiscidae SPATH 1922
Genus Pachydiscus ZITTEL 1884
Subgenus *Pachydiscus* ZITTEL 1884

Type species *Ammonites neubergicus* HAUER 1858:12; pl. 2, figs. 1–4; pl. 3, figs. 1–2, by the subsequent designation of DE GROSSOUVRE 1894:177.

Pachydiscus (Pachydiscus) tweenianus
(STOLICZKA 1865)
(Pl. 2, Fig. 2; Pl. 3, Fig. 1)

Synonymy:

1865 *Ammonites tweenianus* STOLICZKA:107, pl. 55, fig. 1 (only).
1898 *Pachydiscus tweenianus* STOLICZKA; KOSSMAT:102.
1925 *Pachydiscus tweenianus* STOLICZKA; DIENER:109.
1932 *Parapachydiscus twenianus* STOLICZKA (sic!); COLLIGNON:27; pl. 8, figs. 3, 3a.
? 1938 *Pachydiscus* aff. *tweani* STOL. (sic!); COLLIGNON:61; pl. 1, figs. 3, 3a.
1955 *Pachydiscus twenianus* STOLICZKA (sic!); COLLIGNON: 83.
? 1984 *Pachydiscus* cf. *subrobustus* SEUNES; KENNEDY & SUMMESBERGER:161, pl. 8, fig. 4.
1996 *P. (P.) subrobustus* SEUNES; KAPLAN, KENNEDY & ERNST:3 (the discussed specimen from the Gschliefgraben only).

Holotype: by monotypy the original of STOLICZKA 1865:107, pl. 55, fig.1 from the Arialoor group, NW of Arialoor (Tamil Nadu, southern India).

Material: 2 specimens: SCHÜ 71/20, SCHÜ 71/54 from the greenish-grey sand-siltstone of Wentneralm II.

Description Both specimens are internal moulds with corroded surface, preserved in hard siliceous silty to sandy greenish-grey matrix. SCHÜ 71/54 (D 211,7, WH 93,6, U 51,6, U% 24,4) shows a surface partially brownish coloured by a rusty limonitic crust. SCHÜ 71/20 (D 172,9, Wb 45) is partially preserved in dark flint connecting the specimen with the adherent sediment. The specimen is coated by a bright greenish crust. The part of the body-chamber of this specimen is broken and displaced. Coiling is moderately involute, with about 60 percent of the preceding whorl covered. The whorl height increases rapidly possibly exaggerated by lateral compaction. The whorl section appears to have been compressed with convergent inner and outer flanks, maximum breadth being mid-flanks or just below mid-flanks. The umbilicus is shallow with a low vertical to subvertical wall and a gently rounded umbilical shoulder. Ornament consists of about 22–24 distant broad and low primary ribs. They arise without a distinct bulla at the umbilical shoulder passing over the flank in a slight concavity. About midflank one or two intercalated ribs occur. All ribs weaken and finally disappear on the body-chamber, first the intercalated ones, then the primaries. The youngest part of the body-chamber is smooth. All ribs project forward over the venter. No branching of the ribs can be observed.

Discussion: *Pachydiscus tweenianus* (STOLICZKA) is distinguished from all other Campanian Pachydiscidae by its characteristic coarse ribbing, which disappears on the body-chamber.

P. perfidus DE GROSSOUVRE (1894:213; pl. 34, fig. 1) from the Late Campanian is a closely related species which differs in having more distant and coarser ribs, arising from an elongate bulla.

P. haldemsis (SCHLÜTER) (see below), predominantly a Late Campanian species (KENNEDY & SUMMESBERGER 1984; KENNEDY & JAGT 1998), is distinguished by its narrower, somewhat irregular and occasionally branching ribs. It was decribed in detail by KENNEDY & SUMMESBERGER 1984 (p. 158 ff.).

P. subrobustus SEUNES (1892, pl.4, fig.1), another allied Late Campanian species, is distinguished by its narrower, bipartite and tripartite ribs.

P. cf. *subrobustus* SEUNES (KENNEDY & SUMMESBERGER 1984:161, pl. 8, fig. 4) from the Late Campanian of the Gschliefgraben (Austria) is very close in style of ribbing and coiling and might be conspecific with *P. (P.) tweenianus*.

Eupachydiscus levyi (DE GROSSOUVRE (1894:178, pl. 21; pl. 30, fig. 1) is an Early Campanian ally, differing by its more widely spaced primaries arising from a distinct bulla and strengthening with increasing size.

P. launayi DE GROSSOUVRE (1894:184, pl. 19) from the Early Campanian (base de l'assise P^1 "de M.ARNAUD") is stouter and more evolute and has regularly branching ribs which become rursiradiate on the body-chamber.

P. ambiguus DE GROSSOUVRE (1894:198, pl. 29, fig. 3) from the assise P^3, is a microconch of *P. (P.) haldemsis* (SCHLÜTER) (KENNEDY 1986: 45, 50; Text-fig. 11).

P. lundgreni DE GROSSOUVRE (1894:198), (SCHLÜTER 1872:56, pl. 17, figs. 4–7) from the Campanian of NW-Germany differs by its smooth flanks. Ribbing is reduced to the venter.

P. duelmensis SCHLÜTER; (DE GROSSOUVRE 1894:199, pl. 20; 200; KAPLAN & KENNEDY 1995, p. 27, pls. 9–12) from the Early Campanian differs in having a more inflated section, narrower umbilicus and in having a denser and finer ribbing.

P. soyaensis MATSUMOTO & MIYAUCHI from the Campanian of Japan has a narrower umbilicus and more narrowly spaced, finer ribs. *P. sahekii* MATSUMOTO & MIYAUCHI is also distinguished by a narrower umbilicus and more and much more narrowly spaced ribs. A few primary ribs arise from a distinct bulla at the umbilicus. On the adult body-chamber the primaries persist, while intercalated ribs disappear.

E. isculensis (REDTENBACHER) is distinguished by its narrower umbilicus and more inflated flanks and rounded section. It occurs in the Late Santonian of the Austrian Gosau Group (SUMMESBERGER 1979) and has

also been described from the Early Campanian (DE GROSSOUVRE 1894:185,187).

Occurrence: *Pachydiscus tweenianus* is recorded herein from outside India for the first time. Associated *P. haldemsis*, inoceramid bivalves (p. 163), echinoids and nannoflora (CC19 – ?CC21; p. 172) indicate an Late Campanian age. According to poor data it seems to be a Tethyan species.

Pachydiscus (Pachydiscus) haldemsis
(SCHLÜTER 1867)
(Pl. 2, Figs.1, 3)

Synonymy:

1867 *Ammonites haldemsis* SCHLÜTER:19, fig. 1.
1984 *Pachydiscus haldemsis* (SCHLÜTER); KENNEDY & SUMMESBERGER: p. 158; pl. 4, figs. 1–5; pl. 5, fig.1; pl. 6, fig. 2; pl. 7, figs. 1–11; pl. 13, fig. 1; pl. 14, fig. 2 (With synonymy).
1986 *Pachydiscus haldemsis* (SCHLÜTER); KENNEDY:45; pl.4, figs. 1–3; pl. 5, figs. 7–14; text-figs. 11 A–D, F, G; 17 (With additional synonymy).
1996 *Pachydiscus (Pachydiscus) haldemsis* SCHLÜTER; SANTAMARIA ZABALA:7; pl. 1, figs. 1, 4, 5.
1997 *Pachydiscus (Pachydiscus) haldemsis* (SCHLÜTER 1867); KENNEDY & KAPLAN: p. 40, pl. 4, figs. 5-8; pl. 5, fig. 4; pl. 6, figs. 1, 2; pl. 7, figs. 2, 3; pls. 8, 9; pl. 10, figs. 5, 8 (With additional synonymy).
1998 *Pachydiscus (Pachydiscus) haldemsis* (SCHLÜTER); KENNEDY & JAGT:158, pl. 1, figs. 2–4.

Lectotype: The lectotype of *Ammonites haldemsis* designated by KENNEDY & SUMMESBERGER 1984:158 is the original of SCHLÜTER 1867 (pl. 3, fig. 1) from the Late Campanian of Haldem, Westphalia, refigured by KENNEDY & SUMMESBERGER (1984: pl.14, fig. 2)

Material: a single specimen, SCHÜ 71/53 from Gams, Wentneralm II.

Description: The adult specimen is a deformed internal mould slightly elongated to an ellipse. The surface is abraded by tectonic activity and partially coated by a limonitic brown crust. Coiling is moderately involute, with about 60 percent of the preceding whorl covered. The whorl height increases moderately, possibly exaggerated by lateral compaction. The whorl section appears to have been compressed with convergent inner and outer flanks, maximum thickness being mid-flanks. The umbilicus is shallow with a low vertical to subvertical wall and an abruptly rounded umbilical shoulder. Ornament consists of about 25 distant broad and low primary ribs and approximately 40 intercalated ones. The primary ribs arise at or close to the umbilical shoulder, first curve backward and flex forward at mid-flank, projecting forwards again over the venter. The distances between the primaries are slightly irregular becoming larger towards the end of the body-chamber. The short and regularly spaced intercalatories arise close to the ventrolateral shoulder recalling the ventral ribbing of *P. (P.) neubergicus*. The sutur is not visible.

	D	Wh	Wb	U	U%
SCHÜ 71/53	151,5	63,4	—	38,6	25,5

Table 2. Measurements of *Pachydiscus (P.) haldemsis* (SCHLÜTER) from the Late Campanian of Wentneralm II.

Discussion: The present species differs from co-occurring *Pachydiscus (P.) tweenianus* by its finer and more densely spaced, slightly falcoid ribs.

Occurrence: *P. (P.) haldemsis* is a widely distributed species predominantly known from the Northern Temperate Realm (KENNEDY & SUMMESBERGER, 1984:160). The present record is the first from the Tethyan Realm. The stratigraphic range of *P. (P.) koeneni* DE GROSSOUVRE, which according to KENNEDY & SUMMESBERGER (1984) is a synonym of *P. (P.) haldemsis*, is the Late Campanian *Phaleratum* to *Polyplocum* Zones (BLASZKIEWICZ 1980:42, table 1) in the Vistula River valley, where it is best dated. HANCOCK et al. (1993:143, text-fig. 4) showed this to be approximately *Belemnitella minor* Zone and nannozones CC19/CC20. In Belgium it occurs in the Late Campanian Zeven Wegen Member (Gulpen Fm.), together with *Neancyloceras ? phaleratum* (GRIEPENKERL) (KENNEDY & JAGT 1998).

Pachydiscus (Pachydiscus) cf. *launayi*
DE GROSSOUVRE 1894
(Pl. 3, Fig. 2; Pl. 4, Fig. 1; Pl. 5, Fig.1)

Compare:

1894 *Pachydiscus launayi* DE GROSSOUVRE: 184, pl. 19.
? 1955 *Anapachydiscus franciscae* COLLIGNON: 53; pl. 15, figs. 1–3.
1986 *Pachydiscus (Pachydiscus) launayi* DE GROSSOUVRE; KENNEDY:38; pls. 2, figs. 1, 2; pl. 7, figs. 6,7; pl. 10, fig. 15; pl. 13, fig. 2, 3, 6; text-figs. 4C, 5B (With synonymy).
1989 *Pachydiscus (Pachydiscus)* aff. *launayi* DE GROSSOUVRE; JAGT:8; pl. 6, figs. 2–5.
1995 *Pachydiscus (Pachydiscus)* cf. *launayi* DE GROSSOUVRE; WIPPICH:52; pl. 2, figs. 3, 4.
1996 *Pachydiscus (Pachydiscus) launayi* (DE GROSSOUVRE, 1894); SANTAMARIA ZABALA:7; pl.1, fig. 3.
1998 *Pachydiscus (Pachydiscus) launayi* DE GROSSOUVRE; KENNEDY & JAGT:159, pl. 6, figs.1, 2.

Material: 3 large specimens, SCHÜ 71/56, SCHÜ 71/46, NHMW 1997/z127/1 and a large fragment, NHMW 1997/z130/1.

Description: all specimens are internal moulds, preserved in reddish matrix, diagenetically flattened, laterally compacted and distorted (e.g. NHMW 1997/z127/1) by tectonical stressing. This is indicated also by slicken-side striation and calcitic crusts at the surface. Nevertheless observations are still possible and justify a description and tentative interpretation.

Coiling seems to have been moderately involute with rapidly increasing whorl-height and with about 60 or more % of the preceding whorl being covered. The

umbilicus is shallow with oblique umbilical wall and distinct umbilical shoulders. The ornament is preserved in places. Strong and relatively narrowly spaced ribs arise at the umbilical shoulder, are straight or slightly prorsiradiate on the flanks, fading out somewhat in the outer third of the flanks and crossing the venter in a distinct convexity. There is a distinct change of ornament already on the phragmocone: ribs become indistinct undulations or efface almost completely. Partially visible sutures (NHMW 1997/z/127/1) are undecipherable.

Discussion: It seems most likely that the large pachydiscids from the Wentneralm I belong to *Pachydiscus launayi* DE GROSSOUVRE. In view of the poor preservation, open nomenclature is used. They differ from co-occurring *Pachydiscus (Pachydiscus)* sp. indet. juv. in having more distinct and partially rursiradiate ribs and the gently rounded umbilical shoulder of the latter.

Occurrence: *Pachydiscus (Pachydiscus) launayi* DE GROSSOUVRE is definitely an Early Campanian species known from the French Aquitaine basin in Unit C I (NEUMANN & PLATEL 1983:117, tab. 1), or the assises P^1 and P^2 of ARNAUD (KENNEDY 1986:17, table 2), from Madagascar (COLLIGNON 1955:36; pl. 5, figs. 1a-b) and from Liège and Limburg (Belgium) (JAGT 1989, KENNEDY & JAGT 1998). The co-occurrence of *P.(P.)* cf. *launayi* and *H.* cf. *pseudogardeni* is a strong indication that the Wentneralm I site is situated below the first occurrence of *Eupachydiscus levyi* (DE GROSSOUVRE) in the *Gonioteuthis quadrata* Zone sensu BLASZKIEWICZ (1980, table 1) and in unit C II (NEUMANN & PLATEL 1983:117, table 1) in the traditional Early Campanian *Placenticeras bidorsatum* Zone.

	D	Wh	Wb	U	U%
SCHÜ 71/56	291	138,7	52,4	62,8	21,6
SCHÜ 71/46	210,9	85,6	41,7	59,5	28,2
NHMW97/z127/1	170	78	26,5	37	21,7

Table 3. Measurement of *Pachydiscus (P.)* cf. *launayi* DE GROSSOUVRE from the Early Campanian of Wentneralm I. The values of SCHÜ 71/46 and NHMW 1997/z127/1 have been influenced by distortion.

Pachydiscus (Pachydiscus) sp. indet. juv.
(Pl. 4, Fig. 2)

Material: a single specimen, SCHÜ 71/52 a, from Wentneralm I.

Description: SCHÜ 71/52 a is a relatively small internal mould of a phragmocone with partially preserved body-chamber. It is preserved in a reddish matrix without adherent shell. The relatively slender general shape seems to have been slightly exaggerated by lateral compaction. The umbilicus is relatively shallow with an oblique umbilical wall and a gently rounded umbilical shoulder. It has about 30 primary ribs per whorl and 20 intercalated ones at a diameter of 85 mm. The primaries arise at the umbilical shoulder, the intercalatories at about mid flank. The ribs become more widely spaced at the beginning of the body-chamber, being rursiradiate at the smaller diameter and becoming straight towards the final portion.

	D	Wh	Wb	U	U%
SCHÜ 71/52 a	103,6	43	—	28,5	27,5

Table 4. Measurements of *Pachydiscus (P.)* sp. indet. juv. of SCHÜ 71/52 a from Wentneralm I.

Discussion: *Pachydiscus (Pachydiscus)* sp. indet. juv. is very close to *Pachydiscus (Pachydiscus) haldemsis* as described by KENNEDY & SUMMESBERGER (1984), DE GROSSOUVRE (1894; *P. (P.) koeneni*) and BLASZKIEWICZ (1980; *P. (P.) koeneni*). It differs from these in having a flatter umbilical wall, straighter ribs and lower whorl height. Open nomenclature is preferred; other Early Campanian congeners are less close. The material is too poor for the erection of a new species.

Occurrence: A sample taken from the specimen yielded a poor nannoflora (p. 173) indicating nannozones CC17–CC22b, with *Micula* cf. *praemurus* suggesting a Late Santonian to Late Campanian age.

Superfamily Hoplitaceae H. DOUVILLÉ 1890
Family Placenticeratidae HYATT 1900
Genus ***Placenticeras*** MEEK 1876

Placenticeras spec. indet. juv.

Material 1 specimen (NHMW 1997z/0138/1) from the Campanian of Krimpenbach, collected in 1996.

Description: The specimen is a badly worn and elongated inner mould of a juvenile whorl, preserved in greenish-grey sandy to silty matrix. The shape is typical of juveniles of the genus: a high lanceolate whorl section, the umbilical shoulder gently rounded with an oblique umbilical wall. The venter is very narrow and concave. The double keel is entire. The maximum width of the whorl is in the inner third of the flanks. The flanks gently converge towards the venter and apparently were ornamented by delicate falcoid ribs, nearly invisible now by post-diagenetic corrosion. The umbilicus is covered by sediment, which makes it impossible to determine whether there were umbilical tubercles or not. Maximum length of the elongated diameter is 54 mm, width is about 7 mm. No suture is visible.

Discussion Open nomenclature is preferred, since juveniles of the Late Santonian *polyopsis* group or the Early Campanian *milleri-bidorsatum* group are indistinguishable.

Occurrence: Krimpenbach, Steiermark. Co-occurring inoceramids of the *muelleri* group (p. 164)

make a latest Santonian age likely, i.e. *Paraplanum* Zone in ammonite terms.

The Campanian Ammonite Faunas of the Gosau Group in the Gams area

1. Krimpenbach (greenish-grey sediment; Late Santonian):
   Placenticeras spec. indet. juv.
2. Wentneralm I (reddish sediment, Early Campanian):
   Desmophyllites sp. indet. juv.
   Hauericeras cf. *pseudogardeni* (SCHLÜTER 1872)
   Pachydiscus (Pachydiscus) cf. *launayi* DE GROSSOUVRE 1984
   Pachydiscus (Pachydiscus) sp. indet. juv.
3. Wentneralm II (grey sediment, Late Campanian):
   Pachydiscus (Pachydiscus) haldemsis (SCHLÜTER 1867)
   Pachydiscus (Pachydiscus) tweenianus (STOLICZKA 1865)

Palaeogeographic and palaeoecologic conclusion

Wentneralm I indicates palaeogeographical connections with the NW European Cretaceous, *Pachydiscus (Pachydiscus) haldemsis* from Wentneralm II being a widely occurring species in NW Europa and Poland (KENNEDY & SUMMESBERGER 1984) here recorded from the Tethyan Realm for the first time. Its occurrence in the Helvetic unit of the Gschliefgraben as well (KENNEDY & SUMMESBERGER 1984), intermediate between the Northern Temperate and the Tethys Realm, underscores the importance of the Gschliefgraben for palaeogeographical reconstructions.

All ammonites from the Wentneralm are relatively large or very large. There is no known locality in the Campanian of the Gosau Group with comparable faunas or comparable size of the specimens. The mechanism behind the possible selection by transportation are unknown, local environmental conditions possibly responsible for extreme growth are not known either. Echinoids are the only epi/endobenthic dwellers, inoceramids the only bivalve group present. Predominance of the latter two invertebrate groups leads to the assumption that prevailing environmental conditions were close to those of the Gschliefgraben (KENNEDY & SUMMESBERGER, TRÖGER, SUMMESBERGER & SKOUMAL, JAGT, this volume): an open marine environment, relatively deep water, muddy seafloor, precluding the growth/occurrence of a diverse benthic or sessile fauna.

Class Bivalvia
Supraorder Pteriomorphia BEURLEN 1944
Order Pteroidea NEWELL 1965
Family Inoceramidae GIEBEL 1852

Genus ***Cataceramus*** Cox 1969
(ex HEINZ nomen nudum)

Type species *Inoceramus goldfussianus* D'ORBIGNY 1846 (= *Inoceramus balticus* BÖHM 1907)

Cataceramus balticus (BÖHM) subsp. indet.
(Pl. 8, Fig.6 ; Text-fig. 6)

Lectotype: the original of BÖHM (1909: pl. 11, fig. 2) by subsequent designation of GIERS (1964).

Compare

1997 *Cataceramus balticus* (BÖHM); WALASZCZYK: 8; pl. 12, figs. 1, 2, 4, ?5 (With complete synonymy).

Material Internal moulds of two right (NHMW 1997/z/158/3,8) and two left valves (NHMW 1997/z/158/1,12) from Wentneralm I in the Gams area.

Distance from UP	DU A	DU B	DU C
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) in distances from the umbonal pole (UP). A = NHMW 1997/z/158/1, B = NHMW 1997/z/158/3, C = NHMW 1997/z/158/8, all from Wentneralm I.

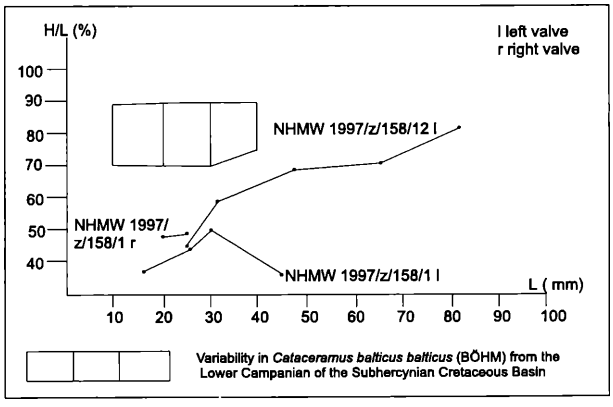


Figure 5: Diagram showing comparison of H/L ratio at *Cataceramus balticus* (BÖHM) subsp. indet. from Wentneralm I with H/L ratio of *C. balticus balticus* (BÖHM) from the Early Campanian of the Subhercynian Cretaceous Basin.

Remarks In shape and H/L-ratios there are distinct differences between *Cataceramus balticus* BÖHM subsp. indet. and *Cataceramus balticus balticus* J. BÖHM including *Cataceramus balticus haldemensis* (GIERS). The shape, development of the umbonal region and the total angle of *Cataceramus balticus marcki* (GIERS) are comparable. In contrast to *Cataceramus balticus* (J. BÖHM) subsp.indet. in *Cataceramus balticus*

marcki (GIERS) the H/L-ratio shows strong increases (170–180).

O c c u r r e n c e : *Cataceramus balticus* was first described (BÖHM 1909) from the Early Campanian Dülmener Schichten. It occurs in the European Northern Temperate Realm. Its occurrence in Romania (LUPU & SORNAY 1978 has recently been confirmed by WALASZCZYK (1997). *C. balticus* occurs in several subspecies (*C. b. balticus* (BÖHM), *C. b. ellipticus* (GIERS), *C. b.* aff. *haldemensis* (GIERS), *C. balticus* (BÖHM) subsp. indet.) in the Campanian of the Austrian Gschliefgraben (TRÖGER et al. 1999). WALASZCZYK (1997) showed *Cataceramus balticus* to range from Early Campanian to the early Late Campanian. *C. b. marcki* (GIERS) ranges from the latest Santonian to the earliest Late Campanian (*Polyplocum* Zone).

Cataceramus balticus cf. ***haldemensis*** (GIERS), 1964
(Pl. 9, Figs. 2, 4, 5; Pl. 10, Fig. 1; Text-fig. 6)

S y n o n y m y : For complete synonymy see WALASZCZYK (1997). Following GIERS (1964) we consider ‚*Inoceramus*' *haldemensis* GIERS to be a representatative of the *Cataceramus balticus* group, unlike WALASZCZYK (1997).

M a t e r i a l : 4 internal moulds of left valves (NHMW 1997/z/159/4, 5,6,13?) and 3 internal moulds of right valves NHMW 1997/z/159/ 8,9,10) from Wentneralm II, Gams area.

P r e s e r v a t i o n : All specimens are incomplete and deformed by compaction (NHMW 1997/z/159/ 4, 8, 9, 10) with radial cracks. Portions of the wing and of the anterior margin are missing in all specimens. NHMW 1997/z/159/5 without beak. All specimens are preserved in a greenish-grey matrix.

D e s c r i p t i o n Medium- to large-sized; inequilateral; shape *C. balticus*-like. Beak not separated from the wing. Anterior margin straight to convex at the umbonal pole. Geniculations with a change of the undulation shape and distance at all specimens. The H/L ratio is comparable with that of the holotype and a population of this species from Libya (see Text-fig.6). Total angles: 95–125° (pin part affected by compaction). Distance of the undulations varies between 2,5–5mm. *Endocostea* scar in specimen NMHW 1997/z/159/8.

R e m a r k s : The specimens from Wentneralm agree with *Cataceramus balticus haldemensis* (GIERS) in general shape, shape of the umbonal pole, H/L ratio and geniculations with a population from Libya. The H/L ratio in the holotype is higher than that in the specimens described (Text-fig.6).

Stratigraphic distribution: *Cataceramus balticus haldemensis* (GIERS) is the index fossil of the *haldemensis* Zone of the Late Campanian (WALASZCZYK 1997).

Geographic distribution: Europe, N Africa

Cataceramus ex gr. ***balticus*** (BÖHM)
(Pl. 7, Figs. 1, 3)

M a t e r i a l : Two badly preserved internal moulds, a single right (NHMW 1997/z/144/3) and a left valve (NHMW 1997/z/144/5) from Krimpenbach.

P r e s e r v a t i o n : The specimens are deformed by compaction and incomplete. Parts of the wings and the central margins are missing.

D e s c r i p t i o n : Mediumsized, inequilateral, shape *balticus*-like.

	1	2
Height (incomplete):	60,0 mm	65,0 mm
Length (incomplete):	60,0 mm	93,5 mm
Hinge line (length):	30,2 mm	38,8 mm
Anterior margin:	10,8 mm	10,4 mm
Total angle:	120°	

Table 6. Measurements of *Cataceramus* ex gr. *balticus*; 1 is NHMW 1997/z/144/3, 2 is NHMW 1997/z/0144/5.

The umbo is slightly bent to the anterior margin. It slightly rises above the hinge line, the beak is not separated from the wing. Hinge line straight. The growth lines are bent to the beak at the wing (125–130°). Growth axis slightly prosocline (25–50° in NHMW 1997/z/144/3. H/L ratio in NHMW 1997/z/144/3 ascending from 70 to 83 %. Undulations toprounded. No „Anwachsschnittreifen" – see *Cordiceramus muelleri germanicus* (HEINZ). A small *Endocostea* scar is visible in NHMW 1997/z/144/3.

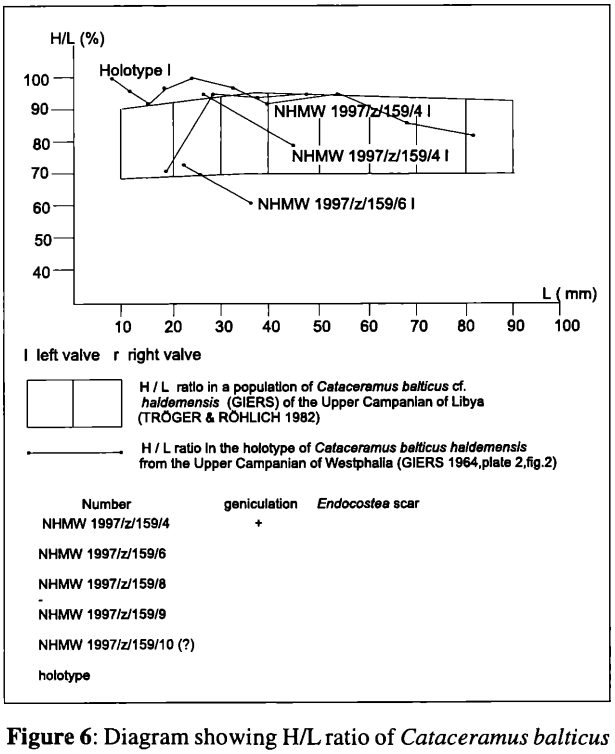


Figure 6: Diagram showing H/L ratio of *Cataceramus balticus* cf. *haldemensis* (GIERS) from Wentneralm II and the presence of geniculations and of *Endocostea* scars.

Distance from UP	DU
10–30 mm	2,41 mm
30–50 mm	3,86 mm
50–70 mm	5,20 mm

Table 7. Average undulation intervals (DU) in different distances from the umbonal pole (UP) ascending in NHMW 1997/z/144/3.

R e m a r k s according to the shape both specimens belong to the *balticus* group. The similar Late Santonian cordiceramids can be excluded by lack of the „Anwachsschnittreifen" But in the Early Campanian *Inoceramus balticus balticus* (J. BÖHM) the H/L-ratio is higher.

Genus ***Endocostea*** WHITFIELD,1877

T y p e s p e c i e s *Inoceramus (Endocostea) typicus* WHITFIELD

Endocostea aff. ***impressa*** (D'ORBIGNY)
(Pl. 8, Figs.1, 2; Text-fig. 7)

S y n o n y m y

1842 *Inoceramus impressus* D'ORBIGNY: 515, pl.409.
* 1957 *Inoceramus impressus* D'ORBIGNY-SORNAY: Paleont. Univers. figs. 4, 5; N.S., no. 129, figs. 1–5.

R e m a r k s According to SORNAY (1957), the lectotype of *Endocostea impressa* D'ORBIGNY is no.7592 A in D'ORBIGNY's Collection (refigured by SORNAY (1957, fig.4) from the Campanian/Maastrichtian boundary.
M a t e r i a l 2 internal moulds of right valves (NHMW 1997/z/158/9,11) from Wentneralm I.
P r e s e r v a t i o n Both specimens are incomplete. Parts of the wing and the ventral margin are missing.
D e s c r i p t i o n Small to medium-sized, inequilateral. Shape elongated arcuate. 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, top-rounded. The undulations are curved to umbonal pole (angle 115–120°). Total angles: 94°, 110°(lectotype 102°).

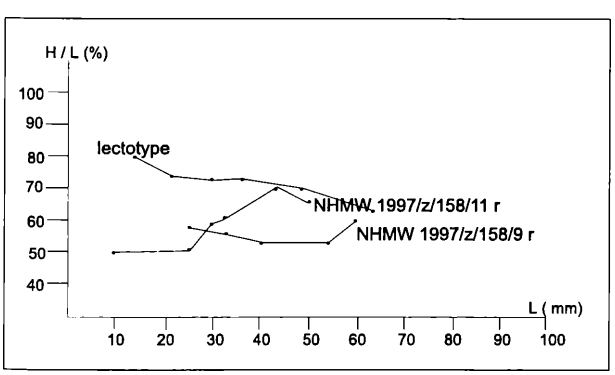


Figure 7: Diagram showing H/L ratio in *Endocostea* aff. *impressa* (D'ORBIGNY) from Wentneralm I. Lectotype: no.7592 A in D'ORBIGNY's collection. r = right valve.

Distance from UP (mm)	DU A	DU B
10–30 mm	3,51 mm	3,60 mm
30–50 mm	———	———

Table 8. Average undulation intervals (DU) in distances from umbonal pole(UP). A = NHMW 1997/z/1958, B = D'ORBIGNY collection no. 7592 A.

Total angle (94–110°, lectotype:102°).

R e m a r k s : The specimens from Wentneralm agree in shape and development of the beak with the lectotype. *Endocostea* scars are absent. The H/L ratio of the Wentneralm specimens differs remarkably from that of the lectotype. It is possible, that they belong to Early Campanian precursors of the *Endocostea impressa* group.

Genus ***Selenoceramus*** HEINZ, 1932

T y p e s p e c i e s *Inoceramus selenae* SEITZ 1967

Selenoceramus inflexus (BEYENBURG)
(Pl. 7, Figs. 2, 4 (cf.); Pl. 8, Figs. 3, 4; Pl. 10, Figs. 2, 3; Text-fig. 8)

S y n o n y m y

1936 *Endocostea inflexa* BEYENBURG: 295, pl. 11, figs. 1–3; pl. 12, figs. 1, 3.
1967 *Inoceramus (Selenoceramus) inflexus* BEYENBURG; SEITZ: 98–101; pl. 12, fig. 5; pl. 19, figs. 3, 4; pl. 20, figs. 1–3; text-figs. 4a, b, 18.

M a t e r i a l Internal moulds of left (NHMW 1997/z/158/2,10) and right valves (NHMW 1997/z/158/5,6,7) from Wentneralm I. Internal moulds of left (cf.-NHMW 1997/z/144/4) and right valves (cf. NHMW 1997/z/144/9) from Krimpenbach.
P r e s e r v a t i o n All specimens are incomplete internal moulds deformed by compaction especially in the umbonal regions. Parts of the wing and the ventral margin are missing.
D e s c r i p t i o n Valve medium-sized, inequilateral. Shape axe like. Anterior margin convex. No anterior auricle. Beak terminal to subterminal, slightly prosogyrate and slightly differentiated from the wing. Geniculations are present. The interval between the undulations (concentric ribs) strongly increases from the geniculation to the ventral margin. The valve is even near the ventral margin in some cases. The undulations are top-rounded.The average undulation intervals fluctuate between 2,0–4,8 mm (mainly 3,0 mm) on the umbonal regions (10–30 mm from UP). Total angle: 95–145° (mainly 120–130°). The trend in of the L/H-ratios (Text-fig.7) agrees with those described by SEITZ (1967) for *Selenoceramus inflexus*.
R e m a r k s *Selenoceramus inflexus* differs from members of the *Cataceramus balticus* group including *Endocostea barabini* (MORTON), which are similiar in shape, particularly by the strong decrease in the H/

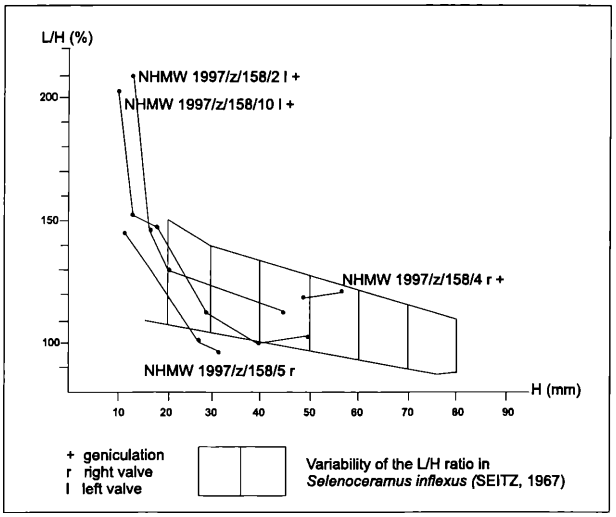


Figure 8: Diagram showing L/H ratio in *Selenoceramus inflexus* (BEYENBURG) from Wentneralm I. + geniculation; r = right valve, l = left valve.

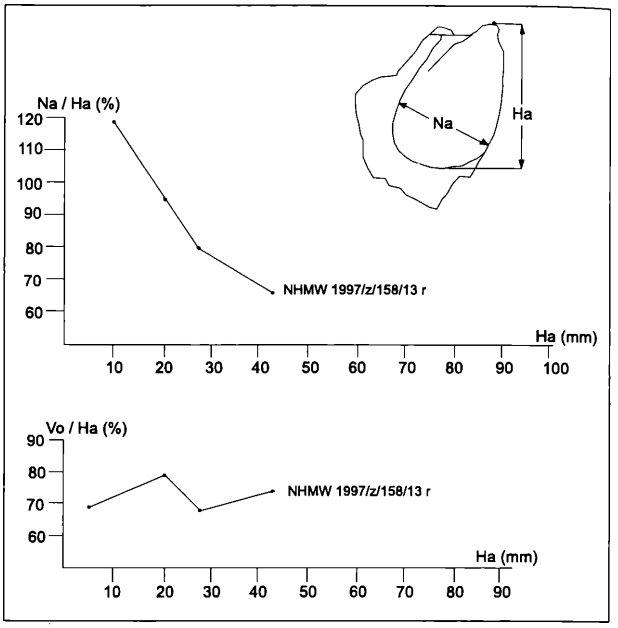


Figure 9: Diagram showing Na/Ha- and Vo/Ha ratio in *Sphenoceramus* aff. *angustus* (BEYENBURG) from Wentneralm I. r = right valve, l = left valve.

L-ratio between H = 10–30 mm and the shape of the cross section.
Stratigraphic distribution: Early Campanian, *patootensiformis* beds (SEITZ 1967).
Geographic distribution: W Europe (Münsterland).

Genus ***Sphenoceramus*** J.BÖHM, 1915

Type species *Inoceramus cardissoides* GOLDFUSS, 1922

Sphenoceramus aff. ***angustus*** (BEYENBURG 1936)
(Pl. 8, Fig. 5; Text-fig. 9)

Remarks For complete synonymy see SEITZ (1965). The lectotype of *Sphenoceramus angustus* is the specimen of *Inoceramus lobatus* MÜNSTER figured by WEGNER (1905:164, text-fig.7).
Material: A single internal mould of a right valve (NHMW 1997/z/158/13) from Wentneralm I.
Preservation: Poorly preserved (without shell) and incomplete. Portions of the wing and the posterior margin are missing. Flattened by compression; radial cracks especially at the anterior margin.
Description: Medium-sized; shape rhomboidal to arcuate; inequilateral. Height (incomplete): 52.5 mm; length (incomplete): 50,8 mm. Total angle deformed by compaction: 110°. Anterior margin convex, completely deformed by compaction. Hinge line straight. Undulations poorly preserved, growth lines not visible. Growth axis prosocline (angles: 53–57°). Average undulation distances:10 mm (30–50 mm from the umbonal pole). For Na/Ha and Vo/Ha ratio see Text-fig. 9.
Remarks Based on shape, a comparison with *Sphenoceramus angustus* is possible. However the absence of the greatest part of the wing precludes a more precise identification.
Stratigraphic distribution: Early Campanian. According to SEITZ (1965) upper portion of the *patootensiformis*-beds.
Geographic distribution: Europe and W Asia (VOIGT 1996)

Genus ***Inoceramus*** J.SOWERBY 1814

Type species: *Inoceramus cuvieri* J. SOWERBY (COX 1969, p. N.315 by subsequent designation of COX (1969:N315).

Inoceramus cf. ***bosenbergensis*** WALASZCZYK 1997
(Pl. 9, Fig. 3; Text-fig. 10)

Holotype is RE A 1438, the original of WALASZCZYK (1997, pl. 27, fig. 1) (Ruhrland Museum, Essen, Germany).
Synonymy: For complete synonymy see WALASZCZYK (1997).
Material: 3 internal moulds of left valves (NHMW 1997/z/159/2,3,7 from Wentneralm II, Gams area.
Preservation: All specimens are incomplete. Portions of the wing, of the posterior margin and the ventral margins are missing. The umbo is not preserved in NHMW 1997/z/159/2. All specimens are slightly deformed by compaction pressure, partly with radial cracks.
Description: Medium-sized, inequilateral, shape subtrapezoidal. Beaks slightly diffentiated from the wing, prosogyrate. Anterior margins straight to concave immediately at the umbonal pole. Geniculation with a change of undulation shape und intervals at H= 52,5 mm (NHMW 1997/z/159/7). The undulations are flexure-like bent at the corner hinge line/posterior

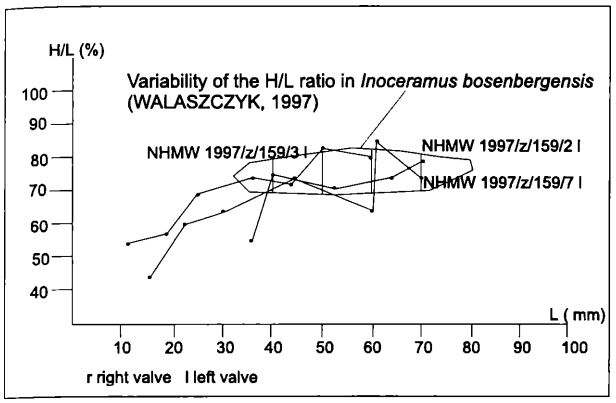


Figure 10: Diagram showing H/L ratio in *Inoceramus* cf. *bosenbergensis* WALASZCZYK from Wentneralm II. r = right valve, l = left valve.

Distances from UP	A	B
10–30 mm	———	3,13 mm
30–50 mm	4,75 mm	4,75 mm

Table 9. Average undulation intervals (DU) in different distances from the umbonal pole (UP). A = NHMW 1979/z/159/2, B = NHMW 1979/z/159/3.

margin at the specimen NHMW 1997/z/159/7. The H/L ratio (see Text-fig.10) is comparable to that of specimens from the type locality Bosenberg in Westphalia. Total angles: 110°, 128°. Growth axis prosocline, slightly bent to the hinge line (40–56°).
Stratigraphic distribution: Late Campanian (*basiplana/stobaei-vulgaris basiplana* Zones) according to WALASZCZYK (1997).
Geographic distribution: W Europe, Westphalia (WALASZCZYK 1997).

Inoceramus planus MÜNSTER 1836
(Pl. 9, Fig. 1; Text-fig. 11)

For synonymy see WALASZCZYK (1997).
Lectotype: Specimen figured by GOLDFUSS (1834–40), pl.113, fig.1b, according to GIERS (1964).
Material: Internal mould of a single right valve (NHMW 1997/z/159/1) from Wentneralm II, Gams area.
Preservation Preserved in a greenish-grey matrix; incomplete. Portions of the anterior margin and of the wing are missing. Flattened by compaction pressure.
Description Medium-sized; inequilateral. Shape subcircular. Beak prosogyrate and slightly divided from the wing. Hingeline straight. Anterior margin convex. Total angle: 130° specimen of GIERS 1964: 130°). Delta increasing from 32° to 50°. Average distance of the undulations between 10–30 from the umbonal pole 2,13 mm (specimen of GIERS 1964: 3,61 mm) and 30–50 mm from the umbonal pole 2,76 mm (specimen of GIERS 1964:4,14 mm). For H/L ratio see

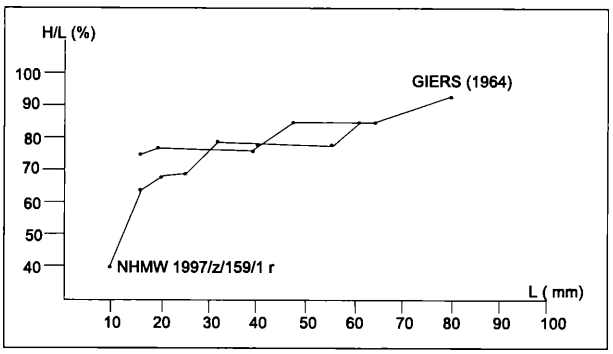


Figure 11: Diagram showing H/L ratio in *Inoceramus planus* MÜNSTER from Wentneralm II compared to GIERS's (1964, table 3, fig. 2) type specimen from the *Polyplocum* Zone of Haldem (Germany). r = right valve.

Text-fig.11. Small geniculation at the anterior margin.
Remarks: The present specimen is comparable to the one figured by GIERS (1964: pl. 3, fig. 2) and WALASZCZYK (1997, pl. 30, fig. 4).
Stratigraphic distribution: Late Campanian (*stobaei/basiplana–polyplocum* Zones).
Paleogeographic distribution: W and E Europe (WALASZCZYK 1997).

Inoceramus aff. *borilensis* JOLKIČEV
(Pl. 10, Fig. 4)

Compare:
1997 *Inoceramus* aff. *borilensis* JOLKIČEV; WALASZCZYK, p. 37; pl. 28, figs. 1–5 (With synonymy).

Material A single internal mould (NHMW 1997/z/159/13) of a poorly preserved left valve from the Wentneralm II.
Preservation: Incomplete. The wing, posterior margin, ventral margin and large portions of the anterior margin are not preserved, thus precluding an exact identification.
Description Tall. Shape of the umbonal region *balticum*-like. The geniculation in the region of the umbo allows a comparison with two specimens of *Inoceramus* aff. *borilensis* JOLKIČEV, described by WALASZCZYK 1997 (pl. 28, figs. 1, 5) from the Vorhelm Schichten (Late Campanian *stobaei/basiplana–vulgaris/basiplana* Zone) of the Münsterland (Germany).

Genus *Cordiceramus* HEINZ 1932

Type species: *Inoceramus cordiformis* SOWERBY 1825

Cordiceramus muelleri cf. *germanicus* (HEINZ)
(Pl. 6, Figs. 1–3; Text-fig. 12)

Synonymy
1928 *Inoceramus germanicus* HEINZ: 82.
1933 *Germanoceramus germanicus* HEINZ; HEINZ: 250, pl. 21, fig. 2.

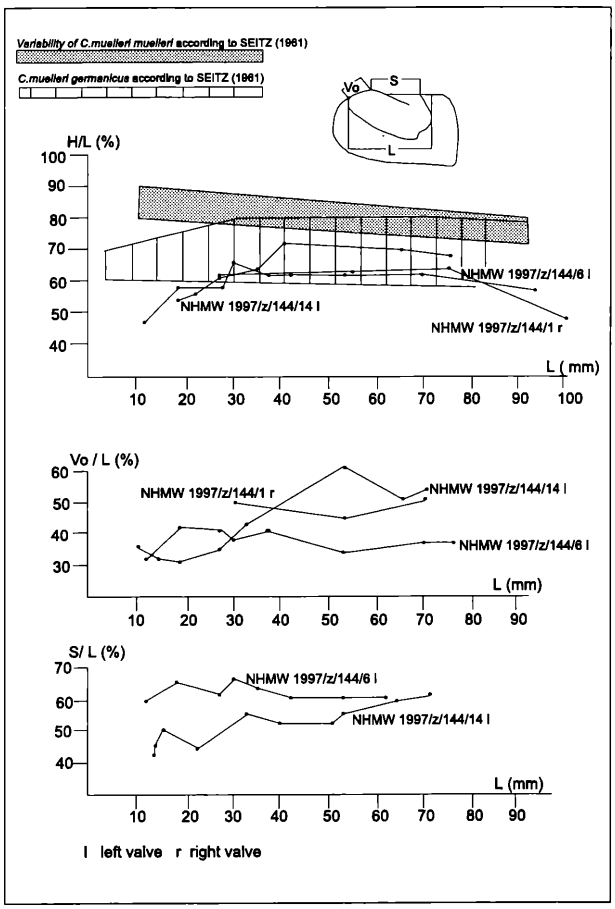


Figure 12: Diagram showing H/L-, S/L and Vo/L ratio in *Cordiceramus muelleri* cf. *germanicus* (HEINZ) from Krimpenbach. r = right valve, l = left valve.

Distance from UP	DU A	DU B	DU C
10–30 mm	2,57 mm	2,75 mm	3,3 mm
30–50 mm	3,92 mm	4,60 mm	6,0 mm
50–70 mm	6,63 mm	———	10,0 mm

Table 10. Average undulation intervals (DU) in different distances from the umbonal pole (UP). A = NHMW 1997/z/144/6, B = NHMW 1997/z/144/14, C = holotype. Total angles: 132–148°.

1961 *Inoceramus (Cordiceramus) mülleri germanicus* HEINZ; SEITZ:131, pl. 7, fig. 6; pl. 8, figs. 1, 6, 7; pl. 15, fig. 1; text-figs. 29, 30.

H o l o t y p e according to SEITZ (1961:131) is Hg.57 in the Museum of Lünen (HEINZ 1933, pl. 21, fig. 2).

M a t e r i a l : 2 internal moulds of left valves (NHMW 1997/z/144/6,14) and one internal mould of a right valve (NHMW 1997/z/144/1) from the Krimpenbach area.

P r e s e r v a t i o n Incomplete. Portions of the wings, of the anterior margins and the ventral margins are missing. The specimens are flattened by compaction.

D e s c r i p t i o n : Medium-sized, inequilateral, shape elongated subtrapezoidal. Beak not separated from the wing. Anterior margin slightly convex to straight. Hinge line straight. Course of the undulations follows the shape. Corners K 1–3 (see SEITZ 1961) rounded. So-called „Diagonalleiste" developed in NHMW 1997/z/144/6 (pl. 6, fig. 3 – arrow). Growth axis prosocline, slightly concave toward hinge line. All growth lines cut the undulation under pointed angles (pl. 6, figs. 1–3). For Na/Ha- and Vo/Ha ratio see Text-fig. 12.

R e m a r k s : The Na/Ha ratio of the present specimens is comparable to that of *Cordiceramus muelleri germanicus* (HEINZ) described by SEITZ (1961) – see Text-fig. 12. In the holotype and specimens figured by SEITZ (1961:134) the average intervals of the undulations in 10–30 mm and 30–50 mm distance from the umbonal pole are larger (Text-fig. 12). Total angles: 132–148°.

Stratigraphic distribution: Late Santonian (SEITZ 1961).
Geographic distribution: W Europe

Biostratigraphic conclusion

The inoceramid assemblages at the three localities are different. Krimpenbach of latest Santonian to earliest Campanian based on the occurrence of *Cordiceramus muelleri* cf. *germanicus* (HEINZ). *Selenoceramus* cf. *inflexus* (BEYENBURG)and *Cataceramus* aff. *balticus* (J. BÖHM) may testify to earliest Campanian age. Wentneralm I of Early Campanian age (*patootensiformis* Zone) is based on co-occurence of sphenoceramids and *Selenoceramus inflexus*. The inoceramid assemblage of Wentneralm II is typical of the Late Campanian interval *agdjakendsis/vorhelmensis - haldemensis* Zones of WALASZCZYK (1997), which correlate approximately with the traditional *vulgaris– polyplocum* Zone.

The three localities yielded the following inoceramid assemblages:

KRIMPENBACH (greenish grey matrix):
Cordiceramus muelleri cf. *germanicus* (HEINZ)
Selenoceramus cf. *inflexus* (BEYENBURG)
Cataceramus aff. *balticus* (J. BÖHM)

WENTNERALM I (reddish matrix):
Selenoceramus inflexus (BEYENBURG)
Sphenoceramus aff. *angustus* (BEYENBURG)
Cataceramus balticus (BÖHM) subsp.indet.
Endocostea aff. *impressa* (D'ORBIGNY)

WENTNERALM II (greenish-grey matrix):
Cataceramus balticus cf. *haldemensis* (GIERS)
Cataceramus sp.
Inoceramus cf. *bosenbergensis* WALASZCZYK
Inoceramus aff. *borilensis* JOLKIČEV
Inoceramus planus MÜNSTER

Echinoidea

The holasteroid genus *Echinocorys* LESKE 1778 and the micrasterid *Micraster* L. AGASSIZ 1836 are amongst the most characteristic irregular echinoid taxa of the boreal/temperate North European Province and the Northern Transitional Subprovince of northern Spain. It has been

shown that their various species can be used to correlate faunal events or migrations within a sequence stratigraphic scheme (ERNST & WOOD 1996). Of *Echinocorys* it has often been claimed that numerous ‚species' (or rather, morphotypes) are good marker fossils for various portions of the European Late Cretaceous (WRIGHT & SMITH 1987; HANCOCK et al. 1993). However, taxonomy still lacks stability and is based mainly on largely typological interpretations of authors (e.g. LAMBERT 1903; SMISER 1935). A modern revision of the various ‚species' groups is called for.

The present material comprises three specimens from the collections of the Naturhistorisches Museum Wien and eleven specimens from the L. SCHÜSSLER Collection (Leoben), which can be assigned to at least six species. These compare fairly well with elements of Early/Late Campanian echinoid faunas from northwest Germany, northeast Belgium and Poland.

Class Echinoidea
Order Holasteroida DURHAM & MELVILLE 1957
Family Echinocoridae LAMBERT 1917

Echinocorys sp. 1
(Pl. 11, Figs. 1, 2)

M a t e r i a l : The SCHÜSSLER collection includes a single internal mould, SCHÜ 71/33, preserved in reddish matrix, from Reitergraben which correlates with Wentneralm I, measuring 82.2 mm in overall length, 75.1 mm in width and 56.5 mm in height.

D i s c u s s i o n : To a certain extent, this specimen resembles a few tests in ‚populations' of *E.* gr. *conoidea* from northeast Belgium. This group is here interpreted on the basis of the type material: two specimens in the GOLDFUSS Collection at the Rheinische Friedrich-Wilhelms-Universität Bonn (registration no.343a, b), one of them preserving the test, the other being an internal flint mould. The test specimen clearly shows the type of preservation seen in ‚populations' from the Lixhe 1 Member (Gulpen Formation) and is thus of Late Maastrichtian age. SMISER (1935), on the other hand, considered *E. conoidea* to be (mostly) of Campanian age (see also KÜCHLER & KUTZ 1989).

There is also a superficial resemblance to some tests usually assigned to the *pyramidata* group (non *pyramidalis* SMISER 1935), which typically is almost symmetrically conical and which appears to characterise the late(st) Campanian and Early (earliest) Maastrichtian throughout NW Europe. ERNST (1972: pl.6, fig.4) recorded a broadly similar, conical form from the Early Campanian (*pilula* Zone) of the Hannover area, but this differs from the Gams area specimen in being better rounded. MACZYNSKA's (1989) illustration of *E. pyramidata* from the Polish Campanian appears closer to the *turrita* group, which according to LAMBERT (1903) is restricted to the earliest *quadrata* Zone (Early Campanian). However, HANCOCK et al. (1993) considered *E. turrita* in southern England to characterise the youngest part of the Early Campanian (i.e. top of *quadrata* Zone), which corresponds to what KÜCHLER & KUTZ (1989) recorded for northern Spain.

The present specimen cannot be confused with representatives of the *conica* group, which in NW Germany (ERNST 1972, 1975; SCHULZ et al. 1984) ranges from the *papillosa* Zone (Early Campanian) to the *conica/mucronata* Zone (late Campanian), with a distinct acme in the upper *gracilis/mucronata* Zone (latest Early Campanian). For the time being, it must remain in open nomenclature.

Echinocorys sp. 2 (cf. ***fonticola*** ARNAUD 1897)
(Pl. 11, Fig. 3)

M a t e r i a l and discussion:Three specimens in the NHMW collections (NHMW 1997/128/1; NHMW 1997/129/1a,b; from Wentneralm I, Gams/ Hieflau (Steiermark), preserved in reddish matrix, are crushed and heavily distorted. Despite this poor state of preservation these specimens can be seen to differ from *Echinocorys* sp. 1 (see above). The least ill-preserved specimen appears to have been large (> 100 mm in length), inflated, rounded and depressed and with a short apical system. This set of features characterises the *fonticola* group, as interpreted by HANCOCK et al. (1993). Those authors recorded typical *E. fonticola* from the Early Campanian of southwest France, and a closely similar form from the earliest *quadrata* Zone (Early Campanian) of southern England.

Because of the poor preservation of the Gams specimens this identification is tentative at best.

Echinocorys gr. ***subglobosa*** (GOLDFUSS 1829)
(Pl. 11, Fig. 5)

1903 *Echinocorys subglobosus*, GOLDFUSS, 1826; LAMBERT: 62, pl. 2, figs. 7, 8.
1935 *Echinocorys subglobosus* GOLDFUSS (*Ananchytes*); SMISER: 15, fig. 3.

M a t e r i a l : The SCHÜSSLER collection includes two specimens, SCHÜ 71/6 [Reitergraben] and SCHÜ 71/38 [Forststraße west Rabenmauer bzw. Rödlsteinsattel], both from greenish- matrix corresponding with Wentneralm II.

D i s c u s s i o n : The smaller specimen (SCHÜ 71/38) measures 86.3 mm in overall length, is fairly well preserved, and closely resembles specimens from the older part of the late Campanian (*conica/mucronata* and *basiplana/spiniger* Zones) in northeast Belgium (see also KÜCHLER & KUTZ 1989 for northern Spain). The other specimen is less well preserved; it measures more than 105 mm in overall length and compares well

with material from NW Germany (especially from the *basiplana/spiniger* Zone). Although depressed, this specimen is close to some forms assigned to *E. ovata* (LESKE 1778) in the literature (e.g. LAMBERT 1903; SMISER 1935), which HANCOCK et al. (1993) recorded from the Early Maastrichtian (? and latest Campanian).
ERNST (1975) recorded the *gibba/marginata* group to range from the middle *lingua/quadrata* to the latest *conica/papillosa* Zones (Early Campanian) in the Hannover area, and *subglobosa* from the lower *papillosa* (Early Campanian) into the *vulgaris/basiplana* (= *roemeri*) Zones, with a distinct maximum in the *stobaei/basiplana* (= *basiplana/spiniger*) Zone (see also CHRISTENSEN et al., 1975; SCHULZ et al., 1984; SCHÖNFELD et al., 1996).
Remarks: The SCHÜSSLER collection includes two more tests, SCHÜ 71/59, labelled: Forststraße vom Rödlstein zur Wentneralm, which equals Wentneralm I and SCHÜ 71/9 from Reitergraben, in grey matrix equalling Wentneralm II, assignable to the genus *Echinocorys*. They are both poorly preserved, one specimen lacking more than half the test, the other being strongly laterally deformed, and cannot be identified to species/group.

Order Spatangoida CLAUS 1876
Suborder Micrasterina FISCHER 1966
Family Micrasteridae LAMBERT 1920

Micraster glyphus SCHLÜTER, 1869
(Pl. 12, Figs. 1,3,5)

1869 *Micraster glyphus* SCHLÜTER: 235, pl. 1, fig. 2.
1970b *Micraster (Micraster) glyphus* SCHLÜTER 1869; ERNST: pl. 17, fig. 4.
1972 *Micraster* m.f. *schroederi/glyphus*; ERNST: pl. 5, fig. 3.
1975 *Micraster glyphus* SCHLÜTER 1869; STOKES:70, fig. 291 (with additional synonymy).

specimen	length	width	height
SCHÜ 71/3	84.8	85.7	29.7
SCHÜ 71/37	93.0	85.3	41.2
SCHÜ 71/57	82.8	84.8	46.7

Table 11. Dimensions of *Micraster glyphus* SCHLÜTER from the Late Campanian of Wentneralm II. Data in mm; all measurements are approximate on account of varying degrees of compaction and distortion).

Material: The SCHÜSSLER collection includes three specimens, SCHÜ 71/3 [Reitergraben], SCHÜ 71/37 [‚aus dem Anstehenden, oberhalb des Reitergraben Wasserfalles'], and SCHÜ 71/57 [westlich Rödelsteinsattel (Forststraße Böschung)], all from the Wentneralm II.
Dimensions (in mm; all measurements are approximate on account of varying degrees of compaction and distortion).
Discussion: The species is here interpreted on the basis of the type material in the SCHLÜTER collection (no. 11a, 11b; Institut für Paläontologie, Rheinische Friedrich-Wilhelms-Universität Bonn), and of the literature (ERNST 1970b, 1972; STOKES 1975). Interestingly, the latter author (STOKES 1975: 71) mentioned a unique specimen from the Gosau Formation of Austria in the J. LAMBERT Collection (Paris) under the name of *Micraster gosaviensis* LAMBERT (a manuscript name ?) which he thought, ‚est vraisemblablement un *M. glyphus*.'
Despite the fact that the present specimens are poorly to moderately preserved, they all show the test features that characterise representatives of the *Micraster schroederi/glyphus* lineage. In size, ambital outline and features of the labrum they compare well with late Campanian ‚populations', in particular from northern Germany, and are here referred to *M. glyphus*.
In the late Cretaceous sections in the Hannover area and in the standard section for the NW German white chalk facies, the *M. schroederi/glyphus* group first appears in the *pilula* Zone (Early Campanian) and ranges at least into the upper *basiplana/spiniger* Zone, perhaps even higher into the late Campanian (ERNST, 1975; SCHULZ et al., 1984; SCHÖNFELD et al., 1996).
There are comparable records of the *schroederi/glyphus* group from the Liège-Limburg basin (Belgium, the Netherlands), where the first representatives occur at the base of the late Campanian Zeven Wegen Member (Gulpen Formation). Small- to medium-sized specimens, including forma *planus* MACZYNSKA 1968 (see also STOKES, 1975), occur throughout this member, which has been shown to be correlatable with the NW German *conica/mucronata*, *basiplana/ spiniger* and *roemeri* Zones, and *phaleratum* Zone in ammonite terms (KENNEDY & JAGT 1998). The group appears to range into the latest Campanian (‚*langei*' Zone) Beutenaken Member (Gulpen Formation) of this area.

Micraster gr. ***fastigatus/stolleyi***
(Pl. 11, Figs. 4, 6; Pl. 12, Figs. 2, 4, 6)

1970b *Micraster (Gibbaster) gibbus* (LAMARCK 1816); ERNST: pl. 18, fig. 5.
1970b *Micraster (Isomicraster) stolleyi* LAMBERT 1901; ERNST: pl. 18, figs. 6, 7.
1970c *Micraster (Isomicraster) stolleyi* LAMBERT; ERNST: pl. 5, figs. 7, 8.
1972 *Micraster (Gibbaster) gibbus* (LAMARCK); ERNST: pl. 2, fig 7; pl. 4, fig. 5.
1972 *Micraster (Isomicraster) stolleyi* LAMBERT; ERNST: pl. 2, fig. 8; pl. 4, fig. 6.
1975 *Micraster fastigatus* Gauthier 1887; STOKES:69, fig. 29j, pl.4, figs.7–9; pl. 5, figs 1, 2 (with additional synonymy).
1975 *Micraster stolleyi* LAMBERT 1901; STOKES:79, fig. 30f (with additional synonymy).

Material: The SCHÜSSLER collection includes three

specimen	length	width	height
SCHÜ 71/15	63.2	65.2	41.9
SCHÜ 71/47	63.1	64.6	47.8
SCHÜ 71/60	56.4	62.9	40.4

Table 12. Dimensions of *Micraster* gr. *fastigatus/stolleyi* from Wentneralm (I, II); in mm; all approximate.

specimens, SCHÜ 71/47 [zwischen Rödlstein Sattel und Wentner-Alm (aus dem Anstehenden), Forststraße Böschung], SCHÜ 71/60 [zwischen Rödlsteinsattel und Wentner-Alm (aus dem Anstehenden), Forststraße Böschung) and SCHÜ 71/15 [Reitnergraben]. The first two specimens are from Wentneralm I, the last-named is from Wentneralm II.

Discussion: In the literature it has been pointed out that the distinction between *M. fastigatus* and *M. stolleyi* can occasionally be difficult, which holds true for the present specimens as well.

STOKES (1975) is followed here in the interpretation of both species; he demonstrated that his *Micraster fastigatus* was the same species as *M. gibbus* of German authors (ERNST 1970a–c, 1972, 1975). The true *Micraster gibbus* is a Coniacian-Santonian species (STOKES 1975, 1976, 1977; FOURAY 1981), which appears to be restricted to the Anglo-Paris province. Typical *M. fastigatus* have an anal fasciole, which, however, is often diffuse or poorly developed, and differ from *M. stolleyi* by a more convex upper side and periproct situated at 35–55% of total test height. Typical *M. stolleyi* have periproct situated at 25–45% of total test height, and the anal fasciole is generally missing. STOKES (1975) remarked that, as evolved specimens of *M. fastigatus* are difficult to distinguish from early representatives of *M. stolleyi*, the former is more or less arbitrarily considered to be of early Campanian, and the latter of late Campanian age. KÜCHLER & KUTZ's (1989) record of, *M. (Isomicraster)* aff. *stolleyi*' from the latest Campanian of northern Spain appears to be one of the youngest representatives of this group.

The Gams area specimens are comparatively large in comparison with ‚populations' from the Hannover area (Germany; FRERICHS 1989), and in this respect are closer to Polish material (MACZYNSKA 1968). Of the two specimens from Wentneralm I, SCHÜ 71/60 is comparatively well preserved. In the absence of an anal fasciole, and in having a markedly smaller anal angle, this specimen differs from most of the specimens of *M. fastigatus* from the Hannover area, and is closer to *M. stolleyi* from the same area. On the other hand, the posterior portion of the labrum is narrow, as are the sternal plates, and these characters compare more favourably with *M. fastigatus* than with *M. stolleyi*. The Wentneralm II specimen (SCHÜ 71/15) shows a wide labrum and wide sternal plates, lacks an anal fasciole and closely matches the larger specimens in ‚populations' of *M. stolleyi* from the Hannover area.

As the Wentneralm I specimens cannot be confidently assigned to either *M. fastigatus* or *M. stolleyi*, they are here, together with the Wentneralm II specimen, referred to as *M.* gr. *fastigatus/stolleyi*.

CHRISTENSEN et al. (1975), who revised the definition of the important coleoid cephalopod taxon *Belemnitella m. mucronata* (VON SCHLOTHEIM 1813) from the Late Campanian, listed *M. stolleyi* amongst the other macrofossil taxa from that part of the German, unteres Obercampan'. It falls within the *Hoplitoplacenticeras vari* Zone, and the scaphitid *Trachyscaphites spiniger*, one of the characteristic zonal species, allows trans-Atlantic correlations.

In the Liège-Limburg basin (NE Belgium, SE Netherlands), *M. stolleyi* ranges from the *basiplana/spiniger* to equivalents of the *roemeri* Zone (JAGT in prep.). Amongst the ammonite species recorded from the late Campanian Zeven Wegen Member (Gulpen Formation) are *Pachydiscus haldemsis* (SCHLÜTER 1867) and *Neancyloceras ? phaleratum* (GRIEPENKERL 1889) (KENNEDY & JAGT 1998), documenting the *phaleratum* Zone. The Vaals Formation in northeast Belgium, which is Early (but not earliest) Campanian in ammonite terms, has yielded, amongst other species, *Pachydiscus launayi* DE GROSSOUVRE, 1894. However, it has not yielded any representatives of the genus *Micraster*, but the externally similar brissid genus *Diplodetus* (STOKES 1979) is represented.

Conclusions

For Wentneralm I an Early Campanian age is favoured on the basis of *Echinocorys* sp. 2 (cf. *fonticola*) and *Micraster fastigatus*, whereas *E.* gr. *subglobosa*, *M. glyphus* and *M. stolleyi* suggest a middle Late Campanian age for Wentneralm II.

WENTNERALM I (reddish matrix)
Echinocorys sp. 1
Echinocorys sp. 2 (cf. *fonticola* ARNAUD 1897)
Micraster gr. *fastigatus/stolleyi*

WENTNERALM II (greenish-grey matrix)
Echinocorys gr. *subglobosa* (GOLDFUSS, 1829)
Micraster glyphus SCHLÜTER, 1869
Micraster gr. *fastigatus/stolleyi*

KRIMPENBACH (greenish-grey matrix)
no echinoids

Foraminifera

Krimpenbach
no data concerning foraminifera

Wentneralm I (red siltstones)

Data on foraminifera from the red siltstones stem from a few thinsections only. Sample GAM 230 from the base of the Rödlstein section yielded the following planktonic marker species:

Globotruncana cf. *arca* (CUSHMAN)

Globotruncana linneiana (D'ORBIGNY)
Globotruncanita cf. *elevata* (BROTZEN)
Globotruncanita stuartiformis (DALBIEZ)
Rosita fornicata (PLUMMER)

R. fornicata and *G. linneiana* both first occur in the (Late) Santonian to Early Campanian, whereas the FO of *G. elevata* and *G. stuartiformis* marks a level near the base of the Campanian (ROBASZYNSKI et al. 1984; GALE et al. 1995). This assemblage is indicative for the *Elevata* Zone of the Early Campanian in terms of planktonic foraminiferal zonations (e.g. ROBASZYNSKI et al. 1984; CARON 1985). A Late Santonian to early Early Campanian age is very unlikely based on the absence of *Dicarinella concavata/asymetrica*, although it cannot be excluded in view of the limited number of thin sections studied.

The integration of foraminiferal data of KOLLMANN (1964) from a larger sample area around the Wentneralm indicates a wider age range for red siltstones to marlstones. Samples 1026 and 1030 contained *G. elevata* only and are consistent with the results above. On the other hand, samples 1010 and 1024 yielded a rich planktonic microfauna:

Globotruncana arca (CUSHMAN)
Globotruncana ventricosa WHITE
Globotruncana linneiana (D'ORBIGNY)
Globotruncanita cf. *elevata* (BROTZEN)
Globotruncanita subspinosa (PESSAGNO)
Globotruncanita stuartiformis (DALBIEZ)
Rugoglobigerina cf. *rotunda* (BRÖNNIMANN)
Ventilabrella glabrata CUSHMAN

This assemblage with *G. ventricosa*, *G. subspinosa* and *R.* cf. *rotunda* can be assigned to the upper part of the *Ventricosa* Zone of the „Middle Campanian", below the *Calcarata* Zone (e.g. ROBASZYNSKI et al. 1984; CARON 1985). These samples therefore document the presence of a considerably younger red siltstone facies than that documented from locality Wentneralm I.

Wentneralm II (grey siltstones)

One sample (GAM 183) from the grey interval, taken near the inoceramid locality Wentneralm I, yielded a relatively rich microfauna, including important planktonic and benthic marker species:

Archaeoglobigerina blowi (PESSAGNO)
Globotruncana linneiana (D'ORBIGNY)
Globotruncanita stuartiformis (DALBIEZ)
Rosita fornicata (PLUMMER)
Rosita patelliformis (GANDOLFI)
Bolivinoides decoratus (JONES)
Bolivinoides cf. *draco miliaris* HILTERMANN & KOCH

R. fornicata and *G. linneiana* both first occur in the (Late) Santonian to Early Campanian, whereas the FO of *G. stuartiformis* marks a level near the base of the Campanian (ROBASZYNSKI et al. 1984). The FO of *R. patelliformis* is relatively weakly defined, but normally indicates assemblages clearly above the base of the Campanian (ROBASZYNSKI et al. 1984). The *Bolivinoides* lineage, including *B. decoratus*, documents a Campanian age (KOCH 1977). *B.* cf. *draco miliaris* even indicates late Late Campanian to Early Maastrichtian based on correlations with the Lägerdorf section in northern Germany (SCHÖNFELD 1988: *Polyplocum* to *Langei* Zones), but only a single small specimen was found, which might represent an earlier morphotype of this species.

Several samples taken from KOLLMANN (1964) have been re-evaluated during this study. Samples 1027 and 1190 from grey marlstones yielded the marker species:

Globotruncana arca (CUSHMAN)
Globotruncana linneiana (D'ORBIGNY)
Globotruncana linneiana obliqua HERM
Globotruncanita cf. *elevata* (BROTZEN)
Globotruncanita stuartiformis (DALBIEZ)
Rosita fornicata (PLUMMER)
Stensioeina pommerana BROTZEN

These samples again indicate the *Elevata* Zone of the Early Campanian in terms of planktonic foraminiferal zonations (e.g. ROBASZYNSKI et al. 1984; CARON 1985), where *G. ventricosa* marks the base of the Middle Campanian. Also the benthic foraminifer *St. pommerana* starts in the latest Santonian and is typical of the Campanian. A Late Santonian to early Early Campanian age can be excluded by the absence of *Dicarinella concavata/asymetrica*.

The other samples (1049, 1065, 1189) appear to indicate a higher level because of the presence of *G. ventricosa* and *B. draco miliaris* together with the above-mentioned foraminifera. The FO of *G. ventricosa* defines the base of the *Ventricosa*-Zone (e.g. CARON, 1985), for which a „Middle Campanian" age may be assumed following the suggestions of the Subcommisssion on Cretaceous Stratigraphy (LAMOLDA, 1995).

Based on foraminiferal assemblages the total possible stratigraphical range of the grey siltstones to silty marls is late Early Campanian to Early Maastrichtian.

Calcareous Nannofossils

Krimpenbach

Only one of four nannofossil samples from the Krimpenbach locality contained calcareous nannofossils. Although the assemblage is poor and only moderately preserved, it can be dated according to standard nannofossil zonations for the Late Cretaceous (important species marked with *).

NHM KRIMP 1997/144/3

Arkhangelskiella sp. (small forms)
* *Calculites obscurus* (DEFLANDRE 1959) PRINS & SISSINGH 1977
Calculites ovalis (STRADNER 1963) PRINS & SISSINGH 1977

Chiastozygus litterarius (GORKA 1957) MANIVIT 1971
Cretarhabdus crenulatus BRAMLETTE & MARTINI 1964
Cribrosphaerella ehrenbergii (ARKHANGELSKY 1912) DEFLANDRE 1952
Cylindralithus sp.
Eprolithus sp.
Eiffellithus eximius (STOVER 1966) PERCH-NIELSEN 1968
Eiffellithus turriseiffelii (DEFLANDRE & FERT 1954) REINHARDT 1965
Glaukolithus diplogrammus (DEFLANDRE 1954) REINHARDT 1964
Lucianorhabdus cayeuxii DEFLANDRE 1959
* *Lucianorhabdus cayeuxii* DEFLANDRE 1959 (ssp. B)
Lucianorhabdus maleformis REINHARDT 1966
Micula decussata VEKSHINA 1959
Prediscosphaera cretacea (ARKHANGELSKY 1912) GARTNER 1968
Reinhardtites sp.
Tranolithus orionatus (REINHARDT 1966) PERCH-NIELSEN 1968
Watznaueria barnesae (BLACK 1959) PERCH-NIELSEN 1968

The biostratigraphic interpretation of this sample indicates a Late Santonian to early Early Campanian age. The marker species of nannofossil standard zone CC 17 (SISSINGH 1977; PERCH-NIELSEN 1985), *C. obscurus* is present together with curved *Lucianorhabdus cayeuxii*, defining subzone CC 17b (WAGREICH 1992). Additional indicators of a Santonian – Early Campanian age are *Eprolithus* sp., *Lucianorhabdus maleformis*, and *Reinhardtites* sp., which are very rare or absent in Late Campanian samples from the Gosau Group (WAGREICH 1988, 1992; WAGREICH & KRENMAYR 1993). According to the zonations by BURNETT (1998) the sample has a wider age range from UC11c to UC12 (Late Coniacian to early Early Campanian).

Wentneralm I (red siltstones)

Nannofossil samples taken from the red siltstones and samples taken from ammonite individuals of fauna Wentneralm I yielded very poor results. Only a single sample taken from *Pachydiscus (P.)* sp. indet. juv. (SCHÜ 71/52, pl. 4, fig. 2) contained a significant nannofossil assemblage.

Calculites obscurus (DEFLANDRE 1959) PRINS & SISSINGH 1977
Calculites ovalis (STRADNER 1963) PRINS & SISSINGH 1977
Cretarhabdus crenulatus BRAMLETTE & MARTINI 1964
Eiffellithus eximius (STOVER 1966) PERCH-NIELSEN 1968
Lucianorhabdus cayeuxii DEFLANDRE 1959
Micula decussata VEKSHINA 1959
Micula cf. *praemurus* (BUKRY 1973) STRADNER & STEINMETZ 1984
Prediscosphaera cretacea (ARKHANGELSKY 1912) GARTNER 1968
Watznaueria barnesae (BLACK 1959) PERCH-NIELSEN 1968

The biostratigraphic interpretation of this poor nannofossil assemblage indicates a Campanian age. In terms of the standard nannofossil zonation (SISSINGH 1977; PERCH-NIELSEN 1985) CC17 (FO of *C. obscurus*, Late Santonian) up to CC22b (LO of E. *eximius*, Late Campanian) are possible. *M.* cf. *praemurus* is common from CC21 onwards in the Nierental Formation of the „Gams basin" (WAGREICH & KRENMAYR 1993), but only one poorly preserved specimen was found.

Wentneralm II (grey siltstones)

Nannofossils in samples from the grey siltstones are not abundant, but assemblages were rich enough for biostratigraphic interpretations. Nannofossil assemblages from two representative samples are given here: Sample GAM 183 was taken from a marly layer in the lower outcrop area below the Rödlstein (contained also a significant microfauna, see above) and sample GAM 123 (important species marked with *):

GAM 183

* *Arkhangelskiella cymbiformis* VEKSHINA 1959
Biscutum constans (GORKA 1957) BLACK 1959
Biscutum sp.
* *Broinsonia parca constricta* HATTNER, WIND & WISE 1980
* *Broinsonia parca parca* (STRADNER 1963) BUKRY 1969
* *Calculites obscurus* (DEFLANDRE 1959) PRINS & SISSINGH 1977
Chiastozygus litterarius (GORKA 1957) MANIVIT 1971
Cretarhabdus crenulatus BRAMLETTE & MARTINI 1964
Cribrosphaerella ehrenbergii (ARKHANGELSKY 1912) DEFLANDRE 1952
* *Eiffellithus eximius* (STOVER 1966) PERCH-NIELSEN 1968
Eiffellithus turriseiffelii (DEFLANDRE & FERT 1954) REINHARDT 1965
Gartnerago obliquum (STRADNER 1963) NOEL 1970
Helicolithus trabeculatus (GORKA 1957) VERBEEK 1977
Glaukolithus diplogrammus (DEFLANDRE 1954) REINHARDT 1964
Glaukolithus spiralis BRAMLETTE & MARTINI 1964
Lucianorhabdus cayeuxii DEFLANDRE 1959 (A)
Lithraphidites carniolensis carniolensis DEFLANDRE 1963
Manivitella pemmatoidea (DEFLANDRE in MANIVIT 1965) THIERSTEIN 1971
Micula decussata VEKSHINA 1959
Ottavianus giannus RISATTI 1973
Prediscosphaera cretacea (ARKHANGELSKY 1912) GARTNER 1968

* *Quadrum* aff. *gartneri* PRINS & PERCH-NIELSEN in MANIVIT et al. 1977 (small morphotype)
Russellia multiplus (PERCH-NIELSEN 1973) WIND & WISE 1977
Tranolithus phacelosus STOVER 1966
Vekshinella stradneri ROOD et al. 1971
Watznaueria barnesae (BLACK 1959) PERCH-NIELSEN 1968
Zeugrhabdotus embergeri (NOEL 1959) PERCH-NIELSEN 1984

GAM 123

* *Arkhangelskiella cymbiformis* VEKSHINA 1959
Bipodorhabdus cf. *brooksi* (BUKRY 1969) CRUX 1982
Biscutum constans (GORKA 1957) BLACK 1959
Braarudosphaera bigelowi (GRAN & BRAARUD 1935) DEFLANDRE 1959
* *Broinsonia parca constricta* HATTNER, WIND & WISE 1980
* *Broinsonia parca parca* (STRADNER 1963) BUKRY 1969
Calculites obscurus (DEFLANDRE 1959) PRINS & SISSINGH 1977
* *Ceratolithoides aculeus* (STRADNER 1961) PRINS & SISSINGH in SISSINGH 1977
Cretarhabdus crenulatus BRAMLETTE & MARTINI 1964
* *Eiffellithus eximius* (STOVER 1966) PERCH-NIELSEN 1968
Eiffellithus turriseiffelii (DEFLANDRE & FERT 1954) REINHARDT 1965
Glaukolithus diplogrammus (DEFLANDRE 1954) REINHARDT 1964
Glaukolithus spiralis BRAMLETTE & MARTINI 1964
Helicolithus trabeculatus (GORKA 1957) VERBEEK 1977
Lucianorhabdus cayeuxii DEFLANDRE 1959
Lucianorhabdus cayeuxii DEFLANDRE 1959 (ssp. B - curved morphotype)
Lithraphidites carniolensis carniolensis DEFLANDRE 1963
* *Lucianorhabdus maleformis* REINHARDT 1966
Micula decussata VEKSHINA 1959
Prediscosphaera cretacea (ARKHANGELSKY 1912) GARTNER 1968
Quadrum aff. *gartneri* PRINS & PERCH-NIELSEN in MANIVIT et al. 1977 (small morphotype)
Quadrum cf. *gothicum* (DEFLANDRE 1959) PRINS & PERCH-NIELSEN in MANIVIT et al. 1977
Rucinolithus sp. (8 rays)
Vekshinella stradneri ROOD et al. 1971
Watznaueria barnesae (BLACK 1959) PERCH-NIELSEN 1968
Zeugrhabdotus embergeri (NOEL 1959) PERCH-NIELSEN 1984

Sample GAM 183 may be assigned to nannofossil zone CC19, probably zone CC19b based on PERCH-NIELSEN's zonation (1985). The presence of *B. parca parca*, *B. parca constricta* and large *A. cymbiformis* (10 (μ) and the absence of *Marthasterites furcatus* (LO on top of zone CC19a) and *C. aculeus* (FO base of zone CC20) indicates an Early Campanian age (e.g. SISSINGH 1977).

Sample GAM 123 additionally contains the marker species *C. aculeus* and therefore indicates nannofossil zone CC20. Zone CC21 cannot be excluded, although the marker species for the base of CC21, *Quadrum sissinghi* is not present. The abundance of nannofossils in the samples is low, therefore this rare species may have been overlooked.

Biostratigraphical conclusions

Late Santonian/Early Campanian age of the Krimpenbach Formation at the Krimpenbach locality, dated by nannofossils and inoceramids, leads to the conclusion, that the base of the Krimpenbach Formation must be older than Late Santonian. Microfaunal and nannofossil data for the red sandstones to siltstones of locality Wentneralm I are scarce. Rare planktonic foraminifera indicate the *Elevata* Zone of the Early Campanian (ROBASZYNSKI et al. 1984; GALE et al. 1995). The poor nannofossil assemblage is in accordance with these data. Based on data from the overlying grey siltstones, the red siltstones of locality Wentneralm I most prob-

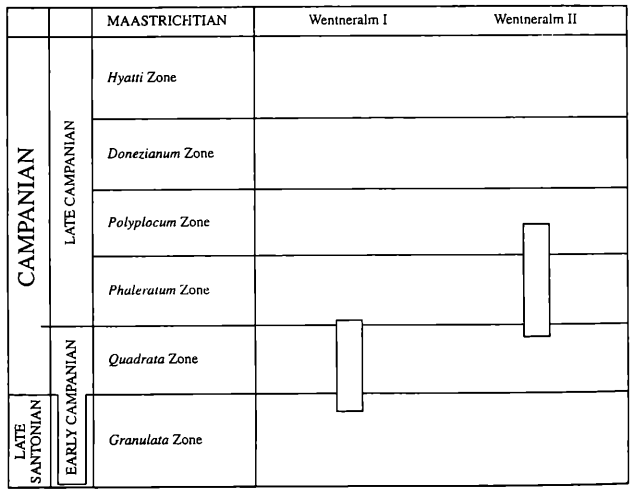
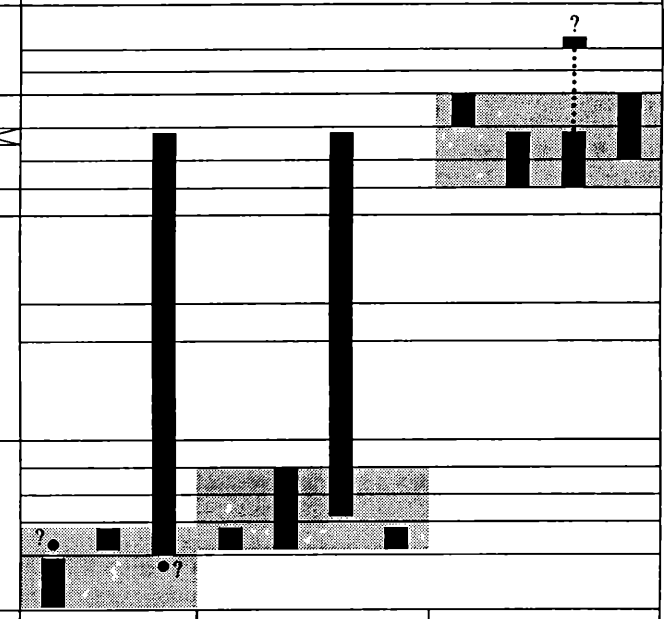


Table 13. Biostratigraphical range of the fossil sites Wentneralm I and Wentneralm II in terms of ammonite stratigraphy (with alterations after BLASZKIEWICZ 1980).

ably represent a level within the interval from nannofossil zones CC17 to CC18/19a.
An important indication for the minimum age of the grey siltstones and thus for the locality Wentneralm II is given by sample GAM 222 from overlying soft pelagic to turbiditic marls in the Krimpenbach section (Text-fig. 2). The nannofossil assemblage documents nannofossil zone CC22a/b, portions of which can be correlated to the *Calcarata* Zone of planktonic foraminiferal zonations (e.g. WAGREICH & KRENMAYR 1993), which indicates a level in the Late Campanian (SCHÖNFELD & BURNETT 1991). A Maastrichtian age can therefore be excluded for the grey siltstones. Based on our data, the grey siltstones of the Wentneralm area com-

Chronostratigraphy	Biostratigraphy NW Germany	Inoceramid assemblage zones	IZ
EARLY MAASTRICHTIAN	*Lanceolata* Zone		
LATE CAMPANIAN	*Grimmensis/Granulosus* Zone		
	Langei Zone		
	Polyplocum Zone	*Cat. haldemensis* Zone	33
	Vulgaris Zone	Unnamed Zone	
	Basiplana/Spiniger Zone	*Cat. vorhelmensis* Z. - *Inoc. agdjakendsis* Z.	32
	Conica/Mucronata Zone	*Cat. beckumensis* Zone	31
EARLY CAMPANIAN	*Gracilis/Mucronata* Zone	*Sph. sarumensis* Zone - *Cat. dariensis* Zone	30
	Conica/Gracilis Zone		
	Papillosa Zone		
	Senonensis Zone		
	Pilula/Senonensis Zone	*Sphe. patootensiformis* Zone	29
	Pilula Zone		
	Lingua/Quadrata Zone		
	Granulataquadrata Zone		
LATE SANTONIAN	*Marsupites/Granulata* Zone		



Range of Gams Inoceramids

Cordiceramus muelleri cf. *germanicus* (HEINZ)
Selenoceramus cf. *inflexus* (BEYENBURG)
Cataceramus sp. aff. *balticus* (J. BÖHM)
Selenoceramus inflexus (BEYENBURG)
Sphenoceramus sp. aff. *angustus* (BEYENBURG)
Cataceramus balticus (BÖHM) subsp. indet.
Endocostea sp. aff. *impressa* (D'ORBIGNY)
Cataceramus balticus cf.*haldemensis* (GIERS)
Inoceramus cf. *bosenbergensis* WALASZCZYK
Inoceramus sp. aff. *borilensis* JOLKIČEV
Inoceramus planus MÜNSTER

Krimpenbach | Wentneralm I | Wentneralm II

Biostratigraphical range of the sites Krimpenbach, Wentneralm I and Wentneralm II 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), PETRASCHECK (1906), RIEDEL (1931), SCHULZ & SCHMID (1983), SCHULZ (1979), ULBRICH (1971) and unpublished data.

Sphe - *Sphenoceramus*
Sph. - *Sphaeroceramus*
Cat. - *Cataceramus*

Inoceramid zones after WALASZCZYK (1997), IZ Inoceramid zones after TRÖGER (1989), TRÖGER et al. (this volume).

Table 14. Biostratigraphical range of the sites Krimpenbach, Wentneralm I and Wentneralm II. Inoceramids.

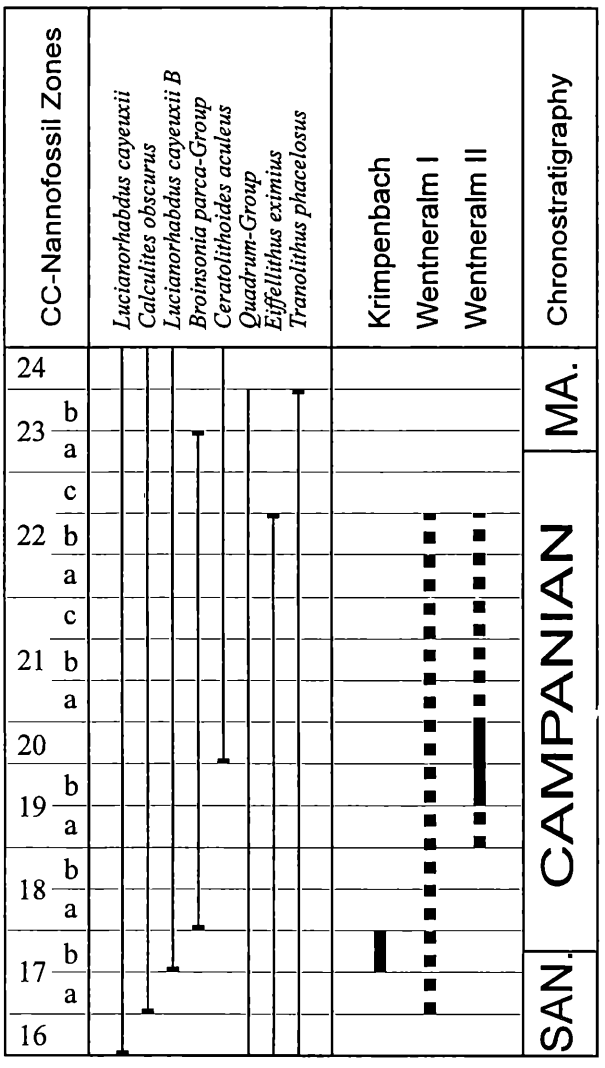


Table 15. Biostratigraphical range of the Krimpenbach Formation compared to the Cretaceous nannofossil standard zones by PERCH-NIELSEN (1985) with modifications according to WAGREICH (1992) and WAGREICH & KRENMAYR (1993). Ranges of important nannofossil species present in the samples of the Krimpenbach Formation are shown in the left-hand column.

prise a sedimentary succession from nannofossil zone CC19 up to CC21 and include the upper part of the *Elevata* Zone and the *Ventricosa* Zone of planktonic foraminifera. According to the correlations by BURNETT (1998), a late Early Campanian to Late Campanian age is probable.

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PLATE 1

Fig. 1: *Hauericeras* cf. *pseudogardeni* (SCHLÜTER); SCHÜ 71/58; Lower Campanian, Wentneralm I, Gams/Hieflau, Steiermark; x 0,5.

Figs. 2, 3: *Desmophyllites* sp. indet. juv., SCHÜ 71/52 b; Lower Campanian, Wentneralm I, Gams/Hieflau, Steiermark; x 2.

PLATE 1

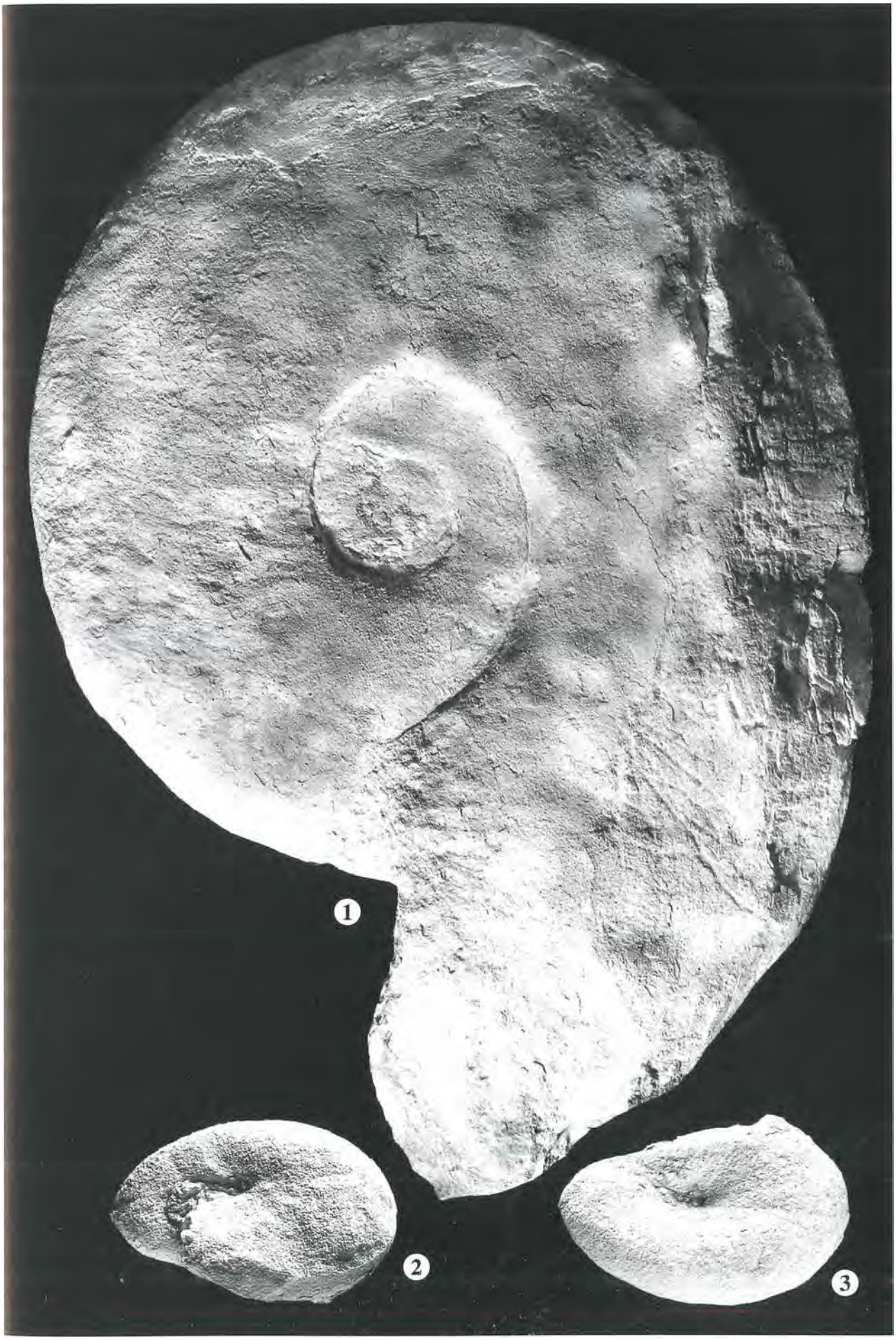

PLATE 2

Figs. 1, 3: *Pachydiscus (Pachydiscus) haldemsis* (SCHLÜTER); SCHÜ 71/53; Upper Campanian, Wentneralm II, Gams/ Hieflau, Steiermark; x 1.

Fig. 2: *Pachydiscus (Pachydiscus) tweenianus* (STOLICZKA); SCHÜ 71/54; Upper Campanian, Wentneralm II, Gams/Hieflau, Steiermark; x 0,5.

PLATE 2

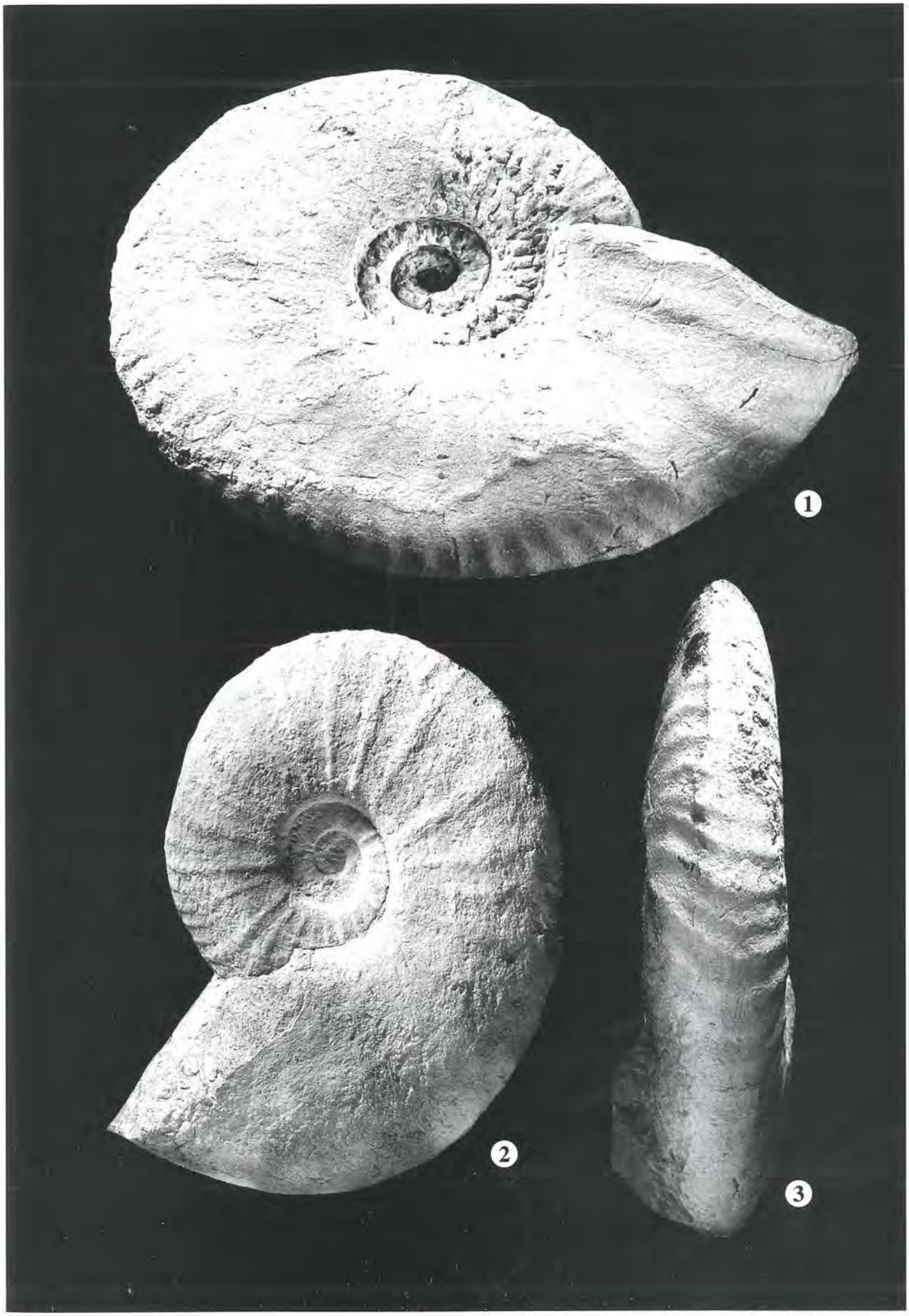

PLATE 3

Fig. 1: *Pachydiscus (Pachydiscus) tweenianus* (STOLICZKA); SCHÜ 71/20; Upper Campanian, Wentneralm II, Gams/Hieflau, Steiermark; x 0,5.

Fig. 2: *Pachydiscus (Pachydiscus)* cf. *launayi* DE GROSSOUVRE; NHMW 1997/127/1; Lower Campanian, Wentneralm I, Gams/Hieflau, Steiermark; x 1.

PLATE 3

PLATE 4

Fig. 1: *Pachydiscus (Pachydiscus)* cf. *launayi* DE GROSSOUVRE; SCHÜ 71/56; Lower Campanian, Wentneralm I, Gams/Hieflau, Steiermark; x 0,5.

Fig. 2: *Pachydiscus (Pachydiscus)* spec. indet. juv.; SCHÜ 71/52 a; Lower Campanian, Wentneralm I, Gams/Hieflau, Steiermark; x 1.

PLATE 4

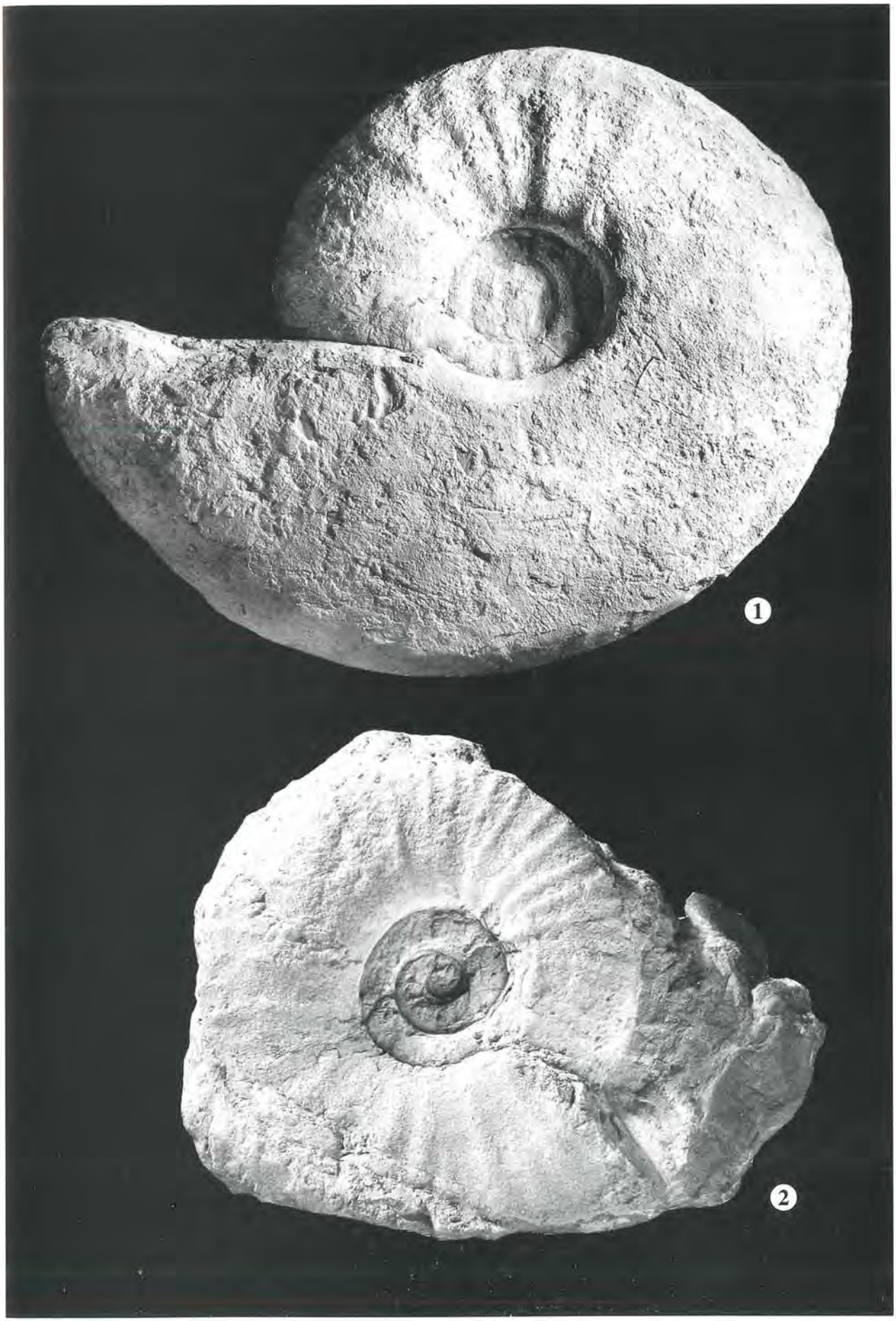

PLATE 5

Fig. 1: *Pachydiscus (Pachydiscus)* cf. *launayi* DE GROSSOUVRE; SCHÜ 71/46; Lower Campanian, Wentneralm I, Gams/Hieflau, Steiermark; x 1.

PLATE 5

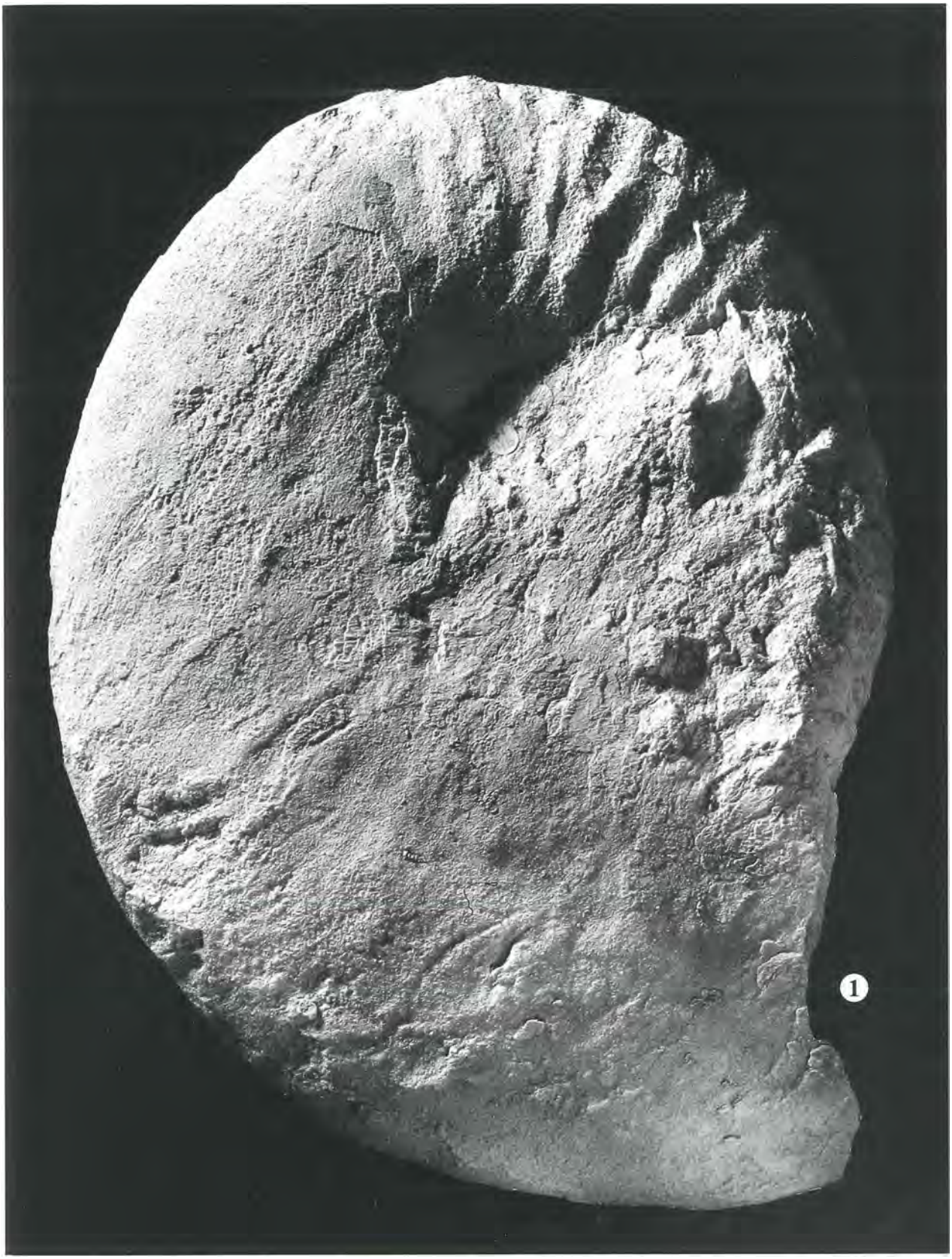

PLATE 6

Fig. 1: *Cordiceramus muelleri* cf. *germanicus* (HEINZ) (NHMW 1997/z/144/1)

Fig. 2: *Cordiceramus muelleri* cf. *germanicus* (HEINZ) (NHMW 1997/z/144/14)

Fig. 3: *Cordiceramus muelleri* cf. *germanicus* (HEINZ) (NHMW 1997/z/144/6)

All specimens are from the Krimpenbach site near Wildalpen, Styria, Gams area; all are uppermost Santonian–lowest Campanian. All figures are x 1.

PLATE 6

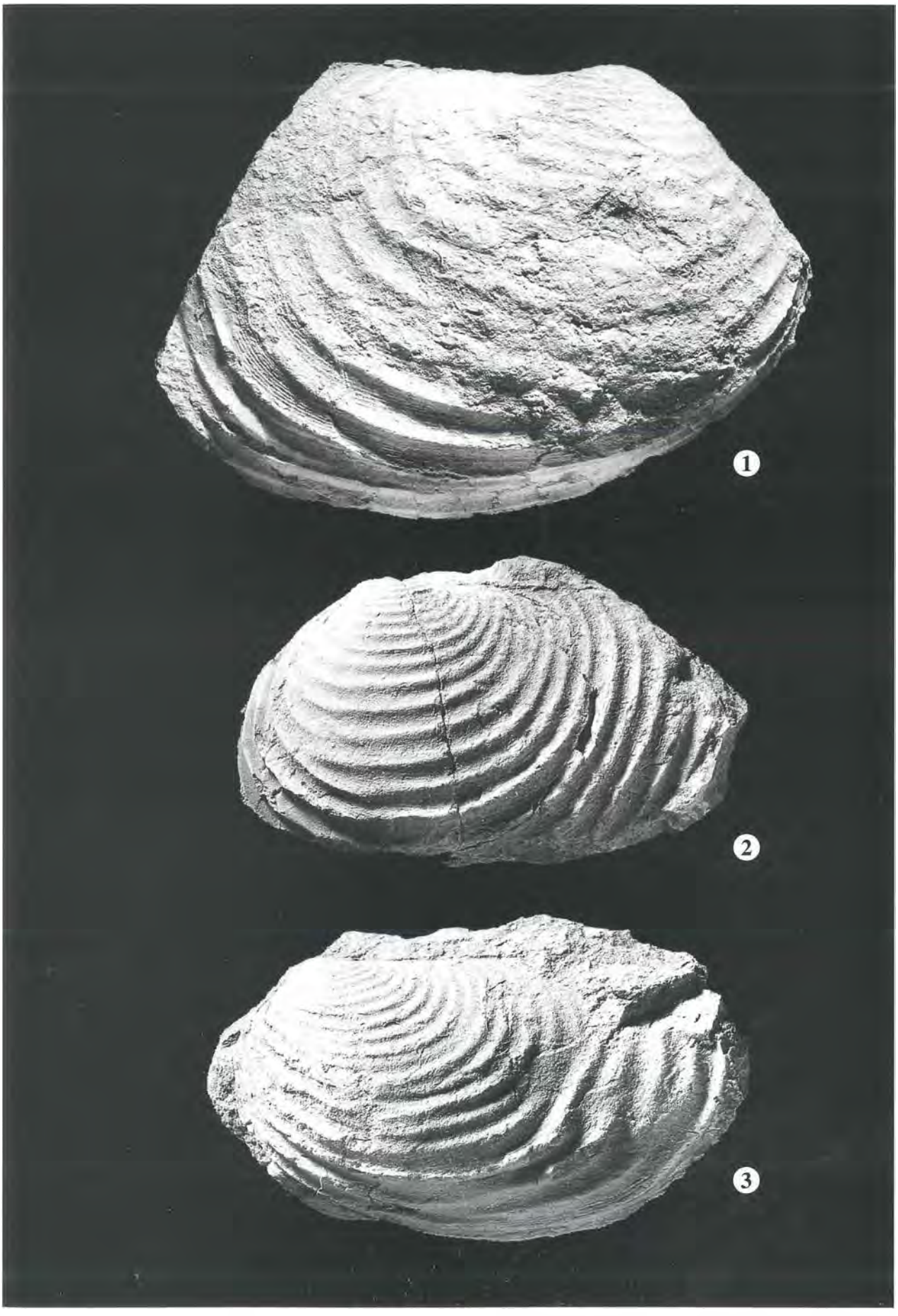

PLATE 7

Fig. 1: *Cataceramus* ex gr. *balticus* (BÖHM) (NHMW 1997/z/144/5)

Fig. 2: *Selenoceramus* cf. *inflexus* (BEYENBURG) (NHMW 1997/z/144/9)

Fig. 3: *Cataceramus* ex gr. *balticus* (BÖHM) (NHMW 1997/z/144/3)

Fig. 4: *Selenoceramus* cf. *inflexus* (BEYENBURG) (NHMW 1997/z/144/4)

All specimens are from the Krimpenbach site near Wildalpen, Styria, Gams area; all are uppermost Santonian – lowest Campanian. All figures are x 1.

PLATE 7

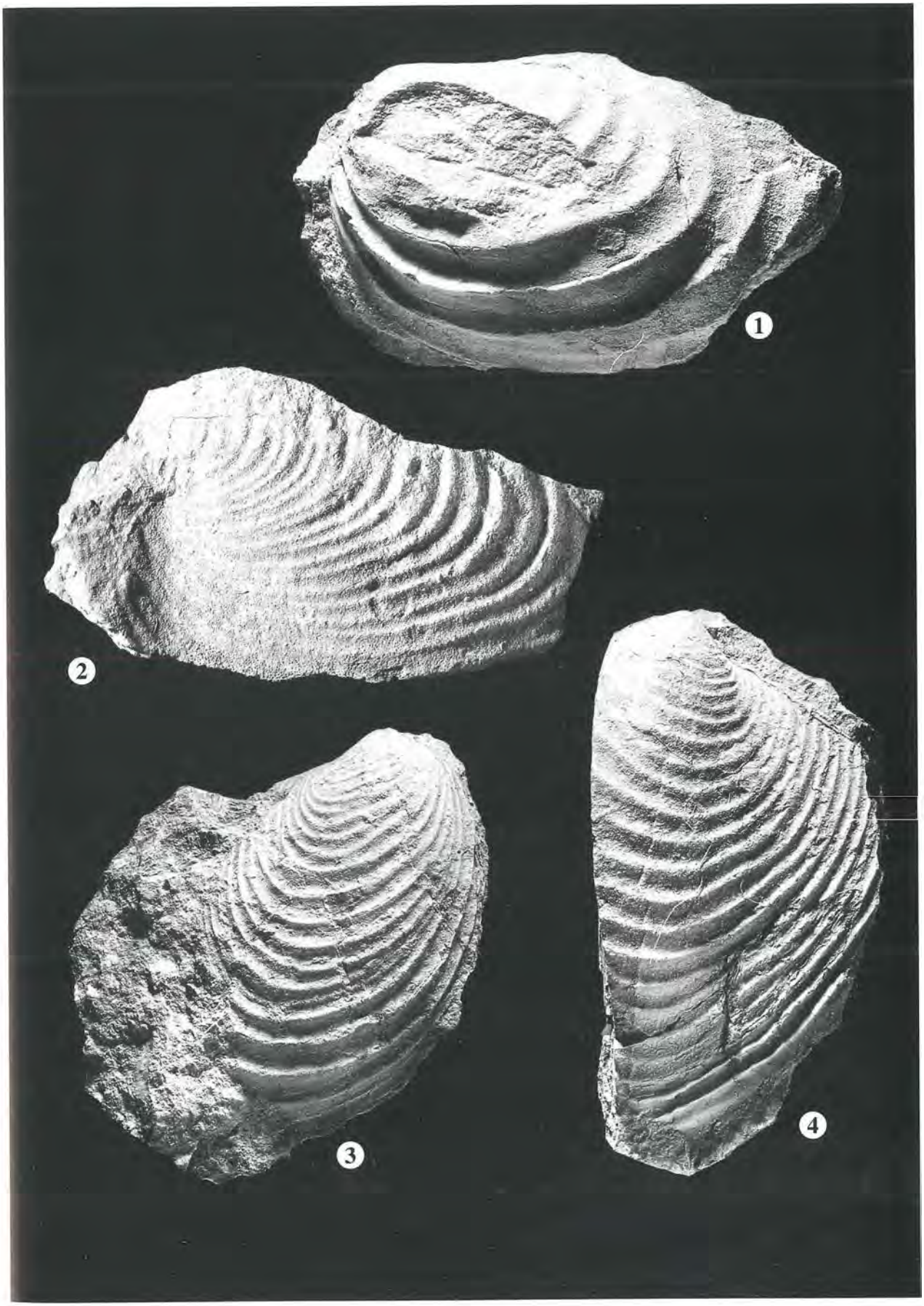

PLATE 8

Fig. 1: *Endocostea* aff. *impressa* (D'ORBIGNY) (NHMW 1997/z/158/9)

Fig. 2: *Endocostea* aff. *impressa* (D'ORBIGNY) (NHMW 1997/z/158/11)

Fig. 3: *Selenoceramus inflexus* (BEYENBURG) (NHMW 1997/z/158/10)

Fig. 4: *Selenoceramus inflexus* (BEYENBURG) (NHMW 1997/z/158/6)

Fig. 5: *Sphenoceramus* aff. *angustus* (BEYENBURG) (NHMW 1997/z/158/13)

Fig. 6: *Cataceramus balticus* (BÖHM) subsp.indet. (NHMW 1997/z/158/12)

All specimens are from the Wentneralm I site near Gams, Gams area, Styria; Krimpenbach Formation, all are Lower Campanian. All figures are x 1.

PLATE 8

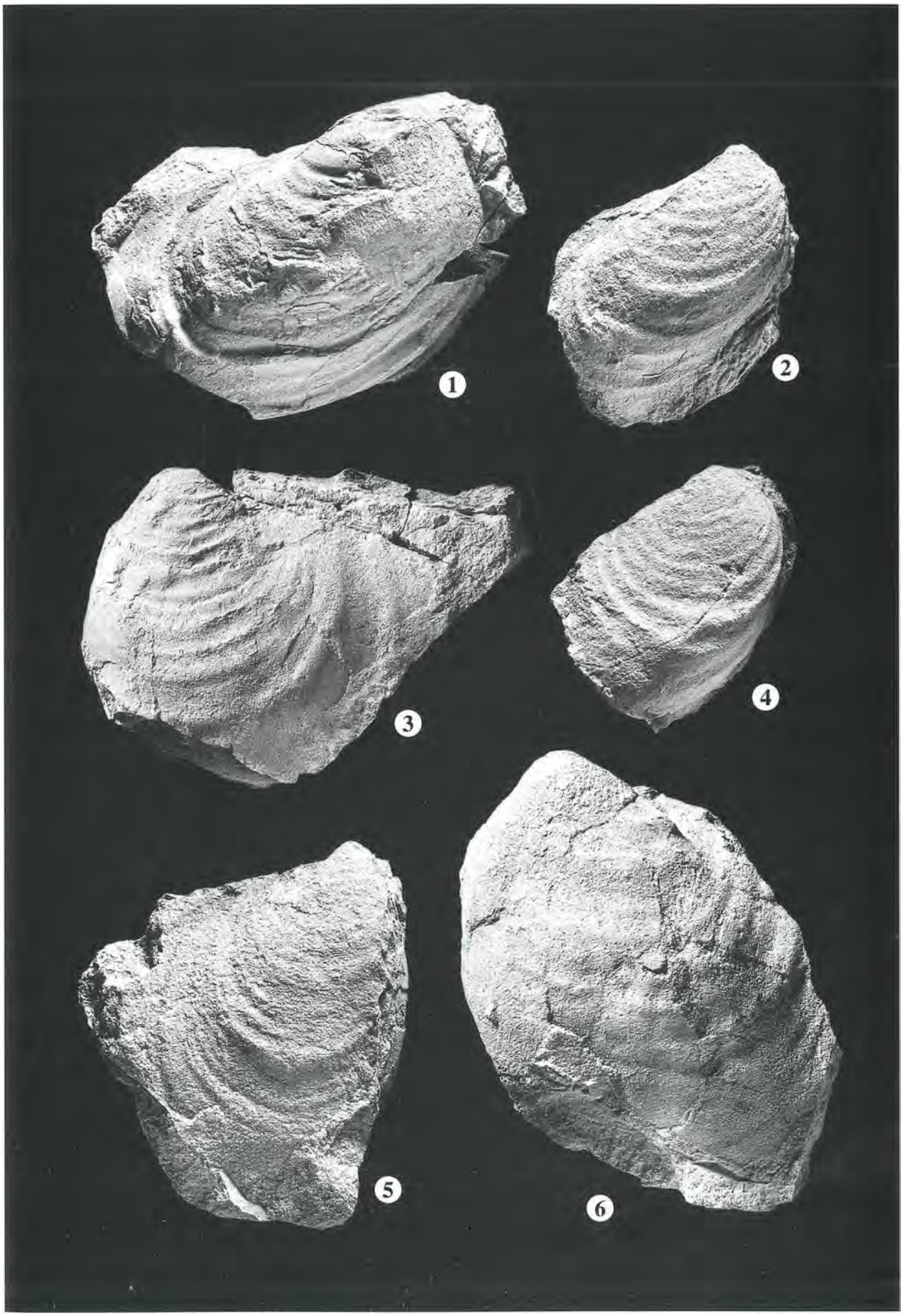

PLATE 9

Fig. 1: *Inoceramus planus* MÜNSTER (NHMW 1997/z/159/1)

Fig. 2: *Cataceramus balticus* cf. *haldemensis* (GIERS) with geniculation, deformed by compaction. (NHMW 1997/z/159/4)

Fig. 3: *Inoceramus* cf. *bosenbergensis* WALASZCZYK (NHMW 1997/z/159/7)

Fig. 4: *Cataceramus balticus* cf. *haldemensis* (GIERS) (NHMW 1997/z/159/8)

Fig. 5a, b: *Cataceramus balticus* cf. *haldemensis* (GIERS) (NHMW 1997/z/159/6)

All specimens are from the Wentneralm II site near Gams, Gams area, Styria; Krimpenbach Formation, all are lower Upper Campanian. All figures are x 1.

PLATE 9

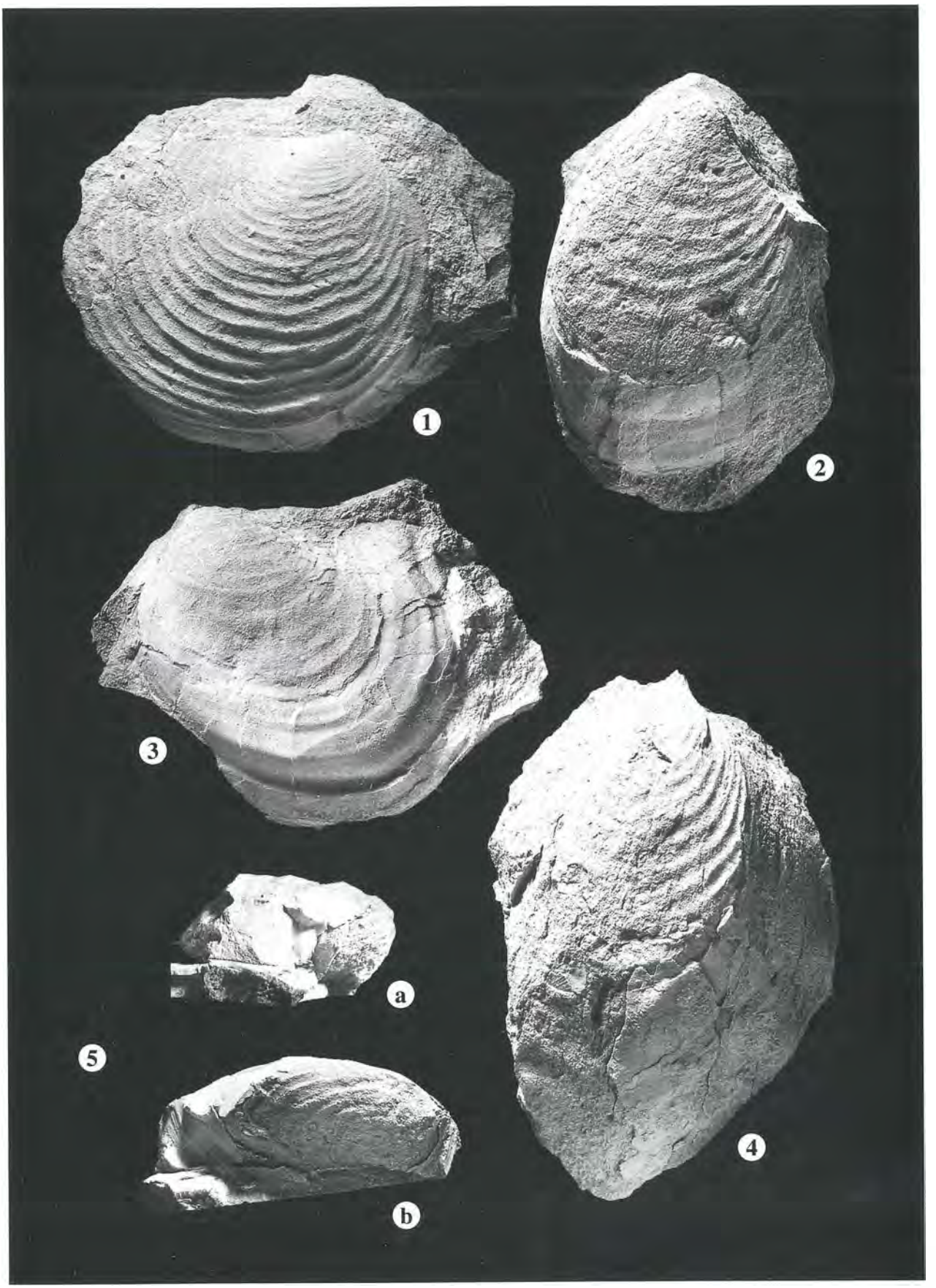

PLATE 10

Fig. 1: *Cataceramus balticus* cf. *haldemensis* (GIERS) with geniculation (NHMW 1997/z/159/9)

Fig. 2: *Selenoceramus inflexus* (BEYENBURG) with *Endocostea* scar (NHMW 1997/z/158/7)

Fig. 3: *Selenoceramus inflexus* (BEYENBURG) with geniculation, highly deformed by compaction (NHMW 1997/z/158/5)

Fig. 4: *Inoceramus* aff. *borilensis* JOLKIČEV (NHMW 1997/z/159/13)

All specimens are from the Krimpenbach Formation, figs. 1,4 are from Wentneralm II site; figs. 2, 3 are from Wentneralm I site; figs. 1,4 are lower Upper Campanian, figs. 2, 3 are Lower Campanian. All figures are x 1.

PLATE 10

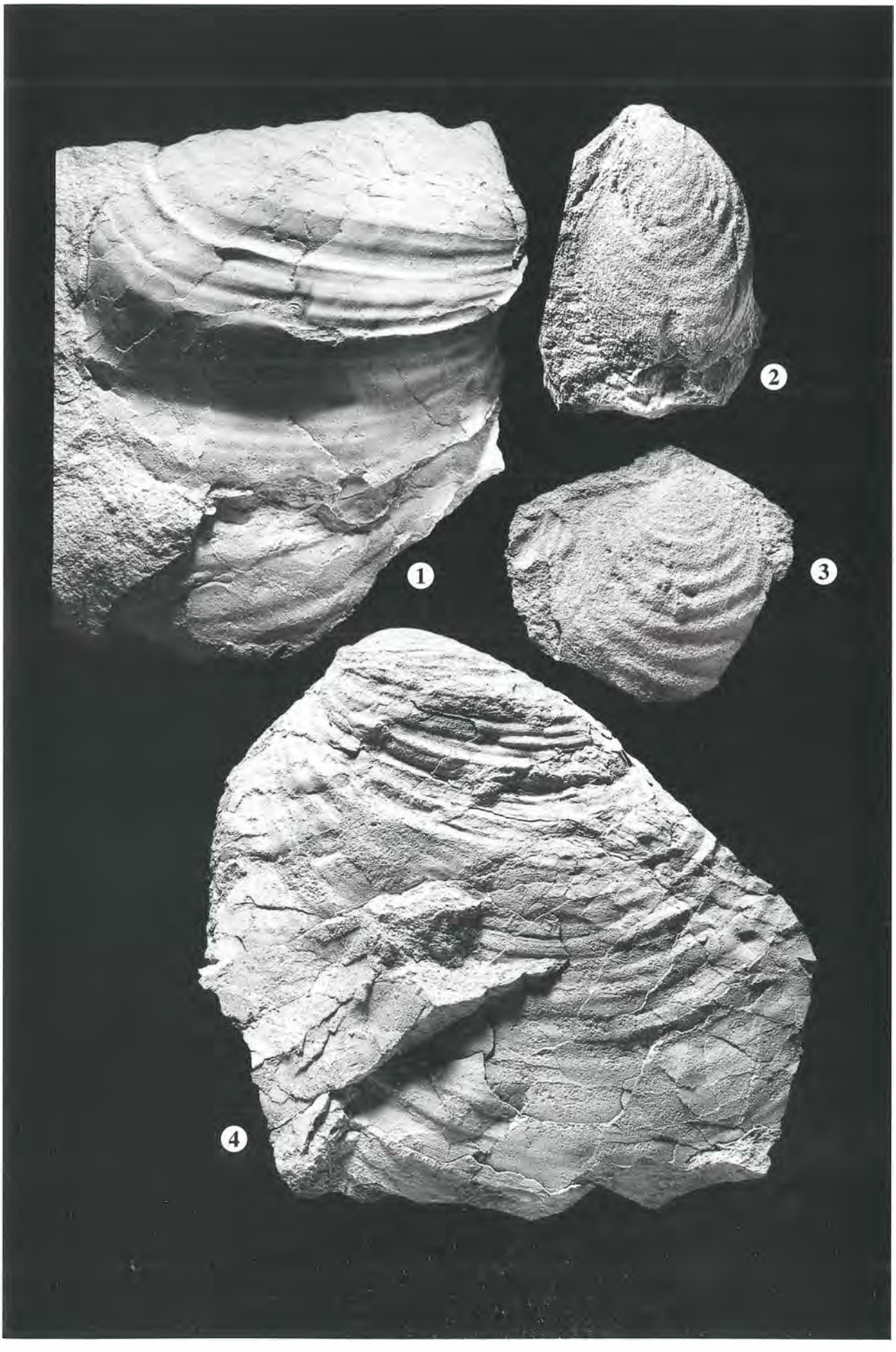

PLATE 11

Fig. 1, 2: *Echinocorys* sp. 1; Wentneralm I, Lower Campanian. Reitergraben; SCHÜ 71/33.

Fig. 3: *Echinocorys* sp. 2 (cf. *fonticola* ARNAUD, 1897); forest road, Wentneralm I; NHMW 1997/128/1.

Fig. 4, 6: *Micraster* gr. *fastigatus/stolleyi*; Wentneralm II; Upper Campanian; Reitergraben; SCHÜ 71/15.

Fig. 5: *Echinocorys* gr. *subglobosa* (GOLDFUSS); Wentneralm II, Upper Campanian; Reitergraben; SCHÜ 71/38.

All specimens are from Gams near Hieflau from the area around Wentneralm. All figures are x 1.

PLATE 11

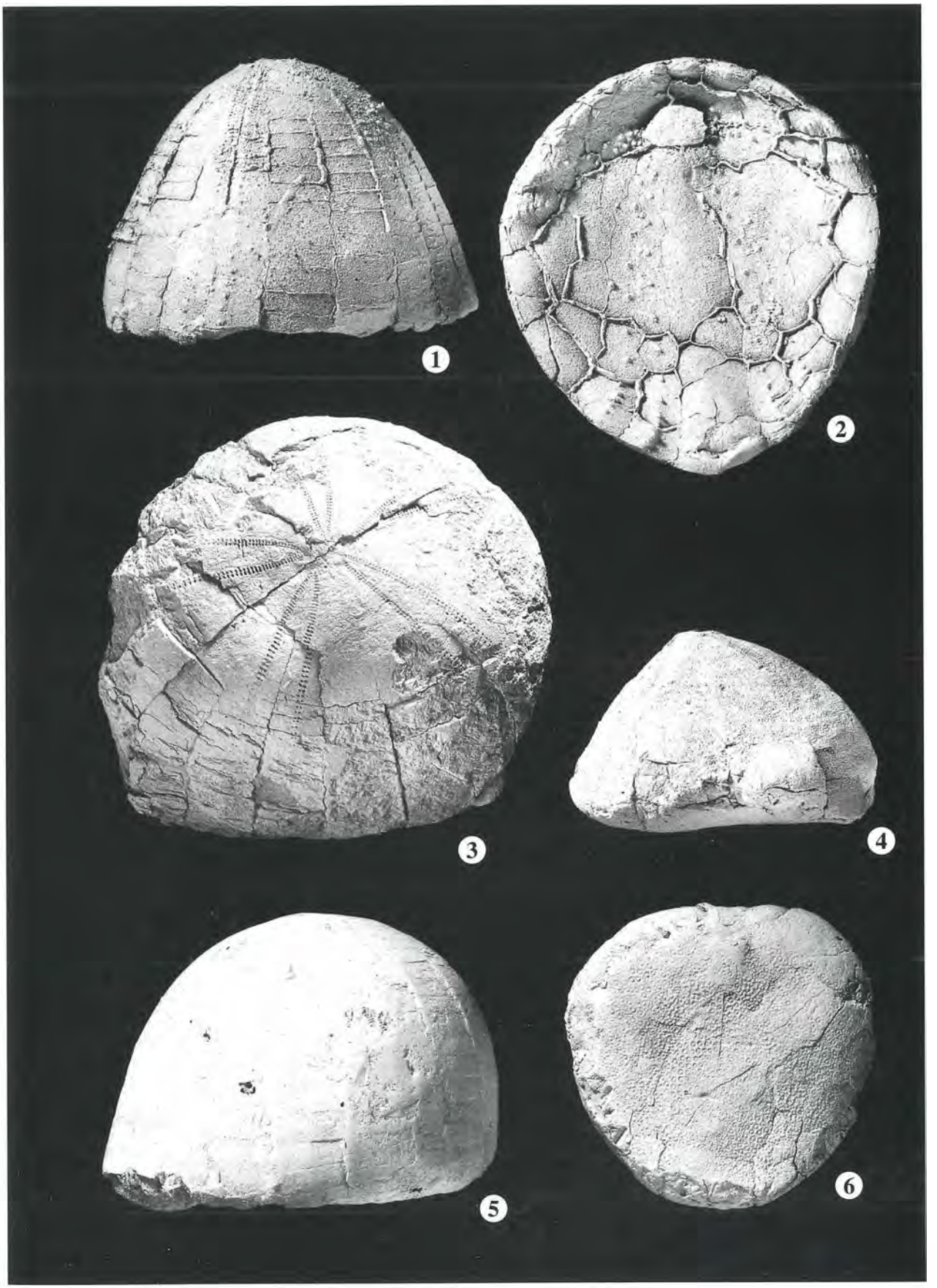

PLATE 12

Fig. 1: *Micraster glyphus* SCHLÜTER; Wentneralm II, Upper Campanian; Reitergraben; SCHÜ 71/37.

Fig. 2, 4, 6: *Micraster* gr. *fastigatus/stolleyi*; Wentneralm I; Lower Campanian, Rödlsteinsattel; SCHÜ 71/60.

Fig. 3, 5: *Micraster glyphus* SCHLÜTER; Wentneralm II, Upper Campanian; W of Rödlsteinsattel; SCHÜ 71/57.

All specimens are from Gams near Hieflau from the area around Wentneralm. All figures are x 1.

PLATE 12